The X-ray Universe 2017

6−9 June 2017
Centro Congressi Frentani
Rome, Italy

A conference organised by the European Space Agency
XMM-Newton Science Operations Centre
National Institute for Astrophysics, Italian Space Agency
University Roma Tre, La Sapienza University

ABSTRACT BOOK

Oral Communications and Posters

Edited by
Simone Migliari, Jan-Uwe Ness

Organising Committees

Scientific Organising Committee

M. Arnaud	Commissariat á l'énergie atomique Saclay, Gif sur Yvette, France
D. Barret (chair)	Institut de Recherche en Astrophysique et Planétologie, France
G. Branduardi-Raymont	Mullard Space Science Laboratory, Dorking, Surrey, United Kingdom
L. Brenneman	Smithsonian Astrophysical Observatory, Cambridge, USA
M. Brusa	Università di Bologna, Italy
M. Cappi	Istituto Nazionale di Astrofisica, Bologna, Italy
E. Churazov	Max-Planck-Institut für Astrophysik, Garching, Germany
A. Decourchelle	Commissariat á l'énergie atomique Saclay, Gif sur Yvette, France
N. Degenaar	University of Amsterdam, the Netherlands
A. Fabian	University of Cambridge, United Kingdom
F. Fiore	Osservatorio Astronomico di Roma, Monteporzio Catone, Italy
F. Harrison	California Institute of Technology, Pasadena, USA
M. Hernanz	Institute of Space Sciences (CSIC-IEEC), Barcelona, Spain
A. Hornschemeier	Goddard Space Flight Center, Greenbelt, USA
V. Karas	Academy of Sciences, Prague, Czech Republic
C. Kouveliotou	George Washington University, Washington DC, USA
G. Matt	Università degli Studi Roma Tre, Roma, Italy
Y. Nazé	Université de Liège, Belgium
T. Ohashi	Tokyo Metropolitan University, Japan
I. Papadakis	University of Crete, Heraklion, Greece
J. Hjorth	University of Copenhagen, Denmark
K. Poppenhaeger	Queen's University Belfast, United Kingdom
N. Rea	Instituto de Ciencias del Espacio (CSIC-IEEC), Spain
T. Reiprich	Bonn University, Germany
M. Salvato	Max-Planck-Institut für extraterrestrische Physik, Garching, Germany
N. Schartel (co-chair)	European Space Agency, Villanueva de la Cañada, Spain
A. Schwope	Leibniz-Institut für Astrophysik Potsdam, Germany
B. Stelzer	Universität Tübingen, Germany & INAF, Osservatorio Astronomico di Palermo, Italy
T. Takahashi	Institute of Space and Astronautical Science, Kanagawa, Japan
J. Tomsick	University of California, Berkeley, USA
P. Uttley	University of Amsterdam, The Netherlands
N. Webb	Université de Toulouse, France
A. Zdziarski	N. Copernicus Astronomical Center, Warsaw, Poland

Local Organising Committee

Simone Migliari (co-chair) (XMM-Newton Science Operations Centre)
Jan-Uwe Ness (co-chair) (XMM-Newton Science Operations Centre)
Matthias Ehle (XMM-Newton Science Operations Centre)
Norbert Schartel (XMM-Newton Science Operations Centre)
Giuliana Giobbi (co-chair) (INAF - OAR, Astronomical Observatory of Rome)
Manuela Bischetti (INAF - OAR, Astronomical Observatory of Rome)
Piergiorgio Casella (INAF - OAR, Astronomical Observatory of Rome)
Gian Luca Israel (INAF - OAR, Astronomical Observatory of Rome)
Francesca Marchi (INAF - OAR, Astronomical Observatory of Rome)
Maria Teresa Menna (INAF - OAR, Astronomical Observatory of Rome)
Alessandro Papitto (INAF - OAR, Astronomical Observatory of Rome)
Enrico Piconcelli (INAF - OAR, Astronomical Observatory of Rome)
Giustina Vietri (INAF - OAR, Astronomical Observatory of Rome)
Federico Vincentelli (INAF - OAR, Astronomical Observatory of Rome)
Luca Zappacosta (INAF - OAR, Astronomical Observatory of Rome)
Alessandra De Rosa (INAF - IAPS, Institute of Astrophysics & Planetary Science, Rome)
Lorena Hernandez (INAF - IAPS, Institute of Astrophysics & Planetary Science, Rome)
Francesca Panessa (INAF - IAPS, Institute of Astrophysics & Planetary Science, Rome)
Silvia Zampieri (INAF - IAPS, Institute of Astrophysics & Planetary Science, Rome)
Andrea Marinucci (University Roma Tre)
Riccardo Middei (University Roma Tre)
Alessia Tortosa (University Roma Tre)
Simonetta Puccetti (ASI-ASDC Italian Space Agency - ASI Data Center)
Fernanda Lupinacci (La Sapienza University, Rome)

Contents

Chapter 1

Invited Speakers

Ultraluminous X-ray sources

Matteo Bachetti[1]
[1] *INAF-Osservatorio Astronomico di Cagliari*

The extreme emission of Ultraluminous X-ray Sources (ULX) represents a unique testing environment for compact objects population studies and the accretion process. Their nature has long been disputed. Their luminosity, well above the Eddington luminosity for a stellar-mass black hole, was often considered evidence for intermediate-mass black holes, or a signature of a poorly known regime of super-Eddington accretion. Both these interpretations are important to better understand the accretion process and the evolution of massive black holes. The last few years have seen a dramatic improvement of our knowledge of these sources. In particular, the super-Eddington interpretation for the bulk of the ULX population has gained a strong consensus, even more after the discovery of three neutron star-powered ULXs, at 100-1000 times their Eddington luminosity. I will review the progress done in the last few years on these exciting sources.

Recent Progress on Supernova Remnants - Progenitors, Evolution, Cosmic-ray Acceleration

Aya Bamba[1]
[1] *University of Tokyo, Tokyo, Japan*

Supernova remnants supplies heavy elements, kinetic and thermal energies, and cosmic rays, into the universe, and are the key sources to make the diversity of the universe. On the other hand, we do not know the fundamental issues of supernova remnants, such as (1) what their main progenitors are, (2) how they evolve into the realistic (non-uniform) interstellar space, and (3) which type of supernova remnants can accelerate cosmic rays to the knee energy. Recent X-ray studies with XMM-Newton, Chandra, Suzaku, NuSTAR, and Hitomi, progressed understandings of these issues, and found that each issue connect others tightly. In this paper, we will overview these progresses with focusing the above three topics, and discuss what we should do next.

Probing Dark Matter using X-ray Observations

Esra Bulbul[1]
[1] *MIT*

A well-motivated warm dark matter candidate, sterile neutrinos, can radiatively decay and emit X-rays detectable in observations of large dark matter aggregations such as galaxies and clusters of galaxies. I will review the current and past efforts on searching for decaying dark matter in galaxy clusters and galaxies with a special focus on the 3.5 keV line. Additionally, I will summarize how the recent constraints can be improved using the future Athena XIFU observations.

X-rays from the Solar System

Konrad Dennerl[1]
[1] *Max-Planck-Institut für extraterrestrische Physik, Garching, Germany*

While the beginning of X-ray astronomy was motivated by solar system studies (Sun and Moon), the main research interest soon shifted outwards to much more distant and exotic objects. However, the ROSAT discovery of X-rays from comets in 1996 and the insight that this 'new' kind of X-ray emission, charge exchange, was underestimated for a long time, has demonstrated that solar system studies are still important for X-ray astrophysics in general. While comets provide the best case for studying the physics of charge exchange, the X-ray signatures of this process have now also been detected at Venus, Mars, and Jupiter, thanks to Chandra and XMM-Newton. An analysis of the X-ray data of solar system objects, however, is challenging in many respects. This is particularly true for comets, which appear as moving, extended X-ray sources, emitting a line-rich spectrum at low energies. Especially for XMM-Newton, which has the unparalleled capability to observe with five highly sensitive X-ray instruments plus an optical monitor simultaneously, it is a long way towards photometrically and spectroscopically calibrated results, which are consistent between all its instruments. I will show this in my talk, where I will also summarize the current state of solar system X-ray research.

Outflows in X-ray binaries

Maria Diaz Trigo[1]
[1] *ESO*

Accretion onto neutron stars and black holes powers the most luminous phenomena in the Universe. Associated to it is the existence of outflows, in the form of uncollimated winds or highly collimated relativistic jets. The origin of outflows and their feedback to the environment is one of the most debated topics in astrophysics today. In this talk I will review the current understanding of accretion disc winds in X-ray binaries, their launching mechanism and their relation to specific accretion states. I will also discuss the potential interplay between the appearance/disappearance of such winds and relativistic jets and the insight gained with ongoing multi-wavelength observational programmes focused on the variability of such phenomena.

X-rays from AGN in a multi wavelength context

Chris Done[1]
[1] *University of Durham, UK*

I will review what we know about the way the observed spectral energy distribution changes with mass and mass accretion rate, and propose a global model for the accretion flow structure which includes the soft X-ray excess, in both broad and narrow line seyfert 1s. I will show that many of the most extreme NLS1s are supereddington, so should be powering strong winds, and show how this can explain the difference between the 'complex' NLS1 such as 1H0707 and the 'simple' ones which do not show such extreme variability yet have similar mass and mass accretion rates. I will discuss the resulting source geometry and how this can explain the fast lag-frequency spectra, and show how this opens the way to a quantitive model for the power carried by winds and jets in AGN feedback.

Probing general relativistic precession around stellar-mass black holes with tomography and polarimetry

Adam Ingram[1]
[1] *University of Amsterdam, Amsterdam, The Netherlands*

Accreting stellar-mass black holes often show a quasi-periodic oscillation (QPO) in their X-ray flux, and an iron emission line in their X-ray spectrum. The iron line is generated through disc reflection, and its shape is distorted by rapid orbital motion and gravitational redshift. The physical origin of the QPO has long been debated, but is often attributed to LenseThirring precession, a General Relativistic effect causing the inner flow to precess as the spinning black hole twists up the surrounding spacetime. This predicts a characteristic rocking of the iron line between red- and blueshift as the receding and approaching sides of the disc are respectively illuminated. I will first talk about our XMM-Newton and NuSTAR observations of the black hole binary H 1743-322 in which the line energy varies systematically over the ~ 4 s QPO cycle, as predicted. This result has enabled us to map the inner accretion disc using tomographic techniques for the first time. I will then talk about the quasi-periodic swings in X-ray polarisation angle predicted by the precession model, and show how we can go about measuring such swings with the recently selected NASA Small explorer mission IXPE and proposed missions such as XIPE and eXTP.

XMM-Newton observations of the inner accretion flow in Active Galactic Nuclei

Erin Kara[1]
[1] *University of Maryland, College Park, MD, USA*

Active Galactic Nuclei can produce as much or more electromagnetic and kinetic luminosities than the combined stellar luminosity of an entire galaxy. Though the masses of the central black holes are typically 500-1000 times less their host galaxies, AGN appear to play a vital role in regulating the growth of the most massive galaxies. The energy output from AGN comes from the gravitational potential energy of the infalling material and the rotational energy of the black hole. In both cases, most of the energy is released very close to the black hole, and therefore, probing the relativistic region of the inner accretion flow is essential to understanding how AGN work and effect their environments. In this review, I will focus on the ways in which XMM-Newton observations are used to probe these compact environments, including the new technique of X-ray reverberation mapping, which allows us to map the gas falling on to the black hole and measure the effects of strongly curved spacetime close to the event horizon.

"Damn that's bright!" - why ignoring the Eddington limit is so much fun

Matthew Middleton[1]
[1] *University of Southampton*

Decades of studying compact objects has led to an explosion in our understanding, yet some puzzles remain unanswered. Whilst the vast majority of Galactic black hole binary systems accrete at a rate below their classical Eddington limit, several appear to exceed it and whilst doing so show the most dramatic of phenomenology including the most powerful ballistic jet events and equatorial outflows. Standing alone as the most extreme example is the Galactic microquasar SS433. Long considered by some to be a Galactic 'ultraluminous X-ray source', it is literally shrouded in mystery thanks to an optically thick wind obscuring the central regions. I will discuss these systems and new work which sheds light on SS433 and how it might fit into the growing picture of super-critically accreting sources.

SZ observations to study the physics of the intra-cluster medium

Etienne Pointecouteau[1,2]
[1] *CNRS; IRAP; 9 Av. colonel Roche, BP 44346, F-31028 Toulouse cedex 4, France*
[2] *Université de Toulouse; UPS-OMP; IRAP; Toulouse, France*

Recent Sunyaev-Zeldovich surveys have delivered new catalogues of galaxy clusters over the whole sky and out to distant redshifts. The new generation of SZ facilities (NIKA, MUSTANG, ALMA) now focuses on high angular resolution and high sensitivity. I will discuss the current status of SZ observations and the perspective with the future instruments for the measurement of physical properties of galaxy clusters, and their relevance to the study of the ICM physics. I will also discuss the natural synergy between the SZ signal and the X-ray emission from the hot intra-cluster medium.

The puzzling orbital period evolution of the LMXB AX J1745.6-2901

Gabriele Ponti[1], Kishalay De[1], Teodoro Munoz-Darias[2], Luigi Stella[3], Kirpal Nandra[1]
[1] *Max Planck Institute fur Extraterrestrische Physik (MPE Garching)*
[2] *IAC, La Laguna, Tenerife*
[3] *INAF Osservatorio Astronomico di Roma*

The discovery of gravitational waves through mergers of binary black holes raises the question of how such compact systems form, renewing issues related to the orbital evolution of binary systems. Eclipsing X-ray binaries are excellent tools to constrain the orbital period evolution and how the system loses angular momentum. I will present an X-ray eclipse timing analysis (spanning an interval of more than 20 yr) of one of such objects, AX J1745.62901. Its orbital period is decreasing at a rate Pdotorb=4.03+-0.32 e11 s s1, at least one order of magnitude larger than expected from conservative mass transfer and angular momentum losses due to gravitational waves and magnetic braking, and it might result from either non-conservative mass transfer or magnetic activity changing the quadrupole moment of the companion star. I will also show that imprinted on the long-term evolution of the orbit, there are highly significant eclipse leadsdelays of 1030 s, characterized by a clear state dependence in which, on average, eclipses occur earlier during the hard state. Finally, I will discuss whether accretion disc winds might have an impact onto the orbital evolution.

Probing the hot intracluster medium with X-ray observations

Gabriel Pratt[1]
[1] *CEA Saclay - Département dAstrophysique, 91191 Gif-sur-Yvette CEDEX, France*

X-ray observations give access to measurements of the distribution, density, temperature, and abundances of the hot intra-cluster medium. I will review recent progress in X-ray observations of clusters, and comment on areas where future observations will have a large impact.

The role of X-rays in exoplanet evolution and habitability

Peter Wheatley[1]
[1] *University of Warwick, UK*

It is becoming increasingly apparent that the X-ray and EUV radiation of stars can have a profound effect on the evolution and habitability of their surrounding exoplanets. This includes the erosion of giant planets, in some cases down to their rocky cores, and the removal of water and atmospheres from otherwise habitable planets. In other cases X-ray irradiation may improve habitability by stripping thick primordial atmospheres. In this talk I will describe the rapid progress in this field in recent years, including the direct detection of X-ray irradiation and evaporation of individual exoplanets and the detection of the first X-ray transits. I will also show how X-ray observations are playing a crucial role in assessing the potential habitability of recently-discovered Earth-sized planets around nearby M dwarfs. Finally I will outline suggestions that exoplanet magnetospheres might influence stellar activity and that exoplanets themselves could be detectable sources of X-rays.

Transitional Millisecond Pulsar Binaries

Domitilla de Martino[1], Alessandro Papitto[2]
[1] *INAF-Osservatorio Astronomico di Capodimonte Napoli*
[2] *INAF-Osservatorio Astronomico di Roma*

The extremely fast rotation of millisecond pulsars is the outcome of a Gyr-long accretion phase onto a neutron star of material transferred through an accretion disc from a low mass late-type companion star. After this phase during which the binary shines as a bright low-mass X-ray binary (LMXB), the mass transfer rate declines allowing the activation of a radio/gamma-ray pulsar (MSP) powered by the rapid rotation of its magnetic field. The tight link between LMXBs and MSPs was first testified in 2009 by PSRJ1023+0038 that years before was in an accretion state. The recent suprising discovery of three binary systems, dubbed transitional MSPs, switching from accretion to rotation-powered emission and viceversa has shown the existence of a peculiar intermediate evolutionary phase during which LMXB and MSP states interchange on timescales compatible with those of the variations of the mass-inflow. Transitions were observed during outburst but also in an extremely peculiar sub-luminous disc state during which both accretion and ejection may take place. The main observational properties of known and candidate systems in both disc and disc-free states and ongoing efforts to understand the coupling of accretion and ejection and the role of magnetic fields in driving outflows will be presented.

Chapter 2

Solicited Speakers

The Athena science case in context

Xavier Barcons[1]
[1] *Instituto de Fisica de Cantabria (CSIC-UC), 39005 Santander, Spain*

The Athena X-ray observatory mission has been conceived to study the Hot and Energetic Universe. This includes determining the physical and chemical evolution of the hot baryonic component in the Universe, assembling into the gravitational potential wells in large-scale structures as well as the phenomena generated around black holes, capable of shaping galaxies and clusters through feedback phenomena. In this talk, I will develop in detail the science objectives of Athena along these lines, as well as in other areas of Astrophysics where its contribution will be transformational. I will particularly highlight the role of the Athena observatory in the astronomical landscape of the late 2020s, where synergies with large optical/IR and sub/mm facilities have been already identified through a joint ESO-Athena synergy exercise, and likewise with large radio facilities through an on-going SKA-Athena synergy exercise.

The Athena X-ray Integral Field Unit

Didier Barret[1]
[1] *IRAP*

The Athena X-ray Integral Field Unit (X-IFU) is a high-resolution X-ray spectrometer, providing 2.5 eV spectral resolution, over a 5' (equivalent diameter) field of view, and count rate capabilities up to 1 Crab in the 0.2-12 keV range. Approaching the end of its feasibility study (scheduled around the end of 2017), I will briefly recall the scientific objectives of Athena driving the X-IFU specifications and will describe its current baseline configuration and the expected performances. I will outline the on-going technology developments that will enable the X-IFU.

The X-IFU will be developed by an international consortium led by France (IRAP/CNES), the Netherlands (SRON), Italy (IAPS), with ESA member state contributions from Belgium, Finland, Germany, Poland, Spain and Switzerland, and international partner contributions from Japan and the United States.

This talk is given on behalf of the X-IFU Consortium.

The XMM Cluster Outskirts Project (X-COP)

Dominique Eckert[1]
[1] *University of Geneva, Switzerland*

The outskirts of galaxy clusters (typically the regions located beyond R500) are the regions where the transition between the virialized ICM and the infalling material from the large-scale structure takes place. As such, they play a central role in our understanding of the processes leading to the virialization of the accreting gas within the central dark-matter halo. I will give an overview of the XMM cluster outskirts project (X-COP), a very large program on XMM to study the virial region of galaxy clusters with unprecedented details. I will show how X-ray observations can be combined with the Sunyaev-Zeldovich signal to recover the thermodynamic properties and hydrostatic mass of the ICM, bypassing the need for expensive X-ray spectroscopic observations. I will discuss the results obtained using this technique on Abell 2142 and Abell 2319 and give prospects for the results expected using the full X-COP sample. I will also present recent results on the search for warm-hot baryons in the filaments connected to clusters, emphasizing on the discovery of 3 filaments of 10-million-degree gas connected to the massive cluster Abell 2744.

An overview of results emerging from a 1.5 Ms long exposure of the highly variable AGN IRAS13224-3809

Andrew Fabian[1], Michael Parker[1], Ciro Pinto[1], Anne Lohfink[1], Douglas Buisson[1], William Alston[1], Erin Kara[2], Edward Cackett[3], Chia-Ying Chiang[3], Thomas Dauser[4], Barbara De Marco[5], Luigi Gallo[6], Javier García[7], Fiona Harrison[7], Jiachen Jiang[1], Ashley King[8], Matthew Middleton[9], Jon Miller[10], Giovanni Miniutti[11], Christopher Reynolds[2], Phil Uttley[12], Dominic Walton[1], Daniel Wilkins[8], Abderahmen Zoghbi[10]
[1] *Institute of Astronomy, Cambridge, UK*
[2] *University of Maryland, Maryland, USA*
[3] *Wayne State University, Michigan, USA*
[4] *Universitat Erlangen-Nurnberg, Bamberg, Germany*
[5] *Max-Planck-Institut fur extraterrestrische Physik, Garching, Germany*
[6] *Saint Mary's University, Halifax, Canada*
[7] *California Institute of Technology, California, USA*
[8] *Stanford University, California, USA*
[9] *University of Southampton, Southampton, UK*
[10] *University of Michigan, Michigan, USA*
[11] *Centro de Astrobiologia (CSIC-INTA), ESAC, Madrid, Spain*
[12] *University of Amsterdam, Amsterdam, The Netherlands*

IRAS13224-3809 is the most rapidly variable AGN in the Sky. 1.5 Ms of new XMM data were obtained in summer 2016 together with about 500 ks of simultaneous NuSTAR data. This NLS1 galaxy shows strong reflection signatures in its spectrum and also its variability in terms of high frequency soft lags (reflection-dominated soft flux follows after the power-law coronal harder flux). The new data have also revealed a variable ultrafast outflow in the source. The spectral-timing results will be reviewed and put in context with a model for the innermost regions around the black hole.

The enhanced X-ray Timing and Polarimetry mission

Marco Feroci[1]
[1] *INAF/IAPS, Rome, Italy*

eXTP is a mission of the China National Space Admninistration and Chinese Academy of Sciences, with an important participation by a consoritium of European institutions. The mission is aimed at addressing forefront science questions concerning the behavior of matter under extreme conditions of gravity, density and magnetism. The scientific payload composed of four experiments: the Spectroscopy Focusing Array (SFA, 0.5-10 keV), a set of 9 X-ray telescopes, for a total effective area of about 0.6 m2 at 6 keV, the Large Area Detector (LAD, 2-30 keV), a set of collimated detectors for an effective area of 3.4 m2 at 6 keV, the Polarimetry Focusing Array (PFA, 2-10 keV), a set of 4 X-ray telescopes equipped with an imaging X-ray polarimeter, and the Wide Field Monitor (WFM,2-50 keV), imaging 4 sr simultaneously, with arcmin resolution. The launch is foreseen before 2025. I will report about the status and progress in the mission design and study.

Athena: mission concept, study status, and optics development

Matteo Guainazzi[1], Athena Study Team
[1] *ESTEC/ESA, Keplerlaan 1, 2201AZ Nordwijk, The Netherlands*

Athena is the L-class mission selected by the European Space Agency (ESA) to address the theme of "the Hot and energetic Universe" in the Cosmic Vision program. Officially selected for L2 with a launch date in 2028, Athena is currently in the study phase, to be proposed for 'adoption' around 2019/20.

The Athena mission concept comprises two instruments: the X-ray Integral Field Unit (X-IFU) a cryogenic imaging spectrometer covering the 0.3 to 10 keV energy range with unprecedented energy resolution; and the Wide Field Imager (WFI) covering the 0.1 to 12 keV energy range, based on a silicon active pixel sensor. It features a large field of view, excellent spatial and energy resolution and count rate capabilities up to the Crab regime.

The 12-m focal length Athena mirror provides effective area of $\simeq$2 m^2 at 1 keV, angular resolution of 5 arc seconds Half Energy Width at <7 keV, and field of view diameter >40 arc minutes. This combination is made possible by the Silicon Pore Optics technology developed by ESA and Cosine Measurement Systems over the last decade.

In this talk I will review the mission concept, optics development, and study status.

The XMM-Newton View of the x¡0.4 Warm Hot Intergalactic Medium

Fabrizio Nicastro[1]
[1] *IANF - OSservatorio Astronomico di Roma / Smithsonian Astrophysical Observatory*

We present preliminary results from the whole 1.6 Ms XMM-Newton observation of the z> 0.4 Blazar 1ES 1553+113. The final 1.6 Ms spectrum of 1ES 1553+113 has reached a 90% sensitivity of 4 mA to absorption line equivalent width. In the XMM-Newton and Chandra grating archives such sensitivities are reached only in the spectra of the brightest blazar in the Universe, Mkn 421, which however explores a line-of-sight pathlength > 10 times shorter than that seen against 1ES 1553+113. According to the most conservative theoretical predictions at least 2 WHIM OVII Ka absorbers should have been detected down to these sensitivities and up to such pathlengths. However, the RGS spectrum of 1ES 1553+113, which clearly detects several all the expected Galactic absorption lines down to such sensitivities and hints to a bunch of even weaker Galactic transitions, does not show any intervening absorption line securely identifiable with WHIM. This clearly questions predictions at a significance larger than 90% and opens a number of questions that desperately need to be properly investigated and possibly addressed, both theoretically and observationally, before the advent of the next generation of high-resolution X-ray spectrometers.

eROSITA on SRG

Peter Predehl[1]
[1] *MPI für extraterrestrische Physik*

eROSITA is completely calibrated, assembled and tested. It was shipped to Russia in January 2017. Now the integration with spacecraft and the Russian telescope ART-XC is ongoing. The launch from Baikonur using a Proton rocket is planned for March 2018. The performance of the telescope is within the original specification.

The Wide Field Imager for Athena

Arne Rau[1], Kirpal Nandra[1], Norbert Meidinger[1], Markus Plattner[1]
[1] *Max Planck Institute for extraterrestrial Physics, Garching, Germany*

The Wide Field Imager (WFI) is one of the two scientific instruments of Athena, ESA's next large X-ray Observatory with launch in 2028. The instrument will provide two defining capabilities to the mission sensitive wide-field imaging spectroscopy and excellent high-count rate performance. It will do so with the use of two separate detectors systems, the Large Detector Array (LDA) optimized for its field of view ($40' \times 40'$) with a 100 fold survey speed increase compared to existing X-ray missions, and the Fast Detector (FD) tweaked for high throughput and low pile-up for point sources as bright as the Crab. In my talk I will present the key performance parameters of the instrument and their links to the scientific goals of Athena and summarize the status of the ongoing development activities.

The XMM-Newton Very Large Program on Cosmology with High-Redshift Quasars

Guido Risaliti[1]
[1] *Università di Firenze, Italy*

The non-linear relation between the X-ray and UV emission in quasars can be used to estimate the distance of quasars with a precision of 0.2 dex. Based on this property, we built a Hubble Diagram of quasars up to z∼6. This provides a new way to test the cosmological model at high redshift, and to measure the cosmological parameters. So far, we filled the Hubble Diagram with SDSS quasars with serendipitous XMM observation. This is an efficient method up to z∼2-2.5, but at higher redshifts pointed observations are needed in order to constrain the cosmological models. XMM-Newton will observe 30 optically bright quasars at z∼3, allowing to measure the expansion rate of the Universe at z=3 with a 8% precision. This will provide a tight test of the standard LCDM model, and an improvement of the constraints on the possible evolution of the equation of state of the dark energy.

X-ray polarimetry an upcoming 'new' tool in Astronomy

Paolo Soffitta[1]
[1]*IAPS/INAF*

Sensitive X-ray polarimetry promises to solve many different issues in X-ray Astronomy: from disentangling physics from geometry removing degeneracies in models of magnetars and X-ray binaries hosting neutron stars, to mapping ordered magnetic fields in Supernova Remnants and Pulsar Wind Nebulae. It constrains emission mechanisms in blazars and solves the mistery of X-ray emission from cold molecular clouds in the galactic center. Moreover it can answer to questions of fundamental physics. XIPE the X-ray Imaging Polarimetry Explorer accomplished phase A as an ESA M4 candidate and IXPE the Imaging X-ray Polarimetry explorer was selected as next SMEX mission by NASA for a flight in late 2020. In this talk I will describe both missions and their ability to make energy, time and angle resolved polarimetry thanks to a detector developed at this aim and to X-ray optics with a large effective area.

CHEERS: Chemical enrichment of clusters of galaxies measured using a large XMM-Newton sample

Jelle de Plaa[1]
[1]*SRON Netherlands Institute for Space Research*

The Chemical Enrichment RGS Sample (CHEERS) is aimed to be a sample of the most optimal clusters of galaxies for observation with the Reflection Grating Spectrometer (RGS) aboard XMM-Newton. It consists of 5 Ms of deep cluster observations of 44 objects obtained through a very large program and archival observations. The main goal is to measure chemical abundances in the hot Intra-Cluster Medium (ICM) of clusters to provide constraints on chemical evolution models. Especially the origin and evolution of type Ia supernovae is still poorly known and X-ray observations could contribute to constrain models regarding the SNIa explosion mechanism. Due to the high quality of the data, the uncertainties on the abundances are dominated by systematic effects. By carefully treating each systematic effect, we increase the accuracy or estimate the remaining uncertainty on the measurement. The resulting abundances are then compared to supernova models. In addition, also radial abundance profiles are derived. In the talk, we present an overview of the results that the CHEERS collaboration obtained based on the CHEERS data. We focus on the abundance measurements. The other topics range from turbulence measurements through line broadening to cool gas in groups.

Chapter 3

Solar System, Exoplanets and Star-Planet-Interaction

A Systematic Search for Solar Wind Charge Exchange Emission from the Earth's Exosphere with Suzaku

Daiki Ishi[1], Kumi Ishikawa[2], Yuichiro Ezoe[1], Takaya Ohashi[1], Yoshizumi Miyoshi[3], Naoki Terada[4]

[1]*Department of Physics, Tokyo Metropolitan University, Hachioji, Japan*
[2]*Institute of Space and Astronautical Science, JAXA, Sagamihara, Japan*
[3]*Solar-Terrestrial Environment Laboratory, Nagoya University, Nagoya, Japan*
[4]*Department of Geophysics, Tohoku University, Sendai, Japan*

We report on a systematic search of all the Suzaku archival data covering from 2005 August to 2015 May for geocoronal Solar Wind Charge eXchange (SWCX). In the vicinity of Earth, solar wind ions strip an electron from Earth's exospheric neutrals, emitting X-ray photons (e.g., Snowden et al. 1997). The X-ray flux of this geocoronal SWCX can change depending on solar wind condition and line of sight direction. Although it is an immediate background for all the X-ray astronomy observations, the X-ray flux prediction and the dependence on the observational conditions are not clear.

Using the X-ray Imaging Spectrometer onboard Suzaku which has one of the highest sensitivities to the geocoronal SWCX, we searched the data for time variation of soft X-ray background. We then checked the solar wind proton flux taken with the WIND satellite and compared it with X-ray light curve. We also analyzed X-ray spectra and fitted them with a charge exchange emission line model constructed by Bodewits et al. (2007). Among 3055 data sets, 90 data showed SWCX features. The event rate seems to correlate with solar activity, while the distribution of SWCX events plotted in the solar magnetic coordinate system was relatively uniform.

XMM observations of Pluto

Carey M. Lisse[1], Ralph L. McNutt[1], Konrad Dennerl[2]

[1]*Johns Hopkins University Applied Physics Laboratory*
[2]*Max-Planck-Institut für extraterrestrische Physik*

We have used XMM to observe the Pluto system in late March 2017. Following up on the reported detection of 7 photons representing X-ray emission by Chandra (Lisse et al., Icarus 287, 103), XMM searched for emission from the system, expecting approximately 10 times as many photons in 1/3 the observing time. If the results of the XMM measurements are as expected, then detections of other large KBOs with lossy atmospheres should be possible, ushering in the era of XMM KBO X-ray astronomy. In this talk we describe the preliminary results of our March 2017 XMM Pluto observations.

SPI-ing Exoplanets

Antonio Maggio[1]
[1] *INAF - Osservatorio Astronomico di Palermo*

Star-Planet Interaction (SPI) is a broad phenomenological term which encompasses a variety of physical effects relevant for the evolution of extra-solar planetary systems, in particular those hosting giant gas planets in close orbits around their parent star. While theoretical expectations of SPI are abundant, observational signatures are still elusive with current instrumentation and adopted observing strategies. In particular, recent X-ray observations provided intriguing indications of different SPI-driven effects, including enhanced coronal emission and flaring activity related to the phase of the planetary orbit, but for a few specific planet hosting stars, while results based on statistical studies are controversial. I will review the state of the art on the matter, and possible future developments with Athena and SKA that will help us for a better characterization of exoplanets and their abitability conditions.

Transmitted and polarized scattered fluxes by the exoplanet HD 189733b in X-rays

Frederic Marin[1], Nicolas Grosso[1]
[1] *Astronomical observatory of Strasbourg*

Thousands of exoplanets have been detected, but only one exoplanetary transit was potentially observed in X-rays from HD 189733A. What makes the detection of exoplanets so difficult in this band? Using Monte-Carlo radiative transfer simulations, we compute the amount of X-ray coronal flux reprocessed by the extended evaporating-atmosphere of HD 189733b. In the 0.25 - 2 keV energy band, the maximum depth of the XMM-Newton light curve is about 1.6 percent at 47 min apart from the transit center on the geometrically thick and optically thin corona, and little sensitive to the metal abundance (assuming that adding metals in the atmosphere would not dramatically change the density-temperature profile). Regarding a direct detection of HD 189733b in X-rays, we find that the amount of flux reprocessed by the exoplanetary atmosphere from egress to transit decays from 3 to 5 orders of magnitude fainter than the flux of the host star. Additionally, the degree of diluted linear polarization emerging from HD 189733A is lower than 0.003%, and largest near planetary greatest elongations. This implies that neither the modulation of the X-ray reprocessed flux with the orbital phase nor the scattered-induced continuum polarization can be observed with current X-ray facilities.

Suzaku observation of Jovian X-rays around solar maximum

Masaki Numazawa[1], Yuichiro Ezoe[1], Kumi Ishikawa[2], Takaya Ohashi[1], Yoshizumi Miyoshi[3], Tomoki Kimura[4], Yasunobu Uchiyama[5]
[1] *Tokyo Metropolitan University*
[2] *ISAS/JAXA*
[3] *Nagoya University*
[4] *RIKEN*
[5] *Rikkyo University*

We report on Suzaku observation of Jupiter when the solar activity went toward its maximum. Suzaku found diffuse X-ray emission associated with Jovian inner radiation belts thanks to its higher sensitivity in 1–5 keV from an observation in 2006 (Ezoe *et al*. 2010). To understand a relation of this emission to the solar activity, we conducted a new Suzaku observation. We found the diffuse emission around Jupiter in 1–5 keV and point-like emission in 0.2–1 keV in the same way as 2006. The luminosity of the point-like emission in 0.2–1 keV increased by a factor of $\sim$3–5. This is most likely due to an increase of the solar activity. In contrast, that of the diffuse emission in 1–5 keV varied by a factor of 1.3 ± 0.7. This suggests that the diffuse emission does not relate to the solar activity significantly, which supports a hypothesis that it is caused by inverse-Compton scattering by high-energy electrons of $\sim$50 MeV or more in the inner radiation belts, because Jovian synchrotron radio emission caused by high-energy electrons seen near Jupiter ($<$2 Rj) does not have a significant variation against the solar activity.

Chapter 4

Star formation, Young Stellar Objects, Cool and Hot Stars

Properties of accreting young stars and their disks: comparison between high energy observations and MHD models of accretion shocks

Rosaria Bonito[1], Salvatore Orlando[1], Costanza Argiroffi[2,1], Marco Miceli[2,1]
[1] *INAF - Osservatorio Astronomico di Palermo, Italy*
[2] *Dipartimento di Fisica e Chimica - Universita' di Palermo, Italy*

We compare multi-band (X-rays and UV) observations of accretion shocks, formed where the disk material accreting onto a young star impacts its surface, with MHD models. Our models account for the main physical effects: radiative cooling, thermal conduction, gravity, and a description of the stellar atmosphere. We synthesize the spectral properties of the impact regions accounting for the inclination of the system with respect to the line-of-sight, the local absorption, and the Doppler shift due to plasma motion along the line-of-sight. By comparing the synthetic spectra with the observations of star-disk systems (e.g. TWHya), we investigate the luminosity and the profiles of several lines, focusing on the X-ray and UV bands, and also the Doppler shift of the main emission lines and its observability. Understanding the high energy radiation emerging from the accretion shocks is fundamental to constrain heating and ionization of circumstellar material, and eventually disk lifetime. The future X-ray mission Athena, expected to have a significant higher A_{eff} with respect to current telescopes, will allow for analysis of a consistent statistical sample of young accreting stars and the exploration of the influence of different environments and conditions (age, mass) on the physics of accreting plasma in star-disk systems.

A legacy survey of early B-type stars using the RGS

Yael Nazé[1], Constantin Cazorla[1], Thierry Morel[1]
[1] *University of Liège, Belgium*

Despite their relatively large incidence among early-type stars, only a few B-stars have been observed with X-ray gratings. We therefore undertook a legacy project with XMM to gather high-resolution spectra of a set of early B stars selected on the basis of their high RASS count rate. This poster presents the preliminary results of this project.

The coronae of Kepler superflare stars

Stefan Czesla[1], Klaus F. Huber[1], Juergen H.M.M. Schmitt[1]
[1]*Hamburger Sternwarte*

Kepler has revealed a population of apparently solar-like, slowly rotating G-type stars showing enormous white-light flares, which release energies exceeding that of known solar flares by many orders of magnitude. The existence of such extreme releases of magnetic energy on seemingly innocuous suns raises the question whether also the coronal properties of these stars are somehow exceptional and, ultimately, whether even the Sun itself may produce superflares at some point. We present XMM-Newton X-ray observations of a sample of Kepler superflare stars. These allow us to obtain a snapshot of their coronal properties and to study their relation to the coronae of normal stars and the Sun.

Estimation of the Star Formation Rate (SFR) through Data Analysis of Swift's Long GRBs from 2008 to 2017

Mauricio Elías Chávez[1], Oscar Mario Martínez Bravo[1]
[1]*Benemérita Universidad Autónoma de Puebla, Puebla, México*

This work presents a research about the Star Formation Rate (SFR), using data analyzing of a sample from 2008 to 2017 of Gamma Ray Bursts (GRBs) submitted by Swift Gamma-Ray Burst Mission, This work is based on the empirical model proposed by Yüksel, Kistler & Beacom. (2008), basically the SFR is measured using long-GRBs considering a core-collapsed model of high rotating massive stars with low metallicity. Studying $\epsilon(z)$ which accounts the production rate of long-GRBs with additional evolutive effects, parameterizing of the form $\epsilon(z) = \epsilon_0(1 + z)$, where ϵ_0 is a unknown constant which include the total conversion of the SFR rate to GRB rate in a luminosity range given, finally we discuss the possible effect in the chemical evolution of galaxies at high redshift.

Local protoplanetary disk ionisation by T Tauri star energetic particles

Federico Fraschetti[1], Jeremy Drake[2], Ofer Cohen[3], Cecilia Garraffo[2]
[1] *University of Arizona, USA*
[2] *Smithsonian Astrophysical Observatory, USA*
[3] *University of Massachussetts, Lowell, USA*

The evolution of protoplanetary disks is believed to be driven largely by viscosity. The ionization of the disk that gives rise to viscosity is caused by X-rays from the central star or by energetic particles released by shock waves travelling into the circumstellar medium. We have performed test-particle numerical simulations of GeV-scale protons traversing a realistic magnetised wind of a young solar mass star with a superposed small-scale turbulence. The large-scale field is generated via an MHD model of a T Tauri wind, whereas the isotropic (Kolmogorov power spectrum) turbulent component is synthesised along the particles' trajectories. We have combined Chandra observations of T Tauri flares with solar flare scaling for describing the energetic particle spectrum. In contrast with previous models, we find that the disk ionization is dominated by X-rays except within narrow regions where the energetic particles are channelled onto the disk by the strongly tangled and turbulent field lines; the radial thickness of such regions broadens with the distance from the central star (5 stellar radii or more). In those regions, the disk ionization due to energetic particles can locally dominate the stellar X-rays, arguably, out to large distances (10, 100 AU) from the star.

Time resolved X-ray spectral analysis during optical dips and accretion bursts in stars with disks of NGC 2264 from Chandra/ACIS-I and CoRoT data

Mario Giuseppe Guarcello[1], Ettore Flaccomio[1], Giuseppina Micela[1], Costanza Argiroffi[1,2], Salvatore Sciortino[1], Laura Venuti[1,2], John Stauffer[3], Luisa Rebull[3], Ann Marie Cody[4]
[1] *INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134, Palermo, Italy*
[2] *Dip. di Fisica e Chimica, Università di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy*
[3] *Spitzer Science Center, California Institute of Technology, Pasadena, CA 91125, USA*
[4] *NASA Ames Research Center, Kepler Science Office, Mountain View, CA 94035, USA*

The simultaneous X-ray and optical observations with excellent time resolution of T Tauri stars with disks may provide insight on the accretion process and the properties of the inner disk. This was one of the motivations of the CSI 2264 campaign. In this talk I will show the results obtained from time resolved X-ray spectral analysis from deep Chandra/ACIS-I observations during the optical dips and accretion bursts isolated in the CoRoT light curves of the disk-bearing members of NGC 2264. These simultaneous Chandra-CoRoT data allow us to find evidence of increasing X-ray absorption during the optical dips, to study the composition of the material responsible for the variable extinction in these stars with disks, and to find evidence for soft X-ray emission observed during the optical bursts, and thus related to the accretion process.

X-rays as a new tool to study the winds of hot subdwarf stars

Sandro Mereghetti[1], Nicola La Palombara[1]
[1] *IASF-Milano, INAF, v.E.Bassini 15, I-20133 Milano, Italy*

In recent years, thanks to XMM-Newton and Chandra, it has been possible to detect X-ray emission from several hot subdwarf stars or place interesting upper limits. X-rays are observed from subdwarfs in binary systems, where they result from wind accretion onto a white dwarf or neutron star companion, as well as from single hot subdwarfs, in which X-rays are probably due to shock instabilities in the wind. In both cases, X-ray data provide useful information for our understanding of the weak radiation-driven winds of these low mass stars, which are difficult to study with the techniques and observations typically used for massive hot stars. After reviewing the properties of the X-ray emission from hot subdwarfs, we will report on the most recent results on the three X-ray brightest sdOs (HD 49798, BD +37 442, and BD +37 1977), discuss the implications of the non-detections of sdB+WD binaries, and present the prospects for future X-ray observations of hot subdwarfs.

Colliding winds in evolved massive stars systems

Yael Naze[1], et al.[1]
[1] *FNRS/Universite de Liege (B)*

Massive stars drive strong outflows called stellar winds. When they form a binary, these winds collide, sometimes giving rise to intense X-ray emission. In this contribution, we report on the monitoring of several massive binaries composed of evolved objects, analyzing the changes in absorption, temperature and flux as a function of phase. We further compare the results to the output of models, in order to constrain the winds strengths.

Zeta Pup variability revisited

Yael Naze[1], et al.[1]
[1] *FNRS/Universite de Liege (B)*

In 2013, we reported on the variability properties of zeta Puppis, one of the hottest and closest massive stars. In particular, while short-term stochastic variability seems absent, "trends" with a typical timescale longer than the exposure length were detected. Since then, such features were found in other objects as well, and the favored scenario links them to co-rotating wind structures. Using new observations as well as optical photometry, we revisit the variability of zeta Pup with the aim of assessing the CIR scenario.

Ages and Distances to Star Forming Regions from the synergy of X-rays and IR observations

Ignazio Pillitteri[1,2], Scott Wolk[2], Tom Megeath[3], Alyssa Goodman[2], Salvatore Sciortino[1]
[1] *INAF-Osservatorio Astronomico di Palermo, Palermo, Italy*
[2] *Harvard-Smithsonian Center for Astrophysics, Cambridge (MA), USA*
[3] *University of Toledo, OH USA*

Star formation occurs in molecular clouds of different sizes and time scales. While infrared (IR) surveys provide deep knowledge of the cold emission of protostars and stars with disks, X-rays are important to identify embedded stellar objects and stars that have lost their disks and likely formed planets. I will present two examples of the synergy between X-rays and IR observations that led to identify two new stellar clusters in Orion and Rho Ophiuchi, and determine their distances and ages.

A survey of long-term X-ray variability in cool stars

John Pye[1], Simon Rosen[1], Andrew Read[1], Duncan Law-Green[1], Michael Watson[1], Paul O'Brien[1]
[1] *University of Leicester, Leicester, United Kingdom*

X-ray variability in cool stars can be indicative of coronal magnetic field changes and reconfiguration from a variety of phenomena, including flare events (typical timescales of minutes – hours), active-region evolution (hours – days – weeks), rotational modulation (hours – days – weeks), and activity cycles (years – decades). As part of the EXTraS project (Exploring the X-ray transient and variable sky – http://www.extras-fp7.eu/), we have performed a systematic survey of long-term X-ray variability using the ∼decade-long public database of XMM-Newton observations (3XMM). We are thus focussing here on timescales from ∼a day to ∼a decade, using average flux values from individual XMM-Newton observations. Though the resulting sampling is often highly non-uniform in time, the light-curves can provide valuable insights into the magnetic activity outside of shorter-term flaring episodes. We have taken a number of stellar samples (Hipparcos-Tycho, Simbad...) and evaluated statistical properties of the flux distributions, and compared these across, for example spectral type, and with previously-published estimates. We are also examining the potential effects of flare events on the apparent long-term variability estimates. We report here on overall variability distributions and extreme cases, focussing on serendipitously-observed stars (yielding in some sense an unbiased sample).

The flaring activity of pre-main sequence stars in NGC6530

Gregor Rauw[1], Marie Nelissen[1], Yael Nazé[1]
[1] *Institute of Astrophysics & Geophysics, University of Liège, Belgium*

We have obtained XMM-Newton observations of the very young open cluster NGC6530 at four different epochs. The data reveal a wealth of relatively faint X-ray sources that are correlated with PMS members of NGC6530. We have investigated the X-ray properties of these sources with emphasis on their flaring activity. We compare our results with the properties of the sources (stellar masses, rotation rates,...) as inferred from optical studies.

The eROSITA all-sky survey - Stars in X-rays

Jan Robrade[1]
[1] *Hamburger Sternwarte, Hamburg, Germany*

eROSITA (extended Roentgen Survey Imaging Telescope Array) is the prime instrument on the Russian SRG spacecraft to be launched in 2018. eROSITA will perform an all-sky survey (eRASS) at low to medium X-ray energies that is unprecedented, given its sensitivity, energy range, spectral and angular resolution as well as its eightfold sky coverage.

Stars constitute the majority of galactic X-ray sources in the eRASS and the expected detection of several hundred thousands of stellar systems down to fluxes of $F_{\rm X} \approx 10^{-14}$ erg s^{-1} cm^{-2} at 0.3 - 10.0 keV energies allows to explore them in great detail. Highlighted science themes include the study of nearby stars, young stellar populations, YSOs and star formation regions. The eRASS sources enable a systematic investigation of the coronal properties of magnetically active solar-like or fully convective stars and thereby stellar dynamos, their evolution and activity-age-rotation relations. Stellar variability is covered on multiple timescales, addressing flare statistics to activity cycles. Other topics range from massive stars to the irradiation of extrasolar planetary systems.

A Correlation on Stellar Flares detected with MAXI ~ Quiescent Luminosity vs. Flare Energy ~

Ryo Sasaki[1], Yohko Tsuboi[1], Satoru Katsuda[1], Ken Yabuki[1], Yumiko Nakamura[1], Yasuharu Sugawara[2], Masaru Matsuoka[3], the MAXI team[3]
[1] *Department of Physics, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan*
[2] *ISAS, JAXA, 3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa, 229-8510, Japan*
[3] *MAXI team, RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan*

MAXI has detected more than a hundred of huge flares from twenty–seven active stars (RS CVn system, Algol system, dMe star, dKe star, Young Stellar Object and K-type variable star). The flare energies range from 6×10^{33} to 9×10^{39} in the 2–20 keV. All flares locate the high ends of their own categories (Tsuboi et al. 2016).
We compare the largest X-ray flare energy in 7.25 years (running period of MAXI from 2009 August to 2016 December) ($E_{\rm tot,max}$) with quiescent state X-ray luminosity ($L_{\rm x,q}$) for each object. Each $L_{\rm x,q}$ is extracted from the 1RXS catalogue (Voges et al. 1999). As a result, we discover a correlation of $E_{\rm tot,max} \propto L_{\rm x,q}^{1.2}$, for the first time. This correlation is consistent with a hypothesis that both flares and quiescent state X-ray emissions originate from magnetic activities. In addition, given the diversity of our stellar samples, we suggest that flare mechanisms are intrinsically the same among all the stellar flare systems. We will present our detailed interpretation of the intriguing correlation we found.

The future X-ray Sun

Christian Schneider[1], Moritz Guenther[2]
[1] *Hamburger Sternwarte*
[2] *MIT*

The future X-ray Sun

Stellar activity currently experiences an enormous increase in interest due to its relevance for exoplanetary atmospheres and habitability. Stellar activity has long been thought to decay continuously with age. Recent studies of chromospheric activity tracers, however, cast doubt on a further decrease after an initial settling phase. X-ray emission is a prime activity indicator and has, compared to chromospheric emission, the benefit of lacking basal emission. To measure how the activity of solar analogs evolves with age, we obtained the first systematic X-ray survey of solar analogs with ages between five and ten Gyrs. I will present initial results from XMM-Newton observations suggesting that old Suns are surprisingly weak X-ray emitters. Comparing coronal with chromospheric activity tracers of the very same stars further suggests that the X-ray to chromospheric emission ratio is potentially evolving with age.

Activity and rotation of the X-ray emitting Kepler stars

B. Stelzer[1,2], D. Pizzocaro[3,4], E. Poretti[5], G. Micela[2], A. Belfiore[3], M. Marelli[3], D. Salvetti[3], A. De Luca[3,6]
[1] *Eberhard Karls Universitaet, Tübingen, Germany*
[2] *INAF - Osservatorio Astronomico di Palermo, Italy*
[3] *INAF - IASF Milano, Italy*
[4] *Universita' degli Studi dell'Insubria, Varese, Italy*
[5] *INAF - Osservatorio Astronomico di Brera, Italy*
[6] *Istituto Universitario di Studi Superiori, Pavia, Italy*

The relation between magnetic activity and rotation periods in late-type stars provides fundamental information on the stellar dynamo and spin evolution. In spite of its importance for stellar physics, homogeneous samples of stars with accurate and sensitive measurement of both rotation period and magnetic activity have been hard to come by. The Kepler mission represents a significant step forward, providing high-cadence optical light curves for thousands of stars, from which the rotation period can be measured observing the brightness modulation due to star spots. A cross-match of the Kepler Input Catalog with the 3XMM-DR5 Catalog and subsequent careful inspection for likely non-stellar sources yields more than 100 late-type stars. We have developed an algorithm which identifies rotation periods and white-light flares in the Kepler light curves. We have calculated the X-ray luminosity from the 3XMM-DR5 count rates, and searched the light curves provided by the EXTraS (Exploring the X-ray Transient and variable Sky) FP-7 project for X-ray flares. Here we discuss the correlation between various measures for coronal and photometric activity (from the XMM-Newton and the Kepler data, respectively) and the Kepler rotation periods and Rossby number.

Calibrating the time-evolution of the X-ray emission of M dwarfs

Beate Stelzer[1,2]
[1] *Eberhard-Karls Universitaet Tübingen,Germany*
[2] *INAF - Osservatorio Astronomico di Palermo, Italy*

The time-evolution of the X-ray emission of M stars is fundamental for our understanding of stellar dynamos and the irradiation of planet atmospheres with high-energy photons. However, the (X-ray) activity - age relation is still unconstrained, mainly due to the difficulty in the age determination. Our approach is to determine the evolution of X-ray luminosity (L_x) and X-ray plasma temperature (T_x) with age for M dwarfs, observing M stars in wide pairs with a white dwarf that (through its progenitor and cooling age) serves as chronometer for a reliable age constraint. We present XMM-Newton and Chandra observations of 13 such systems spanning ages of 1-7 Gyrs. Overall, we observe a decrease of L_x with age, but there are also two outliers with unexpectedly strong X-ray emission. Due to the high sensitivity of the observations we could analyse the X-ray spectrum for four M stars. This has allowed us to derive a relation between coronal temperature and flux - to our knowledge for the first time for M stars with known age.

The X-ray monitoring of the long-period colliding wind binaries

Yasuharu Sugawara[1], Yoshitomo Maeda[1], Yohko Tsuboi[2]
[1] *Institute of Space and Astronautical Science, JAXA, Japan*
[2] *Chuo university, Japan*

We present the first results from XMM-Newton and Swift observations of two long-period colliding wind binaries WR19 and WR125 around periastron passages. Mass-loss is one of the most important and uncertain parameters in the evolution of a massive star. The X-ray spectrum off the colliding wind binary is the best measure of conditions in the hot postshock gas. By monitoring the changing of the X-ray luminosity and column density along with the orbital phases, we derive the mass-loss rates of these stars. It is known that WR19 (WC5+O9; P=10.1 yr) and WR125 (WC7+O9; P> 24.3 yr) are the dust-making binaries. Each periastron is expected to come in 2016–2017. Since 2016, we carry out on-going monitoring campaigns of WR19 and WR125 with XMM-Newton and Swift. On these observations, the X-rays from WR19 and WR125 were detected for the first time. In the case of WR19, as periastron approached, the column density increased, which indicates that the emission from the wind-wind collision plasma was absorbed by the dense Wolf-Rayet wind. We will discuss the wind properties of these binaries.

Giant Stellar Flares detected with MAXI

Yohko Tsuboi[1], Ryo Sasaki[1], Yumiko Nakamura[1], Ken Yabuki[1], Atsushi Kawagoe[1], Soichiro Kaneto[1], Yasuharu Sugawara[2], Hitoshi Negoro[3], the MAXI team[4]
[1]*Department of Physics, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan*
[2]*ISAS, JAXA, 3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa 229-8510, Japan*
[3]*Department of Physics, Nihon University, 1-8 Kanda-Surugadai, Chiyoda-ku, Tokyo 101-8308, Japan*
[4]*MAXI team, RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan*

Since the launch in 2009 August, with the unprecedentedly high sensitivity as an all-sky X-ray monitor, MAXI has caught more than a hundred of huge flares from stars. Most of them are from low-mass, active stars (RS CVn systems, an Algol system, dMe systems, a dKe system, Young Stellar Objects). With the total radiative energy of 10^{34}–10^{39} ergs, the MAXI detections have broken the record of the largest flaring magnitudes in each stellar categories (e.g. RS CVn and so on). The enlarged sample of intense flares has enabled us to do systematic studies in various viewpoints. One of the studies is our discovery of a universal correlation between the flare duration and the intrinsic X-ray luminosity, which holds for 5 and 12 orders of magnitude in the duration and LX, respectively (Tsuboi et al. 2016).
Besides low-mass stars, a historically brightest X-ray flare has been detected with MAXI from the massive star system, Eta Carinae (Negoro et al. 2014).
Here, we introduce the studies of stellar flares obtained in 7.25-year monitoring with MAXI.

The XMM-Newton View of Wolf-Rayet Bubbles

Martín A Guerrero[1], Jesús A Toalá[2]
[1]*Instituto de Astrofísica de Andalucía (IAA-CSIC), Granada, Spain*
[2]*Instituto de Radioastronomía y Astrofísica (IRyA-UNAM), Morelia, Mexico*

The powerful stellar winds of Wolf-Rayet (WR) stars blow large bubble into the circumstellar material ejected in previous phases of stellar evolution. The shock of those stellar winds produces X-ray-emitting hot plasmas which tells us about the diffusion of processed material onto the interstellar medium, about processes of heat conduction and turbulent mixing at the interface, about the late stages of stellar evolution, and about the shaping of the circumstellar environment, just before supernova explosions. The unique sensitivity of *XMM-Newton* has been key for the detection, mapping and spectral analysis of the X-ray emission from the hot bubbles around WR stars. These observations underscore the importance of the structure of the interstellar medium around massive stars, but they have also unveiled unknown phenomena, such as blowouts of hot gas into the interstellar medium or spatially-resolved spectral properties of the hot gas, which disclose inhomogeneous chemical abundances and physical properties across these bubbles.

Chapter 5

White Dwarfs, Cataclysmic Variables and Novae

Broad-band properties of newly identified magnetic Cataclysmic Variables

Federico Bernardini[1,2], Domitilla de Martino[2], Koji Mukai[3,4], Maurizio Falanga[5]
[1] *New York University Abu Dhabi, United Arab Emirates*
[2] *INAF-Osservatorio Astronomico di Capodimonte Napoli, Italy*
[3] *CRESST and X-ray Astrophysics Laboratory, GSFC NASA*
[4] *University of Maryland Baltimore USA*
[5] *International Space Science Institute, Bern Switzerland*

The subclass of magnetic Cataclysmic Variables has recently boosted in number thanks to X-ray follow-ups of candidates from the Integral and Swift surveys. We here report recent identifications of a sample of new systems outlining peculiarities and commonalities and discuss the role of these systems in the context of galactic X-ray source populations.

Early X- and HE γ-ray emission from the symbiotic recurrent novae V745 Sco & RS Oph.

Laura Delgado[1], Margarita Hernanz[1]
[1] *ICE (CSIC-IEEC), Bellaterra (Barcelona), Spain*

RS Oph was the first nova for which evidence of particle acceleration during its 2006 outburst was found. In recent years, several nova explosions - eight classical and two symbiotic recurrent novae - have been detected by Fermi/LAT at E>100 MeV. In most cases, this emission has been observed early after the explosion, around the optical maximum, and for a short period of time. The high-energy γ-ray emission is a consequence of π^0 decay and/or Inverse Compton, which are related to particle (p and e^-) acceleration in the strong shock between the nova ejecta and the circumstellar matter. Our aim is to understand the acceleration process through the analysis of contemporaneous X-ray emission, and in particular, through the evolution of the shock wave. A deep analysis of early X-ray observations of the symbiotic recurrent novae V745 Sco (2014) by Swift/XRT, Chandra/HETG and NuStar, and RS Oph (2006) by XMM-Newton/EPIC and RGS, Swift/XRT and BAT and RXTE/PCA is presented taking into account the contemporaneous information from the IR and radio observations. This provides for the first time a global view of the early evolution of a nova remnant and its relationship with particle acceleration.

XMM-Newton observation of nova like system MV Lyr and search for source of the fast variability detected in *Kepler* data

Andrej Dobrotka[1], Jan-Uwe Ness[2], Shin Mineshige[3], Achille Nucita[4,5]
[1] *ATRI, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology, Trnava, Slovakia*
[2] *XMM-Newton Science Operations Center, European Space Astronomy Center, Madrid , Spain*
[3] *Department of Astronomy, Graduate School of Science, Kyoto University, Kyoto, Japan*
[4] *Department of Mathematics and Physics E. De Giorgi, University of Salento, Lecce, Italy*
[5] *INFN, Sez. di Lecce, Lecce, Italy*

Nova like system MV Lyr is present in the *Kepler* field yielding a high cadence long lasting light curve ideal for detailed study of the fast variability. Scaringi et al. (2012) detected four frequency components in the corresponding power density spectra, and the modelling of the highest component suggests an expanded hot geometrically thick optically thin X-ray corona as a source (Scaringi 2014). In such case the X-rays are reprocessed into optical radiation by the underlying geometrically thin disc. Such interpretation requires a direct X-ray observation to confirm the model or to suggest another way of research. We present analysis of our *XMM-Newton* data of MV Lyr where we detected the searched highest frequency component in both the X-ray and UV light curves. Furthermore, the X-ray spectra are described by either a two temperature collisional plasma or a cooling flow model. The latter yields a considerably lower mass accretion rate than expected in the bright state, suggesting an evaporated medium with low density and high temperature. Therefore, we confirm the model where a geometrically thick X-ray corona is surrounding the central region of a standard geometrically thin accretion disc, the so called sandwiched model.

Reanalysis of high-resolution XMM-Newton data of V2491 Cygni using models of collisionally ionized hot absorbers

Cigdem Gamsizkan[1], Solen Balman[1]
[1] *Middle East Technical University, Ankara, Turkey*

The classical nova V2491 Cyg was observed twice by XMM-Newton Reflection Grating Spectrometer (RGS) on May 20.6 and May 30.3, 2008 in outburst. Our aim is to reanalyse the archival RGS data of this classical nova and model the complex absorption features that are seen in the high resolution X-ray spectra. The RGS data can be best fitted with two collisionally ionized hot absorber and a photoionized warm absorber model (plus a model for interstellar absorption and dust absorption) together with a blackbody model for the continuum. The two collisionally ionized hot absorption components have temperatures $\mathrm{kT}_1 \simeq 1.0 - 3.6$ keV and $\mathrm{kT}_2 \simeq 0.4 - 0.87$ keV with *rms* velocities $\sigma_{\mathrm{v1}} \sim 872$ km/s and $\sigma_{\mathrm{v2}} \sim 56$ km/s. We find blackbody temperatures in a range 61-91 eV yielding a white dwarf (WD) mass of 1.15-1.3 $\mathrm{M}_\odot$, but our analysis on the second observation reveals a second blackbody component with effective temperature 120-131 eV and effective radius about 10 % of the WD. The further details of the analysis and results can be found in Balman & Gamsizkan (2017).

Breaking the Habit - The peculiar 2016 eruption of the remarkable recurrent nova M31N 2008-12a

Martin Henze[1]
[1] *Institut de Ciencies de l'Espai, Barcelona, Spain*

Since its discovery in 2008, the Andromeda galaxy nova M31N 2008-12a has been observed in eruption every single year. This makes it the most extreme member of the new class of Rapidly Recurring Novae (RRN) which show repeated eruptions within a time span of only a decade or shorter. Such frequent outbursts indicate the presence of high mass accretion onto a white dwarf that is extremely close to the Chandrasekhar mass limit, thereby making RRN the most promising observable candidates for the progenitors of type-Ia supernovae known today.

The previous three eruptions of M31N 2008-12a have displayed remarkably homogeneous multi-wavelength properties. From a relatively faint peak the optical light curve declined rapidly by two magnitudes in less than two days. Early spectra showed high velocities that declined significantly within days and displayed clear helium and nitrogen lines throughout. The supersoft X-ray source phase of the nova began extremely early around day six after eruption and only lasted for about two weeks.

In contrast, the delayed 2016 eruption showed significant deviations from the established pattern. In this talk, I will discuss the observational results and their impact on our understanding of the physics and evolution of this unique nova.

Simultaneous modelling of X-ray emission and optical polarization of intermediate polars: the case of V405 Aur

Isabel J. Lima[1], Claudia V. Rodrigues[1], Karleyne M. G. Silva[2], G. Juan M. Luna[3], Flávio D' Amico[1], Jaziel G. Coelho[1]
[1] *Instituto Nacional de Pesquisas Espaciais , Sao José dos Campos, Brazil*
[2] *Gemini Observatory, Chile*
[3] *Instituto de Astronomia y Física del Espacio, Buenos Aires, Argentina*

Intermediate polars are compact binaries in which mass transfer occurs from a low-mass star onto a magnetic white dwarf. A shock structure is formed in the magnetic accretion column nearby the white-dwarf surface. High-energy emission is produced in the post-shock region and the main physical process envolved is bremsstrahlung and line emission. Some systems show optical polarization, which may be also originated in the post-shock region. Our main goal is to study the magnetic structure of intermediate polars by simultaneously modelling optical polarimetry and X-ray data using the CYCLOPS code. This code was developed by our group to peform multi-wavelength fitting of the accretion column flux. It considers cyclotron and free-free emission from a 3D post-shock region, which is non-homogeneous in terms of density, temperature, and magnetic field. In this study, we present our modelling of the optical polarization and X-ray emission of V405 Aurigae, the intermediate polar that has the highest magnetic field. Previous studies of this system were not successful in proposing a geometry that explains both the optical and X-ray emissions.

X-ray observations of FO Aqr during the 2016 low state

Mark Kennedy[1,2], Peter Garnavich[2], Colin Littlefield[2], Paul Callanan[1], Koji Mukai[3,4], Erin Aadland[5], Marissa Kotze[6,7], Enrico Kotze[6,8]
[1] *University College Cork, Cork, Ireland*
[2] *University of Notre Dame, Notre Dame, USA*
[3] *CRESST and X-ray Astrophysics Laboratory, NASA Goddard Space Flight Center, Greenbelt, USA*
[4] *University of Maryland, Baltimore, USA*
[5] *Minnesota State University, Moorhead, USA*
[6] *South African Astronomical Observatory, South Africa*
[7] *South African Large Telescope, South Africa*
[8] *University of Cape Town, Cape Town, South Africa*

In 2016, the intermediate polar FO Aquarii was found to be in its first recorded low state, with observations dating back to 1923. We present X-ray observations of FO Aqr taken during 2016, the first X-ray data taken of any intermediate polar when in a low accretion state. The Swift and Chandra data taken during the low accretion state both show a softer spectrum when compared to archival data taken when FO Aqr was in a high state. The X-ray spectrum in the low state shows a significant increase in the ratio of the soft X-ray flux to the hard X-ray flux due to a change in the partial covering fraction of the white dwarf and a change in the hydrogen column density. XMM-Newton observations during the subsequent recovery suggest that the system had not returned to its typical high state by November 2016. The partial covering fraction varied significantly in the recovery state. Finally, we find an apparent phase difference between the high state X-ray pulse and recovery X-ray pulse of 0.17, which may be related to a restructuring of the X-ray emitting regions within the system.

The mysterious companion of the hot subdwarf HD 49798

Sandro Mereghetti[1], Fabio Pintore[1], Paolo Esposito[2], Nicola La Palombara[1], Andrea Tiengo[3,1], GIan Luca Israel[4], Luigi Stella[4]
[1] *IASF-Milano, INAF, v.E.Bassini 15, I-20133 Milano, Italy*
[2] *Anton Pannekoek Institute, Univ. of Amsterdam, The Netherlands*
[3] *IUSS, Pavia, Italy*
[4] *Osservatorio Astronomico di Roma, INAF, Monte Porzio Catone, Italy*

The system HD 49798/RXJ0648.0-4418 is the only X-ray binary in which the companion star is a hot subdwarf. The short orbital period (1.5 days), circular orbit, and element abundances suggest that this system is the outcome of a common envelope evolution of a couple of intermediate mass stars. The X-ray pulsations at 13.2 s indicate that the compact object, with a dynamically measured mass of 1.3 solar masses, is a neutron star or a white dwarf. Given the large mass, the latter possibility, favoured by the low X-ray luminosity, implies that this system might be a good candidate progenitor for a type Ia supernova explosion. However, our recent discovery of a secular spin-up at a rate of 2×10^{-15} s s^{-1} is best explained assuming that the compact object is a neutron star fed by wind accretion. I discuss the possible interpretations of this unique system, showing that its X-ray spectral and timing properties are different from those of classical X-binaries and cataclismic variables, possibly due to the peculiar nature of the mass donor star.

NuSTAR Observations of Fermi-detected Novae, V339 Delphini and V5668 Sagitarii

Koji Mukai[1,2], Thomas Nelson[3], Jennifer Sokoloski[4], Laura Chomiuk[5], Thomas Finzell[5], Justin Linford[6], Jennifer Weston[7], Michael Rupen[8], Amy Mioduszewski[9]
[1]*CRESST and X-ray Astrophysics Laboratory, NASA/GSFC, Greenbelt, USA*
[2]*Department of Physics, University of Marilayd, Baltimore County, Baltimore, USA*
[3]*Department of Physics & Astronomy, University of Pittsburgh, Pittsburgh, USA*
[4]*Columbia Astrophysics Laboratory, Columbia University, New York, USA*
[5]*Department of Physics & Astronomy, Michigan State University, East Lansing, USA*
[6]*Department of Physics, The George Washington University, Washington, USA*
[7]*Green Bank Observatory, Green Bank, USA*
[8]*Dominion Radio Astrophysical Observatory, Kaleden, Canada*
[9]*National Radio Astronomy Observatory, Socorro, USA*

Ten Galactic novae have been detected as transient GeV gamma-ray sources with Fermi/LAT to date, presumably due to shock acceleration that produces relativistic particles. This unexpected discovery highlights the complexity of the mass ejection process in novae. It has also added a new class of objects in which particle acceleration can be studied. We can in principle study the same shock in X-rays through their thermal emission and the lower energy extension of the non-thermal emission. Here we present our NuSTAR observations of two Fermi-detected novae, V339 Del and V5668 Sgr, that were carried out while they were being detected with the LAT. We did not detect thermal or non-thermal emissions from these novae. Our results place a tight limit on the properties of the putative shocks in V339 Del and V5668 Sgr. We also compare our results with previous reports of possible detection of non-thermal hard X-rays from novae, and discuss the implications in the context of our current understanding of the complicated process of mass ejection in novae.

The value of qualitative conclusions for the interpretation of Super Soft Source grating spectra

Jan-Uwe Ness[1]
[1]*XMM-Newton Science Operations Centre, ESAC-ESA, Madrid, Spain*

High-resolution (grating) X-ray spectra of Super Soft Sources (SSS) contain a large amount of information. Main-stream interpretation approaches apply radiation transport models that, if uniquely constrained by the data, would provide information about temperature and mass of the underlying white dwarf and chemical composition of the ejecta. The complexity of the grating spectra has so far prohibited unique conclusions because realistic effects such as homogeneous density distribution, asymmetric ejecta, expansion etc open up an almost infinite number of dimensions to the problem. Further development of models are with no doubt needed, but unbiased inspection of the observed spectra is needed to narrow down where new developments are needed.

I will illustrate how much we can already conclude without any models and remind of the value of qualitative conclusions. I will show examples of past and recent observations and how comparisons with other observations help us to reveal common mechanisms. Albeit the high degree of complexity, some astonishing similarities between very different systems are found which can tailor the development of new models.

I will give a short presentation to trigger more discussion to think about how to stimulate new model developments to bring qualitative and quantitative interpretation approaches together.

Nova LMC 2009 and other Magellanic Clouds Novae: increasing diversity in the nova X-ray research

Marina Orio[1], Martin Henze[2], Jan-Uwe Ness[3], Sou Her[4]
[1]*INAF-Padova, Italy and Dept. of Astronomy, University of Wisconsin-Madison, USA*
[2]*Institut de Ciències de lEspai (CSIC-IEEC), Spain*
[3]*XMM-Newton Science Operations Center, ESAC, Spain*
[4]*Dept. of Astronomy, University of Wisconsin-Madison, USA*

Nova LMC 2009a had an outburst in February of 2009 and was recognized as coincident with Nova LMC 197b, hence it is a recurrent nova. Bode et al. (2016, ApJ, 818, 145) noticed similarities with the Galactic nova KT Eri. These authors suggested that the secondary is an evolved star, with a likely orbital period of 1.2 days, and that the white dwarf is massive, above 1.1. M(sol). We followed the nova with XMM-Newton with four RGS grating exposures, revealing differences from KT Eri and from another well studied recurrent nova with a subgiant, U Sco. On day 90 the spectrum was dominated by emission lines, with a low level of continuum originating from the central source. On days 165 and 197 a luminous supersoft X-ray source emerged, with deep absorption features of nitrogen and oxygen, while several emission lines remained prominent. The central source appeared to have cooled on day 230. Ness et al. (2015, A&A, 578, 39) discovered a modulation with a 33 s period for part of the XMM-Newton exposures' time; here we explore spectral and flux variability on different timescales. Finally, we show serendipitous archival X-ray light curves of other recent novae in the Magellanic Clouds.

Multi-wavelength properties of two supersoft X-ray sources CAL83 and RXJ0513.9-6951

Andry Fitiavana Rajoelimanana[1], Petrus Meintjes[1], Phil Charles[2,3,4]
[1]*University of the Free State, Bloemfontein, South Africa*
[2]*School of Physics and Astronomy, Southampton University, Southampton, UK*
[3]*Department of Astrophysics, University of Oxford, Oxford, UK*
[4]*ACGC, University of Cape Town, Rondebosch, South Africa*

Supersoft X-ray sources (SSS) are highly luminous ($\sim 10^{38}$ erg s^{-1}), yet low temperature 10^6 K sources, interpreted as a white dwarf (WD) accreting matter at a very high rate from its (heavy) companion, leading to Eddington-limited, steady hydrogen burning on the WD surface at T$\sim$15-80 eV. A large fraction of this energy irradiates the surface of the disc, which gives rise to a reprocessed flux much larger than the intrinsic disc luminosity, accounting for the large optical and UV fluxes detected in SSS. We present the multi-wavelength properties of two prototypical LMC SSS, CAL83 and RXJ0513.9-6951, with particular emphasis on the anti-correlation between their X-ray and optical behaviour. Our SALT spectra show variable high excitation OVI emission as a function of optical brightness state, and which we link to the cyclic changes in the temperature and size of the WD, and hence the mass accretion rate.

The accretion column of AE Aqr

Claudia Vilega Rodrigues[1], Karleyne M. G. Silva[2], G. Juan M. Luna[3], Jaziel G. Coelho[1], Isabel J. Lima[1], Joaquim E. R. Costa[1], José Carlos N. de Araújo[1]
[1] *Instituto Nacional de Pesquisas Espaciais/Brazil*
[2] *Gemini Observatory/Chile*
[3] *Instituto de Astronomía y Física del Espacio/Argentina*

AE Aqr is a magnetic cataclysmic variable, whose white dwarf rotates at the very fast rate of 33 s modulating the flux from high energies to optical wavelengths. There are many studies about the origin of its emission, which consider emission from a rotating magnetic field or from an accretion column. Recent observations have not found emission from AE Aqr in gamma rays, a shortcoming of the pulsar-like model. Furthermore, X-ray data can be fit using thermal models. Here we present a successful modeling of AE Aqr phase-resolved X-ray emission using the Cyclops code, which considers the emission of a magnetic accretion column. The model takes into consideration the 3D geometry of the system, allowing to properly represent the white-dwarf auto eclipse, the pre-shock column absorption, and the varying density and temperature of a tall accretion column. To our knowledge, we present the first physical modeling of AE Aqr phase-dependent emission in high energies.

The SSS classical nova V5116 Sgr

Gloria Sala[1,2], Jan-Uwe Ness[3], Jochen Greiner[4], Margarita Hernanz[5,2]
[1] *Universitat Politècnica de Catalunya, Barcelona, Spain*
[2] *Institut d'Estudis Espacials de Catalunya, Barcelona, Spain*
[3] *XMM-Newton Science Operations Centre, Madrid, Spain.*
[4] *Max-Planck-Institute für extraterrestrische Physik, Garching b.M., Germany*
[5] *Instituto de Ciencias del Espacio, CSIC, Bellaterra, Spain*

XMM-Newton observed the nova V5116 Sgr during its supersoft phase (SSS). V5116 Sgr showed a decrease of the flux by a factor around 8 during 2/3 of the orbital period. The broad band EPIC spectra remain unchanged during the different flux phases, suggesting an occultation of the central source in a high inclination system. While the global SED does not change significantly, the RGS spectrum is changing between the high and the low flux phases. The non-occultation phase shows a typical white dwarf atmosphere spectrum, dominated by absorption lines. During the low flux periods an extra component of emission lines is superimposed to the soft X-ray continuum. This supports the picture of V5116 Sgr as the clearest example of a system switching between the SSa class of SSS novae, with spectra dominated by absorption lines, and the SSe class, showing an emission lines component. In addition, the simultaneous OM images allow us to find a phase solution for the X-ray light-curve. A thick rim of the accretion disk as the one developed for the SSSs CAL 87, RX J0019.8, and RX J0513.9 could provide a plausible model both for the optical and the X-ray light curve of V5116 Sgr.

Triggered high-state simultaneous XMM-Newton/NuSTAR observations of AM Herculis

Axel Schwope[1], Hauke Worpel[1], Iris Traulsen[1]
[1] *Leibniz-Institut für Astrophysik Potsdam (AIP), An der Sternwarte 16, 14482 Potsdam, Germany*

We report on simultaneous XMM-Newton/NuSTAR observations of the prototypical polar AM Herculis. The observations were triggered by an optical monitoring programme indicating a stable high accretion state. For the first time, AM Herculis could be observed in its reversed mode of accretion with imaging CCDs and full phase coverage for several subsequent binary cycles. The observations revealed several novelties: (1) Ultraviolet, soft and hard X-ray light curves displayed a complete new morphology; (2) a spectral analysis of the soft flares originating from the secondary (far) pole was possible for the first time; (3) extended phases of complete soft X-ray absorption were indicating a complex distribution of cold intra-binary matter; (4) the joint NuSTAR/XMM-Newton spectrum revealed the Compton reflection hump due to scattered radiation from the white-dwarf surface; (5) the Fe-line complex thought to originate from the main (regular) pole showed pronounced dissimilarities with its behavior in the regular accretion mode in year 2005.

X-ray Spectra of the Cataclysmic Variable LS Peg using XMM-Newton and SWIFT data

Nasrin Talebpour Sheshvan[1], Armin Nabizadeh[1], Solen Balman[1]
[1] *Department of Physics, Middle East Technical University, Ankara, Turkey*

LS Peg is a Cataclysmic Variable (CV) suggested as Intermediate Polar (IP) because of similar properties to those observed in IP systems. We used archival *XMM-Newton* observation of LS Peg in order to study the X-ray characteristics of the system. We show LS Peg light curves in several different energy bands, and discuss about orbital modulations and power spectral analysis. Unlike the previous spectral analysis of the EPIC-MOS data by fitting a hot optically thin plasma emission model with a single temperature, we simultaneously fit EPIC spectrum (pn+MOS) using a composite model of absorption (*tbabs*) along with two different partial covering absorbers plus a multi-temperature plasma emission component in *XSPEC*. In addition, we find a Gaussian emission line at 6.4 keV. For LS Peg the maximum temperature of the plasma distribution is found to be $\sim$ 14.8 keV with a luminosity of $\sim 5{\times}10^{32}$erg s^{-1} translating to an accretion rate of $\sim 1.27{\times}10^{-10}$ M$_{\odot}$ yr^{-1}. We present spectra for orbital minimum and orbital maximum. In addition, we use SWIFT observations of the source in order to make a comparison. We elaborate on the geometry of accretion and absorption in the X-ray emitting region with articulation on the magnetic nature.

Multiwavelength monitoring of a very active dwarf nova AX J1549.8-5416 with an unusually high duty cycle

Guobao Zhang[1], Joseph Gelfand[1], David Russell[1], Fraser Lewis[2], Nicola Masetti[3], Federico Bernardini[1], Ileana Andruchow[4], L Zibecchi[4]

[1]*New York University Abu Dhabi, P.O. Box 129188, Abu Dhabi, UAE*

[2]*Faulkes Telescope Project, School of Physics and Astronomy, Cardiff University, 5 The Parade, Cardiff, CF24 3AA, Wales*

[3]*INAF-Istituto di Astrofisica Spaziale e Fisica Cosmica di Bologna, via Gobetti 101, 40129 Bologna, Italy*

[4]*Facultad de Ciencias Astronómicas y Geofisicas, Universidad Nacional de La Plata, Paseo del Bosque, B1900FWA La Plat*

We present new optical, UV and X-ray observations of a highly variable dwarf nova(DN) AX J1549.8-5416. The multiwavelength analysis of three mini-outbursts and one normal outburst represent one of the most complete multiwavelength studies of a DN and help to refine the relationship between the X-ray, UV and optical emission in this system. We find that the UV emission is delayed the optical (1.0-5.4 days) during the rising phase of the outburst. The X-ray emission is suppressed during the peak of the optical outburst and recovers during the end of the outburst. We also analyse archival Swift, Chandra and XMM-Newton observations of the source. Our estimated high duty cycle suggests the X-ray luminosity of this source should be larger than 10E32 erg/s in quiescence. We find a roughly anti-correlation between X-ray and UV flux. The X-ray spectra of XMM-Newton and Chandra can be well described either by a single temperature thermal plasma model or by an isobaric cooling flow model when its X-ray flux is high.

Chapter 6

Isolated Neutron Stars & Magnetars

The influence of quantum vacuum friction on pulsars

Jaziel G. Coelho[1]
[1] *Instituto Nacional de Pesquisas Espaciais, So José dos Campos - SP, Brazil*

We firstly revisit the energy loss mechanism known as quantum vacuum friction (QVF), clarifying some of its subtleties. Then we investigate the observables that could easily differentiate QVF from the classical magnetic dipole radiation for pulsars with braking indices (n) measured accurately. We show this is specially the case for the time evolution of a pulsars' magnetic dipole direction ($\dot{\phi}$) and surface magnetic field ($\dot{B}\_0$). As it is well known in the context of the classic magnetic dipole radiation, $n < 3$ (as pulsars' measurements show) would only be possible for positive ($\dot{B}\_0/B\_0 + \dot{\phi}/\tan\phi$), which, for instance, leads to $\dot{B}\_0 > 0$ ($\dot{\phi} > 0$) when ϕ (B_0) is constant. On the other hand, we show that QVF can result in very contrasting predictions with respect to the above ones. Finally, even in the case $\dot{B}\_0$ in both aforesaid models for a pulsar has the same sign, for a given ϕ, we show that they give rise to different associated timescales, which could be another way to falsify QVF.

Gravitational waves from pulsars with measured braking index

Jaziel G. Coelho[1]
[1] *Instituto Nacional de Pesquisas Espaciais, So José dos Campos - SP, Brazil*

We study the putative emission of gravitational waves (GWs) in particular for pulsars with measured braking index. We show that the appropriate combination of both GW emission and magnetic dipole brakes can naturally explain the measured braking index, when the surface magnetic field and the angle between the magnetic dipole and rotation axes are time dependent. Then we discuss the detectability of these very pulsars by aLIGO and the Einstein Telescope. We call attention to the realistic possibility that aLIGO can detect the GWs generated by at least some of these pulsars, such as Vela, for example.

Where Are the R-modes? Chandra Observations of Millisecond Pulsars

Simin Mahmoodifar[1], Tod Strohmayer[1]
[1] *NASA's Goddard Space Flight Center, Greenbelt, USA*

We present the results of *Chandra* observations of two non-accreting millisecond pulsars PSRs J1640+2224 (J1640) and J1709+2313(J1709), with low inferred magnetic fields in order to constrain their surface temperatures, obtain limits on the amplitude of unstable r-modes in them and make comparisons with similar limits obtained for a sample of accreting LMXB neutron stars (NSs). We detect both pulsars in the X-ray band for the first time. We found upper limits on the global surface temperature of these pulsars that are $\sim 3.3 \times 10^5 - 4.7 \times 10^5$K. These sources are several Gyr old. In all standard cooling models NSs cool to surface temperatures less than 10^4K in less than 10^7 yr. While we derived *upper limits* on the surface temperatures of these sources, they appear to be consistent with the values *measured* for PSR J0437-4715 and J2124-3358. Taken together these results suggest that the surface temperatures of at least some MSPs are significantly higher, given their ages, than standard cooling models would suggest. For pulsars that are inside the r-mode instability window, r-mode dissipation can provide a potential source of reheating.

A deep XMM-Newton look on the "Magnificent Seven" isolated neutron star RX J1605.3+3249

Adriana Mancini Pires[1], Axel Schwope[1], Frank Haberl[2], Christian Motch[3], Silvia Zane[4], Vyacheslav Zavlin[5]
[1] *Leibniz-Institut für Astrophysik Potsdam (AIP, Germany)*
[2] *Max-Planck-Institut für extraterrestrische Physik (MPE, Germany)*
[3] *Observatoire Astronomique de Strasbourg (France)*
[4] *Mullard Space Science Laboratory (MSSL, UK)*
[5] *Marshall Space Flight Center (NASA, US)*

The thermally emitting isolated neutron star (INS) RX J1605.3+3249 is the third brightest in the group dubbed the "Magnificent Seven". Magnetic field decay may explain why these neutron stars rotate more slowly and have higher thermal luminosities and magnetic field intensities than standard pulsars of similar age. Previous XMM-Newton observations of the source revealed a shallow and energy-dependent periodic signal, as well as evidence of a fast spin-down. Such intriguing properties suggest a high dipolar magnetic field and an evolution from a magnetar. We targeted the INS with XMM-Newton to confirm its candidate timing solution, understand the energy-dependent amplitude of the modulation, and investigate the origin of the broad and narrow spectral features of the source. We report here the preliminary results of our programme.

A long XMM-Newton campaign on the mode-switching radio pulsar PSR B0943+10

Sandro Mereghetti[1]
[1]*IASF-Milano, INAF, v.E.Bassini 15, I-20133 Milano, Italy*

Observations obtained in the last years challenged the widespread notion that rotation-powered neutron stars are steady X-ray emitters. Besides the few pulsars showing "magnetar-like" activity, in at least one remarkable object, PSR B0943+10, significant variations, correlated to radio-mode switching have been discovered. Their study opens a new window to investigate the processes responsible for the pulsar radio and high-energy emission.

An XMM-Newton Large Program, with simultaneous radio observations with LOFAR, LWA and Arecibo, allowed us to detect X-ray pulsations also during the fainter state and to better constrain the spectral and variability properties of PSR B0943+10. In both radio states the pulsed emission can be described by a thermal blackbody with temperature of a few 10^6 K and the unpulsed emission by a power-law.

We discuss a scenario in which both unpulsed non-thermal emission, likely of magnetospheric origin, and pulsed thermal emission from a small polar cap ($\sim$1500 m^2) with a strong non-dipolar field ($\sim 10^{14}$ G), are present during both modes and vary in intensity in a correlated way. This is broadly consistent with the predictions of the partially screened gap model and does not necessarily imply global magnetospheric rearrangements to explain the mode switching.

The long-lasting tail of a bright burst from the magnetar 1E 1547.05408: the effect of the dust-scattering.

Fabio Pintore[1], Sandro Mereghetti[1], Andrea Tiengo[1], Giacomo Vianello[2], Elisa Costantini[3], Paolo Esposito[4]
[1]*INAF IASF Milano, Via E. Bassini 15, 20133 Milano, Italy*
[2]*SLAC National Accelerator Laboratory, Stanford University, Stanford, CA 94305, USA*
[3]*SRON Netherlands Institute for Space Research, Sorbonnelaan, 2, 3584-CA, Utrecht, The Netherlands*
[4]*Anton Pannekoek Institute for Astronomy, University of Amsterdam, Postbus 94249, 1090-GE Amsterdam, The Netherlands*

We report on a bright burst, followed by an X-ray tail lasting 10 ks, detected during an XMM-Newton observation of the magnetar 1E 1547.05408 carried out on 2009 February 3. The burst, also observed by Swift/BAT, showed a spectral shape well described by the sum of two blackbodies with temperatures of 4 keV and 10 keV and a fluence in the 0.3-150 keV energy range of 1e-5 erg cm-2. The X-ray tail had a fluence of 4e-8 erg cm-2. Thanks to the knowledge of the distances and relative optical depths of three dust clouds between us and 1E 1547.05408, we carried out a spectral and temporal analysis of the tail and we found that most of the X-rays in the tail can be explained by dust scattering of the burst emission, except for the first 20-30 s after the burst. We also point out that other X-ray tails observed after strong magnetar bursts may contain a non-negligible contribution due to dust scattering.

Magnetar-like emission in different neutron star classes

Nanda Rea[1,2]
[1] *Institute of Space Sciences (CSIC-IEEC), ES*
[2] *University of Amsterdam, NL*

I will present new results on magnetar-like transient events in neutron stars having low dipolar fields or generally catalogued as normal radio pulsars or central compact objects. I will then present simulations of magnetic field evolution that might explain the apparently puzzling behaviour of these objects. Strong surface magnetic field might be an almost ubiquitous properties of pulsars, regardless their external dipolar magnetic field measured via their spin down properties.

Chapter 7

Interacting Binaries and Galactic Black Holes

X-ray reprocessing: Through eclipse spectra of high and low mass X-ray binaries

Nafisa Aftab[1], Biswajit Paul[1]
[1] *Raman Research Institute, Bengaluru 560080, Karnataka, India*

A difficult aspect of studying reprocessed X-rays in X-ray binary systems is that the reprocessed emission is detected along with the primary emission, which is much brighter. During eclipse, the primary emission is blocked by the companion star and only the reprocessed emission is detected, allowing study of the reprocessing agent. We have studied 9 High Mass X-ray Binaries (HMXBs) and four Low Mass X-ray Binaries (LMXBs) during eclipse and out-of-eclipse phases with XMM-NEWTON. In most cases, during eclipse the continuum component of the spectrum is reduced by a factor of 20-50, but the iron emission lines in HMXBs are reduced by a smaller factor leading to a large equivalent width. This indicates a large size for the line emission region in these HMXB systems. However, there are significant system to system differences. 7 observations of LMXB EXO 0748-676 carried out over a 2 months period shows all the eclipse spectrum to be non-varying, indicates a consistent accretion scenario. The out-of-eclipse spectrum shows variation below 5 keV presumably due to variation in the accretion disk structures. We try to infer the wind and accretion disk characteristics, which are the reprocessing agents in the HMXB and LMXB systems respectively.

Modeling X-ray and gamma-ray emission in the intrabinary shock of pulsar binaries

Hongjun An[1]
[1] *Chungbuk National University*

We present broadband SED and light curve, and a wind interaction model for the gamma-ray binary 1FGL J1018.6−5856 (J1018) which exhibits double peaks in the X-ray light curve. Assuming that the X-ray to low-energy gamma-ray emission is produced by synchrotron radiation and high-energy gamma rays by inverse Compton scattering in the intrabinary shock (IBS), we model the broadband SED and light curve of J1018 using a two-component model having slow electrons in the shock and fast bulk-accelerated electrons at the skin of the shock. The model explains the broadband SED and light curve of J1018 qualitatively well. In particular, modeling the synchrotron emission constrains the orbital geometry. We discuss potential use of the model for other pulsar binaries.

Revealing new spectral components using broad-band variability of the inner accretion flow of black hole binaries

Magnus Axelsson[1,2], Chris Done[3]
[1] *Tokyo Metropolitan University, Tokyo, Japan*
[2] *Stockholm University, Stockholm, Sweden*
[3] *Durham University, Durham, UK*

The geometry of the inner accretion flow in X-ray binaries is complex, with multiple regions contributing to the observed emission. Frequency-resolved spectroscopy is a powerful tool in breaking this spectral degeneracy. The technique has previously been used to study quasi-periodic oscillations, supporting the presence of an inhomogeneous hot flow inside a truncated accretion disc. We have now extended this technique to the broad-band 0.1–10 Hz components in the power spectrum of Cygnus X-1. The results show that the components have different spectra, and thus originate in different parts of the flow. We confirm the coupling between Comptonized emission and rapid variability, but also find the presence of a new spectral component above ~ 10 keV. We discuss the implications of these results for our picture of the accretion flow.

The X-ray Pulsar 2A 1822-371 as a super-Eddington source

Ann-Sofie Bak Nielsen[1], Alessandro Patruno[1,2]
[1] *Leiden Observatory, Leiden University, Leiden, The Netherlands*
[2] *ASTRON, the Netherlands Institute for Radio Astronomy, Dwingeloo, The Netherlands*

The LMXB pulsar 2A 1822-371 is a slow accreting x-ray pulsar which shows several peculiar properties. The pulsar is observed to spin-up continuously on a timescale of 7000 years , shorter than expected for these type of systems. The orbital period is expanding on an extremely short timescale that challenges current theories of binary evolution. Furthermore, the presence of a thick accretion disc corona poses a problem, since we observe X-ray pulsations which would otherwise be smeared out by the Compton scattering. I propose a solution to all of the above problems by suggesting that the system may be a super-Eddington source with a donor out of thermal equilibrium. I propose that 2A 1822-371 has a thin accretion outflow being launched from the inner accretion disk region. The solution reconciles both the need for an accretion disk corona, the fast spin-up and the changes in the orbital separation. I will also present preliminary results obtained with new XMM-Newton data that show the possible presence of a low frequency modulation similar to those observed in two accreting millisecond pulsars. Given the relatively strong magnetic field of 2A 1822-371, the modulation requires a super-Eddington mass transfer rate, further strengthening the proposed scenario.

Comparing the X-ray and optical emission of transient low mass X-ray binaries

Federico Bernardini[1], David Russell[1], A.W. Shaw[2], F. Lewis[3], P.A. Charles[2], J.P. Lasota[4], J. Casares[5]

[1] *New York University Abu Dhabi*

[2] *Department of Physics & Astronomy, University of Southampton, Southampton SO17 1BJ, UK*

[3] *Faulkes Telescope Project, School of Physics & Astronomy, Cardiff University, The Parade, CF24 3AA, Cardiff, Wales*

[4] *Institut dAstrophysique de Paris, CNRS et Sorbonne Universites, UPMC Paris06, UMR 7095, 98bis Bd Arago, F-75014 Paris*

[5] *Instituto de Astrofisica de Canarias, E-38205 La Laguna, Santa Cruz de Tenerife, Spain*

I will present the latest results of our multiwavelength monitoring campaign of transient low mass X-ray binaries focusing on two outbursts occurred in 2015. The study of the X-ray–optical correlation and the analysis of the spectral energy distribution (from radio to the X-ray band) of the neutron star system SAX J1808-3658 shed light on the emission processes at work during its outburst and suggest that X-ray reprocessing from the accretion disk likely dominates the optical emission. In the case of the black hole (BH) system V404 Cyg, the optical photometry shows a seven days optical precursor to the X-ray outburst. We also fortuitously collected an optical spectrum 13 hours before the first X-ray trigger. It shows an intense Hα emission, seven times the quiescent level, confirming that the disk entered the outburst state before the X-ray outburst began. We propose that the outburst is produced by a viscousthermal instability triggered close to the inner edge of a truncated disk. An X-ray delay of a week corresponds to the time needed to refill the inner region and hence move the edge of the disk inwards, allowing matter to reach the central BH, finally turning on the X-ray emission.

Photoionisation instability of winds in X-ray binaries

Stefano Bianchi[1]

[1] *Università degli Studi Roma Tre*

Accretion disc winds in X-ray binaries have been recently recognised to be a major ingredient of accretion. Recent results indicate that they can carry away more matter than the one accreted onto the compact object, that their presence appears connected with the state of the accretion disc and with the absence of the jet. Here we present the case of AX J1745.6-2901, a neutron star Low Mass X-ray Binary showcasing intense ionised Fe K absorption only during the soft state. Thanks to the availability of a large number of simultaneous XMM-Newton and NuSTAR spectra, we accurately determine the X-ray spectral energy distribution and its variations between the states. We observe that the ionised absorber lies always on a stable branch of the photo-ionisation stability curve during the soft state, while it becomes unstable during the hard state. The same process might explain the disappearance of the high ionisation absorber/wind during the hard state in other systems.

Discovery of a 26.2 day period in the long-term X-ray light curve of the Be/X-ray pulsar SXP 1323

Stefania Carpano[1], Frank Haberl[1], Richard Sturm[1]
[1] *Max-Planck-Institut für extraterrestrische Physik, Garching, Germany*

SXP 1323 is one of the longest-period Be/X-ray pulsars known in the Small Magellanic Cloud. Analysing systematically the large set of calibration observations available for the source from Suzaku, XMM-Newton and Chandra, we discovered a 26.188+-0.045d period which confirms the optical period derived from OGLE data and that we therefore interpret as the orbital period. This period is short with respect to what is expected from the spin/orbital period relationship. We furthermore study the long term evolution of the pulse period and report a very rapid spin-up with a period decreasing from 1340s to 1100s in a time range from 2006 to end 2016. SXP 1323 is therefore a peculiar Be/X-ray binary for either the long pulse period and corresponding short orbital period, and for the rapid spin-up for several years. It is necessary to continue to monitor the source in the next years to establish the long-term behaviour of the spin period.

A Multi Wavelength Study of the Gamma Ray Binaries LMC P3 and 1FGL J1018.6-5856

Joel Coley[1,2,4], Robin Corbet[3,4], Patricia Boyd[4], Guillaume Dubus[5], Neven Vulic[6]
[1] *NASA Postdoctoral Program*
[2] *Universities Space Research Association, Columbia, MD USA*
[3] *University of Maryland Baltimore County CRESST, Baltimore, MD USA*
[4] *NASA Goddard Space Flight Center, Greenbelt, MD USA*
[5] *UJF-Grenoble I/CNRS-INSU, Grenoble, France*
[6] *University of Maryland College Park, College Park, MD USA*

Persistent gamma-ray emission dominates the radiative output of gamma-ray binaries, which are thought to be the evolutionary precursors to X-ray binaries. Often, this is attributed to particle acceleration in the shock from the winds of an optical companion and rapidly spinning pulsar or inverse Compton scattering of UV photons in the relativistic jet of an accreting compact object. We present here a multi-wavelength analysis of the two most luminous gamma-ray binaries LMC P3 and 1FGL J1018.6-5856 with the Australia Compact Telescope Array (ATCA), Fermi Large Area Telescope (LAT), Swift, SOAR and SALT to better understand the properties of their orbital modulations. The newly discovered LMC P3 in the Large Magellanic Cloud is currently the only gamma-ray binary found outside the Milky Way and is significantly more luminous than similar binary systems at all energy bandpasses. We find the radio amplitude modulation in 1FGL J1018.6-5856 to decline with increasing frequency, which is a possible indication of free-free absorption. The best-fit spectral model of the Swift XRT data consists of a single powerlaw with photon index 1.31.7 modified by an absorber that fully covers the source. This is possible evidence that 1FGL J1018.6-5856 is a non-accreting system.

X-ray reverberation: a tool to constrain the (evolving) disc geometry in BHXRBs

Barbara De Marco[1], Gabriele Ponti[2], Pierre-Olivier Petrucci[3]
[1] *Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences*
[2] *Max Planck Institut für Extraterrestriche Physik*
[3] *Institut de Planétologie et d'Astrophysique de Grenoble*

Fast X-ray variability of accreting black hole (BH) systems is a powerful tool to probe the inner accretion flow close to the BH. The variable primary X-ray radiation interacts with any surrounding matter, including the accretion disc. Short light travel time delays are expected between the primary and the reprocessed emission in the disc. These X-ray reverberation lags can be used to map the geometry of the very inner regions of the accretion flow. X-ray reverberation lags have been extensively studied in active galactic nuclei. I will present results obtained from the study of X-ray reverberation in BH X-ray binaries (BHXRB). I will discuss new detections of X-ray reverberation from a recent observing campaign of GX 339-4, which caught the source during the return to the hard state at the end of its 2014-2015 outburst. Comparison with previous detections show evidences of evolving disc geometry as a function of the accretion regime.

EXTraS discovery of a 1.2-s X-ray pulsar in M31

P. Esposito[1], G. L. Israel[2], A. Belfiore[3], G. Novara[4], L. Sidoli[3], G. A. Rodrǵuez Castillo[2], A. De Luca[3], A. Tiengo[4], F. Haberl[5], R. Salvaterra[3]
[1] *University of Amsterdam, The Netherlands*
[2] *Astronomical Observatory of Rome, INAF, Italy*
[3] *IASF Milano, INAF, Italy*
[4] *IUSS Pavia, Italy*
[5] *Max-Planck-Institut für extraterrestrische Physik, Germany*

A systematic search for periodic signals in the XMM-Newtons EPIC archive carried out within the EXTraS project resulted in the discovery of a 1.2-s flux modulation in 3XMM J004301.4+413017. It is the first accreting neutron star in M31 for which the spin period has been detected. Besides this distinction, 3XMM J0043 proved to be an interesting system. Doppler shifts of the spin modulation revealed an orbital motion with period with period of 1.27 d and the analysis of optical data shows that, while the source is likely associated to a globular cluster, a counterpart with V $\sim$ 22 outside the cluster cannot be excluded. The emission of the pulsar appears rather hard (most data are described by a power law with photon index <1) and, assuming the distance to M31, the 0.3–10 keV luminosity was variable, from $\sim 3 \times 10^{37}$ to 2×10^{38} erg/s. Based on this, we discuss two main possible scenarios for 3X J0043: a peculiar low-mass X-ray binary, perhaps similar to 4U 1822–37 or 4U 1626–67, or an intermediate-mass X-ray binary akin Her X–1.

A soft mHz quasi periodic oscillation in the fastest accreting millisecond pulsar.

Carlo Ferrigno[1], Enrico Bozzo[1], Andrea Sanna[2], Fabio Pintore[3], Alessandro Papitto[4], Alessandro Riggio[2], Luciano Burderi[2], Tiziana Di Salvo[5], Rosario Iaria[5], Antonino D'Ai[6]
[1] *ISDC, University of Geneva, Versoix, Switzerland,*
[2] *Dipartimento di Fisica, Università degli Studi di Cagliari, Italy*
[3] *INAF-Istituto di Astrofisica Spaziale e Fisica Cosmica , Milano, Italy,*
[4] *INAF, Osservatorio Astronomico di Roma, Monteporzio Catone, Italy*
[5] *Universitaà degli Studi di Palermo, Dipartimento di Fisica e Chimica, Palermo, Italy*
[6] *INAF/IASF Palermo, Palermo, Italy*

We illustrate the peculiar X-ray variability displayed by the accreting millisecond X-ray pulsar IGR J00291+5934 in a 80 ks-long joint Nustar and XMM-Newton observation performed during the source outburst in 2015. The lightcurve of the source is characterized by a flaring behavior, with typical rise and decay timescales of ∼120 s. The flares are accompanied by a remarkable spectral variability, with the X- ray emission being generally softer at the peak of the flares. A strong QPO is detected at ∼8 mHz in the power spectrum of the source and clearly associated to its flaring-like behaviour. This feature has the strongest power at soft X-rays (<3 keV). We carried out a dedicated hardness-ratio resolved spectral analysis and a QPO-phase resolved spectral analysis together with an in-depth study of the source timing properties to investigate the origin of this behaviour. We discuss that it could be due either a disk-instability like the hearth-beat in the black-hole binary GRS 1915+105, or, less likely, to unstable nuclear burning on the neutron star surface, as observed in the burster 4U 1636−536. This phenomenology could be ideally studied with the large throughput and wide energy coverage of present and future instruments.

Sub-second optical and X-ray timing correlations in V404 Cygni

Poshak Gandhi[1], Matteo Bachetti[2], Vik Dhillon[3], Rob Fender[4], Fiona Harrison[5], Julien Malzac[6], Sera Markoff[7], John Tomsick[8], Dom Walton[9], Piergiorgio Casella[10]
[1] *University of Southampton, Southampton, UK*
[2] *INAF, Cagliari, Italy*
[3] *University of Sheffield, UK*
[4] *University of Oxford, UK*
[5] *Caltech, Pasadena, USA*
[6] *Universite de Toulouse, France*
[7] *Anton Pannekoek Institute, Amsterdam, The Netherlands.*
[8] *University of California, Berkeley, California*
[9] *Insitute of Astronomy, Cambridge, UK*
[10] *INAF, Roma, Italy*

The 2015 outburst of V404 Cygni was the most prolific X-ray binary outburst of the century so far, and the binaries community came together in coordinating several global monitoring campaigns. We will review some of the main lessons learnt from multiwavelength fast (sub-second) timing efforts. In particular, we will show strong evidence pointing to a jet origin for the most rapid detected optical variability on timescales of just ∼ 30 ms. The source of such optical variations has hitherto been controversial, with a magnetically-active corona, an advective flow, a jet or a combination of components having been suggested. Using data from ULTRACAM and NuSTAR, we find an optical delay with respect to X-rays of ∼ 0.1s, with this delayed cross-correlation signal strengthening together with a brightening AMI radio jet. A red optical spectral slope and high brightness flare temperatures further point to the inner jet being the most plausible emission source. Our result sets a characteristic elevation of $\sim 10^3$ Schwarzschild radii for the jet base optical emission zone above the black hole. This size scale appears to be common to other sources and is thus constraining for jet MHD and internal shock models.

X-ray Reflection from Black Hole Binary Accretion Disks: Coronal Geometry, Disk Truncation and Iron Abundance

Javier Garcia[1,2,3], Thomas Dauser[2], James Steiner[4], Victoria Grinberg[5], Fiona Harrison[1], Joern Wilms[2], Jeffrey McClintock[3], John Tomsick[6]

[1] *Cahill Center for Astronomy and Astrophysics, California Institute of Technology, Pasadena, CA 91125, USA*

[2] *Dr.-Karl-Remeis-Sternwarte & ECAP, Universität Erlangen-Nürnberg, Sternwartstrasse 7, 96049, Bamberg, Germany*

[3] *Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA*

[4] *MIT Kavli Institute for Astrophysics and Space Research, MIT, 70 Vassar Street, Cambridge, MA 02139*

[5] *European Space Astronomy Centre (ESA/ESAC), Science Operations Department, Villanueva de la Canada (Madrid), Spain*

[6] *Space Sciences Laboratory, 7 Gauss Way, University of California, Berkeley, CA 94720-7450, USA*

In order to explore the rich phenomenology of black hole binaries (BHBs) in the X-ray band, it is crucial to employ accurate and sophisticated models. During the past decade, a wealth of spectral and timing data have been accumulated and analyzed. In some cases, results from these analyses are found to be in disagreement. For example, estimates for the location of the disk inner-radius in GX 339-4 from reflection spectroscopy, QPOs, and reverberation studies are in serious discord by more than an order of magnitude, some studies finding large truncation radius, while others predicting a disk that extends close to the inner-most stable circular orbit. Additionally, models implementing a lamppost geometry for the illumination of disk seem to reproduce the observations well, but they have been recently challenged on theoretical grounds. Finally, there is growing observational evidence for very large iron abundances inferred from modeling reflection spectra of both BHBs and AGN, unexpectedly exceeding the Solar value for factors of a few. In this presentation we review our current efforts to address the observational and theoretical challenges posed by these three issues.

Opening the CHOCBOX: clumpy stellar winds in Cyg X-1

Victoria Grinberg[1], Phil Uttley[2], Joern Wilms[3], James Miller-Jones[4], Katja Pottschmidt[5,6], Shu Niu[1,7], Maria Hirsch[1], the CHOCBOX collaboration[1,2,3,4,5,6,7]

[1] *ESA/ESTEC, Noordwijk, The Netherlands*

[2] *UVA, Amsterdam, The Netherlands*

[3] *Remeis Observatory & ECAP, Bamberg, Germany*

[4] *Curtin University, Perth, Australia*

[5] *GSFC, Greenbelt, USA*

[6] *CRESST, Baltimore, USA*

[7] *Purple Mountain Observatory, Nanjing, China*

Winds of O/B-stars are key drivers of enrichment and star formation and evolution. Yet, our understanding of their clumpy structure is limited. Luckily, high mass X-ray binaries,where the compact object accretes from the stellar wind of the companion, are perfect laboratories to study such winds: the X-ray radiation from the vicinity of the compact object is quasi-pointlike and effectively X-rays the clumps crossing the line of sight. We observed the high mass X-ray binary Cyg X-1 with XMM for 7 consecutive days with simultaneous coverage with NuSTAR, INTEGRAL and VLBA. One of our main aims was to probe the wind of the O-type companion in an unprecedented uninterrupted campaign, spanning more than an orbital period and including two superior conjunctions where we expect the densest wind. Here, we present first results from the CHOCBOX (Cyg X-1 Hard state Observations of a Complete Binary Orbit in X-rays) campaign and compare them to previous work, in particular multi-year studies of absorption variability and high resolution snapshots with Chandra-HETG. We argue that the clumps have a complex structure with hotter outer and colder inner layers and are not symmetrical.

Radiation Hydrodynamic simulations of Coronae and Disk winds in X-ray Binaries

Nick Higginbottom[1], Daniel Proga[2]
[1] *University of Southampton, Southampton, UK*
[2] *UNLV, Las Vegas, USA*

X-ray spectra of several Low Mass X-ray binaries show evidence of disk-winds in the high/soft state. A promising driving mechanism for these outflows is the thermal expansion of X-ray heated material in the outer disk atmosphere. First, we demonstrate through hydrodynamical simulations that the properties of thermally-driven winds depend critically on the shape of the thermal equilibrium curve, which determines the thermal stability of the irradiated material. For a given SED, the thermal equilibrium curve depends on the balance between the heating and cooling mechanisms at work. Then, we use the photoionization code Cloudy to generate heating and cooling rates based on current atomic data, which we use in a 2.5D hydrodynamic model to simulate thermal winds in a typical black-hole X-ray binary. The resulting flow, calculated in the optically thin limit, has a significant mass-loss rate, likely at the level where the wind could affect the inner disk and cause state change. Finally, we discuss a more complete simulation of a disk wind in a low mass X-ray binary, dropping the assumption that the wind is everywhere optically thin, using our Monte-Carlo radiative transfer code to calculate the radiation field within the wind and to update the heating rates.

Searching for low mass X-ray binaries in the Magellanic Clouds

Tana Joseph[1], Itumeleng Monageng[2], Lee Townsend[2], Naomi van Jaarsveld[2], Ann Mao[3], Sharmila Goedhardt[4], Jacco van Loon[5]
[1] *South African Astronomical Observatory, Cape Town, South Africa*
[2] *University of Cape Town, Cape Town, South Africa*
[3] *Max Planck Institute for Radio Astronomy, Bonn, Germany*
[4] *SKA South Africa, Cape Town, South Africa*
[5] *University of Keele, Staffordshire, UK*

The Magellanic Clouds are our nearest galactic neighbours. Their proximity allows us to probe their content and structure more deeply than other nearby galaxies. Their extragalactic nature also circumvents the problems of distance determination encountered within our own Galaxy. In addition, the low metallicity of the SMC means that this galaxy has similar conditions to the early Universe. Currently, there is only one low mass X-ray binary known in the Magellanic Clouds (LMC X-2). Recent deep XMM and Chandra observations allow us to probe the X-ray point source population in search for more such systems. By combining X-ray data with sensitive radio observations from the MeerKAT telescope, as well as optical, infrared and UV data, we hope to reveal the population of low mass X-ray binaries in Magellanic Clouds. By studying the populations of X-ray sources in the Magellanic Clouds we will be able to further constrain X-ray binary formation and evolution scenarios.

Monitoring of the peculiar X-ray binary pulsar SAX J0635+0533

Nicola La Palombara[1], Sandro Mereghetti[1]
[1]*INAF - IASF Milano*

SAX J0635+0533 is a binary pulsar with a very short pulsation period (P = 33.8 ms) and a high long-term spin down ($\dot{P} > 3.8 \times 10^{-13}$ s s^{-1}), which suggests a rotation-powered (instead of an accretion-powered) nature for this source. While it was discovered at a flux level around 10^{-11} erg cm^{-2} s^{-1}, between 2003 and 2004 it was detected with XMM-Newton with an average flux of $\sim 10^{-13}$ erg cm^{-2} s^{-1}; moreover, the flux varied of over one order of magnitude on time scales of a few days. This large flux variability is difficult to explain for a rotation-powered pulsar, while the matter accretion onto the NS surface implies a very low magnetic field (B $\sim 10^8$ G). Therefore, the nature of SAX J0635+0533 remained uncertain.

Between 2015 and 2016 we performed a monitoring campaign with Swift, detecting the source between 10^{-13} and 10^{-12} erg cm^{-2} s^{-1}; moreover, with a systematic analysis of all the observations performed with RXTE we revealed that between 1999 and 2001 the source remained active at a flux level above 10^{-12} erg cm^{-2} s^{-1}.

Here we report in detail these results and discuss their impact on the assessment of the source nature.

High-resolution spectral analysis of transient pulsars in the Small Magellanic Cloud

Nicola La Palombara[1], Lara Sidoli[1], Paolo Esposito[2], Fabio Pintore[1], Andrea Tiengo[3], Sandro Mereghetti[1]
[1]*INAF - IASF Milano*
[2]*Amsterdam University*
[3]*IUSS Pavia*

At low energies the spectra of several X-ray binary pulsars show a significant excess over the main power-law component. Although various physical processes (both thermal and non-thermal) have been invoked to produce this excess, its origin is still unclear. The best sources to study this type of feature are the transient pulsars in the Small Magellanic Cloud, which can reach high luminosities ($L_{\rm X} > 10^{38}$ erg s^{-1}) and, thanks to the low absorption in the SMC direction, can provide high statistics spectra at low energies. In the last three years we observed with XMM-Newton the large outburst of three of these transient pulsars (RX J0059.2-7138, SMC X-2, and IGR J01572-7259). Thanks to the high throughput and spectral resolution of XMM, these observations allowed us to investigate at an unprecedented level of detail their spectral and timing properties at soft X-ray energies. We found that these sources show a pulsed emission also at low energies, and that they are characterized by a significant thermal component of low temperature (kT $\sim$ 0.2 keV); moreover, we discovered several emission and absorption features, which are very likely produced by photoionization of plasma located above the inner regions of the accretion disc.

A Hard Look at Accreting NS LMXBs

Renee Ludlam[1], Jon Miller[1], Edward Cackett[2], Nathalie Degenaar[3], Andrew Fabian[4], Michael Parker[4], John Tomsick[5], Matteo Bachetti[6], Didier Barret[7], Lorenzo Natalucci[8]
[1] *University of Michigan, Ann Arbor, United States of America*
[2] *Wayne State University, Detroit, United States of American*
[3] *University of Amsterdam, Amsterdam, Netherlands*
[4] *Institute of Astronomy, Cambridge, United Kingdom*
[5] *University of California, Berkeley, United States of America*
[6] *INAF/Osservatorio Astronomico di Cagliari, Selargius (CA), Italy*
[7] *Universit de Toulouse,Toulouse, France*
[8] *Istituto Nazionale di Astrofisica, Roma, Italy*

NuSTAR has allowed for the performance of inner disk measurements that are unbiased by pile-up effects. From these measurements we are able to infer different properties about the neutron star itself, such as constraints to the equation of state, magnetic field estimates, and the extent of the boundary layer. We will compare the magnetic field strengths from reflection modeling methods to those seen for accreting millisecond X-ray pulsars. NuSTAR has observed a number of neutron stars over range of Eddington ratios, which has allowed us to probe the extent of the inner disk over a range of mass accretion rates. There does not appear to be a clear trend between mass accretion rate and the location of the inner disk radius. The combined observing power of NuSTAR and the XMM-Newton/RGS have revealed multiple relativistic disk lines in the neutron star X-ray binary 1RXS J180408.9-34205 during its 2015 outburst (Fe Kα detected with NuSTAR; N VII, O VII, and O VIII detected in the RGS). These features may originate from different zones of ionization within the disk, however deeper joint observations are needed to fully map the run of ionization with disk radius.

The effects of spectral hardness changes on reverberation lags

Guglielmo Mastroserio[1], Adam Ingram[1], Michiel van der Klis[1]
[1] *Anton Pannekoek Institute, University of Amsterdam, Amsterdam, The Netherlands*

Accreting black holes show characteristic reflection features in their X-ray spectrum, including an iron Kα line, which results from hard X-ray continuum photons illuminating the accretion disk. Measuring the reverberation lag resulting from the difference in path length between direct and reflected emission, and the spectral distortions to the iron line caused by rapid orbital motion and gravitational redshift, provides a powerful tool to probe the innermost regions around the black hole. Previous reverberation studies, both for supermassive and stellar-mass black holes, have largely ignored spectral variability of the continuum. However, this is a potentially important effect, since a hardening of the continuum spectrum causes non-linear changes in the shape of the reflection spectrum as different transitions in the disk are excited and the ionisation balance is changed. We have studied the effect of a pivoting continuum power-law on the reverberation lag spectrum, assuming the lamppost geometry, and developed an analytic description. Our model accounts self-consistently for both continuum and reverberation lags. We have applied it to Cygnus X-1 cross-specta for the 0.015-32 Hz Fourier frequency range, obtaining good fits and constraining the continuum and reflection parameters.

The thermal state of KS 1731-260 after 14.5 years in quiescence

Rachael Merritt[1], Edward Cackett[1], Edward Brown[2], Dany Page[3], Andrew Cumming[4], Nathalie Degenaar[5,6], Alex Deibel[2], Jeroen Homan[7], Jon Miller[8], Rudy Wijnands[5]
[1]*Department of Physics & Astronomy, Wayne State University, Detroit, MI 48201, USA*
[2]*Department of Physics & Astronomy, NSCL, JINA-CEE, Michigan State University, East Lansing, MI 48824, USA*
[3]*Instituto de Astronomía, Universidad Nacional Autónoma de México, México, D. F. 04510*
[4]*Department of Physics and McGill Space Institute, McGill University, Montreal, QC, H3A 2T8, Canada*
[5]*Anton Pannekoek Institute for Astronomy, University of Amsterdam, 1098 XH Amsterdam, the Netherlands*
[6]*Institute of Astronomy, University of Cambridge, Cambridge CB3 0HA, United Kingdom*
[7]*Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, Cambridge, MA 02139, USA*
[8]*Department of Astronomy, University of Michigan, Ann Arbor, MI 48109-1104, USA*

Crustal cooling of accretion-heated neutron stars provides insight into the stellar interior of neutron stars. The neutron star X-ray transient, KS 1731−260, was in outburst for 12.5 years before returning to quiescence in 2001. We have monitored the cooling of this source since then through *Chandra* and *XMM-Newton* observations. Here, we present a 150 ks *Chandra* observation of KS 1731−260 taken in August 2015, about 14.5 years into quiescence, and 6 years after the previous observation. We find that the neutron star surface temperature is consistent with the previous observation, suggesting that crustal cooling has likely stopped and the crust has reached thermal equilibrium with the core. Using a theoretical crust thermal evolution code, we fit the observed cooling curves and constrain the core temperature ($T\_c = 9.35 \pm 0.25 \times 10^7$ K), composition ($Q_{imp} = 4.4^{+2.2}_{-0.5}$) and level of extra shallow heating required ($Q_{sh} = 1.36 \pm 0.18$ MeV/nucleon). We find that the presence of a low thermal conductivity layer, as expected from nuclear pasta, is not required to fit the cooling curve well, but cannot be excluded either.

NuSTAR monitoring of Eta Carinae

Christos Panagiotou[1], Roland Walter[1]
[1]*University of Geneva, Geneva, Switzerland*

The eta Carinae binary system hosts one of the most massive stars featuring the highest known mass-loss rate. This dense wind encounters the much faster wind expelled by the stellar companion, dissipating mechanical energy in the shock and accelerating particles. NuSTAR observed eta Carinae ten times around the 2014 periastron. The X-ray flux varied in a similar way as observed during the previous periastrons, increasing to a maximum a few days before periastron and decreasing steeply to a deep minimum before recovering. NuSTAR gives us access to the continuum, obscuration and to Iron line emission. We used a two-temperature model to fit the continuum originating from the wind-wind collision (WWC) region. After correction for the obscuration, we find that the intrinsic continuum feature a short period of reduced emission and can therefore probe the collapse of the WWC region close to periastron and its occultation by the primary star. The Fe Kα line is probing independently the response of the intrinsic continuum variability and the location where this reprocessing takes place.

A propeller model for the sub-luminous accretion disk state of transitional millisecond pulsars

Alessandro Papitto[1], Domitilla de Martino[2], Enrico Bozzo[3], Carlo Ferrigno[3], Nanda Rea[4], Diego Torres[4]
[1]*INAF Osservatorio Astronomico di Roma, Monte Porzio Catone (Roma), Italy*
[2]*INAF Osservatorio Astronomico di Capodimonte, Napoli, Italy*
[3]*ISDC University of Geneva, Versoix, Switzerland*
[4]*IEEC-CSIC Institute of Space Sciences, Barcelona, Spain*

Transitional millisecond pulsars are quickly rotating neutron stars that perform transitions between a radio pulsar state and an accretion regime, on time scales of the order of a few days. X-ray observations performed by XMM-Newton revealed a wealth of information about the properties of the accretion flows on these pulsars. X-ray pulsations were detected both at a luminosity typical of accreting ms pulsars (few x 1E36 erg/s), and unexpectedly also at a much lower level (few x 1E33 erg/s), at which accretion onto the neutron star surface is expected to be completely inhibited by the centrifugal barrier set by the quickly rotating magnetosphere. Together with the peculiar X-ray flux variability on both short (less than 1 s) and long (up to 10 hr) time scales, and the relatively bright gamma-ray emission observed at GeV energies, these properties suggest that a significant fraction of the in-flowing mass is ejected from the disk-magnetosphere boundary. I will present a model of the high energy emission of transitional ms pulsars based on the hypothesis that these systems are found in a propeller state, and discuss the possibility of identifying low luminosity X-ray sources with a bright gamma-ray counterpart as ms pulsars.

High-speed X-ray emitting ejecta from a high-mass gamma-ray binary with a middle-aged pulsar

George Pavlov[1], Oleg Kargaltsev[2], Jeremy Hare[2]
[1]*Pennsylvania State University, University Park, USA*
[2]*George Washington University, Washington DC, USA*

Observing the famous high-mass, eccentric gamma-ray binary PSR B1259–63/LS 2883 with the *Chandra* Observatory, we detected X-ray emitting clumps moving from the binary with speeds of 0.03–0.08 c, with a hint of acceleration. The clumps are being ejected with the binary period, 3.4 yr, presumably when the pulsar passes through the disk of the fast-rotating high-mass companion, around binary periastrons. The hard spectra of the clumps can be interpreted as synchrotron emission of relativistic electrons. I will present the results of 8 observations in 2009–2017 and discuss possible interpretations of this unique phenomenon.

First Optical observation of a microquasar at sub-milliarsec scale: SS 433 resolved by VLTI/GRAVITY

Pierre-Olivier Petrucci[1], Idel Waisberg[2], Jean-Baptiste Lebouquin[1], Jason Dexter[2], Guillaume Dubus[1], Karine Perraut[1], Pierre Kervella[3], the GRAVITY collaboration[1]
[1]*Institute of Planetology and Astrophysics of Grenoble*
[2]*Max Planck Institute fur extraterrestrische Physik*
[3]*Laboratoire d'etudes spatiales et d'instrumentation en astrophysique*

We present the first Optical observation at sub-milliarcsec (mas) scale of the famous microquasar SS 433 obtained with the GRAVITY instrument on the VLTI interferometer. This observation reveals the SS 433 inner regions with unprecedent details: The K-band continuum emitting region is dominated by a marginally resolved point source (< 1 mas) embedded inside a diffuse background accounting for 10% of the total flux. The significant visibility drop across the jet lines present in the K-band spectrum, together with the small and nearly identical phases for all baselines, point toward a jet that is offset by < 0.5 mas from the continuum source and resolved in the direction of propagation, with a size of $\sim$2 mas. Jet emission so close to the central binary system implies that line locking, if relevant to explain the 0.26c jet velocity, operates on elements heavier than hydrogen. Concerning The Brγ line, it is better resolved than the continuum and the S-shape phase signal present across the line suggests an East-West oriented geometry alike the jet direction and supporting a (polar) disk wind origin. This observation show the potentiality of Optical interferometry to constrain the inner regions of high energy sources like microquasars.

XMM-NuSTAR monitoring of GX 339-4 during its transition back to the hard state: spectral analysis

Pierre-Olivier Petrucci[1], Maica Clavel[2], Barbara DeMarco[3], Gabriele Ponti[4], Stephane Corbel[5], Jerome Rodriguez[6], Mickael Coriat[7], Julien Malzac[7], Renaud Belmont[7], Jonathan Ferraira[1]
[1]*Institute of Planetology and Astrophysics of Grenoble*
[2]*Berkeley University*
[3]*Copernicus Astronomical Center of the Polish Academy of Sciences*
[4]*MPE Garching*
[5]*Paris-Saclay University*
[6]*CEA, Paris*
[7]*IRAP, Toulouse*

GX 339-4 was observed simultaneously with XMM and NuSTAR (PI: Petrucci) during its transition back to the hard state at the end of its 2015 outburst. Six observations, each separated by a few days, allow to follow the spectral and timing evolution of the X-ray emission of the source. While the timing properties are presented in an associated proposed talk (DeMarco et al.), we will focus here on the spectral analysis, detailing the changes of the disk-hot corona emission, as well as the variation of the iron line profile. Simultaneous Radio and IR observations were also obtained during the campaign and will be presented.

Hybrid hot flow as the source of optical-to-X-ray emission of black hole binaries

Juri Poutanen[1], Alexandra Veledina[2]
[1] *University of Turku, Turku, Finland*
[2] *Nordita, Stockholm, Sweden*

The nature of emission from black hole binaries has been a matter of debates for decades. In the soft state, most of the radiation seems to be produced by a standard cool thin accretion disc, while in the hard state the Comptonization of some seed photons is the best-bet model for the emission. The emission from the jet was also sometimes involved to explain not only the radio, but even the optical and the X-ray data. We show how the hot flow model successfully describes multiple datasets including broad-band IR-X-ray spectra, timing properties such as X-ray and optical power-spectra density, cross-correlations between optical and X-rays and quasi-periodic oscillations observed over a broad energy range. As examples, we will use (quasi)-simultaneous data obtained by multiple space and ground observatories (e.g. RXTE, XMM-Newton, VLT) for GX 339-4, XTE J1550-564 and Swift J1753.5-0127. We will also demonstrate that the jet cannot be responsible for the emission neither in the optical nor in the X-ray domain.

Propagating mass accretion rate fluctuations in black hole X-ray binaries: quantitative tests

Stefano Rapisarda[1], Adam Ingram[1], Michiel van der Klis[1]
[1] *Anton Pannekoek Institute for Astronomy (API), Amsterdam (NL)*

Over the past 20 years, a consistent phenomenology has been established to describe the variability properties of Black Hole X-ray Binaries (BHBs). However, the physics behind the observational data is still poorly understood. The recently proposed model PROPFLUC assumes a truncated disc/hot inner flow geometry, with mass accretion rate fluctuations propagating through a precessing inner flow. These two processes give rise respectively to broad band variability and QPO. Because of propagation, the emission from different regions of the disc/hot flow geometry is correlated. In our study we applied the model PROPFLUC on different BHBs (including XTE J1550-564 and Cygnus X-1) in different spectral states, fitting jointly the power spectra in two energy bands and the cross-spectrum between these two bands. This represents the first study to utilize quantitive fitting of a physical model simultaneously to observed power and cross-spectra. For the case of XTE J1550-564, which displays a strong QPO, we found quantitative and qualitative discrepancies between model predictions and data, whereas we find a good fit for the Cygnus X-1 data, which does not display a QPO. We conclude that the discrepancies are generic to the propagating fluctuations paradigm, and may be related to the mechanism originating the QPO.

X-ray and Optical Explorations of Spiders

Mallory Roberts[1], Hind Al Noori[1], Rodrigo Torres[1], David Russell[1], Maura Mclaughlin[2], Pete Gentile[2]
[1] *New York University Abu Dhabi*
[2] *West Virginia University*

Black widows and redbacks are binary systems consisting of a millisecond pulsar in a close binary with a companion which is having matter driven off of its surface by the pulsar wind. X-rays due to an intrabinary shock have been observed from many of these systems, as well as orbital variations in the optical emission from the companion due to heating and tidal distortion. We have been systematically studying these systems in radio, optical and X-rays. Here we will present an overview of X-ray and optical studies of these systems, including new XMM-Newton data obtained from several of these systems, along with new optical photometry.

Obscured BeXRBs through infrared spectroscopy

José Joaquín Rodes[1], Guillermo Bernabeu[1], José Miguel Torrejón[1], Antonio Maggazù[2]
[1] *University of Alicante, Alicante, Spain*
[2] *Telescopio Nazionale Galileo, Tenerife, Spain*

The identification and spectral characterization of the optical/infrared counterparts in X-ray binaries is an essential step to understand the physics of these systems. We report on the first infrared spectroscopy of three INTEGRAL X-ray binary sources which present high absorption. Our spectra show that almost all the significant features are in emission, consistent with a Be companion star. We correct the infrared excess taking into account the circumstellar envelope emission in order to obtain a refined estimation of the distance to the X-ray sources and their X-ray luminosities. Based on these results we discuss how their X-ray characteristics fit into the BeX-ray scenario.

The Swift Supergiant Fast X-ray Transient Project

Patrizia Romano[1]
[1] *INAF Osservatorio Astronomico di Brera*

We present the Swift Supergiant Fast X-ray Transients project, a systematic study of SFXTs and classical supergiant X-ray binaries (SGXBs) through efficient long-term monitoring of 17 sources including SFXTs and classical SGXBs across more than 4 orders of magnitude in X-ray luminosity on timescales from hundred seconds to years. We derived dynamic ranges, duty cycles, and luminosity distributions to highlight systematic differences that help discriminate between different theoretical models proposed to explain the differences between the wind accretion processes in SFXTs and classical SGXBs. Our follow-ups of the SFXT outbursts provide a steady advancement in the comprehension of the mechanisms triggering the high X-ray level emission of these sources. In particular, the observations of the outburst of the SFXT prototype IGR J17544-2619, when the source reached a peak X-ray luminosity of 3×10^{38} erg s^{-1}, challenged for the first time the maximum theoretical luminosity achievable by a wind-fed neutron star high mass X-ray binary. We propose that this giant outburst was due to the formation of a transient accretion disc around the compact object. We also created a catalogue of over 1000 BAT flares which we use to predict the observability and perspectives with future missions.

On the long-term orbital evolution of the accreting millisecond X-ray pulsar SAX J1808.4-3658

Andrea Sanna[1], Luciano Burderi[1], Tiziana Di Salvo[2], Alessandro Riggio[1], Rosario Iaria[2]
[1] *University of Cagliari*
[2] *University of Palermo*

SAX J1808.4-3658 is the first AMXP discovered among the 19 systems currently known. This peculiar source has repeatedly gone in outburst with relatively short recurrence time (almost 2.5 years), making it the best-sampled amoung the AMXPs. The timing and orbital properties of SAX J1808.4-3658 have been extensively studied; while the timing behaviour of the spin frequency is still debated because of timing noise in the phase delays, the orbital parameters are on the other hand known with extreme precision. Several interpretations have been proposed in the past to explain the fast rate at which the orbital period of the source it has been observed evolving, but no general agreement has been reached yet. Here I present the timing analysis of SAX J1808.4-3658 using XMM-Newton and NuStar data collected during its 2015 outburst. From the timing analysis of the pulse phase delays we obtained an updated set of orbital parameters that we compared with those of the previous outbursts to investigate the evolution. In this work we also focused on the value of the orbital period derivative of the system to constrain its secular evolution and further investigate the causes of such a fast orbital evolution.

Using mHz QPOs to put constraints on neutron star size and equation of state

Holger Stiele[1], Wenfei Yu[2], Albert Kong[1]
[1] *National Tsing Hua University, Institute of Astronomy, Guangfu Road 101, Sec. 2, Hsinchu, Taiwan*
[2] *Shanghai Astronomical Observatory, Nandan Road 80, Shanghai, China*

We performed a variability study of archival XMM-Newton data of 4U 1636–536, a neutron star (NS) low mass X-ray binary, and investigated the energy dependence of its low frequency variability. Here we present the results of our waveform analysis and phase resolved spectral investigations of the mHz quasi-periodic oscillations (QPOs). Our study showed that the oscillations are not caused by variations in the blackbody temperature of the NS, but revealed a correlation between the change of the count rate during the mHz QPO pulse and the spatial extent of a region emitting blackbody emission. The maximum size of the emission area allowed us to obtain a lower limit on the size of the NS that rules out equations of state that prefer small NS radii.

Timing studies of the soft emission in the low-hard state of black hole X-ray binaries with XMM-Newton

Holger Stiele[1], Albert Kong[1]
[1] *National Tsing Hua University, Institute of Astronomy, Guangfu Road 101, Sect. 2, Hsinchu,Taiwan*

Almost all low mass black hole X-ray binaries are transient sources. Most of these sources show a certain pattern during outburst: the evolution from low hard state through intermediate state(s) into high soft state and the returning to the hard state at lower luminosity. However, there are outbursts that remain in the hard state. Using the technique of covariance spectra we can investigate the variability of individual spectral components on different time scales. Here we present the results of a comprehensive study of covariance spectra for a sample of black hole X-ray binaries obtained during the two outburst patterns outlined above and discuss what covariance spectra can tell us about outburst evolution. Furthermore we present covariance ratios obtained during the decaying branch of an outburst and show that their evolution is consistent with increased disc instabilities.

Stellar winds and accretion in HMXBs

Jose Miguel Torrejón[1], Graciela Sanjurjo-Ferrín[1], Konstantin Postnov[2], Lida Oskinova[3], Jose Joaquín Rodes-Roca[1], Guillermo Bernabéu[1]
[1] *Institute of Physics Applied to Sciences and Technologies, University of Alicante, Alicante, Spain*
[2] *Sternberg Astronomical Institute, Lomonosov State University, Moscow, Russia*
[3] *Institute for Physics and Astronomy, University Potsdam, Germany*

High Mass X-ray Binaries are excellent laboratories where current models of stellar winds and accretion physics can be tested. In this talk we will present XMM-Newton and Chandra observations of several HMXBs in order to explore the structure of the stellar wind of their massive star donors and its interplay with the accretion onto the neutron star. In particular we will explore the wind clumps providing some direct measurements of their physical properties and how these compare with the theoretical expectations from state of the art stellar wind models. Finally, we will explore briefly the accretion physics onto the magnetized NS and how it is influenced by the stellar wind structure.

Spectral and temporal properties of BeXRB pulsars during super-Eddington outbursts

Gerorgios Vasilopoulos[1], Frank Haberl[1], Fillipos Koliopanos[2,3]
[1] *Max-Planck-Inst. für Extraterrestrische Physik*
[2] *Institut de Recherche en Astrophysique et Planetologie (IRAP), France*
[3] *Université de Toulouse, UPS-OMP, IRAP, France*

Nearby galaxies are well suited for investigating X-ray source populations in environments different to our own Galaxy. Sources in these galaxies have well determined distances and are less absorbed than sources in the Galactic plane. The Large and the Small Magellanic Clouds (MC) are the nearest gas-rich star-forming galaxies and their gravitational interactions are believed to have tidally triggered recent bursts of star formation. Here, we will focus on the X-ray spectral and temporal properties of three Be/X-ray binary pulsars located in the MC that have been observed in the recent years with XMM-Newton during super-Eddington outbursts. Phase-resolved spectral analysis has revealed the presence of a non-pulsating soft component. By analysing multiple observations, corresponding to different luminosity levels, we argue that this component could not originate from the surface of a traditional thin disk, but most probably this emission is a result of reprocessed emission from material located near the NS magnetospheric radius. Interestingly, we find that the temperature of this component does not change much with the luminosity of the system, in contrast to its size that increases with increasing luminosity. We argue that this indicates the formation and expansion of an envelope around the magnetosphere of the NS.

4U 1957+11: Low mass, maximal Kerr black hole, or neutron star?

Michael Nowak[1], Victoria Grinberg[2], Dom Walton[3], Joern Wilms[4]
[1]*MIT-Kavli Institute for Astrophysics, Cambridge, USA*
[2]*ESA,*
[3]*Institute of Astronomy, Cambridge, UK*
[4]*Dr. Karl Remeis-Sternwarte and Erlangen Centre for Astroparticle Physics, Bamberg, Germany*

4U 1957+11 is one of the few black hole candidates that is in both a low mass X-ray binary and in a persistently bright accreting state. It exhibits all the hallmarks of a soft/accretion disk dominated spectrum, with a very high inner disk temperature and extremely small inner radius. These together argue for 4U 1957+11 being the most rapidly spinning black hole in our Galaxy, so long as its mass is ¿ 3 solar masses and distance is greater than 10 kpc. Conversely, it has been argued that its optical lightcurve modulation cannot permit a mass greater than 3 solar masses, and favors a neutron star. Here we reassess the historical RXTE data, using recent revisions of the RXTE calibration. We use these observations, along with an assessment of the RXTE All Sky Monitor lightcurve and the MAXI lightcurve, to place more recent pointed observations in their proper context of the overall behavior of the source. Finally, we describe a set of observations that were performed simultaneously with HST-COS, XMM-Newton, and NuSTAR to critically assess whether or not 4U 1957+11 truly is a persistently accreting, low mass, Kerr black hole residing in the halo of our Galaxy.

Chapter 8

Special Session: ULX

Exploring the Nature of ULX X-3 in NGC 4258

Aysun Akyuz[1], Hasan Avdan[1], Senay Avdan[1], Nazm Aksaker[2], Solen Balman[3]
[1] *Cukurova University, Department of Physics, Adana, Turkey*
[2] *Cukurova University, Technical Sciences of Vocational School, Adana, Turkey*
[3] *Middle East Technical University, Department of Physics, Ankara, Turkey*

We report on the analysis of the archival data of Ultraluminous X-ray Source (ULX) NGC 4258 X-3. Observations of the ULX X-3 have been carried out with Chandra and XMM-Newton covering the time interval 2000-2006. The source has a peak luminosity of $L_x \sim 5.4 \times 10^{39}$ erg s^{-1} however, the luminosity of the source changes a factor of ~ 3 throughout the observations. We have seen no evidence for a possible state transition or spectral variation. Using the luminosity and spectral parameters of the source the mass of the compact object estimated as ∼15 Msun. HST/ACS/WFC archival data have been analyzed to investigate the optical counterpart of ULX X-3. After the relative astrometric correction between Chandra and HST and by carefully examining the images of F435W, F555W and F814W filters multiple sources were identified within the error radius of 0.3 arcsec. The counterpart candidates have absolute magnitudes in the range M_V ∼(-4)(-5.8).We will be discussed how the X-ray and the optical analyses results of ULX X-3 provide insight into the true nature of this source.

Modelling the multiwavelength emission of Ultraluminous X-ray sources accreting above Eddington

Elena Ambrosi[1,2], Luca Zampieri[2]
[1] *Università degli Studi di Padova, Vicolo dell'Osservatorio 3, I-35122, Padova, Italy*
[2] *INAFOsservatorio Astronomico di Padova, INAF, vicolo dellOsservatorio 5, I-35122 Padova, Italy*

Understanding ULXs requires a comprehensive modelling of their multiwavelength emission properties. We compute the optical-through-X-ray emission of ULXs assuming that they are binary systems with stellar-mass or massive-stellar Black Holes and considering the possibility that a non-standard disc sets in when the mass transfer rate ($\dot{M}$) becomes highly super-Eddington. The emission model is applied to self-consistent simulations of ULX binaries. We compare our color-magnitude diagrams (CMDs) with those in the literature and find significant differences in the post main sequence evolution. When the donor is on the main-sequence and $\dot{M}$ is mildly super-Eddington, the behaviour of the system is similar to that found in previous investigations. However, when the donor star leaves the main-sequence and $\dot{M}$ becomes highly super-Eddington, the optical luminosity of the system is systematically larger and the colours show a markedly different evolution. The emission properties depend on the variable shielding of the outer disc and donor induced by the changing inner disc structure. We determine also the effects caused by the onset of a strong optically thick outflow. CMDs in various photometric systems are compared to the observed properties of the optical counterparts of several ULXs, obtaining updated constraints on their donor mass and accretion rate.

Accretion geometry and variability of ULX pulsars

Felix Fuerst[1], Dominic Walton[2], Daniel Stern[3], Matteo Bachetti[4], Didier Barret[5], Murray Brightman[6], Fiona Harrison[6], Vikram Rana[6]
[1]*ESA/ESAC, Madrid, Spain*
[2]*IfA, Cambridge, UK*
[3]*JPL, Pasadana, USA*
[4]*INAF/OAC, Selargius, Italy*
[5]*IRAP/CNRS, Toulouse, France*
[6]*Caltech, Pasadena, USA*

The recent discovery that extreme ($L \geq 10^{40}$ erg/s) ULXs can be powered by neutron stars raises the question how these objects can sustain such inferred luminosities and challenges models for accretion dominated by magnetic fields. All three known ULX pulsars (M82 X-2, NGC 5907 ULX1, and NGC 7793 P13) have pulse periods of around one second and also show orbital and super-orbital periods. By performing time- and phase-resolved spectroscopy over these periods we can constrain the accretion flow, begin to understand the role of beaming, and investigate the level to which the disk accretion is super Eddington. I will present an analysis of NuSTAR and XMM-Newton data of NGC 5907 ULX1 at four different super-orbital phases. While the spectral evolution is compatible with a precessing accretion disk over the super-orbital phase, this is difficult to reconcile with a regime where accretion happens in a slim disk regime. I will also discuss preliminary comparisons between the pulsed spectra of NGC 7793 P13 and M82 X-2 which show distinct differences. This analysis points to potential differences in their accretion geometry, even though their inferred luminosities are similar.

Pulsating ULXs: the most extreme accreting neutron stars

Gian Luca Israel[1], Andrea Belfiore[2], Guillermo Rodriguez[1], Andrea De Luca[2], Andrea Tiengo[3], Luigi Stella[1], Paolo Esposito[4], Ruben Salvaterra[2], Luca Zampieri[5], et al.[1]
[1]*INAF OA Roma, ITALY*
[2]*INAF IASFC Milano, ITALY*
[3]*IUSS Pavia, ITALY*
[4]*UvA, Amsterdam, NETHERLANDS*
[5]*INAF OA Padova, ITALY*

Sifting the XMM archive, the project EXTraS revealed that two more ultraluminous X-ray sources (ULXs), NGC7793 P13 and NGC5907 ULX, host accreting pulsars. The existence of these sources, with a isotropic luminosity in excess of 10^{41} erg/s (about 1000 times the Eddington limit for a neutron star), periods shorter than 1.2 s and characteristic ages smaller than 100 yr, challenges the standard accretion models and questions the frequency of occurrence of such objects with respect to the massive black holes often invoked in ULXs. While the assumption of a mild beaming factor is insufficient to account for their luminosity, a strong multipolar magnetic field close to the neutron star surface can explain their properties. Finally, the timing characteristics of the three known pulsar-ULXs have been considered in the design of a project aimed at looking for the presence of other accreting neutron stars in known ULXs, which will make it possible to understand better the census of pulsar-ULXs.

ULX spectra revisited: Are accreting, highly magnetized neutron stars the engines of ultraluminous X-ray sources?

Filippos Koliopanos[1,2], Georgios Vasilopoulos[3], Matteo Bachetti[4], Olivier Godet[1,2], Natalie Webb[1,2], Didier Barret[1,2]

[1] *Institut de Recherche en Astrophysique et Planetologie (IRAP), France*
[2] *Université de Toulouse; UPS-OMP; IRAP, France*
[3] *Max Planck Institute for extraterrestrial physics (MPE), Germany*
[4] *Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Cagliari, Italy*

In light of recent discoveries of pulsating ULXs and recently introduced models placing neutron stars as the central engines of ULXs, we revisit the spectra of seventeen ULXs, in search of indications that favor this hypothesis. To this end we examined the spectra from XMM-Newton observations of all seventeen sources in our sample. For six sources, these were complimented with spectra from public NuSTAR observations. We demonstrate that the notable (>6 keV) spectral curvature observed in most ULXs, is most likely due to thermal emission, with T> 1keV. More importantly, we find that a double thermal model (comprised of a "cool" and "hot" thermal component) – often associated with emission from neutron star X-ray binaries – describes all ULX spectra in our list. We propose that the dual thermal spectrum is the result of accretion onto highly magnetized NSs, as predicted in recent theoretical models (Mushtukov et al. 2017). We further argue that this finding offers an additional and compelling argument in favor of neutron stars as prime candidates for powering ULXs, as has been recently suggested (King & Lasota 2016; King et al. 2017). In my talk I will discuss the implications of our interpretation along with its merits and shortcomings.

Searching for Outflows in Spectra of Ultraluminous X-ray Sources

Peter Kosec[1], Ciro Pinto[1]

[1] *Institute of Astronomy, Cambridge, United Kingdom*

Ultraluminous X-ray sources are non-nuclear point sources exceeding the isotropic Eddington luminosity of a 10 Solar mass black hole. They could be powered by either sub-Eddington intermediate mass black holes, or lighter objects (stellar-mass black holes or neutron stars) accreting at super-Eddington ratios. The second variant predicts existence of powerful outflows of highly ionised gas at relativistic velocities. So far, they have been found in 2 systems: NGC 1313 X-1 and NGC 5408 X-1. We attempt to find signatures of such outflows in 2 different sources using the RGS spectrometer onboard XMM-Newton. Holmberg IX X-1, a very hard and variable ULX alike NGC 1313 X-1, and Holmberg II X-1, much softer and similar to NGC 5408 X-1. Using systematic Gaussian line search we find evidence for absorption and emission features which are unlikely to be caused by background or random fluctuations. Rigorous search for an ionised absorber at relativistic velocities in Holmberg IX X-1 spectrum finds possible detection of wind at 0.25c, similar to what has been detected in NGC 1313 X-1 and predicted by super-Eddington accretion. For Holmberg II X-1, we find results similar to NGC 5408 X-1 in agreement with their broadband spectral shape.

Pulsing ULXs as highly magnetized neutron stars

Alexander Mushtukov[1], Valery Suleimanov[2], Sergey Tsygankov[3], Juri Poutanen[3,4]
[1] *Anton Pannekoek Institute, University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands*
[2] *Institut für Astronomie und Astrophysik, Universität Tübingen, Sand 1, D-72076 Tübingen, Germany*
[3] *Tuorla observatory, Department of Physics and Astronomy, University of Turku, Väisäläntie 20, FI-21500 Piikkiö, Finland*
[4] *Nordita, KTH Royal Institute of Technology and Stockholm University, Roslagstullsbacken 23, SE-10691 Stockholm, Sweden*

A recent discovery of three pulsing ultraluminous X-ray sources (ULXs) demonstrates that a significant part of ULXs could be magnetized neutron stars with extremely high mass accretion rates. Theoreticians are thus faced with a significant challenge to invent a way for transforming a highly super-Eddington accretion rate into pulsing photon luminosity. We suggested a model of the two tall accretion columns above a strongly magnetized ($B \sim 10^{14}$ G) neutron star surface in the vicinity of the magnetic poles as a source of this radiation, and showed that their luminosity can be as high as 10^{40} erg s^{-1}. We present the basic ideas of the model as well as possible directions for improving the model to increase its maximum possible luminosity. The results of application of the model to the ULX M82 X-2 and to other pulsed ULXs are presented.

NGC 5408 X-2: ULX of Superlatives

Manfred Pakull[1], Fabien Grise[1], Christian Motch[1]
[1] *Observatoire Astronomique, Strasbourg University, CNRS, UMR 7550*

Close to the well-studied ULX NGC 5408 X-1 and its associated X-ray ionised nebula we discovered an even more powerful cousin: X-2. Apparently much less X-ray active (Lx = 1E37 erg/s) than X-1, it nevertheless also excites an extended HeIII region/ synchroton nebula displaying high-ionisation HeII4686 and [NeV]3426 emission lines. This suggests an intrinsic (or previous) X-ray power of several 1E40 erg/s. Even more outstanding is the very luminous Mv = -10 optical counterpart that underwent drastic spectral evolution with strong Halpha emission that increased its equivalent width of some 200A twenty-five years ago to an unprecedented 2000A. The system appears to be in a very rapid stage of binary evolution with currently ongoing huge mass loss and mass transfer to the compact binary component. We will discuss our findings in the framework of a common envelope phase and point out its relevance to evolutionary scenarios of stellar-mass BH-BH mergers.

ULXs from Accreting Neutron Stars: the Light Cylinder, the Stellar Surface, and Everything in Between

Kyle Parfrey[1], Alexander Tchekhovskoy[2]
[1]*Lawrence Berkeley National Laboratory, Berkeley, USA*
[2]*University of California, Berkeley, USA*

I will present results from the first relativistic MHD simulations of accretion onto magnetized neutron stars, performed in general relativity in the Kerr spacetime. The accretion flow is geometrically thick with a relativistic-gas equation of state, appropriate for super-Eddington systems. Four regimes are recovered, in order of increasing stellar magnetic field strength (equivalently, decreasing mass accretion rate): (a) crushing of the stellar magnetosphere and direct accretion; (b) magnetically channeled accretion onto the stellar poles; (c) the propeller state, where material enters through the light cylinder but is prevented from accreting by the centrifugal barrier; (d) almost perfect exclusion of the accretion flow from the light cylinder by the pulsar's electromagnetic wind. A Poynting-flux-dominated relativistic jet, powered by stellar rotation, is produced when the intruding plasma succeeds in opening the pulsar's previously closed magnetic field lines. I will demonstrate the effect of changing the relative orientation of the stellar dipole and the large-scale magnetic field in the accreting plasma, and discuss our results in the context of the neutron-star-powered ULXs, as well as the transitional millisecond X-ray/radio pulsars and jet-launching neutron-star X-ray binaries.

Can the ULX spectral properties unveil the nature of their compact objects?

Fabio Pintore[1], Luca Zampieri[2], Luigi Stella[3], Anna Wolter[4], Sandro Mereghetti[1], Gian Luca Israel[3]
[1]*INAF-IASF Milano, via E. Bassini 15, I-20133 Milano, Italy*
[2]*INAF-Osservatorio Astronomico di Padova, Vicolo dellOsservatorio 5, I-35122 Padova, Italy*
[3]*INAFOsservatorio astronomico di Roma, Via Frascati 44, I-00078, Monteporzio Catone, Italy*
[4]*INAF, Osservatorio Astronomico di Brera, via Brera 28, I-20121 Milano, Italy*

Ultraluminous X-ray sources (ULXs) are a population of extragalactic objects whose luminosity exceeds the Eddington limit for a 10 Msun black hole (BH). Their properties have been widely interpreted in terms of accreting stellar-mass or intermediate-mass BHs. However at least three neutron stars (NSs) have been recently identified in ULXs through the discovery of periodic pulsations. Motivated by these findings we studied the spectral properties of a sample of bright ULXs using a simple continuum model which was extensively used to fit the X-ray spectra of accreting magnetic NSs in the Galaxy. We found that such a model (a power-law with a high-energy exponential cut-off), fits very well most of the analyzed ULX spectra, at a level comparable to that of models involving an accreting BH. On these grounds alone we suggest that other non-pulsating ULXs may host NSs. We found also that above 2 keV the pulsating ULX spectra are harder than that of the majority of the other ULXs of the sample, with only IC 342 X-1 and Ho IX X-1 displaying spectra of comparable hardness. We thus suggest that these two ULXs may host an accreting NS and encourage searches for periodic pulsations in the flux.

Super-Eddington driven winds in ultraluminous X-ray sources

Ciro Pinto[1], Andrew Fabian[1], Dom Walton[1], Matt Middleton[2]
[1] *University of Cambridge, Institute of Astronomy, Cambridge, UK*
[2] *University of Southampton, Physics & Astronomy, Southampton, UK*

The detection of fully-grown supermassive black holes powering active galactic nuclei at high redshift, when the Universe was young, challenges the theories of black holes growth, requiring long periods of high accretion, most likely above the Eddington limit. This is a focus of the next generation large missions, but cannot be done with the current instrumentation due to the large distances. Therefore, we need to study objects accreting at high rates in the nearby Universe. Most ultraluminous X-ray sources (ULXs, luminosities $> 3 \cdot 10^{39}$) show X-ray spectra that are consistent with stellar mass black holes or neutron stars accreting at or above Eddington and provide the best workbench to study super-Eddington accretion and fast growth rates. A few, exceptionally bright, ULXs are good candidates for hosting intermediate mass black holes (e.g. 1000 solar masses), which are thought to be necessary seeds for the formation of supermassive black holes. In this talk I will discuss our very recent, groundbreaking, discoveries that shook this research field such in support for super-Eddington accretion: the detection of relativistic outflows in archetypal ULXs. I will also show our first constraints on mass and accretion rates.

A new catalogue of ultraluminous X-ray sources (and more!)

Timothy Roberts[1], Hannah Earnshaw[1], Dominic Walton[2], Matthew Middleton[3], Silvia Mateos[4]
[1] *Centre for Extragalactic Astronomy, Durham University, Durham, UK*
[2] *Institute for Astronomy, University of Cambridge, Cambridge, UK*
[3] *University of Southampton, Southampton, UK*
[4] *IFCA (CSIC-Universidad de Cantabria), Santander, Spain*

Many of the critical issues of ultraluminous X-ray source (ULX) science – for example the prevalence of IMBH and/or ULX pulsar candidates within the wider ULX population – can only be addressed by studying statistical samples of ULXs. Similarly, characterising the range of properties displayed by ULXs, and so understanding their accretion physics, requires large samples of objects. To this end, we introduce a new catalogue of 376 ultraluminous X-ray sources and 1092 less luminous point X-ray sources associated with nearby galaxies, derived from the 3XMM-DR4 catalogue. We highlight applications of this catalogue, for example the identification of new IMBH candidates from the most luminous ULXs; using high amplitude variability to identify candidate ULX pulsars in the propellor regime; and examining the physics of objects at the Eddington threshold, where their luminosities of $\sim 10^{39}$ erg s^{-1} indicate their accretion rates are $\sim$ Eddington. We also show how the catalogue can be used to start to examine a wider range of lower luminosity (sub-ULX) point sources in star forming galaxies than previously accessible through spectral stacking, and argue why this is important for galaxy formation in the high redshift Universe.

Luminosity function and collective spectrum of bright high-mass X-ray binaries, implications for cosmic X-ray preheating

Sergey Sazonov[1], Ildar Khabibullin[2,1]
[1] *Space Research Institute, Moscow, Russia*
[2] *Max Planck Institute for Astrophysics, Garching, Germany*

Based on a sample of 200 Chandra sources in 27 nearby galaxies and star formation rate and ISM maps for these galaxies, we have constructed the intrinsic, SFR-normalized X-ray luminosity function and collective X-ray spectrum of luminous HMXBs in the local Universe. The integrated HMXB emission is dominated by ultraluminous X-ray sources, with hard ones (those with the 0.25-2/0.25-8 keV flux ratio < 0.6) dominating above 2 keV and soft and supersoft ones (with hardness ratios 0.6-0.95 and > 0.95, respectively) at lower energies. The derived collective spectrum probably represents the angle-averaged X-ray emission of near- and super-critically accreting stellar mass black holes and neutron stars in the local Universe and provides an important constraint on supercritical accretion models. This local statistics suggest that ULXs and supersoft ULXs could significantly heat the Universe by $z \sim 10$ if the specific X-ray emissivity of the young stellar population at that epoch was an order of magnitude higher than at the present epoch.

Outbursts of the intermediate-mass black hole HLX-1: a wind instability scenario

Roberto Soria[1,2,3], Aina Musaeva[3], Kinwah Wu[4], Luca Zampieri[5], Sara Federle[5], Ryan Urquhart[2], Edwin van der Helm[6], Sean Farrell[3]
[1] *NAOC, Chinese Academy of Sciences, Beijing, China*
[2] *ICRAR-Curtin University, Perth, Australia*
[3] *Sydney Institute for Astronomy, The University of Sydney, Australia*
[4] *MSSL, University College London, United Kingdom*
[5] *Dipartimento di Fisica, University of Padova, Italy*
[6] *Sterrewacht Leiden, Leiden University, The Netherlands*

We model the intermediate-mass black hole HLX-1, using *HST*, *XMM-Newton*, and *Swift*. We quantify the relative contributions of a bluer optical component, function of X-ray irradiation, and a redder component, constant and likely coming from an old stellar population. We estimate a BH mass $M \approx 2 \times 10^4 M_\odot$, a spin parameter $a/M \approx 0.9$, and a peak outburst luminosity $L_{\rm X} \approx 0.3 L_{\rm Edd}$. We suggest that the disk is large ($R_{\rm out} \approx 2 \times 10^{13}$ cm) but only the inner annuli ($R \sim$ a few 10^{11} cm) are involved in the X-ray outburst cycle. We propose that outbursts are due to accretion rate oscillations, caused by radiatively-driven disk outflows. We argue that the system has a long-term-average accretion rate of a few percent of Eddington, just below the upper limit of the low/hard state; a wind-driven oscillation can trigger transitions to the high/soft state, with a recurrence period $\sim$1 year (much longer than the binary period, which we estimate as $\sim$10 days). The oscillation that dominated the system in the last decade is now damped. Finally, we highlight similarities between disk winds in HLX-1 and in the Galactic BH V404 Cyg.

The brightest ULXs, the hyper luminous X-ray sources

Natalie Webb[1]
[1] *IRAP, Toulouse, France*

Intermediate mass black holes (IMBHs) are thought to be the building blocks of supermassive black holes that are found in the centres of the more massive galaxies. However, until recently, the observational evidence for IMBHs has been weak, which poses problems for understanding the origin of supermassive black holes. Two promising environments to search for IMBHs include the centres of low mass galaxies and in the most luminous of the ultra lumimnous X-ray sources, the hyper-luminous X-ray sources (HLXs). In this talk I will present recent results on the temporal evolution of the best studied intermediate mass black hole candidate, HLX-1, which has a mass of 1e4 solar masses, as well as discussing a recent study of the environment around this extreme ULX. I will also present preliminary studies of other newly discovered HLXs and discuss the population of IMBH as a whole.

The nature of the ultraluminous X-ray sources

Grzegorz Wiktorowicz[1], Malgorzata Sobolewska[2], Jean-Pierre Lasota[2], Krzysztof Belczynski[1]
[1] *University of Warsaw*
[2] *Nicolaus Copernicus Astronomical Center*

Recently, several ultraluminous X-ray (ULX) sources were shown to host a neutron star (NS) accretor. We perform a suite of theoretical evolutionary calculations to show that, in fact, NSs are the dominat type of ULX accretor. Although black holes (BH) dominate early epochs after the star-formation burst, NSs outweight them after a few 100 Myr and may appear as late as a few Gyr after the end of the star formation episode. If star formation is a prolonged or continuous event (i.e., not a relatively short burst), NS accretors dominate ULX population at any time. Our results show a very clear (and testable) relation between the companion/donor evolutionary stage and the age of the system. Typical NS ULX consists of $\sim 1.2\,M_\odot$ NS and $\sim 1.8\,M_\odot$ MS. Typical BH ULX consist of $\sim 8\,M_\odot$ BH and $\sim 7\,M_\odot$ MS. We also find that the very luminous ULXs ($L_X > 10^{40}$ erg/s) are predominantly BH systems ($\sim 8\,M_\odot$) with Hertzsprung gap donors ($\sim 2\,M_\odot$). However, some NS ULX systems also reach high X-ray luminosities (10^{41} erg/s).

Bright ULXs from Ring Galaxies

Anna Wolter[1], Antonella Fruscione[2], Michela Mapelli[3]
[1]*INAF-Osservatorio Astronomico di Brera Milano ITALY*
[2]*Smithsonian Astrophysical Observatory Cambridge MA USA*
[3]*INAF-Osservatorio Astronomico di Padova Padova ITALY*

Collisional Ring Galaxies (RiGs), with their expanding ring of gas and stars and their high star formation rate are unique objects where to study the most massive products of star formation and shed some light on the nature of ultra luminous X-ray sources (ULXs) found on their rings.

We have recently constructed the X-ray luminosity function of ULXs in RiGs which is mostly consistent with previous results but shows two bright objects at the highest luminosity above the extrapolation of previous models for ULXs. They could be the best cases of Intermediate Mass Black Holes, or further ULXs powered by neutron stars, or even something different (e.g Supernovae).

We will describe in detail the RiGs and their properties and compare the derived XLF with previous results.

Perspectives on Ultraluminous X-ray sources after the discovery of Ultraluminous Pulsars

Luca Zampieri[1]
[1]*INAF-Astronomical Observatory of Padova, Padova, Italy*

Ultraluminous X-ray sources (ULXs) are observationally defined as non-nuclear extragalactic X-ray point sources with inferred (isotropic) luminosity exceeding the Eddington limit for a $\sim 10\,M_{\odot}$ compact object. While in the past few years a certain evidence (and a general consensus) has been gathered in favour of the existence of black hole (BH) remnants in ULXs, the recent discovery of three Ultraluminous X-ray Pulsars has unexpectedly revealed what is likely to be a significant population of neutron star (NS) ULXs. These findings challenge more than ever our present understanding of these sources, their accretion mechanism/history, and their formation pathways. After reviewing some of these intriguing observational facts, we will summarize some perspective studies that we are carrying out to model the multiwavelength variability and broadband spectra of ULXs, including the contribution of an accretion column for NS systems. We derive the luminosity emitted by the latter assuming that a multipolar component dominates the magnetic field close to the NS. The focus is on comparing the simulated multiwavelength emission properties of stellar-mass/massive BHs to those of NS systems, and on confronting the model predictions with the available observations of Pulsar ULXs.

Is SS 433 a misaligned ultraluminous X-ray source? Constraints from its reflected signal in the Galactic plane

Ildar Khabibullin[1,2], Sergey Sazonov[2]
[1] *Max Planck Institute for Astrophysics, Garching, Germany*
[2] *Space Research Institute, Moscow, Russia*

The unique supercritical accretor SS 433 is considered as a Galactic analogue of ULXs, but viewed edge-on, so the observer cannot see its collimated X-ray radiation directly. We evaluate the emission that must arise due to reflection of this putative radiation by atomic gas and molecular clouds in the Galactic plane, and compare the predicted signal with existing data for the region of interest. Assuming that the intrinsic X-ray spectrum of SS 433 is similar to that of ULXs, we obtain an upper limit of $\sim 2 \times 10^{39}$ erg/s on its angular-integrated luminosity in the 2-10 keV energy band, which weakly depends on the assumed half-opening angle, Θ_r, of the emission cone. In contrast, the upper limit on the apparent luminosity of SS 433 (that would be perceived by an observer looking at the system face-on) decreases with increasing Θ_r and is $\sim 3 \times 10^{40}$ erg/s for $\Theta_r > \Theta_p = 21$ deg, where Θ_p is the jets precession amplitude (given that the emission cones precess in the same manner as the jets). This leaves open the possibility that SS 433 is a misaligned ULX. Further investigation of the reflection signal with the focus on the molecular clouds will improve these constraints.

Chapter 9

Supernovae, Long and Short GRBs, GW Events

Measuring cosmological parameters with Gamma-Ray Bursts: status and perspectives

Lorenzo Amati[1]
[1] *INAF - IASF Bologna*

Given their huge isotropic-equivalent radiated energies, up to more than 10^{54} erg released in a few tens of seconds, and their redshift distribution extending up to more than z = 9, Gamma-Ray Bursts (GRB) are in principle a powerful tool for measuring the geometry and expansion rate of the Universe. In the recent years, several attempts have been made to exploit the correlation between the photon energy at which the nuFnu spectrum peaks ("peak energy") and the radiated energy (or luminosity) for "standardizing" GRBs and use them as tools (complementary to other probes like SN Ia, BAO and the CMB) for the estimate of cosmological parameters. These studies show that already with the present data set GRBs can provide a signicant and independent confirmation of $\Omega_M \sim 0.3$ for a flat ΛCDM universe and that the measurements expected from present and next GRB experiments (e.g. Swift, Fermi/GBM, SVOM, CALET/GBM, UFFO) will allow us to substantially improve the constraints on Ω_M and Ω_Λ, and, in particular, to get unique clues on dark energy properties and evolution.

Host galaxies are the obscurers of Gamma-ray bursts

Johannes Buchner[1,2], Steve Schulze[1,2], Franz E. Bauer[1,2,3]
[1] *Pontificia Universidad Católica de Chile*
[2] *Millenium institute for Astrophysics*
[3] *Space Science Institute*

The luminous, high-energy emission of gamma-ray bursts (GRBs) makes them efficient probes of the high-redshift universe. The origin of the obscuration of gamma-ray burst afterglow is still unclear. We study the afterglows metal column densities along the line-of-sight of all Swift-detected long GRBs with an improved hierarchical Bayesian analysis methodology. We characterise follow-up biases and side-step them using SHOALS, an unbiased sub-sample with highly complete follow-up. That survey also measures Spitzer host masses. Overall, the column densities shows little redshift evolution but a significant correlation with host stellar mass. A simple geometrical model explains the width and shape of the column density distribution and the trend with galaxy mass correlation. Our findings implicate the host's galaxy-scale metal gas as the dominant obscurer. From a galaxy evolution perspective, our study places new constraints on the metal gas mass inside galaxies at z=0.5-4. We compare these with modern cosmological simulations (Illustris and EAGLE) and discuss implications for the obscuration of other sources inside high redshift galaxies, such as active galactic nuclei.

A strong test for the forward shock model in GRBs: the 90 Ms follow up of the X-ray afterglow of GRB 130427A.

Massimiliano De Pasquale[1], Mathew Page[2], David Alexander Kann[3], Samantha Oates[4], Steve Schulze[5], Bing Zhang[6], Zach Cano[3], Daniele Malesani[7], Eleonora Troja[8], Luigi Piro[9]
[1]*Department of Astronomy and Space Sciences, Istanbul University, Istanbul, Turkey*
[2]*Mullard Space Science Laboratory - University College London, London, United Kingdom*
[3]*Instituto de Astrofisica de Andalucia (CSIC), Granada, Spain*
[4]*University of Warwick, United Kingdom*
[5]*Weizmann Institute of Science, Israel*
[6]*Department of Physics and Astronomy, University of Nevada, Las Vegas, USA*
[7]*Dark Cosmology Centre, University of Copenhagen, Copenhagen, Denmark*
[8]*NASA Goddard Space Flight Center, Greenbelt, USA*
[9]*Institute of Space Astrophysics and Planetology (INAF), Rome, Italy*

GRB 130427A was the brightest gamma-ray burst detected in 30 years. With an isotropic energy output of 8.510^{53} erg and redshift of 0.34, it combined a very high energy release with a relative proximity to Earth in an unprecedented fashion.

Sensitive X-ray observatories such as XMM-Newton and Chandra have detected the afterglow of this event for a record-breaking baseline of 90 million seconds. The light curve shows a simple power-law decay over more than three decades in time.

In this presentation, we explore the consequences of this result for the scenarios proposed to interpret GRB 130427A, the implication of this outcome in the context of the forward shock model (beaming angle, energetics, surrounding medium), and the scientific prospects of extending GRB afterglow observations for several hundreds of Ms with Athena.

Investigating the X-ray Emission from Type IIn Supernovae

Vikram Dwarkadas[1]
[1]*Astronomy and Astrophysics, University of Chicago, Chicago, IL, USA*

Type IIn supernovae (SNe) are characterized by narrow lines on a broad base in the optical spectrum. A wide diversity in their lightcurves, and in SNe that exhibit IIn features, has greatly complicated the task of identifying their progenitors. IIns have the highest X-ray luminosity of all SNe, generally exceeding 10^{40} ergs s^{-1} at early times, and 10^{38} ergs s^{-1} after several thousand days, and are observable in X-rays decades after explosion. Many of the lightcurves tend to fall off rather steeply at late times, although one interesting case displayed a rising light curve for several thousand days. These characteristics, along with their high luminosities at other wavelengths, imply initial expansion in a very dense medium. At later times the densities decrease faster than expected for expansion in a steady wind. Their X-ray spectra generally show distinct lines, suggesting thermal emission. In this presentation we will show the lightcurves of all IIns that have been observed in X-rays, and compare their lightcurves and spectra to those of other SNe. We summarize the known properties of the X-ray emission from Type IIn SNe, and explore the implications for the SN environment, progenitor mass-loss and the identity of the progenitors.

SNaX - A Database of Supernova X-Ray Lightcurves

Vikram Dwarkadas[1], Mathias Ross[1]
[1]*Astronomy and Astrophysics, University of Chicago, Chicago, IL, USA*

We present the Supernova X-ray Database (SNaX), a compilation of the X-ray data from young supernovae (SNe). The database includes the X-ray flux, luminosity, and basic information on young SNe, days to years after outburst. The original goal and intent were to present a database of Type IIn SNe. Having accomplished this, we are slowly expanding it to include all SNe for which published X-ray data are available. The interface allows one to search for SNe using various criteria, plot all or selected data-points, and download both the data and the plot. The plotting facility allows for significant customization. There is also a facility for the user to submit data that can be directly incorporated into the database. We include an option to fit the decay of any given SN lightcurve with a power-law. The database includes a conversion of most datapoints to a common 0.3-8 keV band so that SN lightcurves may be directly compared with each other. A mailing list has been set up to disseminate information about the database. We outline the structure and function of the database, describe its various features, and outline the plans for future expansion.

Investigating the X-ray and Radio Evolution of SN 2005kd

Vikram Dwarkadas[1], Cristina Romero-Canizales[2], Ratuja Reddy[1], Franz Bauer[3]
[1]*Astronomy and Astrophysics, University of Chicago, Chicago, IL, USA*
[2]*Nucleo de Astronoma de la Facultad de Ingeniera, Universidad Diego Portales, Santiago, Chile*
[3]*Instituto de Astrofsica, Facultad de Fsica, Pontificia Universidad Catolica de Chile, Santiago, Chile*

SN 2005kd is among the most luminous supernovae (SNe) to be discovered at X-ray wavelengths. We have re-analysed all good angular resolution archival X-ray data for SN 2005kd. The data reveal an X-ray lightcurve that decreases as $t^{-1.62\pm0.06}$. Our modelling of the data suggests that the early evolution is dominated by emission from the forward shock in a high-density medium. Emission from the radiative reverse shock is absorbed by the cold dense shell formed behind the reverse shock. Our results suggest a progenitor with a mass-loss rate towards the end of its evolution $> 4.3 \times 10^{-4}\ M_{\odot}\,\mathrm{yr}^{-1}$, for a wind velocity of 10 km s^{-1}, at 4.0 $\times 10^{16}$ cm. This mass-loss rate is too high for most known stars, except perhaps hypergiant stars, or luminous blue variables. The observations are consistent with the fact that Type IIn SNe expand into high-density and high mass-loss rate environments, and also suggest rapid variability in the wind mass-loss parameters within the last 5000 yr of stellar evolution prior to core collapse. We present the radio and X-ray lightcurves of SN 2005kd, and discuss the implications for the evolution of the SN and the identity of the progenitor.

Search for peculiar properties of Gamma-Ray Bursts at high redshift

Graziella Pizzichini[1]
[1] *INAF/IASF Bologna Italy*

Long Gamma-Ray Bursts have been detected at high redshifts, up to 9. I shall present a search for differences between events at different redshifts.

INTEGRAL follow-up of the gravitational wave events

Volodymyr Savchenko[1]
[1] *ISDC, Geneva Observatory*

We used observations of the INTErnational Gamma-Ray Astrophysics Laboratory (INTEGRAL) to search for soft gamma-ray and hard X-ray emission associated with the gravitational wave event GW150914, and gravitational wave trigger LVT151012, discovered by the LIGO/Virgo collaboration in the first scientific run of Advanced LIGO. The highly eccentric orbit of INTEGRAL ensures high duty cycle, long-term stable background, and unobstructed view of nearly the entire sky. This enables us to use the combination of INTEGRAL instruments (SPI-ACS, IBIS/Veto, and IBIS) to provide the tightest constrain on the fluence of a hard X-ray electromagnetic counterpart for the full high-probability sky region of the LIGO trigger. Our results constrain the fraction of the energy promptly released in gamma-rays in 75 keV - 2 MeV energy range in the direction of the observer to the gravitational wave energy to less than about one in a million. Moreover, for LVT151012 the INTEGRAL high-energy imaging instruments, IBIS, SPI, and JEM-X, provided the unique opportunity to search also for long-lasting electromagnetic counterparts of this event over 3 decades in energy, from 5 keV to 8 MeV.

X-ray counterpart of gravitational waves due to binary neutron star mergers: light curves and luminosity function

Hui Sun[1,2]
[1]*Department of Astronomy, School of Physics, Peking University, Beijing, China*
[2]*Kavli Institute for Astronomy and Astrophysics, Peking Univsersity, Beijing, China*

Zhang 2013 proposed a type of GRB-less X-ray transient associated with double neutron star (NS-NS) mergers under the conjecture of a rapidly-spinning magnetar merger product with the line of sight off the short GRB jet. We investigate possible light curves of these transients by considering different observer's viewing angles. We perform Monte Carlo simulations to calculate the peak luminosity function (LF) and event rate density of these X-ray transients. By considering that a fraction of massive neutron stars may be supra-massive and later collapse into black holes after spinning down, we investigate how the predicted LF depends on the equation of state (EoS) of the central object and the geometry of the system. The event rate density of these X-ray transients is around a few tens of $\mathrm{Gpc^{-3}yr^{-1}}$ for luminosity above 10^{45} $\mathrm{erg\,s^{-1}}$. We predict that future X-ray telescopes (such as Einstein Probe) with sensitivity $\sim 10^{-11}$ $\mathrm{erg\,s^{-1}\,cm^{-2}}$ would detect as many as several tens of such transients per year per steradian. Within 200 Mpc, the aLIGO average range for NS-NS mergers, the estimated event rate of these transients is about 1 transient per year all sky.

EXTraS unveils a supernova shock break-out candidate in XMM-Newton archival data

Andrea Tiengo[1,2], Giovanni Novara[1], Gianni Lisini[1], Andrea De Luca[2], Ruben Salvaterra[2], Andrea Belfiore[2], Martino Marelli[2], David Salvetti[2], Sandro Mereghetti[2], Giacomo Vianello[3]
[1]*IUSS Pavia*
[2]*INAF/IASF-Milano*
[3]*Stanford University*

During the search for short X-ray transients within the Exploring the X-ray Transient and variable Sky (EXTraS) project, we discovered a new X-ray source that can be detected only in a ∼5 minutes interval of a ∼21 hours long XMM-Newton observation. Thanks to dedicated follow-up observations, we found that its position is consistent with a galaxy at redshift z=0.092. At this redshift, the transient released 2×10^{46} erg in the 0.3–10 keV energy band. Its luminosity and spectral and timing properties make it an analogue of the X-ray transient associated to SN2008, detected by Swift/XRT during an observation of the nearby supernova-rich galaxy NGC 2770. The discovery of this much more distant transient in a field galaxy during a systematic analysis of the full XMM-Newton archive allows us to better constrain the rate of these rare events.

An X-ray view of short duration gamma-ray bursts

Eleonora Troja, on behalf of a larger collaboration:[1,2]
[1] *University of Maryland - College Park*
[2] *NASA Goddard Space Flight Center*

Short duration gamma-ray bursts (GRBs) are brief flashes of gamma-ray radiation followed by a longer lasting, broadband (from radio to X-rays) afterglow emission. NASA's Swift mission provided breakthrough observations connecting these high-energy transients to the coalescence of two compact objects. Short GRBs are therefore prime candidate electromagnetic counterparts of gravitational wave sources detected by advanced LIGO and Virgo. We carried out a systematic observing campaign of short GRBs aimed at characterizing their X-ray emission in order to 1) constrain the jet collimation and the true rate of events; 2) test the possible presence of isotropic emission components, not related to the standard afterglow emission. We present our preliminary results and discuss their implications for the follow-up of future GW detections.

Chapter 10

Supernova Remnants and Pulsar Wind Nebulae

An X-ray Study of the Galactic Shell-type Supernova RemnantsUsing XMM-Newton and Chandra

Nergis Cesur[1], Aytap Sezer[2], Murat Hudaverdi[1]
[1] *Yildiz Technical University*
[2] *Avrasya University*

We present the results of a study of the Galactic supernova remnants (SNRs) RCW86, Cas A, SN1006, RX J1713.7-3946 and RX J0852.0-4622, which well-known members of the shell-type SNRs. They have limb-brightened morphologies in both X-ray and radio bands. Using archival data from XMM-Newton and Chandra, we investigate the ionization states and plasma structures of across the remnants. Finally, we compared them with other SNRs.

X-ray synchrotron filaments in Cas A: the radio connection

Vladimir Domcek[1], Jacco Vink[1], Maria Arias[1], Ping Zhou[1]
[1] *Anton Pannekoek Institute for Astronomy, University of Amsterdam*

One of the most important themes in X-ray research of the supernova remnants (SNRs) over the last 10-20 years has been cosmic-ray acceleration by SNR shocks.The detection of the X-ray synchrotron emission has proven that young SNRs can accelerate electrons to energies up to 10-100 TeV, which requires a high level of magnetic field turbulence. The narrow widths ofthe X-ray synchrotron filaments in some young SNRs has also shown that magnetic fields are amplified too.

A prediction of an efficient acceleration is that the electron cosmic-ray spectra should not be a power-law but instead should flatten toward the higher energies. Here we test this hypothesis by investigating the spectral index of thin X-ray filaments in Cas A, by comparing the X-ray and the radio fluxes. By doing this we avoid having to model the effects of synchrotron cooling as much as possible, and hence, a "one zone model" is sufficient. So far we found a need for spectral curvature, provided that the synchrotron exponential cut-off is more gradual than assumed by Zirakashvili & Aharonian 2007.

We discuss the implications for this in the context of non-linear shock acceleration and the effects of magnetic field turbulence.

Model for the broadband Crab nebula spectrum with injection of a log-parabola electron distribution at the wind termination shock

Federico Fraschetti[1], Martin Pohl[2]
[1] *University of Arizona, USA*
[2] *University of Potsdam, Germany*

We develop a model of the steady-state spectrum of the Crab nebula encompassing both the radio/soft X-ray and the GeV/multi-TeV observations. By solving the transport equation for TeV electrons injected at the wind termination shock as a log-parabola momentum distribution and evolved via energy losses, we determine analytically the resulting photon differential energy spectrum. We find an impressive agreement with the observations in the synchrotron region. The predicted synchrotron self-Compton accommodates the previously unsolved origin of the broad 200 GeV peak that matches the Fermi/LAT data beyond 1 GeV with the MAGIC data. A natural interpretation of the deviation from power-law of the photon spectrum customarily fit with empirical broken power-laws is provided. This model can be applied to the radio-to- multi-TeV spectra of a variety of astrophysical outflows, including pulsar wind nebulae and supernova remnants. We also show that MeV-range energetic particle distribution at interplanetary shocks typically fit with broken-power laws or Band function can be accurately reproduced by log-parabolas.

Analysis of the XMM-Newton observations of IC443

Emanuele Greco[1], Marco Miceli[1], GIovanni Peres[1], Salvatore Orlando[2], Eleonora Troja[3], Fabrizio Bocchino[2]
[1] *Universita' di Palermo, Dipartimento di Fisica e Chimica*
[2] *INAF-OAPa*
[3] *University of Maryland, NASA GSFC*

We analyze for the first time the full set of archive XMM-Newton EPIC observations of the Galactic Supernova Remnant IC 443. We aim at identifying the contribution of the shocked ejecta and interstellar medium and at the describing the physical and chemical properties of the shocked plasma. We also aim at addressing the presence of overionized plasma and its physical origin. We trace the morphology of Si- and S-rich ejecta with unprecedented spatial resolution, by adopting a novel method to produce maps of equivalent width. We describe in detail the method adopted and the results obtained and present preliminary results of a spatially resolved spectral analysis performed on selected regions, chosen on the basis of our image analysis.

Particle acceleration at pulsar-wind termination shocks

John Kirk[1], Gwenael Giacinti[1]
[1] *Max-Planck Institute for Nuclear Physics, Heidelberg, Germany*

The X-ray emission from pulsar wind nebulae arises from particles accelerated at the shock that terminates the relativistic, strongly magnetized pulsar wind. However, conventional theories of particle acceleration break down at this shock, because the combination of low particle density and strong magnetic field places it outside the domain of validity of MHD. Building on two-fluid (electron and positron) simulations that go beyond MHD, I present new results describing how particles are, nevertheless, injected into a first-order-Fermi-like process and accelerated. In the equatorial zone of the wind, the resulting spectrum is similar to that expected from an unmagnetized, relativistic, MHD shock. But, when integrated over the entire shock, it depends sensitively on the ratio of AC to DC power in the wind - i.e., on the inclination angle of the pulsar's dipole moment. The implications of these findings for the X-ray spectra of PWN will be discussed.

A study of the origin of recombining plasmas in the supernova remnant IC 443

Hideaki Matsumura[1], Takaaki Tanaka[1], Hiroyuki Uchida[1], Takeshi Go Tsuru[1], Hiromichi Okon[1], Katsuhiro Tachibana[1]
[1] *Kyoto University, Japan*

The Suzaku satellite has recently discovered recombining plasmas (RPs) characterized by an ionization temperature higher than an electron temperature (T_e) in some supernova remnants (SNRs). The rarefaction and thermal conduction scenarios are mainly considered, but the formation process of the RPs has not been understood yet. A key in both scenarios is gas environment surrounding the SNR. IC 443 is a Galactic SNR surrounded by dense gas, in which Yamaguchi et al. (2009) discovered an RP. In the southeast, IC 443 has strong CO emissions which provide evidence for interactions between the blast wave and a molecular cloud. To investigate the origin of the RP, we analyzed Suzaku data and performed spatially resolved spectroscopic analysis. Spectra from all regions are well reproduced by two RP components whose T_e are different from each other (~ 0.2 keV and ~ 0.5 keV). The low T_e component is considered to be emitted from the outer part of the SNR because it is stronger in the limb than in the center. In the southeastern regions, T_e of the outer RP is lower (< 0.2 keV) than that in the other regions (> 0.2 keV). This result is better explained by the thermal conduction scenario.

The physical origin of the X-ray emission from SN 1987A

Marco Miceli[1], Salvatore Orlando[2], Oleh Petruk[2]
[1] *Università di Palermo*
[2] *INAF - OAPa*

We revisit the spectral analysis of the set of archive XMM-Newton observations of SN 1987A through our 3-D hydrodynamic model describing the whole evolution from the onset of the supernova to the full remnant development. For the first time the spectral analysis accounts for the single observations and for the evolution of the system self-consistently. We adopt a forward modeling approach which allows us to directly synthesize, from the model, X-ray spectra and images in different energy bands. We fold the synthetic observables through the XMM-Newton instrumental response and directly compare models and actual data. We find that our simulation provides an excellent fit to the data, by reproducing simultaneously X-ray fluxes, spectral features, and morphology of SN 1987A at all evolutionary stages. Our analysis enables us to obtain a deep insight on the physical origin of the observed multi-thermal emission, by revealing the contribution of shocked surrounding medium, dense clumps of the circumstellar ring, and ejecta to the total emission. We finally provide predictions for future observations (to be performed with XMM-Newton in the next future and with the forthcoming Athena X-ray telescope in approximately 10 years), showing the growing contribution of the ejecta X-ray emission.

Spatially resolved spectroscopy of W28 with Suzaku

Hiromichi Okon[1], Takaaki Tanaka[1], Hiroyuki Uchida[1], Takeshi Go Tsuru[1], Katsuhiro Tachibana[1]
[1] *Kyoto University, Japan*

Recent Suzaku observations revealed the presence of recombining plasmas (RPs), which have ionization temperatures higher than electron temperatures. W28 is a middle-aged SNR located on the Galactic Ridge. Sawada et al. (2012) discovered a RP in the central region of the SNR. In the northeastern region, CO emissions and OH masers are detected, indicating interactions between the SNR shock and dense molecular gas (Arikawa et al. 1999; Frail et al. 1994). We analyzed Suzaku data and performed spectral analysis for the northeastern and central regions. We discovered enhanced FeI Kα emissions in the northeast region and FeXXV Kα emissions in the center region. The former could be due to K-shell ionization of the dense gas either by protons or electrons accelerated in the SNR. The latter is attributed to the RP, and helps us constrain the plasma parameters precisely. Each spectrum is well fit by a two-component model: a low-temperature ($\sim$ 0.2 keV) plasma component in collisional ionization equilibrium plus a high-temperature ($\sim$ 0.5 keV) RP. In the northeastern region, we found the low-temperature component is stronger compared with the central region. We will report the analysis result and discuss it with emphasis placed on the formation process of the RP.

The supernova - supernova remnant connection through multi-dimensional magnetohydrodynamic modeling

Salvatore Orlando[1], Marco Miceli[2,1], Oleh Petruk[3,1], Giovanni Peres[2,1]
[1]*INAF - Osservatorio Astronomico di Palermo, Palermo, Italy*
[2]*Dip. di Fisica e Chimica, Universita' di Palermo, Italy*
[3]*Institute for Applied Problems in Mechanics and Mathematics, Lviv, Ukraine*

Supernova remnants (SNRs) are diffuse extended sources often characterized by a rather complex morphology and a highly non-uniform distribution of ejecta. General consensus is that such a morphology reflects, on one hand, pristine structures and features of the progenitor supernova (SN) explosion and, on the other hand, the early interaction of the SN blast wave with the inhomogeneous circumstellar medium (CSM) formed in the latest stages of the progenitor star's evolution. Deciphering X-ray observations of SNRs, therefore, might open the possibility to reconstruct the ejecta structure as it was soon after the SN explosion and the structure and geometry of the medium immediately surrounding the progenitor star. This requires accurate and detailed models which describe the evolution from the on-set of the SN to the full remnant development and which connect the X-ray emission properties of the remnants to the progenitor SNe. Here we show how multi-dimensional SN-SNR magnetohydrodynamic models have been very effective in deciphering X-ray observations of SNR Cassiopeia A and SN 1987A. This has allowed us to unveil the average structure of ejecta in the immediate aftermath of the SN explosion and to constrain the 3D pre-supernova structure and geometry of the environment surrounding the progenitor SN.

Distributions of Shocked Ejecta and Circumstellar Gas in the Galactic Core-Collapse Supernova Remnant G292.0+1.8

Sangwook Park[1], Jayant Bhalerao[1]
[1]*University of Texas at Arlington, Arlington, TX USA*

Based on our deep 530 ks Chandra ACIS data we perform the detailed spatially-resolved spectral analysis of the textbook-type Galactic core-collapse supernova remnant (SNR) G292.0+1.8. We reveal spatial distributions of the overabundant ejecta and the low-abundant circumstellar gas components over the entire SNR in unprecedented detail. We map highly asymmetric distributions of O-, Ne-, Mg-, Si-, S-, and Fe-rich stellar debris. We for the first time identify Fe-rich ejecta regions in G292.0+1.8. These Fe-rich regions are mostly in the northern half of the SNR, and are projected generally closer to the SNR center compared to the bulk of Ne- and Mg-rich regions. We detect a faint emission feature running roughly in parallel with the equatorial belt. Its elongated morphology, low abundances, and the positional coincidence with the mid-infrared emission feature indicate that it is the X-ray counterpart for the projected northern portion of the equatorial "ring" of G292.0+1.8.

Model of synchrotron spectra of pulsar wind nebula associated with PSR J0437-4715

Alexey Petrov[1], Andrei Bykov[1], Sergey Osipov[1]
[1]*Ioffe Institute, Saint-Petersburg, Russia*

An adequate interpretation of multiband observations of pulsar wind nebulae (PWNe) requires quantitative modeling of interaction of relativistic pulsar winds (PWs) with the interstellar medium. When a pulsar moves at a supersonic velocity, a bow shock (BS) is likely to develop, thus forming a zone of converging flows between the BS and the PW termination shock. These flows may carry magnetic inhomogeneities, and the energy-dependent transport through the mentioned zone can result in significant deformation of energy distribution of accelerated particles, especially prominent in the vicinity of the BS. Such transport can be responsible for the variety of PWN morphologies observed in different energy bands.

Here some results of a stationary test-particle Monte-Carlo modeling of propagation of PW $e^{\pm}$ pairs through a PWN with a BS are presented, which include spatially-resolved particle energy distributions and simulated synchrotron spectra. Also, simulated spatial distributions of the synchrotron emission intensity from the modeled source are shown. A possible interpretation of recently obtained multiband (H_α, far-UV and soft X-ray) images of the BS PWN observed around PSR J0437-4715 are suggested.

The XMM-Newton view of the non-thermal supernova remnant HESS J1731-347

Gerd Puehlhofer[1], Victor Doroshenko[1], Fabio Acero[2], Aya Bamba[3], Dmitry Klochkov[1], Wenwu Tian[4]
[1]*Institut fuer Astronomie und Astrophysik Tuebingen, Eberhard-Karls-Universitaet Tuebingen, Germany*
[2]*Laboratoire AIM, IRFU/SAp - CEA/DRF - CNRS - Universite Paris Diderot, CEA-Saclay, France*
[3]*Department of Physics, The University of Tokyo, Japan*
[4]*National Astronomical Observatories, Chinese Academy of Sciences, Beijing Shi, China*

HESS J1731-347 belongs to a small group of supernova remnants that are characterized by a spatially-resolved shell-type TeV morphology and strong synchrotron X-ray emission. We report on XMM-Newton observations of the source that provide for the first time a complete X-ray view of the remnant. The data show an emissivity gradient across the source, which is not observed in the TeV gamma-ray and radio bands. While the broadband spectral analysis is compatible with a pure leptonic emission scenario up to TeV energies, the morphological analysis could be indicative of a blend of hadronic and leptonic TeV emission. We discuss the possibility of an interaction of the supernova remnant with nearby molecular clouds. The results are put into the context of a cosmic ray acceleration and diffusion scenario of the source that has recently been developed.

Modelling Supernova Remnant kinematics and X-ray emission. Some Examples.

Margarita Rosado[1], Jorge Reyes-Iturbide[2]
[1] *Universidad Nacional Autónoma de México, Instituto de Astronomía.*
[2] *Tecnológico de Estudios Superiores de Santiago Tianguistengo, México.*

Confrontation of MHD numerical simulations of Supernova Remnants (SNRs) with observations of X-ray emission complemented with the kinematics derived also from observations of the optical filaments is very useful. In this work we present some examples of this confrontation and the results we derived for the studied SNRs.

A deep Suzaku observation of the Galactic Ia supernova remnant G306.3−0.9

Katsuhiro Tachibana[1], Makoto Sawada[2], Hiroyuki Uchida[1], Yuta Ito[2], Hideaki Matsumura[1], Aya Bamba[1,3], Takeshi Go Tsuru[1], Takaaki Tanaka[1]
[1] *Kyoto University, Japan*
[2] *Aoyama Gakuin University, Japan*
[3] *The University of Tokyo, Japan*

The supernova remnant (SNR) G306.3−0.9 was discovered by Swift in 2011. Its relatively small size confirmed by Chandra implies the SNR is young (Reynolds et al. 2013). XMM-Newton (Combi et al. 2016) and Suzaku (Sezer et al. 2017) discovered strong Fe-Kα, and established a type-Ia origin of the SNR. Recent studies of young Ia SNRs have revealed Fe has lower ionization state than intermediate mass elements (IME) . This implies they maintain a stratified ejecta structure. However, previous studies of G306.3−0.9 assumed Fe and IME have a common ionization timescale. We reanalyzed the Suzaku data with the latest calibration database to study the nature of Fe ejecta and to estimate the age. Spectrum analysis showed the Fe-Kα centroid is 6.47±0.01 keV (O-like), which results in higher electron temperature (> 3 keV) and lower ionization state ($\sim 1.5\times10^{10}$ s cm^3) for Fe than IME. The Hydrogen absorption column density is (1.2-1.3)$\times10^{22}$ cm^{-2}, leading to the conclusion that the distance of the SNR is ~ 20 kpc and the age is ~ 8.5 kyr. The SNR is the first example of still stratified ejecta in the late Sedov phase.

Search for Thermal X-ray Features from the Crab nebula with Hitomi Soft X-ray Spectrometer

Masahiro Tsujimoto[1], Koji Mori[2], Shiu-Hang Lee[3,4], Hiroya Yamaguchi[5], Nozomu Tominaga[6,7], Takashi Moriya[8], Toshiki Sato[9], Aya Bamba[10]

[1] *Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science*
[2] *Department of Applied Physics and Electronic Engineering, Faculty of Engineering, University of Miyazaki*
[3] *Department of Astronomy, Kyoto University*
[4] *RIKEN*
[5] *NASA Goddard Space Flight Center*
[6] *Department of Physics, Faculty of Science and Engineering, Konan University*
[7] *Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo*
[8] *National Astronomical Observatory of Japan*
[9] *Department of Physics, Tokyo Metropolitan University*
[10] *Department of Physics, The University of Tokyo*

The Crab nebula originates from a core-collapse SN in 1054. It has an anomalously low observed ejecta mass for a Fe-core collapse SN. Intensive searches were made for an undetected massive shell to solve this discrepancy. An alternative idea is that the SN1054 is an electron-capture (EC) explosion with a lower explosion energy than Fe-core collapse SNe. In the X-rays, imaging searches were performed for the plasma emission from the shell in the Crab outskirts. However, the extreme brightness hampers access to its vicinity. We used spectroscopic technique using the X-ray microcalorimeter onboard Hitomi. We searched for the emission or absorption features by the thermal plasma and set a new limit. We re-evaluated the existing data to claim that the X-ray plasma mass is $< 1 M_{\odot}$ for a wide range of assumed parameters. We further performed hydrodynamic simulation for two SN models (Fe core versus EC) under two environments (uniform ISM versus progenitor wind). We found that the observed mass limit can be compatible with both SN models if the environment has a low density of <0.03 cm^{-3} (Fe core) or <0.1 cm^{-3} (EC) for the uniform density, or $<10^{14}$ g cm^{-1} for the wind density parameter for the wind environment.

Chapter 11

Galaxies, Diffuse Galactic Emission and Population Studies

Revealing the X-ray main sequence of star formation

James Aird[1], Alison Coil[2], Anotnis Georgakakis[3]
[1] *University of Cambridge*
[2] *UC San Diego*
[3] *MPE*

We present measurements that reveal an "X-ray main sequence" of star formation, providing new, independent constraints on the slope and evolution of the star-forming main sequence. We use deep Chandra imaging to measure the distribution of X-ray luminosities for samples of star-forming galaxies as a function of stellar mass and redshift, using an advanced Bayesian method to push below the nominal X-ray detection limits. Our luminosity distributions exhibit a clear peak at low X-ray luminosities that is associated with star formation, as opposed to AGN that are traced by a broad tail to higher luminosities. By tracking the luminosity of this peak as a function of stellar mass and redshift, we reveal the "X-ray main sequence", with a slope of $\sim$0.6, a normalization that evolves strongly with redshift, and no evidence for a turn-over or flattening at high stellar masses. Comparing to tracers of star formation at other wavelengths indicates that X-rays are providing a robust, relatively direct, yet independent tracer of the average star formation rates of galaxies out to high redshifts.

Interaction of the 100-year old X-Ray flare produced by a central black hole with diffuse gas in the Galactic center

Dmitry Chernyshov[1], Kwong Sang Cheng[2], Vladimir Dogiel[1], Albert Kong[3], Chung Ming Ko[4], Vincent Tatischeff[5], Regis Terrier[6]
[1] *Lebedev's Institute of Physics, Moscow, Russia*
[2] *University of Hong Kong, Hong Kong, PRC*
[3] *National Tsing Hua University, Hsinchu, Taiwan*
[4] *National Central University, Jhongli, Taiwan*
[5] *University of Paris-Sud, Orsay Cedex, France*
[6] *Universite Paris 7 Denis Diderot, Paris Cedex, France*

We investigate an old X-Ray flare produced by a central black hole which is most likely responsible for the transient X-Ray emission from massive molecular clouds in the Galactic center. This flare should ionize diffuse molecular gas and also excite fluorescence lines e.g. neutral iron line at 6.4 keV. It turns out that the observed diffuse 6.4 keV line can be explained by the same X-Ray flare which illuminates dense molecular clouds. The diffuse emission can also be considered as a tool to limit potential duration and intensity of the primary X-Ray flare. We show that charged particles cannot provide necessary iron ionization rate to reproduce the observed emission. On the other hand ionization of neutral hydrogen cannot be provided by a primary flare and should be done by other mechanisms like for example charged particles. We also claim that recently found afterglow from Swift J1644+57 can be produced by similar event and can be a nice example of a Compton echo observed in a distant galaxy.

Fragments of the past activity of Sgr A* inferred from X-ray echoes in Sgr C

Dimitri Chuard[1,2], Régis Terrier[2], Andrea Goldwurm[1,2], Simona Soldi[2], Maica Clavel[3], Mark R. Morris[4], Gabriele Ponti[5], Michael Walls[6], Masha Chernyakova[6,7]
[1] *Irfu/Département d'astrophysique, CEA Paris-Saclay, Gif-sur-Yvette, France*
[2] *APC, Univ. Paris Diderot, CNRS/IN2P3, CEA/Irfu, Obs. de Paris, USPC, Paris, France*
[3] *Space Sciences Laboratory, University of California, Berkeley, USA*
[4] *Department of Physics and Astronomy, University of California, Los Angeles, USA*
[5] *Max-Planck-Institut für extraterrestrische Physik, Garching bei München, Germany*
[6] *School of Physical Sciences, Dublin City University, Dublin, Ireland*
[7] *Dublin Institute of Advanced Studies, Dublin, Ireland*

Giant molecular clouds populating the central molecular zone have a high enough column density to reflect X-rays coming from strong compact sources in their neighbourhood, including possible powerful outbursts from the Galactic supermassive black hole Sgr A*. We study this reflected emission in observations of the molecular complex Sgr C made with the X-ray observatories XMM-Newton and Chandra between 2000 and 2014. We show that this complex exhibits clear variability in both space and time, which strongly favours the reflection scenario, the most likely illuminating source being Sgr A*. By comparing data to Monte-Carlo simulated reflection spectra, we are able to put the best constraints to date on the line-of-sight positions of the main bright clumps of the molecular complex. Ultimately, extending this approach by the inclusion of other molecular complexes allows us to partially reconstruct the past lightcurve of the Galactic supermassive black hole.

Structure of the gas in the Milky Way: X-ray absorption in the cold, warm and hot ISM

Efrain Gatuzz[1], Eugene Churazov[1]
[1] *Max Planck Institute for Astrophysics, Garching, Germany*

High-resolution X-ray spectroscopy is a powerful tool to study the physical conditions of the Galactic interstellar medium (ISM). By using an X-ray source, which acts as a lamp, the absorption features identified in the spectra allows the analysis of ISM properties such as column densities, elemental abundances and ionization degree. We present a detailed analysis of the cold, warm and hot components of the local ISM using 22 galactic and 47 extragalactic X-ray bright sources. Implementing our new ionization equilibrium model IONeq, which includes broadening turbulence, we have measured the hydrogen column densities along every line of sight. We have found that the high-ionization absorption features identified are not intrinsic to the X-ray sources but imprints from the galactic ISM. This hot gas requires a multicomponent density profile in order to model it. Finally, we estimate the halo mass and its contribution to the baryonic census.

The population of high-mass X-ray binaries in the SMC: pulsars vs. non-pulsars

Frank Haberl[1]
[1] *Max Planck Institute for Extraterrestrial Physics, Garching, Germany*

The Small Magellanic Cloud (SMC) is unique with respect to its large number of known Be/X-ray binaries (BeXRBs). A recent compilation of more than 140 (candidate) BeXRBs in the SMC identified about 120 sources with high probability for being genuine BeXRBs. Only for about half of them the spin period of the neutron star is known. I present statistical investigations to address the question why we have not detected pulsations for many BeXRBs, although they show all other properties typical for BeXRBs.

Probing the Interstellar Dust towards the Galactic Centre using X-ray Dust Scattering Halos

Chichuan Jin[1], Gabriele Ponti[1], Frank Haberl[1], Randall Smith[2]
[1] *Max-Planck-Institut für extraterrestrische Physik, Germany*
[2] *Smithsonian Astrophysical Observatory, USA*

Dust scattering creates an X-ray halo that contains abundant information about the interstellar dust along the source's line-of-sight (LOS), and is most prominent when the LOS nH is high. In this talk, I will present results from our latest study of a bright dust scattering halo around an eclipsing X-ray binary at 1.45 arcmin away from Sgr A*, namely AX J1745.6-2901. This study is based on a large set of XMM-Newton and Chandra observations, and is so-far the best dust scattering halo study of a X-ray transient in the Galactic centre (GC). I will show that the foreground dust of AX J1745.6-2901 can be decomposed into two major thick dust layers. One layer contains (66-81)% of the total LOS dust and is several kpc away from the source, and so is most likely to reside in the Galactic disc. The other layer is local to the source. I will also show that the dust scattering halo can cause the source spectrum to severely depend on the source extraction region. Such spectral bias can be corrected by our new Xspec model, which is likely to be applicable to Sgr A* and other GC sources as well.

Hot Gas in Early Type Galaxies

Dong-Woo Kim[1]
[1] *Smithsonian Astrophysical Observatory*

The hot gas in early type galaxies (ETGs) plays a crucial role in understanding their formation and evolution. As the hot gas is often extended to the outskirts beyond the optical size, the large scale structural features identified by Chandra (including jets, cavities, cold fronts, filaments and tails) point to key evolutionary mechanisms, e.g., AGN feedback, merging history, accretion/stripping and star formation and its quenching. In our new project, the Chandra Galaxy Atlas, we systematically analyze the archival Chandra data of 100 ETGs to study the hot ISM. Using uniformly derived data products with spatially resolved spectral information, we will present gas morphology, scaling relations and X-ray based mass profiles and address their implications in comparison with groups/clusters and simulations.

NuSTAR and XMM-Newton observations of the Arches cluster in 2015: fading hard X-ray emission from the molecular cloud

Roman Krivonos[1]
[1] *Space Research Institute (IKI), Moscow, Russia*

We present results of long NuSTAR (200 ks) and XMM-Newton (100 ks) observations of the Arches stellar cluster, a source of bright thermal (kT 2 keV) X-rays with prominent Fe XXV K_alpha 6.7 keV line emission and a nearby molecular cloud, characterized by an extended non-thermal hard X-ray continuum and fluorescent Fe K_alpha 6.4 keV line of a neutral or low ionization state material around the cluster. Our analysis demonstrates that the non-thermal emission of the Arches cloud underwent a dramatic change, with its homogeneous morphology, traced by fluorescent Fe K_alpha line emission, vanishing after 2012, revealing three bright clumps. The declining trend of the cloud emission, if linearly fitted, is consistent with half-life decay time of 8 years. Such strong variations have been observed in several other molecular clouds in the Galactic Centre, including the giant molecular cloud Sgr B2, and point toward a similar propagation of illuminating fronts, presumably induced by the past flaring activity of Sgr A*.

X-raying the hot phase of the LMC interstellar medium

Pierre Maggi[1], Frank Haberl[2], Fabio Acero[1], Jean Ballet[1], Miroslav Filipović[3], Manami Sasaki[4], You-Hua Chu[5], Patrick Kavanagh[6], Sean Points[7], Steve Snowden[8]
[1] *CEA Saclay*
[2] *MPE Garching*
[3] *Univeristy of Western Sydney*
[4] *FAU Erlangen - Nuernberg*
[5] *Institute of Astronomy and Astrophysics, Academia Sinica Taiwan*
[6] *Dublin Institute for Advanced Studies*
[7] *National Optical Astronomy Obsevatory*
[8] *NASA Goddard Space Flight Center*

The hot component of the multi-phase ISM is a tenuous plasma at a temperature of several million degrees, shining brightly in soft X-rays. Studying this phase at large scale in our own Galaxy is hampered by strong absorption and distance uncertainties. In galaxies beyond the Local Group, observational challenges such as low flux and unresolved point source emission pose serious limitations. An ideal middle ground is found in the LMC, the nearest star-forming galaxy, seen almost face-on. We used hundreds of XMM-Newton observations, combining archival data with our own Very Large Programme survey, to cover the central region (5deg × 5deg) of the LMC. In this talk, I will present the early results of this large scale study. I will focus first on some of the challenges of the analysis, in particular those related to background issues and the definition of spectral extraction regions. Then, I will show the resulting spectral properties (in terms of temperature, luminosity, and chemical composition) of the hot LMC ISM at scales from 3 to 30′. Finally, I will discuss the relation between the various phases of the LMC ISM, and the connection between the X-ray diffuse emission and the star formation in the LMC.

Discovery of Galactic OIV and OV X-ray absorption due to transition temperature gas in the PKS 2155-304 spectrum

Jukka Nevalainen[1]
[1] *Tartu Observatory*

Using RGS and LETG, we discovered significant Galactic absorption from blended OIV transitions 1s-2p ^{2}S (22.571 Å), 1s-2p ^{2}P (22.741 Å) and 1s-2p ^{2}D (22.777 Å), and from the OV transition 1s-2p (22.370 Å) from transition temperature gas at $\log T(\mathrm{K}) = 5.2 \pm 0.1$. This is the X-ray counterpart of the previously FUV-detected component, consistent with the predictions of the Galactic Fountain model.

The XMM-Newton View of the Northern Disk of M31

Manami Sasaki[1], Miroslav Filipovic[2], Frank Haberl[3], Despina Hatzidimitriou[4], Martin Henze[5], Patrick Kavanagh[6], Knox Long[7], Paul Plucinsky[8], Benjamin Williams[9]
[1] *Remeis Observatory, University of Erlangen-Nurnberg, Bamberg, Germany*
[2] *Western Sydney University, Penrith, Australia*
[3] *Max-Planck-Institute for extraterrestrial Physics, Garching, Germany*
[4] *University of Athens, Athens, Greece*
[5] *Institute of Space Sciences, Barcelona, Spain*
[6] *Dublin Institute for Advanced Studies, Dublin, Ireland*
[7] *Space Telescope Science Institute, Maryland, USA*
[8] *Harvard-Smithsonian Center for Astrophysics, Cambridge, USA*
[9] *University of Washington, Seattle, USA*

The XMM-Newton survey of M31 revealed extended diffuse emission in the northern disk of M31, which is well correlated with the star-forming ring of the galaxy. The stellar population of this part of M31 has been extensively studied in the optical in the Panchromatic Hubble Andromeda Treasury (PHAT) survey. We have observed the northern disk of M31 in areas within the PHAT footprint in deep XMM-Newton pointings. We have thus obtained a map of the X-ray emission of the hot interstellar medium (ISM) in a spiral galaxy like our own on arcmin scales and a complete list of X-ray sources down to the confusion limit of a few 10^{34} erg/s, with variability and spectral information for most of the sources. We will present the first results of the study of the X-ray source population and that of the hot ISM.

The Classification and Analysis of Distinct X-ray Binary Populations in M81

Paul Sell[1], Andreas Zezas[1], Stephen Williams[1], John Gallagher[2], Kosmas Gazeas[3]
[1] *University of Crete, Heraklion, Greece*
[2] *University of Wisconsin-Madison, Madison, USA*
[3] *University of Athens, Athens, Greece*

We present a detailed analysis of the X-ray point source population of M81. By identifying HST counterparts to Chandra sources, taking into account the chance coincidence probability, we classify a large fraction of the X-ray point source population with unique counterparts: high-mass X-ray binaries and low-mass X-ray binaries in globular clusters. We then compare the shapes of the uncontaminated X-ray luminosity functions and the X-ray properties of sources of different classes to models and other existing work. We also calculate scaling relations with the star formation rate and stellar mass between the different classes of sources in global and sub-galactic scales. One initial, primary result is that the more massive and dense globular clusters are more likely to be associated with X-ray binaries.

An X-ray survey of the Central Molecular Zone: variability of the Fe K emission line

Régis Terrier[1], Maca Clavel[2]
[1] *APC, CNRS/Université Paris Diderot, Paris, France*
[2] *SSL, UC Berkeley, CA, USA*

The observation of varying non-thermal diffuse X-ray emission molecular complexes in the central 300 pc has been interpreted as delayed reflection of a past illumination by bright outbursts of the Galactic SMBH. Determining its light curve over the past centuries requires a detailed knowledge of the gas distribution, which is still lacking. Nevertheless, variability of the reflected emission all over of the central 300 pc, in particular in the 6.4 keV Fe K line, can bring strong constraints. Thanks to a deep scan of the inner 300 pc with XMM in 2012 and to a similar albeit more shallow scan performed in 2000-2001, we performed a detailed study of variability of the 6.4 keV line emission in the region, which we present here. We show that the overall 6.4 keV emission does not strongly vary on average, but variations are very pronounced on smaller scales. The absence of bright steady emission argues against the presence of an echo from an event of multi-centennial duration and most, if not all, of the emission can likely be explained by a limited number of relatively short (i.e. up to 10 years) events.

AGN and star formation activity in the lower-luminosity LIRGs from GOALS

Núria Torres-Albà[1], Kazushi Iwasawa[1,2], David Sanders[3], Jason Chu[3], Tanio Díaz-Santos[4]
[1] *University of Barcelona (ICC-UB), Barcelona, Spain*
[2] *ICREA, Barcelona, Spain*
[3] *University of Hawaii (IFA), Honolulu, USA*
[4] *Universidad Diego Portales, Santiago de Chile, Chile*

We present Chandra observations for a sample of 59 Luminous Infrared Galaxies (LIRGs) from the lower IR luminosity portion of the Great Observatory All-sky LIRG Survey (GOALS). The GOALS is a multiwavelegth survey of the most luminous IR-selected galaxies in the local Universe, at $z < 0.01$. This X-ray study, complimenting the previous work on the higher-luminosity sample, benefits from imaging and spectroscopic data from HST, Spitzer and Herschel. With combined X-ray and mid-IR diagnostics, AGN are found in 34% of the galaxies in the sample, a fraction lower than the 48% found at higher IR luminosities. Chandra observations allow to resolve the extended emission, and derive precise obscuration profiles in the inner regions of these dusty objects. The correlation study of far-IR and X-ray emission shows that the GOALS galaxies without visible traces of AGN appear to be underluminous in X-rays, compared to previously studied star-forming galaxies with lower star formation rates. This result could imply the presence of an absorbed AGN in the majority of LIRGs.

A possible reconnection heating in NGC 6946

Marek Wezgowiec[1,2], Matthias Ehle[3], Rainer Beck[4]
[1] *Obserwatorium Astronomiczne Uniwersytetu Jagiellońskiego, ul. Orla 171, 30-244 Kraków, Poland*
[2] *Astronomisches Institut der Ruhr-Universität Bochum, Universitätsstrasse 150, 44780 Bochum, Germany*
[3] *ESA-ESAC, XMM-Newton Science Operations Centre, P.O. Box 78, 28691 Villanueva de la Cañada, Madrid, Spain*
[4] *Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany*

The grand-design face-on spiral galaxy NGC 6946 apart from its high star formation activity and a massive northern spiral arm, presents "magnetic arms", visible in radio continuum polarization and located between the optical arms. We used X-ray observations of NGC 6946 performed with the XMM-Newton space observatory to disentangle and characterize the emission from point-like sources and extended hot gas from the disk, the "magnetic arms" and the halo. The properties of the hot gas found in and above the "magnetic arms" show indications for gas heating by reconnection, as well as an efficient gas transport from the disk into the halo along the vertical component of the halo magnetic fields.

A deep survey of the X-ray binary populations in the SMC

Andreas Zezas[1], Vallia Antoniou[2]
[1] *University of Crete / FORTH*
[2] *Harvard-Smithsonian Center for Astrophysics*

The Small Magellanic Cloud (SMC) has been the subject of systematic X-ray surveys over the past two decades, which have yielded a rich population of high-mass X-ray binaries consisting predominantly of Be/X-ray binaries. We present results from our deep Chandra survey of the SMC which targeted regions with stellar populations ranging between ∼10–100 Myr. X-ray luminosities down to $\sim 3 \times 10^{32}$ erg/s were reached, probing all active accreting binaries and extending well into the regime of quiescent accreting binaries and X-ray emitting normal stars. We measure the dependence of the formation efficiency of X-ray binaries on age. We also detect pulsations from 19 known and one new candidate pulsar. We construct the X-ray luminosity function in different regions of the SMC, which shows clear evidence for the propeller effect the centrifugal inhibition of accretion due to the interaction of the accretion flow with the pulsar's magnetic field. Finally we compare these results with predictions for the formation efficiency of X-ray binaries as a function of age from X-ray binary population synthesis models.

Chapter 12

Active Galactic Nuclei, Quasars, BL-Lac Objects, TDEs

Phase resolving high-frequency QPOs in AGN

William Alston[1]
[1] *IoA, Cambridge*

Quasi-periodic oscillations (QPOs) are coherent signals arising in the innermost regions of the accretion flow in black hole X-ray binaries (XRBs). They provide important information on the BH mass and spin as well as the structure of the strongly-curved spacetime close to the event horizon. If the accretion process is scale invariant then QPOs should also be present in AGN, however these have been notoriously difficult to detect. I will present the a detailed analysis of the complex spectral behavior of the QPO in the NLS1 galaxy RE J1034+396. At the QPO frequency we observe reverberation signatures - where soft X-ray bands and iron Ka emission lags the continuum. I will discuss how QPO phase-resolved spectroscopy and reverberation allow us to understand the QPO mechanism and geometry of the inner accretion flow.

Optical variability properties of the largest AGN sample observed with Kepler/K2

Ester Aranzana[1], Elmar Körding[1], Phil Uttley[2], Simone Scaringi[3]
[1] *Department of Astrophysics/IMAPP, Radboud University, Nijmegen, The Netherlands*
[2] *Anton Pannekoek Institute for Astronomy, University of Amsterdam, Amsterdam, The Netherlands*
[3] *Department of Physics and Astronomy, University of Canterbury, Christchurch, New Zealand*

We present the first high-frequency optical variability study of a large sample of Active Galactic Nuclei (AGN) observed with the *Kepler*/K2 mission. The sample contains 276 AGN observed over four campaigns with $\sim$ 30-minute cadence selected from the Million Quasar Catalogue with an R magnitude < 19. We performed time series analysis to determine their variability properties by means of the power spectral densities (PSDs) and applied Monte Carlo techniques to find the best model parameters that fit the observed power spectra. A power-law model is sufficient to describe 90 % of the AGN, the other 10 % present bumps and dips deviating significantly from the simple model. The average power-law slope is 2.5 ± 0.5, steeper than the PSDs observed in X-rays, and the rest-frame amplitude variability ranges from $1-10$ % with an average of 2.5 %. We explore correlations between the variability amplitude and parameters such as redshift, magnitude, and black-hole mass. This study also enables us to distinguish between Seyferts and blazars and confirm AGN candidates. The steep PSDs observed are inconsistent with the *damped random walk model* suggesting a different physical mechanism generating the fast variability.

Chandra view on the active nucleus of the restarted radio galaxy CGCG 292-057

Karthik Balasubramaniam[1], Lukasz Stawarz[1,2], Malgorzata Sobolewska[3], Aneta Siemiginowska[3], C.C. Cheung[4], Arti Goyal[1], Dorota Koziel-Wierzbowska[1]

[1] *Astronomical Observatory, Jagiellonian University, ul. Orla 171, PL-30244 Krakow, Poland*

[2] *Institute of Space and Astronautical Science, JAXA, 3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa 252-5210, Japan*

[3] *Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA*

[4] *Space Science Division, Naval Research Laboratory, Washington, DC 20375-5352, USA*

Here we present an analysis of the 90ksec Chandra ACIS-I data for the galaxy CGCG 292-057 (z = 0.054), which is a remarkable system showing at optical wavelengths, strong evidence for a relatively recent merger event. Radio images reveal a similarly complex picture, with a pair of compact young/inner radio lobes confined to the host galaxy, and embedded within larger-scale old/outer radio lobes characterized by the X-shaped morphology. The active nucleus in the system is clearly detected in the newly obtained Chandra data. We model the X-ray spectrum of the core assuming various emission models, including an absorbed power-law, a power-law plus thermal emission component, and a two-temperature thermal plasma. The best fit was however obtained assuming a model consisting of a power-law emission scattered by a hot ionized gas (giving rise to the 6.7 keV iron line). We discuss our results in a general context of the jet-ISM interaction in a post-merger AGN with an intermittent jet activity.

XMM-Newton and NuSTAR joint observations of Mrk 915: a deep look into the X-ray properties

Lucia Ballo[1,2], Paola Severgnini[1], Roberto Della Ceca[1], Valentina Braito[1,3], Sergio Campana[1], Alberto Moretti[1], Cristian Vignali[4,5], Alessandra Zaino[4,1]

[1] *INAF-OABrera*

[2] *XMM-Newton SOC ESA*

[3] *UMBC*

[4] *University of Bologna-DIFA*

[5] *INAF-OABo*

We report on the X-ray monitoring programme (covering slightly more than 11 days) carried out jointly by XMM-Newton and NuSTAR on the nearby intermediate Seyfert galaxy Mrk 915. The X-ray spectra reveal the presence of a two-phase warm absorber: a fully covering mildly ionized structure and a partial covering (90 per cent) lower ionized one. Finally, a high-column density distribution of neutral matter covering a small fraction of the central region is observed, almost constant, in all observations. Main driver of the variations observed between the datasets is a decrease in the intrinsic emission by a factor of 1.5. Slight changes in the innermost ionized absorber are also detected, while the data are consistent with no variation of the second, total covering absorber. A possible interpretation locates this complex ionized absorber in the outer part of the broad line region or in the innermost part of the torus, with the partial covering ionized absorber possibly associated with denser clouds enclosed in a less dense and warmer medium. An option is that the line of sight grazes (and partly intercepts) the walls of the torus, providing us a favoured perspective to observe the structure of a multi-zone absorber.

Identification of relativistic broadening of the Iron Kα line in AGN X-ray spectra observed with Chandra

Linda Baronchelli[1], Kirpal Nandra[1]
[1] *Max-Planck-Institute for extraterrestrial Physics, Garching, Germany*

The study of X-ray spectra of AGN reveals critical details about the inner regions of the accretion flow and about the geometry of the material surrounding an accreting super massive black hole (BH). The X-ray emission coming from the innermost regions of the disc is strongly broadened and skewed by the presence of the BH via Doppler motion and gravitational redshift. The study of the broadening of Iron Kα lines in an AGN population is fundamental to understand the spin distribution and the mass evolution of these objects. In this work, we aim to identify the presence of the relativistic broadening of the Iron Kα in the spectra of an AGN population observed with Chandra. We use the Bayesian X-ray Analysis (BXA, Buchner et al. 2014) as robust statistical tool to determine if the data are better fit by a model containing a relativistic blurring component or by a simpler model. BXA allows us to analyze a large sample of low signal to noise observations and obtain predictions for the population without need to stack the spectra. I will present the preliminary results obtained by applying BXA to 123 AGN in the Chandra Deep Field South (CDF-S).

A *Suzaku*, *NuSTAR* and *XMM-Newton* view on variable absorption and relativistic reflection in NGC 4151

Tobias Beuchert[1,2], Alex G. Markowitz[3], Thomas Dauser[1], Javier A. García[4,5,1,6], Mason L. Keck[7], Jörn Wilms[1], Matthias Kadler[2], Laura W. Brenneman[5], Andrzej A. Zdziarski[8]
[1] *Dr. Remeis-Sternwarte & Erlangen Centre for Astroparticle Physics, Universität Erlangen-Nürnberg, Bamberg, Germany*
[2] *Lehrstuhl für Astronomie, Universität Würzburg, Würzburg, Germany*
[3] *Center for Astrophysics and Space Sciences, University of California, San Diego, USA*
[4] *Cahill Center for Astronomy and Astrophysics, California Institute of Technology, Pasadena, USA*
[5] *Harvard-Smithsonian Center for Astrophysics, Cambridge, USA*
[6] *Alexander von Humboldt Fellow*
[7] *Institute for Astrophysical Research, Boston University, Boston, USA*
[8] *Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, Warsaw, Poland*

We disentangle X-ray disk reflection from complex line-of-sight absorption in NGC 4151 using *Suzaku*, *NuSTAR*, and *XMM-Newton*. Extending upon Keck et al. (2015), we develop a physically-motivated baseline model using the latest lamp-post reflection code `relxillCp_lp`, which includes a Comptonization continuum. We identify two components at heights of 1.2 and 15.0 gravitational radii using a long-look simultaneous *Suzaku*/*NuSTAR* observation but argue for a vertically extended corona as opposed to distinct primary sources. We also find two neutral absorbers (one full-covering and one partial-covering), an ionized absorber ($\log \xi = 2.8$), and a highly-ionized ultra-fast outflow, all reported previously. All analyzed spectra are well described by this baseline model. The bulk of the spectral variability on time-scales from days to years can be attributed to changes of both neutral absorbers, which are inversely correlated with the hard X-ray continuum flux. The observed evolution is either consistent with changes in the absorber structure (clumpy absorber in the outer BLR or a dusty radiatively driven wind) or a geometrically stable neutral absorber that becomes increasingly ionized at a rising flux level. The soft X-rays below 1 keV are dominated by photoionized emission from extended gas, which may act as a warm mirror for the nuclear radiation.

Constraining Disk-Jet Connection in the Radio Source 4C+74.26

Gopal Bhatta[1], Lukasz Stawarz[1], Staszek Zola[1,2], Michal Ostrowski[1], Karthik Balasubramaniam[1], Andrzej Zdziarski[3], Alex Markowitz[3], Agnieszka Kuzmicz[1], Marek Jamrozy[1], Monitor Team[4]

[1]*Astronomical Observatory, Jagiellonian University, ul. Orla 171 , 30-244 Krakow, Poland*

[2]*Mt. Suhora Observatory, Pedagogical University, ul. Podchorazych 2, 30-084, Krakow, Poland*

[3]*Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, Bartycka 18, PL-00-716 Warsaw, Poland*

[4]*Several Observatories*

We present our results of multi-wavelength analysis of the source 4C+74.26, one of the largest known sources associated with a quasar activity, with an aim to investigate the disk-jet connection in AGNs. While in blazar sources the disk/corona component is outshined by strongly beamed jet emission and in radio galaxies it is typically heavily absorbed by the circumnuclear dust, in this radio-loud AGN we see directly the disk (optical), disk corona and disk outflows (X-rays), and relativistic jet (radio). In addition, all these components are bright enough to be monitored on a regular basis. Therefore, it presents an unique opportunity to explore the disk-jet connection in radio sources. We studied multi-frequency cross-correlation in the source using optical, radio and Swift/BAT long-term observations. The results reveal a significant correlation between the optical and the radio emissions in the sense that optical emission lags behind the radio emission by about 250 days. However, as the Swift/BAT observations were found to be mostly dominated by Poisson noise, they were were binned in a 30-day bin before cross-correlating with optical and radio observations. In addition, spectral analysis of the NuSTAR observations was used to constrain the disk and the coronal properties of the source.

A hard X-ray view of the soft excess in AGN

Rozenn Boissay[1], Claudio Ricci[2], Stephane Paltani[3]

[1]*MIT Kavli Institute for Astrophysics and Space Research, Cambridge MA, USA*

[2]*Pontificia Universidad Catolica de Chile, Santiago, Chile*

[3]*Department of Astronomy, University of Geneva, Switzerland*

A soft X-ray emission in excess of the extrapolation of the hard X-ray continuum is detected in many Seyfert 1 galaxies below 1 keV. To understand the uncertain nature of this soft excess, which could be due to warm Comptonization or to blurred ionized reflection, we consider the different behaviors of these models above 10 keV. We present the results of a study done on 102 Seyfert 1s from the Swift BAT 70-Month Hard X-ray Survey catalog. We have performed the joint spectral analysis of Swift/BAT and XMM-Newton data in order to get a hard X-ray view of the soft excess. We discuss the links between the soft-excess strength and the reflection at high energy, the slope of the continuum and the Eddington ratio. We compare our results to simulations of blurred ionized-reflection models and show that they are in contradiction. Indeed, we do not find the expected correlation between the reflection and the soft-excess strengths, neither in individual, nor in stacked spectra. We will also discuss recent results obtained by performing broadband fitting, using different models explaining the soft excess, to simultaneous XMM-Newton and NuSTAR observations of about ten objects of our sample.

A new candidate for a powerful wind detected in a bright IR-galaxy

Valentina Braito[1,2], James Reeves[2,3], Paola Severgnini[1], Roberto Della Ceca[1], Gabriele Matzeu[1,3], Lucia Ballo[1]
[1] *INAF-Osservatorio Astronomico di Brera*
[2] *UMBC*
[3] *Keele University*

We report the discovery of a new candidate for a powerful disk wind, in a nearby and bright starburst-AGN system: MCG-03-58-007. The winds strongly resembles the case of PDS456. MCG-03-58-007 is a relatively X-ray bright Seyfert 2 galaxy for which a deep Suzaku observation unveiled a highly curved spectrum due to a high column density absorber and an extremely steep intrinsic photon index (Gamma = 3). A detailed analysis showed that the steep spectrum is mainly driven by the presence of a deep absorption trough at 7.5-9 keV. This could be accounted for by the presence of a high ionisation, fast (v up to 0.2c) outflowing wind launched from within a few 100Rg from the black hole, whose kinetic output matches the prescription for significant feedback. New deep simultaneous XMM-Newton and NuSTAR observations provided the first direct measurement of the AGN luminosity and more importantly confirms the presence of a powerful X-ray wind. The new observations show rapid spectral variability, whose main driver appears to be the wind itself.

Illuminating the Disk/Corona/Jet Connection in NLS1 Galaxies

Laura Brenneman[1]
[1] *Smithsonian Astrophysical Observatory*

We report on the 200-ks *NuSTAR* observation of the narrow-line Seyfert 1 (NLS1) AGN, PMN J0948+0022, executed simultaneously with an 80-ks *XMM-Newton* observation in 2016. PMN J0948+0022 was chosen because it is one of seven known, powerfully-jetted radio-loud (RL) NLS1s that have been observed with *Fermi*. We will detail our progress toward meeting the following campaign objectives with the analysis of these datasets: (1) Confirming the presence of the soft excess and look for any evidence of reflection, either in Fe K emission or the Compton hump above 10 keV; (2) Determining the correct spectral model across the entire X-ray bandpass (e.g., Comptonization vs. blurred reflection for the soft excess); (3) Measuring the coronal parameters (temperature, optical depth, compactness) by constraining the high-energy cutoff of the power-law and the low-energy UV/optical data simultaneously; (4) Looking for any correlations between the corona, jet and accretion properties by examining radio and Fermi monitoring of the source contemporaneous with the X-ray and UV/optical data and comparing fits to pure disk/corona models vs. jet models; (5) Furthering our understanding of the jet emission mechanism(s) in RLNLS1s by adding new information to the SED modeling of this source.

The Compton-thick Growth of Supermassive Black Holes constrained

Johannes Buchner[1,2]
[1] *MPE*
[2] *Pontificia Universidad Católica de Chile*

A heavily obscured growth phase of supermassive black holes (SMBH) is thought to be important in the co-evolution with galaxies. X-rays provide a clean and efficient selection of unobscured and obscured AGN. Recent work with deeper observations and improved analysis methodology allowed us to extend constraints to Compton-thick number densities. We present the first luminosity function of Compton-thick AGN at z=0.5-4 and constrain the overall mass density locked into black holes over cosmic time, a fundamental constraint for cosmological simulations. Recent studies including ours find that the obscuration is redshift and luminosity-dependent in a complex way, which rules out entire sets of obscurer models. A new paradigm, the radiation-lifted torus model, is proposed, in which the obscurer is Eddington-rate dependent and accretion creates and displaces torus clouds. We place observational limits on the behaviour of this mechanism.

New models for the CLUMPY AGN obscurer

Johannes Buchner[1,5], Murray Brightman[2], Kirpal Nandra[3], Franz E. Bauer[1,4,5]
[1] *Pontificia Universidad Católica de Chile*
[2] *Caltech*
[3] *MPE*
[4] *Millenium institute for Astrophysics*
[5] *Space Science Institute*

It is clear today that the obscurer of active galactic nuclei (AGN), the "torus", is more complex than a donut – a model still often used in X-ray analyses. A realistic model needs to explain X-ray eclipse events and the column density distribution of the AGN population. We construct a new clumpy torus model with these constraints, and Monte Carlo simulate X-ray spectra. Further we consider recent hydrodynamic simulations. Testing against NuSTAR spectra of several Compton-thick AGN, we discover the ubiquitous need for another component: a highly covering, inner Compton-thick reflector. Physical interpretations of this component include a warped (maser) disk or the inner torus wall where clouds launch. We release new xspec tables for our model, with both the inner reflector and the cloud population free to vary in covering factor. Our model can be used self-consistently with CLUMPY infrared emission models for multi-wavelength analyses.

Long term multiwavelength studies of the corona/disc connection in AGN

Douglas Buisson[1], Anne Lohfink[1], Will Alston[1], Andy Fabian[1], Luigi Gallo[2], Erin Kara[3], Abdu Zoghbi[4], Dan Wilkins[5], Jon Miller[4], Ed Cackett[6]
[1]*Institute of Astronomy, University of Cambridge, Cambridge, UK*
[2]*Department of Astronomy and Physics, Saint Marys University, Halifax, Canada*
[3]*Department of Astronomy, University of Maryland, Maryland, USA*
[4]*Department of Astronomy, University of Michigan, Ann Arbor, USA*
[5]*Kavli Institute for Particle Astrophysics and Cosmology, Stanford University, Stanford, USA*
[6]*Department of Physics & Astronomy, Wayne State University, Detroit, USA*

One way of increasing our understanding of AGN is determining the nature of the connection between the optical/UV emitting accretion disc and the X-ray emitting corona. Studies of variability in these two bands are a key tool for gaining insight into the processes involved. We will present results from a sample of long-term AGN monitoring campaigns in the optical, UV and X-ray with Swift. In particular, we will explore UV/optical-X-ray correlations and associated time lags. We will compare these measurements and the UV/optical RMS spectra with theoretical reprocessing models and confront recent claims of the observed lags being longer than those which are expected for a standard thin disc. Additionally, a new Swift monitoring campaign of the z=2 quasar PG 1247+267 allows us to probe the shorter wavelengths at the peak of the accretion disc spectrum, providing information on the region of the disc closest to the black hole. However, not all AGN show such correlations, including IRAS 13224-3809, the subject of a recent 1.5 Ms XMM observation. Using this and other examples, we will explore the possible reasons for the lack of observed correlation.

Results from the use of the X-ray reverberation model KYNREFREV in XSPEC

Maria D. Caballero-Garcia[1]
[1]*Astronomical Institute of the Academy of Sciences (Prague)*

X-ray reverberation mapping has been revealed to be a valuable tool for knowing the physical condition of the accreting black holes and the matter that surrounds them. This is an important case of interest for the exploitation of the data from the next generation of big X-ray satellites (i.e. Athena). A new model has been developed for the use of X-ray astronomical data, mainly through both timing and spectroscopy techniques. Here we present the results obtained by using the KYNREFREV model in the fits of X-ray reverberation time-lags in a sample of Active Galactic Nuclei using XSPEC. The derived constraints on the accretion disc-corona geometry will be discussed.

On the relationship between X-ray, MIR and bolometric luminosities of broad line QSOs

Francisco J. Carrera[1], Pedro J. Fernandez-Manteca[1]
[1] *Instituto de Fisica de Cantabria (CSIC-UC), Santander, Spain*

We have studied a sample of ∼3800 broad-line QSO from SDSS DR12 ($0.2 \leq z \leq 3.7$), cross-correlating it with 3XMM DR6 to get X-ray fluxes and luminosities (using FLIX to get upper limits) and using the results from unWISE to get MIR fluxes and luminosities (and upper limits).

As in previous results, we find a flattening of the 2-10keV vs. 6μm luminosity relationship for the most luminous objects ($43 \leq \log(L_X/cgs) \leq 47$, $43 \leq \log(\nu L_{\nu,6\mu m}/cgs) \leq 47$) with respect to that found for Sy1, which we show that continues within our luminous sample.

Using the bolometric luminosities ($44 \leq \log(L_{bol}/cgs) \leq 47$) from the optical continuum, there is no trend of the MIR-L_{bol} ratio with L_{bol}. On the contrary, the L_X-L_{bol} ratio clearly decreases with increasing L_{bol}, even slightly faster than the Marconi+04 relationship.

We will also discuss the implication of these results on models for the X-ray and MIR emission of QSOs and on their implication for studies of AGN-galaxy coevolution.

Using Microlensing to Probe Strong Gravity Near Supermassive Black Holes

George Chartas[1], Henric Krawczynski[2], Lukas Zalesky[1]
[1] *College of Charleston, Charleston, USA*
[2] *Washington University in St. Louis, USA*

We present a promising new technique (g-distribution method) for measuring the innermost stable circular orbit (ISCO), the inclination angle (i), and the spin of a supermassive black hole. The g-distribution method involves measurements of the distribution of the energy shifts of the relativistic iron line emitted from the accretion disk of a supermassive black hole that is microlensed by stars in a foreground galaxy and a comparison of the measured g-distribution with microlensing caustic simulations. The method has been applied to the gravitationally lensed quasars RX J1131−1231 ($z_s = 0.658$, $z_l = 0.295$), QJ 0158−4325 ($z_s = 1.29$, $z_l = 0.317$), and SDSS 1004+4112 ($z_s = 1.73$, $z_l = 0.68$). For RX J1131−1231 our initial results indicate an ISCO radius of < 8.5 gravitational radii, a spin parameter of $a > 0.8$ and and $i > 55$ degrees. Further monitoring of lensed quasars will provide tighter constraints on their inclination angles, ISCO radii, and spins. We finally compare numerical simulations of microlensing of the Fe Ka line to our observations.

X-ray Lags in PDS456 Revealed by Suzaku Observations

Chia-Ying Chiang[1], Ed Cackett[1], Abdu Zoghbi[2], Andy Fabian[3], Erin Kara[4], Michael Parker[3], Chris Reynolds[4], Dominic Walton[3]
[1]*Department of Physics and Astronomy, Wayne State University*
[2]*Institute of Astronomy, University of Michigan*
[3]*Institute of Astronomy, University of Cambridge*
[4]*Department of Astronomy, University of Maryland*

X-ray reverberation lags from the vicinity of supermassive black holes have been detected in a number of AGN. The soft lag, which is the time delay between the hard and soft X-ray light curves, is usually interpreted as the time difference between the direct and reflected emission, but is alternatively suggested to arise from the direct and scattering emission from distant clouds. By analysing the archival Suzaku observations totalling an exposure time of 770 ks, we discover a soft lag of a few thousands of seconds in the luminous quasar PDS456, which is the longest soft lag reported to date. In this study, we use the maximum likelihood method to deal with discontinuous light curves of Suzanne observations. The result follows the mass-scaling relation for soft lags, which further supports that soft lags originate from the innermost areas of AGN and hence are best interpreted by the reflection scenario.

The Compton-thick AGN fraction from the deepest X-ray spectroscopy in the CDF-S

Amalia Corral[1,2], Ioannis Georgantopoulos[1], Athanasios Akylas[1], Piero Ranalli[2]
[1]*IAASARS (NOA), Athens, Greece*
[2]*Lund Observatory, Lund, Sweden*

Highly obscured AGN, especially Compton-thick (CT) AGN, likely play a key role in the galaxy-AGN co-evolution scenario. They would comprise the early stages of AGN activity, preceding the AGN-feedback/star-formation quenching phase, during which most of both the SMBH and galaxy growth take place. However, the actual CT fraction among the AGN population is still largely unconstrained. The most reliable way of confirming the obscured nature of an AGN by X-ray spectroscopy, but very deep observations are needed to extend local analyses to larger distances. We will present the X-ray spectral analysis of the deepest X-ray data obtained to date, the almost 7Ms observation of the Chandra Deep Field South. The unprecedented depth of this survey allow us to carry out reliable spectral analyses down to a flux limit of 10^{-16} erg cm^{-2} s^{-1} in the hard 2-8 keV band. Besides the new deeper X-ray data, our approach also includes the implementation of Bayesian inference in the determination of the CT fraction. Our results favor X-ray background synthesis models which postulate a low fraction (15%) of CT objects among the obscured AGN population and a high percentage of reflected emission (5%) around the AGN.

The X-ray side of the Broad Line Region

Elisa Costantini[1]
[1] *SRON, Netherlands Institute for Space Research, Utrecht, The Netherlands*

The broad line region (BLR) is very different from an idealised spherical region of gas in motion around the central black hole. Using traditional optical/UV data, different geometries, sometimes contrasting with each other, have been recently explored. The broad line emitting clouds however, do also emit in the X-rays. This emitting gas constitute the energetic portion of the same clouds emitting the UV (Costantini et al. 2007, 2010). Here we present a unique study, using broad line region data of the bright Seyfert1 Mrk509 (Kaastra et al. 2011), taken simultaneously by XMM-Newton RGS, HST-COS and XMM-Newton OM-Grism (Costantini et al. 2016). We use a synthetic, physically motivated, model to fit the multi-wavelength data. The results point to part of the emission (possibly disk-like) coming near the black hole, highlighted by highly-ionized lines. In addition, a larger scale height component, clearly confined by the dust sublimation radius, is characterised by lower ionization ions emission (a bowl-like geometry; Goad et al. 2012). It is the first time that the X-rays provide crucial constraints in the geometrical description of the broad line region.

Unveiling the AGN activity in multiple SMBH systems observed with XMM-Newton

Alessandra De Rosa[1]
[1] *INAF/IAPS*

In this talk we will present results from the MAGNA (Multiple AGN Activity) project focused on the detection and study of multiple supermassive black hole systems. We investigate the physical properties (accretion rate and local environment) of multiple AGN candidates in interacting systems with respect to isolated sources with the goal to understand the mechanisms that trigger AGN activity in different stages of galaxy mergers. We present the study performed with SDSS and XMM data sets of 4 AGN pairs at separations of 20-70 kpc. XMM data allowed us to detect and characterize the AGN in all systems, by measuring the accretion and absorption properties of the sources. In each system at least one object is highly obscured, possibly Compton-thick, in agreement with the hypothesis that galaxy encounters are effective in driving gas inflow. One system however manifests the opposite behaviour showing a pair composed from an unobscured type 1 AGN and a Compton Thick AGN. The talk will reflect on broader implications of these findings.

Average broad-band X-ray spectra of the *NuSTAR* AGN

Agnese Del Moro[1], David Alexander[2], James Aird[3], Franz Bauer[4], Francesca Civano[5]
[1] *Max-Planck-Institute for Extraterrestrial Physics (MPE), Garching, Germany*
[2] *Centre for Extragalactic Astronomy, Durham University, Durham, UK*
[3] *Institute of Astronomy, University of Cambridge, Cambridge, UK*
[4] *Pontificia Universidad Católica de Chile, Santiago, Chile*
[5] *Harvard-Smithsonian Center for Astrophysics, Cambridge, USA*

I will present a study of the average X-ray spectral properties of the *NuSTAR* detected AGN in the ECDFS, EGS and COSMOS fields. We produce stacked spectra in the rest-frame 2-40 keV using *Chandra* and *NuSTAR* data and investigate how the intrinsic spectral parameters, such as the photon index, the strength of the iron Kα line and the Compton-reflection hump, depend on various source properties, i.e., their optical classification, absorbing column density ($N_{\rm H}$) and X-ray luminosity. We also compare our results with the typical assumptions made by several population synthesis models of the cosmic X-ray background (CXB) and find some small discrepancies. Although small, these differences can have a non-negligible impact on the inferred composition of the CXB, in particular on the fraction of Compton-thick sources amongst the whole AGN population.

KYNREFREV - the XSPEC model for X-ray reverberation in the lamp-post geometry

Michal Dovciak[1], Maria Caballero-Garcia[1], Anastasios Epitropakis[2], Iossif Papadakis[2], William Alston[3], Giovanni Miniutti[4], Erin Kara[5], Barbara De Marco[6], Vladimir Karas[1], Giorgio Matt[7]
[1] *Astronomical Institute of the CAS, Prague, Czech Republic*
[2] *University of Crete, Heraklion, Greece*
[3] *Institute of Astronomy, University of Cambridge, Cambridge, UK*
[4] *Centro de Astrobiologia (CSIC-INTA), Madrid, Spain*
[5] *University of Maryland, College Park, Maryland, USA*
[6] *Nicolaus Copernicus Astronomical Center, Warsaw, Poland*
[7] *Universita degli Studi Roma Tre, Rome, Italy*

In the last decade the X-ray reverberation echos produced by reflection of the coronal emission from the inner parts of the accretion disc was observed in several AGN. To estimate the properties of the system showing these features fast and modular XSPEC model is needed. In this contribution we want to introduce such a model that is ready to be used for both the frequency and energy dependencies of lags in the lamp-post geometry and is fast enough for fitting the data effectively. The parameters of the model, like the black hole spin, height of the corona, density of the disc affecting the disc ionisation profile, reflecting disc region (inner and outer edge and azimuthal segment), circular obscuring cloud and others will be described. The black-body reverberation due to the thermalised part of the illuminating radiation, that is important mainly for low mass AGN and for soft X-ray energy band, is included as well. The power-law hard lag for frequency dependence is also available directly in the model.

The XMM-Newton view of γ-ray emitting narrow-line Seyfert 1 galaxies

Filippo D'Ammando[1,2,6], Josefin Larsson[3,6], Monica Orienti[1,6], Eleonora Torresi[2,4,6], Justin Finke[5,6]
[1] *INAF-IRA Bologna*
[2] *Dipartimento di Fisica e Astronomia - Università di Bologna*
[3] *KTH, Department of Physics, and the Oskar Klein Centre, AlbaNova*
[4] *INAF-IASF Bologna*
[5] *U.S. Naval Research Laboratory*
[6] *on behalf of the Fermi Large Area Telescope Collaboration*

The discovery by Fermi-LAT of variable γ-ray emission from radio-loud narrow-line Seyfert 1 galaxies revealed the presence of a third class of AGN with relativistic jets in addition to blazars and radio galaxies. This finding opened challenging questions about the nature of these objects, the formation of relativistic jets, and the disk-jet connection. High quality spectra obtained by XMM-Newton are important to determine if the X-ray spectra of these sources are completely dominated by jet emission or if there are contributions from the accretion flow, such as the soft X-ray excess and the Fe line.

In this talk we discuss the XMM-Newton data of seven of the nine NLSy1 detected by Fermi-LAT. We find that most objects with high-quality spectra show signatures of a soft excess. Thanks to XMM-Newton and Fermi-LAT, we have also built detailed SED for studying the relation between the accretion flow and jet, as well as the emission mechanisms. The circum-nuclear environment of NLSy1 could provide information on the radiative and mechanical feedback. We have investigated this through emission and absorption features arising in their X-ray spectra.

The X-ray properties of these NLSy1 will be compared to those observed in γ-ray emitting radio galaxies and blazars.

A unified spectral variation model for Seyfert 1 Galaxies observed with NuSTAR and XMM/Suzaku

Ken Ebisawa[1], Eriko Kusunoki[1], Misaki Mizumoto[1], Hiroaki Sameshima[2]
[1] *JAXA/ISAS, University of Tokyo*
[2] *Kyoto Sangyo Univ.*

NuSTAR satellite was launched in 2012 and high-quality energy spectra of Seyfert 1 galaxies above $\sim$ 10 keV have been made available for the first time. In this paper, we analyze archival data of the NuSTAR and XMM/Suzaku simultaneous observations of particularly variable Seyfert 1 galaxies, MCG-6-30-15, NGC 4593, NGC 1365, Swift J2127.4+5654 and MCG-5-23-16. Our aim is to construct a unified spectral model that explains spectral variations in 0.2-78 keV with minimum free parameters. Consequently, we were successful to explain observed spectral variations of all the five sources at timescales below $\sim$ 1 day with only two independently variable parameters; partial covering fraction and normalization of the power-law component. In this model, the continuum is composed of disk-black body component, cut-off power-law component, and thin-thermal plasma component, if any. The central X-ray source is fully or partially absorbed by ionized absorbers, and the partial covering fraction is significantly variable. Variations of the partial covering fraction and the power-law normalization mostly explain the soft X-ray variation below $\sim$ 10 keV and the hard X-ray variations above $\sim$ 10 keV, respectively. The variable partial absorbers are composed of two layers with different ionization states/column densities.

An AGN emerging from an obscured state: multi-epoch monitoring of the X-ray and UV absorbers in NGC 985

Jacobo Ebrero[1], Jerry Kriss[2], Vladimir Domcek[3], Jelle Kaastra[4]
[1]*European Space Astronomy Centre (ESAC), Madrid, Spain*
[2]*Space Telescope Science Institute, Baltimore, USA*
[3]*Anton Pannekoek institute, Amsterdam, The Netherlands*
[4]*SRON Netherlands Institute for Space Research, Utrecht, The Netherlands*

Transient obscuration events in nearby AGN are deemed to be more common than originally thought and, if monitored, they are excellent laboratories to probe the physical properties of the circumnuclear gas. We present the results of a monitoring campaign on the Seyfert-1 galaxy NGC 985, which was observed twice in 2015 with XMM-Newton in X-rays and HST-COS in the UV. These observations showed NGC 985 to be recovering from a low flux state with strong soft X-ray obscuration and broad, fast UV absorption, first observed in 2013. The XMM-Newton observations revealed the presence of a multi-component warm absorber (WA). Re-analysis of archival observations showed that some of these components were still present in 2003 and 2013, when the source was obscured, albeit with different ionization states.

In the UV, our 2015 observations show diminished obscuration as well as a weakening of the associated broad UV absorption. In addition, NGC 985 shows a complex set of six narrow absorption features presumably associated with the X-ray WA. All of these UV components show variability on timescales as short as the 12 days between our two observations in 2015 up to the many-year timescales probed by prior HST observations in 2013 and 1999.

The variability of the ten brightest AGN in the XMM CDFS

Serena Falocco[1]
[1]*KTH Royal Institute of Technology*

I have investigated the lightcurves and the time resolved spectra of Active Galactic Nuclei (AGN) with the purpose to explore scenarios of variability in the central engine or in the absorption from circumnuclear material. The sample of AGN is constructed from the XMM-Newton observation of the Chandra Deep Field South. I first explore the lightcurves in fluxes and hardness ratios, in order to check any connection between them. I then investigate the spectra grouped in six epochs, to check their normalisation changes as well as their variability in photon index and X-ray absorption. Finally, I explore the high and low flux states defined, for each source, as the epochs above and below the average flux. This approach helps to check if the flux transitions are connected to spectral changes. I found a widespread X-ray flux variability in AGN, over timescales of months-years. In some cases, the variability in the continuum normalisation is accompanied by hints of spectral variability in the X-ray continuum slope. One source displays a 'steeper when brighter' trend, consistent with the comptonisation scenarios. The remaining sources show flat or anticorrelated trends between photon index and flux.

AGN feedback through UFO and galaxy-wide winds in the early Universe

Chiara Feruglio[1], Enrico Piconcelli[2], Manuela Bischetti[2], Luca Zappacosta[2], Fabrizio Fiore[2]
[1]*INAF OATs*
[2]*INAF OA Roma*

AGN feedback through massive molecular winds is today routinely observed in local AGN host galaxies, but not as such in the early universe. I will present the first evidence for a massive, AGN-driven molecular wind in the z 4 QSO APM08279, which also hosts the most well studied and persistent nuclear semi-raltivistic wind (UFO). This observation directly probes the expansion mechanism of a nuclear wind into the ISM on galaxy wide scales, that so far was constrained by a couple of other objects only (Feruglio et al. 2015, Tombesi et al. 2015). This result also opens the path toward the exploration of molecular AGN-driven winds at early epochs, close after the end of the Epoch of Reionisation (EoR).

Bare AGN: an Unobscured View of the Innermost Accretion Geometry

Marco Fink[1], Thomas Dauser[1], Tobias Beuchert[1,2], Javier García[6,1,3], Dominic J. Walton[4,5], Felix Fürst[7], Jörn Wilms[1]
[1]*Dr.-Karl-Remeis-Sternwarte & ECAP, Universität Erlangen-Nürnberg*
[2]*Lehrstuhl für Astronomie, Universität Würzburg*
[3]*Harvard-Smithsonian Center for Astrophysics*
[4]*Institute of Astronomy, Cambridge University*
[5]*Space Radiation Laboratory, California Institute of Technology*
[6]*Cahill Center for Astronomy and Astrophysics, California Institute of Technology*
[7]*European Space Astronomy Centre (ESA/ESAC), Science Operations Department*

In a systematic study of the relativistic reflection spectra and coronal properties for a sample of bare AGN we analyze high signal-to-noise spectra obtained with the XMM-Newton and NuSTAR observatories utilizing state-of-the-art reflection codes. Features of blurred reflection off an ionized accretion disk are modelled using different flavors of the relativistic ray-tracing code `Relxill`. We show that the more physically motivated and self-consistent lamp-post geometry is largely consistent with fits of broken power-law emissivity profiles. We provide good constraints on parameters describing the compact reprocessing corona, i.e., the reflection fraction and the lamp-post height. The latter are found to be prevalent within 1–10 r_{g}, while our models generally find close-to-maximal black hole spins. These results are discussed and compared with previous studies by Walton et al. (2013).

Modeling Soft Excess with GRMHD Accretion for XMM-Newton Spectra of Bright AGNs

Keigo Fukumura[1], Yoshito Haba[2], Masaaki Takahashi[2], Francesco Tombesi[3,4], Rozenn Boissay[5]
[1] *James Madison University*
[2] *Aichi University of Education*
[3] *University of Maryland College Park*
[4] *Universitadi Roma Tor Vergata*
[5] *MIT*

Despite a number of well-studied X-ray observations of the so called soft excess (SE) from a certain class of AGNs in the past decades, its physical identification has remained to be elusive to date. With the absence of a single leading model, a few competing scenarios have been proposed. In this presentation, we show that the innermost plasma accretion under strong gravity can develop into an MHD shock front at $r < 5r_g$ where incoming thermal disk photons (of ~ 10 eV) are efficiently Compton up-scattered by shock-accelerated electrons in its downstream region to produce the observed SE feature. Considering all the relativistic effects in our treatment, our GRMHD Comptonization model, consisting of (1) disk photon temperature ($kT_{\rm bb}$), electron energy (Θ_e) and inclination ($\theta_{\rm obs}$) for a given black hole spin (a/m), can naturally provide the SE spectra for a fiducial parameter set by solving GRMHD flows. Our calculations indicate that the Comptonizing region is very compact just outside the black hole event horizon resembling a putative "coronae" with a characteristic electron energy on the order of ~ 100 keV determined by shock strength. We also show preliminary spectral analysis results for some stereotypical PG and NLS1 AGNs.

A global view of the accretion/ejection flow in AGN: the role of accretion disk winds

Margherita Giustini[1], Chris Done[2], Daniel Proga[3]
[1] *SRON - Netherlands Institute for Space Research*
[2] *Centre for Extragalactic Astronomy, Department of Physics, University of Durham*
[3] *Department of Physics and Astronomy, University of Nevada, Las Vegas*

By merging theories and X-ray/UV observations we insert winds and failed winds into the geometrical and evolutionary scenarios for the inner regions of Active Galactic Nuclei (AGN). Physically and geometrically different mass accretion flow states onto supermassive black holes correspond to different photon outflows. The photon outflows determine the AGN spectral energy distribution intensity and shape, that affect the presence of different ejection flow states and the consequent mass outflows. The mass and photon accretion and ejection flows in AGN are coupled. We show how by mainly - but not only - varying the Eddington ratio, AGN display different accretion/ejection flows that can explain the observed phenomenology from LLAGN up to highly luminous, super-Eddington QSOs, going through e.g. Seyferts, mini-BAL and BAL QSOs. In particular, during the actively accreting Seyfert/QSO phase of AGN, the presence/absence of powerful line driven accretion disk winds is crucial to explain the observed X-ray/UV phenomenology, including the $\alpha_{ox} - L_{UV}$ correlation and the Baldwin effect.

The fastest disk wind in APM 08279+5255 and its acceleration mechanism

Kouichi Hagino[1], Chris Done[1,2], Hirokazu Odaka[3], Shin Watanabe[1,4], Tadayuki Takahashi[1,4]
[1] *ISAS/JAXA, Sagamihara, Japan*
[2] *University of Durham, Durham, UK*
[3] *Stanford University, Stanford, USA*
[4] *University of Tokyo, Tokyo, Japan*

The luminous high-z quasar APM 08279+5255 has the most powerful ultra-fast outflow (UFO), which is claimed as the fastest disk wind with velocity of 0.7c. This extreme velocity is very important for constraining the physical mechanism to launch the UFOs because only magnetic driving mechanism can accelerate the winds up to velocities above 0.3c, at which radiation drag effects prevent radiation driving. We reanalyze all the observed data of this source with our spectral model of highly ionized disk winds constructed by 3D Monte Carlo radiation transfer simulation. This was applied to an archetypal disk wind in PDS 456, and successfully reproduced all the spectra observed with Suzaku in spite of their strong spectral variability. By applying our spectral model to APM 08279+5255, all the spectra observed with XMM-Newton, Chandra and Suzaku are explained with less extreme outflow velocities of 0.1-0.2c. In our analysis, the high energy absorption features, which were previously interpreted as absorption lines with extremely fast velocities, are produced by iron-K absorption edges from moderately ionized clumps embedded in the highly ionized wind. We also investigate the broadband SED, and find that it is X-ray weak and UV bright, which prefers the radiation driving.

Detection of a possible X-ray Quasi-periodic Oscillation in the Active Galactic Nucleus 1H 0707-495

Pan Haiwu[1,2], Yuan Weimin[1,2]
[1] *Key Laboratory of Space Astronomy and Technology, National Astronomical Observatories, Chinese Academy of Sciences, 20A*
[2] *University of Chinese Academy of Sciences, School of Astronomy and Space Science, Beijing 100049, China*

Quasi-periodic oscillation (QPO) detected in the X-ray radiation of black hole X-ray binaries (BHXBs) is thought to originate from dynamical processes in the close vicinity of the black holes (BHs), and thus carries important physical information therein. Such a feature is extremely rare in active galactic nuclei (AGNs) with supermassive BHs. Here we report on the detection of a possible X-ray QPO signal with a period of 3800 s at a confidence level $> 99.99\%$ in the narrow-line Seyfert 1 galaxy (NLS1) 1H 0707-495 in one data set in 0.2-10 keV taken with *XMM-Newton*. The statistical significance is higher than that of most previously reported QPOs in AGNs. A comprehensive analysis of the optical spectra of this AGN is also performed, yielding a central BH mass $5.2 \times 10^6\, M_\odot$ from the broad emission lines based on the scaling relation. The QPO follows closely the known frequency-BH mass relation, which spans from stellar-mass to supermassive BHs. We suggest that the (high-frequency) QPOs tend to occur in highly accreting BH systems, from BHXBs to supermassive BHs. Future precise estimation of the BH mass may be used to infer the BH spin from the QPO frequency.

Study of a Tidal Disruption Event Candidate

Julia Hampel[1], Thomas Reiprich[1], Michael Freyberg[2], Jochen Greiner[2], Stefanie Komossa[3]
[1] *Argelander-Institut für Astronomie, University Bonn*
[2] *Max-Planck-Institut für extraterrestrische Physik*
[3] *Max-Planck-Institut für Radioastronomie*

During the close encounter of a star with a supermassive black hole, the star might get disrupted by the black hole's tidal forces (tidal disruption events, TDE). The accretion of the stellar material onto the black hole creates luminous emission at different wavelength, including X-rays. We will report the results of an investigation of a bright X-ray source in a set of five ROSAT PSPC observations. The light curve of this event shows an increase in brightness by a factor of nine within eight days, followed by a strong fading over the following 165 days. This observation seems inconsistent with common X-ray source variability, such as active galactic nuclei, and more in favor of a TDE. In order to investigate the possible TDE origin, optical and X-ray spectra have been analyzed. An expected absence of emission lines in the optical and a very soft X-ray spectrum are confirmed. Detailed comparisons with known TDEs show discrepancies in the light curves. Particularly, the increase in brightness happens over a shorter timescale than comparable events. The study of this TDE candidate might help to gain a better understanding of such events, especially for the expected TDE discoveries with the upcoming eROSITA all-sky survey.

Restarting activity in the nucleus of PBC J2333.9-2343

Lorena Hernandez-Garcia[1], Francesca Panessa[1], Marcello Giroletti[2], Gabriele Ghisellini[3], Loredana Bassani[2], Nicola Masetti[2,4], Mirjana Povic[5,6], Angela Bazzano[1], Pietro Ubertini[1], Angela Malizia[2]
[1] *IAPS-INAF, Italy*
[2] *IASF-INAF, Italy*
[3] *OAB-INAF, Italy*
[4] *Universidad Andres Bello, Chile*
[5] *IAA-CSIC, Spain*
[6] *ESSTI, Ethiopia*

Under unification schemes, active galactic nuclei (AGN) can be explained by orientation effects. However, some sources show properties at different frequencies that led to incongruent classifications. This is the case of PBC J2333.9-2343; its optical spectrum is of a type 2 AGN but its X-ray spectrum does not show signs of absorption, and in the radio it has many features typical of a blazar but it is a giant radio galaxy. Using simultaneous data from XMM-Newton, San Pedro Mártir telescope and VLBA, we find that these classifications cannot be attributed to variability. We propose that PBC J2333.2343 is a misaligned blazar that has undergone a restarting activity in its nucleus. Interestingly, it has changed from being a radio galaxy to become a blazar, showing an exceptional change in the direction of the jet that, by chance, occurred in the plane of the sky. It also shows a change in the BLR and increasing variability at all observed wavelengths, which we propose is the result of the accretion being converted from inefficient to efficient as a result of the restarted activity. Moreover, we have detected an outflow in its optical spectra, being the first blazar with an observed optical outflow.

2016 XMM-Newton Observation of IRAS 13224-3809

Jiachen Jiang[1], Michael Parker[1], Andy Fabian[1]
[1] *Institute of Astronomy, University of Cambridge*

We present spectral analysis of the latest 1.5ms XMM-Newton observation of the narrow line Seyfert 1 galaxy IRAS 13224-3809, simultaneous with NuSTAR observations, focusing on the characteristics of the spectral shape and the trend of the parameters with the flux level. It shows extreme and rapid variability and a strong relativistic Fe K line signature during the observation. Additionally, we detect flux-dependent Si XIV and S XVI absorption lines in the stacked spectrum and lower flux level spectrum, with an outflow velocity of 0.24c. These ultra-fast outflow features are consistent in velocity and ionization with the previously detected Fe, Ne and O features from this source. Finally, we try to explore the possibility of high density disk reflection in this source by fitting the soft excess with a variable density version of the reflection model xillver.

New results on Super-Eddington Accretion Flow in NLS1s from XMM-Newton Observations

Chichuan Jin[1], Chris Done[2], Martin Ward[2], Emma Gardner[2]
[1] *Max-Planck-Institut für extraterrestrische Physik, Germany*
[2] *Centre for Extragalactic Astronomy, Department of Physics, University of Durham, UK*

Narrow Line Seyfert 1 Galaxies (NLS1s) have small black hole masses and high, sometimes super-Eddington, mass accretion rates. The physical mechanism of their X-ray emission, especially the soft X-ray excess, has been a controversial topic for many years. We have conducted deep XMM-Newton observations of some bright unobscured super-Eddington NLS1s. Their multi-wavelength properties can be well understood in a unified accretion flow scenario, which contains a standard outer disc, a puffed-up inner disc with strong disc wind, an extended soft X-ray region and a compact hard X-ray region. By considering the inclination angle effect, such a scenario can also explain NLS1s with more complex X-ray properties such as 1H 0707-495, without requiring a large spin parameter. I will also show that these super-Eddington NLS1s are probably the best low-redshift analogies of weak emission-line quasars at high redshifts.

Ionized and molecular gas studies of X-ray selected AGN at high-z

Darshan Kakkad[1], Vincenzo Mainieri[1], Paolo Padovani[1], Bernd Husemann[2], Marcella Brusa[3], Stefano Carniani[4], Mark Sargent[5], Enrico Piconcelli[6], Chiara Feruglio[7], Angela Bongiorno[6]
[1] *ESO-Garching*
[2] *MPIA-Heidelberg*
[3] *INAF-Bologna*
[4] *University of Cambridge*
[5] *University of Sussex*
[6] *INAF-Rome*
[7] *INAF-Trieste*

AGN feedback is often invoked in simulations to reproduce observed properties such as the massive end of galaxy mass functions. While efforts have been underway during the past decade to unveil the feedback effects at both low and high redshift, a direct observational evidence is still elusive in literature. I will present our current efforts on this front for X-ray selected high redshift galaxies using optical and near infrared IFU, single slit and sub-mm spectroscopic observations with WiFeS, SINFONI/VLT, XSHOOTER/VLT, and ALMA. Such a diverse set of high quality multiwavelength dataset sets the stage to understand how AGN affects the ionized as well as molecular gas content of the host galaxy. Some of the key questions addressed by this talk are: Are ionized outflows in high redshift galaxies driven by AGNs or star formation? What are the level of uncertainties in these outflow models and how to reduce them? Are such AGN outflows capable of affecting the molecular gas content in the host galaxy?

The X-ray stable emission in MCG-6-30-15

Elias Kammoun[1], Iossif Papadakis[2,3]
[1] *SISSA, Trieste, Italy*
[2] *Department of Physics, Institute for Theoretical and Computational Physics, University of Crete, Heraklion, Greecce*
[3] *Foundation for Research and Technology - Hellas, IESL, Heraklion, Greece*

The flux-flux plot (FFP) method is a model-independent way that allows to extract the variable and stable components from the X-ray spectra of AGNs showing strong variability. We applied this method to the simultaneous *XMM-Newton* and *NuSTAR* observations of MCG-6-30-15, in the 0.3-40 keV range. The constant component, in the 4-40 keV energy range, is consistent a neutral reflection from distant material ($D > 1.56 \times 10^4\,\mathrm{R_g}$) revealing an iron K line in the 6-7 keV band and a Compton hump peaking at $\sim$ 20 keV. It contributes to $\sim 20\,\%$ of the total emission, on average. The variable component is consistent with a power-law spectrum with a constant photon index ($\Gamma \sim 2$) varying only in normalization without any hint of a relativistic ionized reflection. The FFPs below 3 keV show a clear evidence of a variable warm absorber with the possibility of having a stable component at these low energies.

Determination of the coronal properties of luminous quasars at cosmological redshifts

Elias Kammoun[1], Guido Risaliti[2,3]
[1] *SISSA, via Bonomea, 265 , Trieste ITALY*
[2] *University of Floremce, via G. Sansone 1, Sesto Fiorentino, Florence, Italy*
[3] *INAF - Arcetri Astrophysical Observatory, Largo E. Fermi 5, I-50125, Florence, Italy*

Several precise measurements of high-energy cutoffs in the X-ray spectra of bright local AGN have been reported recently. These measurements can be also done for luminous quasars at cosmological redshifts. The shift of the high-energy cutoff to lower energies, in the observer frame, compensates for the relative faintness of the source, allowing an estimate of the coronal temperature analogous to the ones done for local, low luminosity but very bright AGN. We present the analysis of the joint *XMM-Newton* and *NuSTAR* observations of the luminous radio-quiet quasar QSO B2202-209 (z=0.53; L(2-10 keV)= 1.93×10^{45} erg/s) and the radio-loud quasar 4C+25.05 (z=2.36; L(2-10 keV)= 3.77×10^{46} erg/s). Assuming a Comptonization model, we estimated a coronal temperature of $kT_{\rm e} = (42 \pm 3)$ keV and $KT_{\rm e} = (56 \pm 3)$ keV for a spherical and a slab geometry, respectively, for B2202-209. The unusual X-ray loudness of this quasar ($\alpha_{\rm OX} = 1.00 \pm 0.02$) and the exceptionally strong optical [O III] line, that we found, can be explained by a nearly edge-on disc, leading to a reduction in the observed ultraviolet continuum light. Moreover, the X-ray spectrum of 4C+25.05 allows us to put a low limit on the cutoff energy to be $E_{\rm cut} > 120$ keV.

Time-Resolved SEDs of Blazars Flares

Annika Kreikenbohm[1,2], Daniela Dorner[1], Matthias Kadler[1], Tobias Beuchert[2,1], Michael Kreter[1], Ingo Kreykenbohm[2], Marcus Langejahn[1], Katharina Leiter[1,2], Karl Mannheim[1], Joern Wilms[2]
[1] *Univ Wuerzburg , Germany*
[2] *ECAP, FAU Univ Erlangen-Nuremberg*

The origin of very-high-energy gamma rays in active galactic nuclei is still under debate. While snapshots of spectral energy distributions (SEDs) can usually be explained with simple competing models, the true emission mechanisms may be revealed from dynamic SED studies during exceptional source states. Based on the FACT monitoring program, we have set up a multiwavelength target-of-opportunity program which allows us to measure time-resolved SEDs during blazar flares. While the FACT and Fermi measurements cover the high energy peak continuously, X-ray observations with INTEGRAL and XMM-Newton are triggered in case of a bright flare. To distinguish orphan flares from time lags between the energy bands, this is combined with an X-ray monitoring with the Swift satellite. In December 2015, observations of the X-ray telescopes Swift and INTEGRAL were triggered during a moderately-high flux state of the TeV blazar Mrk 421. Pre- and post observations in X-rays are available from Swift-XRT. In this presentation, the results from the Mrk 421 ToO observations will be summarized.

Chasing obscuring outflows in AGN: Broad, Fast, UV and X-ray Absorption in NGC 3783 and other AGN

Gerard Kriss[1], Jelle Kaastra[2], Mehdipour Missagh[2]
[1]*Space Telescope Science Institute*
[2]*SRON*

Recent intensive multi-wavelength monitoring campaigns on bright, local active galactic nuclei have revealed a new class of UV and X-ray absorbers. They typically show transient, heavy X-ray obscuration in the low-energy spectrum characterized by high column densities of mildly ionized gas. These X-ray obscuration events are accompanied by the appearance of broad, fast, blue-shifted UV absorption lines of moderate ionization, comparable to the X-ray absorbing gas. X-ray column densities typically exceed 10^{22} cm^{-2}, and UV absorption in Ly α, N V, Si IV, and C IV show blue shifts of 1000–8000 km s^{-1} and widths of 500-2000 km s^{-1}. The most prominent of these newly discovered outflows is in NGC 5548, but other examples have also been found in Mrk 335 and NGC 985. Here we report HST observations of broad, fast, UV absorption lines accompanying another case of obscuration in the Seyfert 1 galaxy NGC 3783. The high outflow velocities, variability timescales of a day or less in the X-ray, and the broad widths suggest an origin in a wind from the accretion disk. This low-ionization gas may represent the shielding gas necessary to facilitate disk winds driven by radiative acceleration in UV absorption lines.

Detection of faint broad emission lines in type 2 AGN: The MBH-$\sigma_\star$ relation of type 2 AGN

Fabio La Franca[1], Federica Ricci[1], Francesca Onori[2], Alessandro Marconi[3], Francesco Shankar[4], Eleonora Sani[5]
[1]*Dipartimento di Matematica e Fisica, Università Roma Tre*
[2]*SRON Netherlands Institute for Space Research*
[3]*Dipartimento di Fisica e Astronomia, Università degli Studi di Firenze*
[4]*Department of Physics and Astronomy, University of Southampton*
[5]*European Southern Observatory*

Type 2 active galactic nuclei (AGN) represent the majority of the AGN population. However, due to the difficulties in measuring their black hole (BH) masses, it is still unknown whether they follow the same BH mass-host galaxy scaling relations valid for quiescent galaxies and type 1 AGN. Here we present the locus of hard X-ray selected type 2 AGN having (X-ray based) virial BH mass estimates in the MBH-$\sigma_\star$ plane. Our analysis shows that the BH masses of type 2 AGN are 0.9 dex smaller than type 1 AGN at $\sigma_\star \sim 185$ km s^1, regardless of the (early/late) AGN host galaxy morphology. Equivalently, type 2 AGN host galaxies have stellar velocity dispersions 0.2 dex higher than type 1 AGN hosts at MBH 10^7 Msol.

Inverse-Compton emission from the radio lobes of powerful high-redshift radio galaxies

Dharam Lal[1], Ralph Kraft[2], Martin Hardcastle[3], Christine Jones[2], William Forman[2], Paul Nulsen[2], Judith Croston[4]

[1] *National Centre for Radio Astrophysics (Tata Institute of Fundamental Research)*
[2] *Harvard Smithsonian Centre for Astrophysics - Smithsonian Astrophysical Observatory*
[3] *University of Hertfordshire*
[4] *University of Southampton*

Analysis of the radio synchrotron and X-ray inverse-Compton emission from powerful radio-loud active radio galaxies allows us to determine their particle acceleration processes and electron energy spectra. We have made new Chandra observations along with archival radio data of high-redshift radio galaxies, where we detect inverse-Compton emission from the radio lobes. Here, we present (i) constraints on the densities of the electrons emitting radio synchrotron and inverse-Compton emission in the radio lobes and describe the properties of the particle energy spectrum, and (ii) our understanding of the interplay between the ambient medium and the radio galaxy. Finally, we discuss the importance of multi-wavelength, in particular low-frequency radio imaging, and the role of forthcoming Square Kilometre Array and Athena instruments.

A hard X-ray view of the distant active galactic nucleus (AGN) population with NuSTAR

George Lansbury[1], James Aird[1], David Alexander[2], Carla Fuentes[3], Poshak Gandhi[4], Fiona Harrison[5], Mike Koss[6], Daniel Stern[7], John Tomsick[8], Ezequiel Treister[9]

[1] *Institute of Astronomy, Cambridge University, UK*
[2] *Centre for Extragalactic Astronomy, Durham University, UK*
[3] *Universidad de Concepción, Departamento de Astronomía, Chile*
[4] *School of Physics and Astronomy, University of Southampton, UK*
[5] *Cahill Center for Astrophysics, Caltech, USA*
[6] *Institute for Astronomy, ETH Zurich, Switzerland*
[7] *Jet Propulsion Laboratory, Caltech, USA*
[8] *Space Sciences Laboratory, University of California, Berkeley, USA*
[9] *Instituto de Astrofísica, Pontificia Universidad Católica de Chile, Chile*

New insights into AGNs are being provided by the Nuclear Spectroscopic Telescope Array (NuSTAR), the first focusing telescope with high sensitivity at hard X-ray energies ($E > 10$ keV), and therefore at the peak energies of the cosmic X-ray background (CXB). I will present results from the NuSTAR 40-month serendipitous survey (20 Ms total exposure; 13 sq. degrees), which has yielded a large sample of ≈ 500 hard X-ray sources (primarily AGNs), and will compare with results from targeted NuSTAR samples. A crucial part of the AGN census is to identify and characterise the most highly obscured (Compton-thick) AGNs, which may contribute a large fraction of the overall cosmic growth of black holes, but are normally hidden from view by gas and dust. I will show that NuSTAR is identifying new Compton-thick AGNs, which wouldn't have been identified at other wavelengths. These can inform us about the prevalence of such extreme systems in the general AGN population.

X-Ray Characteristics of Megamaser Galaxies

Katharina Leiter[1,2], Matthias Kadler[1], Joern Wilms[2], Jim Braatz[3], Christoph Grossberger[4], Felicia Krauss[5], Annika Kreikenbohm[2,1], Marcus Langejahn[1,2], Eugenia Litzinger[1,2], Alex Markowitz[6,7]

[1] *Lehrstuhl für Astronomie, Universität Würzburg, Würzburg, Germany*
[2] *Dr. Karl Remeis Sternwarte & ECAP, Universität Erlangen-Nürnberg, Bamberg, Germany*
[3] *NRAO, Charlottesville, USA*
[4] *MPE, Garching, Germany*
[5] *GRAPPA & API , University of Amsterdam, Amsterdam, Netherlands*
[6] *Nicholas Copernicus Astronomical Center (NCAC), Warsaw, Poland*
[7] *Univ. of California, San Diego, Center for Astrophysics and Space Sciences (UCSD/CASS), La Jolla, USA*

Water megamaser galaxies are a rare subclass of Active Galactic Nuclei (AGN). They play a key role in modern cosmology, providing a significant improvement for measuring geometrical distances with high precision. Megamaser studies presently measure H_0 to about 5%. The goal of modern programs is to reach 3%, which strongly constrains the equation of state of dark energy. An increasing number of independent measurements of suitable water masers is providing the statistics necessary to decrease the uncertainties. Studying these objects in X-rays yields important constraints on target-selection criteria for future maser surveys, leading to a higher detection rate. We have studied the X-ray properties of a homogeneous sample of Type 2 AGN with water maser activity observed by XMM-Newton to investigate the properties of megamaser-hosting galaxies compared to a control sample of non-maser galaxies. We find that the X-ray emission in maser galaxies is in general more complex than in non-maser sources. The former exhibit a higher fraction of X-ray absorption and reflection spectra, often to the point of Compton thickness. We also find tentative evidence that the absorption-corrected intrinsic X-ray luminosity plays an important role for the emergence of the megamaser phenomenon in AGN.

Dependence of the broad Fe Kα line on the physical parameters of AGN

Zhu Liu[1,2], Weimin Yuan[1,2], Youjun Lu[2], Francisco Carrera[3], Serena Falocco[4], Xiao-Bo Dong[5,6]

[1] *Key Laboratory of Space Astronomy and Technology, National Astronomical Observatories, CAS, Beijing, China*
[2] *National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China*
[3] *nstituto de F sica de Cantabria (CSIC-UC), Avenida de los Castros, E-39005 Santander, Spain*
[4] *KTH Royal Institute of Technology, Department of Physics and the Oskar Klein Centre, AlbaNova, Stockholm, Sweden*
[5] *Yunnan Observatories, Chinese Academy of Sciences, Kunming, Yunnan 650011, China*
[6] *Key Laboratory for the Structure and Evolution of Celestial Objects, CAS, Kunming, Yunnan, China*

The dependence of the broad Fe K line on the physical parameters of AGN is investigated by applying the X-ray spectra stacking method to a large sample of AGN. A broad line feature is detected ($> 3\sigma$) in the stacked spectra of the high λ_{Edd} sub-sample. The profile of the broad line can be well fitted with relativistic broad line model, with the line energy consistent with highly ionized Fe K line. A model consisting of multiple narrow lines cannot be ruled out, however. We found hints that the Fe K line becomes broader as the λ_{Edd} increases. No broad line feature is shown in the sub-sample of BLS1s, while a broad line might be present, though at low significance, in the sub-sample of NLS1s. Our results indicate that the detection/properties of the broad Fe line may strongly depend on λ_{Edd}, which can be explained if the ionization state and/or truncation radius of the accretion disc changes with λ_{Edd}. The non-detection of the broad line in the BLS1 sub-sample can be explained if the the average EW of the relativistic Fe K line is weak or/and the fraction of sources with relativistic Fe K line is small in BLS1 galaxies.

Spectral-Timing Analysis of the Nearby QSO PG1211+143

Andrew Lobban[1], Ken Pounds[2], James Reeves[1], Simon Vaughan[2]
[1] *Keele University, U.K.*
[2] *University of Leicester, Leicester, U.K.*

I will present the results of a broad-band spectral-timing analysis of PG1211+143; the archetypal source for ultra-fast outflows in AGN. Through the detection of highly-ionized blueshifted absorption lines from Fe K, an ultra-fast outflow is revealed with velocities exceeding 0.1c. A deep 630ks XMM-Newton plus contemporaneous NuSTAR observation has revealed additional complex, multiple-velocity structure in both the soft and hard X-ray bands. The broad-band spectral properties are explored in detail, testing relativistic reflection models and showing that the imprints of physically-realistic wind absorption models are strongly required to match the data in both the soft X-ray and Fe K spectral regions, providing further demonstration of the power of combining the high throughput and resolution of long-look XMM-Newton observations with the unprecedented spectral coverage of NuSTAR. Additionally, I will present complementary timing analysis - in particular, frequency-/energy-dependent X-ray time delays, with well-correlated variations across the XMM-Newton bandpass, with the first detection of a low-frequency hard lag in this source, consistent with the propagating fluctuations model. However, the low-frequency lag behaviour becomes more complex on an inter-orbit basis, suggestive of additional modes of variability. We also detect a high-frequency soft lag peaking at -0.8ks which I discuss in terms of small-scale reverberation.

The AGN activity in a sample of IR Luminous Major Mergers

Nora Loiseau[1], Alessandra de Rosa[2], Stefano Bianchi[3], Tamara Bogdanovich[4], Roberto Decarli[5], Matteo Guanazzi[6], Rubén Herrero-Illana[7], Bernd Husemann[8], Stefanie Komossa[9], Zsolt Paragi[10], Miguel Angel Pérez Torres[11], Enrico Piconcelli[12], Kevin Schawinski[13], Chris Vignali[14]
[1] *XMM-Newton SOC- ESAC/ESA, Spain*
[2] *IAPS, INAF, Italy*
[3] *Uni-Roma 3, Italy*
[4] *Georgia Tech- Physics, USA*
[5] *MPIA, Germany*
[6] *ESTEC/ESA, Netherlands*
[7] *ESO, Chile*
[8] *MPIA-Heidelberg, Germany*
[9] *Germany*
[10] *JIVE, Netherlands*
[11] *IAA, Spain*
[12] *OA-Roma, Italy*
[12] *Physics-ETHZ, Switzerland*
[12] *University of Bologna, Italy*

As part of our study of the nuclear activity in a sample of 70 IR luminous major mergers we obtained XMM-Newton data of 4 more pairs of these galaxies. This is part of our multiwavelength study of the nuclear activity in mergers and groups of galaxies (MAGNA collaboration). Our purpose is to understand in which cases one or both of the galaxies of the major merger would have a massive black hole, and if the interaction stage, or the mass/type of the galaxies have role in the enhanced AGN and/or Starburst activity. X-rays can be the best tool to detect hidden AGN. At present very few mergers of AGN simultaneously active have been detected, most of them serendipitously. We present here the X-ray data of these 4 pairs, which have been selected using their WISE colors as a diagnostic tool. We compare the results for these 8 galaxies with the data of the 33 merging galaxies of this sample previously detected with XMM-Newton or Chandra.

The physical relation between disc and coronal emission in AGN

Elisabeta Lusso[1]
[1] *Centre for Extragalactic Astronomy, Durham University South Road DH1 3LE, UK*

I will present the latest results on our analysis of the non-linear X-ray to UV relation in a sample of ∼550 optically selected quasars from SDSS DR7 cross matched with the latest XMM-*Newton* catalogue 3XMM-DR6. I will show that this correlation is not only very tight, but can be potentially even tighter by including a further dependence on the emission line full-width half maximum. We interpreted this new relation through a very simple, ad-hoc model of accretion disc corona. Our results imply that the $L_{\rm X} - L_{\rm UV}$ relation is the manifestation of an ubiquitous physical mechanism, whose details are still unknown, that regulates the energy transfer from the accretion disc to the X-ray emitting corona in quasars.

Large-amplitude X-ray variability and the accretion disc/corona connection in the Seyfert 1 galaxy PG 1404+226

Labani Mallick[1], Gulab Dewangan[1]
[1] *The Inter-University Centre for Astronomy and Astrophysics, Pune, India*

We present results of a 100 ks XMM-Newton observation of a Seyfert 1 galaxy PG 1404+226 which showed a large-amplitude (a factor of ∼8 in ∼11 ks) X-ray variability during 2016 January. Here we investigate the origin of the soft X-ray excess emission and the disc/corona connection through time-resolved X-ray spectroscopy, root mean square (rms) spectral modelling and UV/X-ray cross-correlation. The UV emission from PG 1404+226 is much less variable (∼4%) compared to the X-ray variability (∼89%) and is observed to lead the X-ray emission by ∼33 ks which can correspond to the sum of the light-crossing time (∼23 ks) between the UV and X-ray emitting regions and the Comptonization timescale (∼9 ks) of the UV seed photons within the hot corona. The X-ray fractional rms spectrum shows an increase in variability with energy and can be fitted only with the blurred reflection model that includes a highly variable intrinsic coronal emission and less variable reflected disc emission. Our broadband spectral-timing analysis imply that the multiple inverse Compton scattering of the UV seed photons produces the primary X-ray emission which is bent down onto the accretion disc due to strong gravity and forms the soft excess emission in PG 1404+226.

Density diagnostics of ionized outflows in active galacitc nuclei

Junjie Mao[1,2], Jelle Kaastra[1,2], Missagh Mehdipour[1], Ton Raassen[1,3], Liyi Gu[1]
[1] *SRON Netherlands Institute for Space Research*
[2] *Leiden Observatory, Leiden University*
[3] *Astronomical Institute Anton Pannekoek", University of Amsterdam*

Ionized outflows in Active Galactic Nuclei are thought to influence their nuclear and local galactic environment. However, the distance of outflows with respect to the central engine is poorly constrained, which limits our understanding of the kinetic power by the outflows. Therefore, the impact of AGN outflows on their host galaxies is uncertain. Given the density of the outflows, their distance can be immediately obtained by the definition of the ionization parameter. Here we carry out a theoretical study of density diagnostics of AGN outflows using absorption lines from metastable levels in Be-like to F-like ions. With the new self-consistent photoionization model (PION) in the SPEX code, we are able to calculate ground and metastable level populations. This enable us to determine under what physical conditions these levels are significantly populated. We then identify characteristic transitions from these metastable levels in the X-ray band. Firm detections of absorption lines from such metastable levels are challenging for current grating instruments. The next generation of spectrometers like X-IFU onboard Athena will certainly identify the presence/absence of these density- sensitive absorption lines, thus tightly constraining the location and the kinetic power of AGN outflows.

Spatially resolved spectroscopy of NGC 4945

Andrea Marinucci[1], Stefano Bianchi[1], Giorgio Matt[1], Emanuele Nardini[2], Guido Risaliti[3]
[1] *Università degli Studi Roma Tre*
[2] *Astrophysics Group, School of Physical and Geographical Sciences, Keele University*
[3] *INAF - Arcetri Observatory*

We present the imaging and spectroscopic analysis of the combined Chandra ACIS-S observations (420 ks long) of one the nearest Compton-thick Seyfert 2 galaxies, NGC 4945 (D=3.7 Mpc, 1 arcsec=18 pc). We performed a spatially-resolved spectroscopy of the circumnuclear environment of the source, picturing the innermost 200 parsecs around the highly absorbed nucleus. While previous studies revealed an extended Iron Ka emission line with the associated reflection continuum, we push this analysis even further, by revealing a spatially variable EW of the neutral iron line and a clump of gas with an intense Fe XXV Ka emission, at a distance d=45 pc from the nucleus. Our findings are in agreement with a clumpy environment and against a homogeneous, monolithic Compton-thick absorber.

Survival of the obscuring torus in the most powerful active galactic nuclei

Silvia Mateos[1], Francisco Carrera[1], Xavier Barcons[1], Almudena Alonso-Herrero[2], Antonio Hernán-Caballero[3], Mat Page[4], Cristina Ramos-Almeida[5,6], Alessandro Caccianiga[7], Takamitsu Miyaji[8], Andrew Blain[9]

[1]*Instituto de Física de Cantabria, CSIC-UC, 39005 Santander, Spain*
[2]*Centro de Astrobiología (CAB, CSIC-INTA), ESAC Campus, E-28692 Villanueva de la Cañada, Madrid, Spain*
[3]*Departamento de Astrofísica, Facultad de CC. Físicas, Universidad Complutense de Madrid, 28040 Madrid, Spain*
[4]*Mullard Space Science Laboratory, University College London, Holmbury St Mary, Dorking, Surrey RH5 6NT, UK*
[5]*Instituto de Astrofísica de Canarias (IAC), E-38205 La Laguna, Tenerife, Spain*
[6]*Departamento de Astrofísica, Universidad de la Laguna (ULL), E-38206 La Laguna, Tenerife, Spain*
[7]*INAF - Osservatorio Astronomico di Brera, via Brera 28, I-20121 Milan, Italy*
[8]*Instituto de Astronomía sede Ensenada, Universidad Nacional Autónoma de México, Km. 103, Carret. Tijuana-Ensenada*
[9]*Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH, UK*

Dedicated searches suggest that the fraction of obscured Active Galactic Nuclei (AGN) decreases substantially with increasing luminosity. To explain these findings receding torus models have often been adopted. I shall present the results of a recent study where we determined the intrinsic fraction of optical type-2 AGN at z<1 and X-ray luminosities from 10^{42} to 10^{45} erg/s. We used a complete X-ray selected sample of 199 AGN, from the Bright Ultrahard XMM-Newton Survey, and the distributions of covering factors of AGN tori derived from CLUMPY torus models. Since these distributions combined over the total AGN population need to match the intrinsic type-2 AGN fraction, we revealed a population of X-ray undetected objects with high-covering factor tori, which are increasingly numerous at higher AGN luminosities. When these "missing" objects are included, we found that Compton-thick AGN account at most for ∼35% of the total population. The intrinsic type-2 AGN fraction is ∼58% and has a weak, non-significant luminosity dependence. Our findings imply that the majority of luminous rapidly-accreting supermassive black holes at z<1 reside in highly-obscured nuclear environments but most of them are so deeply embedded that they have so far escaped detection in X-rays in <10 keV wide-area surveys.

The evidence for a radiatively driven disc-wind in PDS 456

Gabriele Matzeu[1], James Reeves[1,2], Emanuele Nardini[3], Valentina Braito[4], Michele Costa[1], Andrew Lobban[1], Francesco Tombesi[5,6,7]

[1]*School of Physical and Geographical Sciences, Keele University, Keele, UK*
[2]*Centre for Space Science and Technology, University of Maryland, Baltimore County, Baltimore, USA*
[3]*INAF - - Osservatorio Astrofisico di Arcetri, Firenze, Italy*
[4]*INAF - Osservatorio Astronomico di Brera, Merate (LC), Italy*
[5]*X-ray Astrophysics Laboratory, NASA/Goddard Space Flight Center, Greenbelt, USA*
[6]*Department of Astronomy, University of Maryland, College Park, USA*
[7]*Dipartimento di Fisica, Universita' di Roma Tor Vergata, Roma, Italy*

We present a new result, where we find a direct correlation between the disc-wind outflow velocity and the luminosity in the nearby ($z = 0.184$) luminous ($L_{\rm bol} \sim 10^{47}\,{\rm erg\,s^{-1}}$) quasar PDS 456. We analysed all the contemporary *XMM-Newton*, *NuSTAR* and *Suzaku* observations between 2001–2014. We find that the centroid energy of the blue-shifted Fe K profile increases with luminosity. This translates into a positive correlation between the disc-wind outflow velocity and the hard X-ray luminosity, where the wind velocity increases as $v_{\rm w} \propto L^{1/4}$. We show that this is consistent with a wind that is predominately radiatively driven in PDS 456, possibly resulting from its high Eddington ratio.

Chasing obscuring outflows in AGN: discovery in NGC 3783

Missagh Mehdipour[1], Jelle Kaastra[1], Gerard Kriss[2], Massimo Cappi[3], Elisa Costantini[1], Ehud Behar[4], Pierre-Olivier Petrucci[5], Junjie Mao[1], Uria Peretz[4], NGC 3783 team
[1]*SRON Netherlands Institute for Space Research, Utrecht, the Netherlands*
[2]*Space Telescope Science Institute, Baltimore, USA*
[3]*INAF-IASF, Bologna, Italy*
[4]*Technion-Israel Institute of Technology, Haifa, Israel*
[5]*CNRS, IPAG, Grenoble, France*

In 2016 we carried out a Swift monitoring program to track the X-ray hardness variability of eight Seyfert-1 AGN over a year. The purpose of this monitoring was to look for intense X-ray spectral hardening events caused by obscuration, and thereby trigger joint XMM-Newton, NuSTAR, and HST observations of these rare events. This was successfully accomplished for NGC 3783 in December 2016. We found heavy X-ray absorption produced by an obscuring wind in this AGN. As a result of this obscuration, new interesting spectral features appear in the UV and X-ray spectra, which are not present in the previous epochs. Our analysis shows that the obscuring wind partially covers the central source with a column density of few 10^{23} cm^{-2}, outflowing with a velocity of few thousand km s^{-1}. The obscuration in NGC 3783 is variable and lasts for about a month, during which the covering fraction and column density of the wind change. This obscuring wind, likely located near the disk/BLR, is different from the commonly-seen warm-absorber winds. We discuss the origin, role, and implications of such obscuring winds in AGN.

Reverberation Mapping Quasars: X-ray and broadband SED properties

Andrea Merloni[1], Torben Simm[1], Kirpal Nandra[1], Paul J. Green[2]
[1]*Max-Planck Institute for Extraterrestrial Physics*
[2]*Harvard Smithsonian Center for Astrophysics*

An ongoing SDSS reverberation mapping (RM) program (Shen et al. 2015) provides significantly improved black hole mass estimates for a large sample of QSOs out to redshift $\sim$3 in a single 7 square degree field. A recently approved large XMM-Newton program will complete the X-ray coverage of the field, contributing to a unique legacy sample of hundreds of QSOs with accurately measured bolometric luminosity, spectral energy distributions, Eddington ratios and variability properties. As illustration, we present here the X-ray spectral properties of the RM-QSOs derived from the analysis of all existing XMM-Newton and deep Chandra (AEGIS field) observations of the field. Taking advantage of the unprecedented multi-band, multi-epoch imaging and spectroscopy provided by the SDSS-RM campaign, the Pan-STARRS1 medium deep survey and the GALEX time domain survey we study in detail their instantaneous broadband spectral energy distributions to obtain accurate measures of the bolometric luminosity and to test accretion disk models. This data set allows us to dissect correlations between optical/X-ray spectral properties with black hole mass and Eddington ratio, as well as to constrain evolution of the radiative efficiency providing a first handle on black hole spin evolution in a large, statistical sample of AGN.

Multi-wavelength campaign on NGC 7469: The broad-band X-ray spectrum

Riccardo Middei[1]
[1] *Università Roma Tre*

We conducted a multiwavelength six-month campaign to observe the nearby Seyfert galaxy NGC 7469 using several observatories. We report the results of the spectral analysis of the 7 simultaneous XMM-Newton and NuSTAR observations. The source shows a remarkable flux variability between and during the 7 observations, both in the soft and the hard X-ray bands. The smallest variability timescale is only a few ks. Both phenomenological and physically motivated Comptonization and reflection models are used to describe the broad-band (UV/hard X-ray) spectrum of this rich data-set. We derive physical and geometrical constraints on the inner engine and the circumnuclear matter in NGC 7469 by combining the spectral and variability results obtained.

Hitomi Observations of NGC 1275: The First X-ray Microcalorimeter Spectroscopy of Fe-Kα Lines from an Active Galactic Nucleus

Hirofumi Noda[1], Yasushi Fukazawa[2], Richard F. Mushotzky[3], The *Hitomi* collaboration[4]
[1] *Tohoku University, Miyagi, Japan*
[2] *Hiroshima University, Hiroshima, Japan*
[3] *University of Maryland, College Park, USA*
[4] *Various Institutes and Universities*

The origin of the narrow Fe-Kα fluorescence line at 6.4 keV from active galactic nuclei has long been under debate; possibilities are the outer accretion disk, the broad line region (BLR), a molecular torus or the interstellar medium? In February–March 2016, we performed the first X-ray spectroscopy with the microcalorimeter onboard the *Hitomi* satellite of the FR I radio galaxy NGC 1275. With the high energy resolution of ~ 5 eV at 6 keV achieved by *Hitomi*, we detected the Fe-Kα line with high significant, finding an equivalent width ~ 25 eV, and velocity width in the range 500–1400 km/s (FWHM). Because it is narrower than that of broad Hα line of ~ 2750 km/s (Ho et al. 1997), we exclude a large contribution from the accretion disk and BLR. Furthermore, by utilizing imaging analyses and Monte Carlo simulations, we found that Fe-Kα intensity from molecular filaments in the intracluster medium (Salome et al. 2006) is too low. Therefore, we suggest that the source of the Fe-Kα line from NGC 1275 is likely a molecular torus or a rotating molecular disk which extends to hundreds pc (Scharwarchter et al. 2013).

X-ray radio galaxies

Francesca Panessa[1]
[1] *IAPS/INAF, Rome, Italy*

I will present our latest results on a sample of radio galaxies selected at hard X-rays, derived from the INTEGRAL/IBIS and Swift/BAT AGN catalogues. They represent nearly 7-10% of the total AGN population and are characterized by high 20-100 keV luminosities and high Eddington ratios. The radio morphology is typical of FRII galaxies and all of them have an optical classification. For all of them we have an accurate measure of the column density obtained from broad-band spectra (XMM, Chandra, Swift/XRT data combined with IBIS and BAT spectra). We have investigated the role of absorption in AGN with jets, studying their X-ray column density distribution. The observed fraction of absorbed AGN is around 40% among the total sample, and nearly 75% among type 2 AGN. The observed fraction of Compton thick AGN is only 2-3%. Interestingly, nearly 20% of hard X-ray selected radio galaxies are Giant (size larger than 0.7 Mpc), compared to the less than 6% usually found in radio or optically selected sample. A sensible fraction of these old systems experiences episodes of restarting activity. These results will be discussed within the frame of unified and evolutionary models.

Tracing the accretion history of supermassive Black Holes through X-ray variability

Maurizio Paolillo[1]
[1] *Università di Napoli Federico II*

Using the 7Ms observations of the Chandra Deep Field South spanning more than 15 years, we study the variability properties of high-redshift AGNs. We show that distant supermassive Black Holes behave similarly to nearby sources, possessing a red noise PDS with a possible break at high frequencies. We test different models to describe the X-ray variability showing that the observations favour a dependence of the variability on both BH mass and accretion rate. Using this result we trace for the AGN accretion history up to $z \sim 3$ finding that it is consistent with values obtained by different tracers, suggesting an almost constant Eddington rate with a tentative slight increase at $2 < z < 3$. We discuss the future improvements that will be allowed by enlarging the current samples of AGN and by large monitoring programs.

Rapidly variable relatvistic absorption

Michael Parker[1]
[1] *Institute of Astronomy, Cambridge, UK*

I will present results from the 1.5Ms XMM-Newton observing campaign on the most X-ray variable AGN, IRAS 13224-3809. We find a series of six absorption lines with a velocity of 0.24c from an ultra-fast outflow. For the first time, we are able to see extremely rapid variability of the UFO features, and can link this to the X-ray variability from the inner accretion disk. We find a clear flux dependence of the outflow features, suggesting that the wind is ionized by increasing X-ray emission.

A Radio Jet Regulated by an Accretion Disk Following a Stellar Tidal Disruption Flare

Dheeraj R. Pasham[1], Sjoert van Velzen[2]
[1] *MIT*
[2] *Johns Hopkins University*

A tidal disruption flare occurs when a star comes too close to a massive black hole and gets shredded by its tidal forces. A recent flare, ASASSN-14li, has been dubbed the Rosetta stone for thermal tidal disruption flares. One of the remarkable aspects of this source is the detection of a radio flare coincident with its X-ray flare. While the X-rays likely originate from an inner accretion flow, the origin of the radio emission is still actively debated. Previous studies have ascribed the radio emission to synchrotron radiation from the interaction of the freely expanding ejecta with the ambient medium. However, we find that (1) the 16 GHz radio brightness fluctuations are correlated with the X-ray flux changes, and (2) these radio fluctuations lag the X-ray changes by about 13 days. This accretion–jet coupling is inconsistent with all previous models that involve freely expanding shocks. In this talk, I will discuss the implications of this coupling for the origin of its radio emission and the importance of similar observations in the future to understand how jets evolve in their earliest stages.

X-raying the most luminous quasars at cosmic noon

Enrico Piconcelli[1], WISSH Collaboration[2]
[1] *INAF - Osservatorio Astronomico di Roma, Italy*

The WISE/SDSS hyper-luminous (log L_Bol > 47) quasar (WISSH) survey is performing a multi-band systematic exploration of the most luminous AGN shining at the golden epoch of AGN activity (i.e. z $\sim$ 2-4). This gives the opportunity of overcoming the luminosity bias in the exploration of the accretion phenomenon and the impact of AGN radiative output on the host. In this talk, I present the results of our study of the X-ray spectra of 40 WISSH quasars. I report on the correlations between the X-ray and Optical, UV and MIR properties, and the behavior of the X-ray bolometric correction at the brightest end of the luminosity function. I discuss the relative X-ray weakness of these very powerful quasars compared to less luminous AGN. This X-ray weakness can be a key ingredient for accelerating powerful ionized outflows (ubiquitously revealed in the UV/optical spectra of WISSH quasars) and, furthermore, radiation-driven winds can be effective in destroying the X-ray corona and quenching the X-ray emission. The potential offered by Athena in studying this extreme class of AGN is also discussed.

A deep X-ray view of the bare nucleus Seyfert Ark120: unveiling the core of AGN

Delphine Porquet[1]
[1] *Observatoire Astronomique de Strasbourg, Strasbourg, France*

The physical characteristics of the matter around supermassive black hole (SMBH) are currently determined thanks to X-ray observations. However, the origins of the main X-ray spectral components such as the soft X-ray excess, the FeK line complex and the hard X-ray excess are still highly debated. This is difficult to investigate in AGN which show a significant warm absorber that severely distort the continuum. Therefore, AGN which show no (or very weak) warm absorption on the line-of-sight, the so-called "bare AGN" are the best targets to probe the processes at work very close to the SMBH. I will present the first results from an extensive observation campaign (XMM-Newton Large Program, Chandra/HETG, NuSTAR) of Ark120 that is the brightest and cleanest bare AGN known so far. I will focus on the analysis of the deep RGS spectrum, as well as on the X-ray broad band spectrum.

Probing the Properties of AGN Clustering in the Local Universe with Swift-BAT

Meredith Powell[1], Nico Cappelluti[1], Meg Urry[1], Michael Koss[2], Viola Allevato[3], Marco Ajello[4]
[1] *Yale Center for Astronomy and Astrophysics, Yale University, New Haven, CT, USA*
[2] *Department of Physics, ETH Zurich, Zurich, Switzerland*
[3] *Department of Physics, University of Helsinki, Helsinki, Finland*
[4] *Department of Physics and Astronomy, Clemson University, Clemson, SC, USA*

I present the benchmark measurement of AGN clustering in the local universe with the all-sky Swift-BAT survey. The hard X-ray selection (14-195 keV) allows for the detection of some of the most obscured AGN, providing the largest, most unbiased sample of local AGN to date. We derive for the first time the halo occupation distribution (HOD) of the sample in various bins of black hole mass, accretion rate, and obscuration. In doing so, we characterize the cosmic environment of growing supermassive black holes with unprecedented precision, and determine which black hole parameters depend on environment. We then compare our results to the current evolutionary models of AGN.

The Soft X-ray View of Ultra Fast Outflows

James Reeves[1,2], Valentina Braito[1,3], Emanuele Nardini[2,4], Gabriele Matzeu[2,3], Andrew Lobban[2], Michele Costa[2], Ken Pounds[5], Francesco Tombesi[6], Ehud Behar[7]
[1] *University of Maryland, Baltimore County*
[2] *Keele University*
[3] *INAF/Brera*
[4] *INAF/Arcetri*
[5] *University of Leicester*
[6] *University of Maryland, College Park*
[7] *Technion*

The recent large XMM-Newton programmes on the nearby quasars PDS 456 and PG 1211+143 have revealed prototype ultra fast outflows in the iron K band through highlyblue shifted absorption lines. The wind velocities are in excess of 0.1c and are likely to make a significant contribution to the host galaxy feedback. Here we present evidence for the signature of the fast wind in the soft X-ray band from these luminous quasars,focusing on the spectroscopy with the RGS. In PDS 456, the RGS spectra reveal the presenceof soft X-ray broad absorption line profiles, which suggests that PDS 456 is an X-ray equivalent to the BAL quasars, with outflowvelocities reaching 0.2c. In PG 1211, the soft X-ray RGS spectra show a complex of several highlyblue shifted absorption lines over a wide range ofionisation and revealoutflowing components with velocities between 0.06-0.17c. For both quasars, the soft X-ray absorption is highly variable, even on timescales of days and is mostprominent when the quasar flux is low. Overall the results imply the presence of a soft X-ray component of theultra fast outflows, which we attribute to a clumpy or inhomogeneous phase of the disk wind.

AllWISE counterparts to ROSAT and XMMSlew surveys done using NWAY (An accurate algorithm to pair sources simultaneously between N catalogs)

Mara Salvato[1], johannes Buchner[2], Tamas Budavari[3], Tom Dwelly[1], Andrea Merloni[1], Paul Nandra[1], Many More[4]

[1] *MPE, Max-Planck institute for extraterrestrial Physics, Garching, Germany*
[2] *UC, Pontificia Universidad Catolica de Chile, Santiago, Chile*
[3] *JHU, Johns Hopkins University, Baltimore, USA*
[4] *MP, Many Places, Cities, Countries*

At the end of the mission, the eROSITA All-sky X-ray survey will provide the community with about 4 million of point-like sources, down to a limit of $10^{-14} erg/cm^2/s$ in the soft band and $2\text{x}10^{-13} erg/cm^2/s$ in the hard band. The brightest sources however have been already observed by ROSAT, but have been rarely used due to the large uncertainties in their positions, thus making the identification of their right multi-wavelength counterparts a demanding task with uncertain results. New all-sky Optical and IR surveys like GAIA and WISE allow us, for the first time, to provide reliable counterparts to all ROSAT sources, thanks also to the development of a new algorithm, NWAY, based on Bayesian statistic and adoption of color-magnitude priors. This paves the way to new programs of complete characterization of the bright X-ray sky, such as the SDSS-IV/SPIDERS survey started in 2014. In this talk I will briefly present the code and the multiwavelength properties of ROSAT and XMMSLEW counterparts.

The short and long-term variability of the warm absorber in I Zwicky 1

Catia Silva[1,2], Elisa Costantini[2]

[1] *Anton Pannekoek Institute for Astronomy, Amsterdam*
[2] *SRON Netherlands Institute for Space Research, Utrecht*

I Zwicky 1 is a luminous and nearby narrow-line Seyfert 1 galaxy. Previous observations with XMM-Newton revealed ionized absorption by two outflowing gas components which show a puzzling behavior across the years, in apparent contrast with the common knowledge of these systems. Here, we present the results of the multi-wavelength campaign on I ZW 1 which combines simultaneous HST and XMM-Newton observations. Detailed modeling of these data revealed a complex and variable multi-phase ionized absorber which cannot be understood under classical warm absorber models. We find the outflowing gas to be interestingly variable both in short (ks) and long (years) timescales. This variability instead hints at a close connection between the two gas components, possibly both directly made from the accretion disk material.

XZ: X-ray spectroscopic redshifts of obscured AGN

Charlotte Simmonds[1], Johannes Buchner[1,2]
[1] *Pontificia Universidad Católica de Chile, Instituto de Astrofísica, Santiago, Chile*
[2] *Millenium Institute of Astrophysics, Santiago, Chile*

Redshifts are fundamental for our understanding of extragalactic X-ray sources. Ambiguous counterpart associations, expensive optical spectroscopy and/or multi-mission multiwavelength coverage to resolve degeneracies make estimation often difficult in practice.

Here we present a new method to constrain redshifts from the full X-ray spectrum directly, by Bayesian model fitting of low-resolution spectra. We demonstrate our approach on real Chandra Deep Field South data, determining 29 redshifts which have optical spectroscopic redshifts. Our accuracy is up to Δz=0.5, with only three outliers which can be explained by incorrect optical associations.

Through extensive simulations we verify the method. To work optimally, AGN need be obscured and have at least ∼200 (XMM-Newton) or ∼150 (Chandra/ACIS) counts. Not meeting these conditions does not lead to wrong redshifts, only large uncertainties.

We conclude with predictions for the upcoming eROSITA and ATHENA missions.

X-ray study of the environmental impact on the initial stages of a radio source evolution

Malgosia Sobolewska[1], Aneta Siemiginowska[1], Giulia Migliori[2], Matteo Guainazzi[3], Martin Hardcastle[4], Luisa Ostorero[5], Lukasz Stawarz[6]
[1] *SAO*
[2] *CEA-Saclay*
[3] *European Space Research and Technology Centre*
[4] *University of Hertfordshire*
[5] *Universita degli Studi di Torino and Istituto Nazionale di Fisica Nucleare*
[6] *Astronomical Observatory of Jagiellonian University*

Compact Symmetric Objects (CSOs) are thought to be among the progenitors of large-scale radio galaxies. They show radio features typically observed in large-scale radio galaxies (jets, lobes, hot spots), but contained within the central 1 kpc region of the host galaxy. Because the CSOs are symmetric and not affected by beaming, their linear radio size can be translated into the source age if one measures the expansion velocity of the radio source. However, if the jet expansion is disturbed, e.g. by a dense interstellar medium (ISM), the ages derived this way may be biased. Until now we did not have means to discriminate between confined and non-confined radio sources. We present our X-ray studies of CSOs performed with XMM-Newton and Chandra. For the first time, the data reveal the evidence in favor of the hypothesis that in a sub-population of CSOs the medium is Compton Thick and the radio jets may be confined. Thus their kinematic ages may be underestimated. We discuss the implications of our results on the high energy emission models of CSOs, the earliest stages of the radio source evolution, jet interactions with the ISM, diversity of the environments in which the jets expand, and jet-galaxy co-evolution.

Searching for tidal disruption events at an unexplored wavelength

Sébastien Soler[1,2], Natalie Webb[1,2], Richard Saxton[3]
[1] *Université de Toulouse, UPS-OMP, IRAP, Toulouse, France*
[2] *CNRS, IRAP, 9 av. du Colonel Roche, BP 44346, F-31028 Toulouse Cedex 4, France*
[3] *XMM SOC, ESAC, Apartado 78, 28691 Villanueva de la Cañada, Madrid, Spain*

When a star approaches too close to a black hole, the star can be torn apart by the gravitational forces and approximately half the matter falls towards the black hole, causing the luminosity to increase by several orders of magnitude. Such an event is known as a tidal disruption event (TDE). These events can help us locate black holes which would be otherwise to faint to be detected and help us understand the mass function of these objects.

To date only a small sample of candidate TDEs have been detected ($\sim$65), either in the optical or in soft X-rays. However, four TDEs have been observed with hard X-ray spectra. In order to determine if these hard TDEs are the result of a different mechanism to those detected at lower energy, we search for similar events in the 3XMM catalogue. Using spectral and timing characteristics determined from the hard TDEs and cross-correlating 3XMM with other catalogues, we have developed a methodology with which to identify new hard TDEs. In this poster we describe the characteristics used to search for previously undiscovered hard TDEs and present the results of this search and the resulting constraints on the central mechanism in TDEs.

MoCA: A Monte Carlo code for Comptonization in Astrophysics

Francesco Tamborra[1]
[1] *Astronomical Institute of the Czech Academy of Sciences*

Comptonization (i.e. photon up-scattering by hot electrons) is a common process in Astrophysics. In accreting sources such as AGN and X-ray binaries it is particularly relevant and believed to be responsible for the observed hard X-ray component of their spectrum: soft photons produced by the accretion disc are Comptonized by a corona of hot electron whose main properties such as energy, optical thickness and geometry are mostly unknown. In the framework of this scenario we developed MoCA: a self-consistent Monte Carlo code for Comptonization which includes polarization, an ideal tool for discriminating the geometry of such coronae. In the talk we will show the results obtained by our code with particular emphasis on the expected X-ray polarization signal obtained for different geometries in the light of possible X-ray polarimetry future missions such as the M4 ESA candidate XIPE.

NuSTAR spectral analysis of the two bright Seyfert 1 galaxies: MCG +8-11-11 and NGC6814.

Alessia Tortosa[1]
[1] *University Roma Tre*

Nuclear Spectroscopic Telescope Array(*NuSTAR*) recently performed an observation of two bright Seyfert 1 galaxies, namely MCG +8-11-11 (100 ks) and NGC 6814 (150 ks). The goal of these observations is to investigate the Comptonization mechanisms acting in the innermost regions of AGN which are believed to be responsible for the UV/X-ray emission.
MCG +8-11-11 and NGC 6814 are two very bright nearby Seyfert galaxies with a mass of 1.2×10^8 and 1.9×10^7 solar masses respectively and Eddington ratio of 0.35 and 0.008 respectively.
Here we present the results of the spectroscopic analysis of the NuSTAR spectra of these two sources. We show that we have been able to measure the primary emission with high accuracy, disentangling it from the relativistic reflection component, in both sources. This is fundamental to investigate the relationship between the hot corona parameters and other quantities like e.g. the accretion rate and the accretion disk parameters.

Multi-wavelength observations of the high-redshift blazar 4C+71.07

Stefano Vercellone[1]
[1] *INAF - Osservatorio Astronomico di Brera, Via E. Bianchi 46, 23807 Merate (LC), Italy*

The flat-spectrum radio quasar 4C+71.07 has been detected by the AGILE gamma-ray satellite on 2015 October 27–29 and 2015 November 08–10, when it reached a gamma-ray flux (E > 100 MeV) of the order of 1.2×10^{-6} ph cm^{-2} s^{-1} and 3.1×10^{-6} ph cm^{-2} s^{-1}, respectively. Because of its relatively high redshift ($z = 2.172$), this blazar shows a prominent accretion disc bump peaking in the ultra-violet band, which makes this source an excellent candidate to investigate not only the jet emission but also the non thermal one. We investigated its spectral energy distribution by means of almost simultaneous observations covering the cm, mm, near-infrared, optical, ultraviolet, X-ray and gamma-ray energy bands obtained by the GASP-WEBT Consortium, *Swift*, and AGILE satellites. We present the spectral energy distribution of the gamma-ray flare whose energy coverage is more dense, modelling it by means of a one-zone leptonic model.

A quadruple quasar coincident with a giant Lyα nebula and a protocluster at z=2

Cristian Vignali[1,4], Joe Hennawi[2], Enrico Piconcelli[3], Roberto Gilli[4], Elisabeta Lusso[5], Fabrizio Arrigoni-Battaia[6], Xavier Prochaska[7]

[1] *Dipartimento di Fisica e Astronomia, Universita' di Bologna, Italy*
[2] *Max-Planck-Institut fuer Astronomie, Heidelberg, Germany*
[3] *INAF - Osservatorio Astronomico di Roma, Italy*
[4] *INAF - Osservatorio Astronomico di Bologna, Italy*
[5] *Centre for Extragalactic Astronomy, Durham, UK*
[6] *ESO, Garching, Germany*
[7] *University of California, Santa Cruz, US*

The recent discovery of a quadruple AGN non-lensed system embedded in a giant and luminous Lyα nebula at z=2, coupled with the presence of a > 20 overdensity of Lyα emitters (LAEs) at the same redshift, has opened a new observational window in terms of tracing proto-clusters at high redshift. A 140ks Chandra observation of the SDSSJ0841+3921 field has allowed us to characterize the X-ray emission of the four AGN (one being a Type 2 AGN) plus one additional AGN associated with a LAE, and to compare their properties with those of isolated AGN at the same redshift. We report also on the tentative detection of diffuse X-ray emission at the position of the extended Lyα emission.

The Radio to Gamma-ray SED of the Narrow-line Seyfert 1 1H0323+342

Martin Ward[1]

[1] *Physics Department, Durham University, England*

A sub-set of radio-loud narrow line Seyfert 1s, have been detected in gamma-rays by the Fermi Gamma-Ray satellite. Their gamma-ray emission is thought to arise from a relativistic jet. We have obtained new near-infrared spectra and used the profiles of the Paschen lines to estimate the mass of the black hole. Combining this with results from optical lines and X-ray timing analysis we arrive at a value of 2 x 10**E7 solar masses. From modelling the broad-band SED, we drive an Eddington ratio of 0.5, rising to 1.0 for a spinning black hole (a=0.8). Furthermore, we constrain the external photon field, and use a single-zone leptonic jet model to obtain a range of jet-parameters which are consistent with Compton up-scattering to produce the observed gamma-ray spectrum. This low-redshift very well studied AGN can potentially provide a useful laboratory to further our understanding of the jet/disc connection in extragalactic sources.

Investigating the origin of X-ray variability through XMM-Newton and WISE data

Alessandra Zaino[1,2], Cristian Vignali[1,3], Paola Severgnini[2], Roberto Della Ceca[2], Lucia Ballo[4]
[1] *University of Bologna-DIFA*
[2] *INAF-OABrera*
[3] *INAF-OABo*
[4] *XMM-Newton SOC ESA (Spain)*

An efficient diagnostic method to find local (redshift lower than 0.1) Compton-thick AGN consists in selecting sources characterized by hard X-ray colors and low X-ray to mid-IR flux ratio (HR vs. Fx/FIR). This has been done efficiently in the past using 2XMM and IRAS data (Severgnini et al. 2012). In this contribution I will summarize my master thesis work, in which I tested the stability of the HR vs. Fx/FIR diagram using the latest 3XMM and WISE data and I investigated its potentialities in finding interesting spectrally variable (including changing-look) XMM-Newton sources.

A new detection of an UFO in the X-ray spectrum of a lensed QSO

Mauro Dadina[1]
[1] *INAF/IASF Bologna*

The discovery of the "$M_{SMBH} - \sigma$ relation" indicated that a connection between the central black-hole and the hosting galaxies acted during the cosmic time. With the discovery in X-rays of the ultra-fast outflows in nearby AGN, we have most probably probed one of the ingredients that are needed to build-up this mechanism. At high-z, however, such measurements were possible only in an handful of objects and this was possible mainly for the presence of gravitational lenses that magnified otherwise X-ray weak QSO. Following this, we proposed a program to use XMM-Newton and gravitational lenses as telescopes to point bright, lensed and distant QSO to characterize in detail their X-ray spectrum and to detect blushifted absorption lines at E$\sim$7-10 keV (rest frame). Here we present the preliminary results obtained for the z=2.64 QSO MG J0414+0534.

X-ray spectroscopy of polar-scattered Seyfert 1 galaxies

Romana Mikušincová[1], Jiri Svoboda[2]
[1] *Institute of Theoretical Physics, Faculty of Mathematics and Physics, Charles University in Prague*
[2] *Astronomical Institute of the Czech Academy of Sciences, Prague, Czech Republic*

We present a spectral re-analysis of Fairall 51, which is optically a Seyfert 1 galaxy. It does, however, show a very strong polarization in the optical spectrum and as this feature is not characteristic for Seyfert 1 objects, this galaxy may represent a borderline object between Seyfert 1 and Seyfert 2 galaxies and provide with valuable information about the structure of Active Galactic Nuclei. We present results from a study of two archival sets of observations performed in September 2005 and March 2006 by the European satellite XMM-Newton and four observations performed in September 2013 by the Japanese observatory Suzaku. It follows from the spectral analysis that there are at least two or three ionized absorbers in the studied AGN. Based on the spectral variability, we were also able to estimate the location of the variable absorber which appears to be 3 to 60 light days from the central engine, which indicates its origin in the Broad Line Region.

Chapter 13

Special Session: Accretion and Emission Close to the Event Horizon

Contribution of higher order images of accretion disks to relativistic iron lines in the strong deflection limit

Giulio Francesco Aldi[1,2]
[1] *Università degli Studi di Salerno*
[2] *INFN Sezione di Napoli, Gruppo collegato di Salerno*

The shapes of relativistic iron lines observed in spectra of candidate black holes carry the signatures of the strong gravitational fields in which the accretion disks lie. These lines result from the sum of the contributions of all images of the disk created by gravitational lensing, with the direct and first-order images largely dominating the overall shapes. Higher order images created by photons tightly winding around the black holes are often neglected in the modeling of these lines, since they require a substantially higher computational effort. With the help of the strong deflection limit, we present the most accurate semi-analytical calculation of these higher order contributions to the iron lines for Schwarzschild black holes. We show that two regimes exist depending on the inclination of the disk with respect to the line of sight. Many useful analytical formulae can be also derived in this framework.

Testing the Lamp Post Geometry with Relativistic Reflection

Thomas Dauser[1], Javier Garcia[1,2,3], Jörn Wilms[1], Tim Kallman[4]
[1] *Dr.-Karl-Remeis-Sternwarte & ECAP, Universität Erlangen-Nürnberg, Sternwartstrasse 7, 96049, Bamberg, Germany*
[2] *Cahill Center for Astronomy and Astrophysics, California Institute of Technology, Pasadena, CA 91125, USA*
[3] *Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA*
[4] *X-ray Astrophysics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA*

Measurements of relativistic reflection from black holes have shown that in most cases the primary X-ray component producing this reflection is compact and located close to the black hole. Naturally, the emissivity profile as well as the timing properties are well explained by the idealized lamp post geometry, which assumes a point source above the black the hole. However, the actual extent and origin of this primary component is still largely unknown. We will show the implications for the reflected and primary spectrum when assuming such a geometry and how this information can be used to test it. For this purpose, we also present a completely revised reflection model `relxill`, which resolves previous limitations of a single input spectrum and constant ionization over the complete disk, since these properties are in fact expected to change strongly. We will show the ionization gradients predicted by our model in the lamp post geometry, and how such a gradient affects the relativistic reflection spectrum.

On the accuracy of reflection-based SMBH spin measurements

Elias Kammoun[1], Guido Risaliti[2,3], Emanuele Nardini[3]
[1] *SISSA, via Bonomea 265, Trieste, Italy*
[2] *University of Floremce, via G. Sansone 1, Sesto Fiorentino, Florence, Italy*
[3] *INAF - Astrophysical Observatory of Arcetri, Largo E. Fermi 5, Florence, Italy*

The spin is one of the fundamental observable properties of black holes (BHs). Among the various methods used to measure BH spins, the detection of a strong relativistic reflection component in the X-ray spectra is potentially the most powerful, and it has been shown to provide robust results in the least obscured sources. We aim to test, through the simulation of high-quality *XMM-Newton* and *NuSTAR* spectra, how reliable the BH spin measurements that can be currently achieved are in the most general case. Each of the three members of our group simulated several spectra with multiple components that are typically seen in AGNs, such as neutral and warm absorbers, neutral reflection, and thermal emission, plus a relativistic reflection. Then everyone performed blind fits of the spectra produced by the other two members. We show that, in spite of their quality, *single-epoch* observations mostly return poor constraints on the actual BH spin value, and we discuss the possible impact of Athena in this field and how these limitations can be overcome.

Binary black hole embedded in an external magnetic field as site of particle acceleration

Vladimir Karas[1], Ondrej Kopacek[1], Devaky Kunneriath[2], Michal Zajacek[3,4], Silke Britzen[4], Andreas Eckart[3,4]
[1] *Astronomical Institute, Czech Academy of Sciences, Bocni II, CZ-14100 Prague, Czech Republic*
[2] *National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville 22903, VA, USA*
[3] *I. Physikalisches Institut, Universitaet zu Koeln, Zuelpicher Strasse 77, D-50937 Cologne, Germany*
[4] *Max-Planck-Institut fuer Radioastronomie, Auf dem Huegel 69, D-53121 Bonn, Germany*

Black holes can form a compact binary system where the orbital motion reaches a significant fraction of velocity of light. This can bring a black hole into a region of enhanced magnetic field. We demonstrate that a black hole transiting across such a large-scale magnetic filament induces an electric component, which then accelerates electrically charged particles in the inner magnetosphere. We identify the location of the acceleration point near the ergosphere boundary of the black hole as a function of its linear velocity (translatory boost). Members of the binary black-hole system in a tight orbit around each other should exhibit this effect at greater efficiency.

The relativistic Fe Kα line in Seyfert 1 galaxies

Giulia Mantovani[1], Kirpal Nandra[1], Gabriele Ponti[1]
[1] *Max Planck Institute für Extraterrestrische Physik, Garching, Germany*

Relativistic iron lines (Fe Kα) are expected to be an ubiquitous feature in bright AGN. However, a significant fraction of object misses a relativistic line component. We investigated the physical reasons of its absence. To this aim we studied a sample of Seyfert 1 galaxies where controversial results on the presence of a relativistic line have been previously reported. I will show that high statistics is key to reveal the line: the relativistic Fe Kα line is detected at $\geq$95% confidence level in observations where the counts in the 5-7 keV energy band are $\geq 4 \times 10^4$. We also investigated the relationship between the relativistic Fe line and the high energy reflection continuum in NGC 4051. By taking advantage of the unprecedented quality of NuSTAR data, our analysis showed consistency between these features as expected from the standard reflection model in AGN.

Evidence for a decay of the faint flaring rate of Sgr A* from 2013 Aug., 13 months before a rise of the before a rise of the bright one

Enmanuelle Mossoux[1,2], Nicolas Grosso[1]
[1] *Observatoire astronomique de Strasbourg, Université de Strasbourg, France*
[2] *Groupe dAstrophysique des Hautes Energies,Institut dAstrophysique et de Géophysique,Université de Liège,Liège,Belgique*

Thanks to the overall 1999-2015 Chandra, XMM-Newton and Swift observations of the supermassive black hole at the center of our Galaxy, Sgr A*, we tested the significance and persistence of the increase of "bright and very bright" X-ray flaring rate (FR) argued by Ponti et al. (2015). We detected the flares observed with Swift using the binned light curves whereas those observed by XMM-Newton and Chandra were detected using the two-steps Bayesian blocks (BB) algorithm with a prior number of change-points properly calibrated. We then applied this algorithm on the flare arrival times corrected from the detection efficiency computed for each observation thanks to the observed distribution of flare fluxes and durations. We confirmed a constant overall FR and a rise of the FR for the faintest flares from 2014 Aug. 31 and identified a decay of the FR for the brightest flares from 2013 Aug. and Nov. A mass transfer from the Dusty S-cluster Object/G2 to Sgr A* is not required to produce the rise of bright FR since the energy saved by the decay of the number of faint flares during a long time period may be later released by several bright flares during a shorter time period.

Multiwavelength study of the flaring activity of Sagittarius A* in 2014 FebruaryApril

Enmanuelle Mossoux[1,2], Nicolas Grosso[1], Howard Bushouse[3], Andreas Eckart[4,5], Farhad Yusef-Zadeh[6], Dick Plambeck[7], Florian Peissker[4], Monica Valencia-S.[4], Delphine Porquet[1], Doug Roberts[6]

[1] *Observatoire astronomique de Strasbourg, Université de Strasbourg, Strasbourg, France*
[2] *Groupe dAstrophysique des Hautes Energies, Institut dAstrophysique et de Géophysique, Liège,Belgium*
[3] *Space Telescope Science Institute (STScI), 3700 San Martin Drive, Baltimore, MD 21218, USA*
[4] *Physikalisches Institut der Universitat zu Koln, Zulpicher Str. 77, 50937 Koln, Germany*
[5] *Max-Planck-Institut fur Radioastronomie, Auf dem Hugel 69, 53121 Bonn, Germany*
[6] *Department of Physics and Astronomy, CIERA, Northwestern University, Evanston, IL 60208, USA*
[7] *Radio Astronomy Laboratory, University of California, Berkeley, CA 94720, USA*

We studied the flaring activity of the Galactic Center supermassive black hole Sgr A* close to the DSO/G2 pericenter passage with XMM-Newton, HST/WFC3, VLT/SINFONI, VLA and CARMA. We detected 3 and 2 NIR and 2 X-ray flares with HST, VLT and XMM-Newton, respectively. The Mar. 10 X-ray flare has a long rise and a rapid decay. Its NIR counterpart peaked before the X-ray peak implying a variation in the X-ray-to-NIR flux ratio. This flare may be one flare created by the adiabatic compression of a plasmon or 2 close flares with simultaneous X-ray/NIR peaks. The rising radio flux-density observed on Mar. 10 with the VLA could be the delayed emission from a NIR/X-ray flare preceding our observations. On Apr. 2, we observed the start of the NIR counterpart of the X-ray flare and the end of a bright NIR flare without X-ray counterpart. We studied the physical parameters of the flaring region for each NIR flare but none of the radiative processes can be ruled out for the X-ray flares creation. Our X-ray flaring rate is consistent with those observed in the 2012 Chandra/XVP campaign. No increase in the flaring activity was thus triggered close to the DSO/G2 pericenter passage.

Transient iron fluorescence: new clues on the AGN disk/corona?

Emanuele Nardini[1]

[1] *INAF - Osservatorio Astrofisico di Arcetri*

Deep X-ray observations of the so-called 'bare' active galaxies represent the most effective means of probing the physical conditions in the immediate surroundings of a radiatively efficient supermassive black hole, thus aiding our understanding of the emission processes in AGN. Indeed, the structure and properties of the putative X-ray corona, and the nature of coupling with the disk, are still largely unknown. The recent, surprising discovery of transient iron fluorescence on timescales of 10–15 hours during the 7.5 days of *XMM–Newton* monitoring of Ark 120, the nearest and X-ray brightest bare AGN, poses several challenges to the commonly adopted X-ray emission paradigm of a very compact corona. Such a rapid variability implies that the inner accretion flow is highly dynamic and inhomogeneous, involving the presence of orbiting hotspots, density gradients, or other forms of clumpiness and instability. Whatever the case, these results offer a compelling glimpse of what could be achieved in the future with *Athena*'s capabilities.

Corona accretion in active galactic nuclei and the observational test

Erlin Qiao[1], B.F. Liu[1]
[1] *National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China*

In this talk, we propose a new accretion model, in which the matter is accreted initially in the form of a vertically extended, hot gas (corona) to the central supermassive black hole by capturing the interstellar medium or the stellar wind in active galactic nuclei (AGNs). In this scenario, when the initial mass accretion rate is greater than about 0.01 $\dot{M}_{\rm Edd}$, at a critical radius $r_{\rm d}$, part of the hot gas begins to condense on to the equatorial disc plane of the black hole, forming an inner cold accretion disc. Then, the matter is accreted in the form of a disc-corona structure extending down to the ISCO of the black hole. We calculate the theoretical structure and the corresponding emergent spectra of the model. It is shown that the model can naturally explain the origin of the X-ray emission in AGNs. Meanwhile the model predicts a new geometry of the accretion flow, which can very well explain some observations, such as the correlation between the hard X-ray slope Γ and the reflection scaling factor R found in AGNs. Finally, we discuss the potential applications of the model to high mass X-ray binaries.

A deep stare into the abyss: spectral-timing an entire binary orbit of Cygnus X-1

Phil Uttley[1], on behalf of the CHOCBOX team[2]
[1] *University of Amsterdam*
[2] *CHOCBOX team*

At the end of May 2016, XMM-Newton observed the high mass black hole X-ray binary Cygnus X-1 in the hard state for an entire week, simultaneous with NuSTAR, INTEGRAL, and a suite of radio interferometers. Besides studies of the stellar wind and the X-ray/jet connection, the main goal of this campaign - which we call CHOCBOX, Cyg x-1-1 Hard State Observations of a Complete Binary Orbit in X-rays - was to carry out the most detailed X-ray spectral-timing study of an accreting black hole in the hard state to date, to shed completely new light on the emission geometry of the very innermost regions in this state.

In this talk, I will present results from our X-ray spectral-timing work on the CHOCBOX data, including unprecedented sensitivity to the disk reverberation signal from a stellar-mass black hole system. I will discuss the constraints on the disk and coronal geometry imposed by the reverberation signal, as well as the hard continuum lags seen at lower frequencies, which we are now able to model together with the reverberation in a self-consistent physical picture which connects the disk and coronal variability.

V404 Cyg with NuSTAR: relativistic reflection, jets and spin

Dominic Walton[1], The NuSTAR X-ray Binaries Team[2]
[1] *Institute of Astronomy, University of Cambridge, Cambridge, UK*
[2] *Various*

In summer 2015 the Galactic LMXB V404 Cyg, one of the closest known black hole binary systems, went through its first major outburst in 25 years, triggering a massive multiwavelength monitoring campaign to cover this remarkable event. In this talk, I will discuss results from the NuSTAR contribution to this campaign, focusing in particular on the data obtained during the height of the outburst activity. These data reveal a variety of extreme behaviour, from intense Eddington level flares to strong relativistic reflection. The contemporaneous onset of radio emission strongly suggests that this X-ray flaring is related to jet activity, with the ejected plasma/base of the jet becoming the source of illumination of the disc. We are able to use the reflection observed to place constraints on the system geometry during these events, finding that the X-ray emitting regions in the jet are located very close to the black hole. In addition, our reflection analysis also allows us to place the first constraints on the black hole spin, and we find that V404 Cyg likely hosts a rapidly rotating black hole.

Revealing structure within the coronae of Seyfert galaxies

Dan Wilkins[1]
[1] *Kavli Institute for Particle Astrophysics and Cosmology, Stanford University, USA*

Detailed analysis of the reflection and reverberation of X-rays from the innermost regions of AGN accretion discs reveals the structure and processes that produce the intense continuum emission and the extreme variability we see, right down to the innermost stable orbit and event horizon of the black hole.

Observations of Seyfert galaxies spanning more than a decade have enabled measurement of the geometry of the corona and how it evolves, leading to orders of magnitude of variability. They reveal processes the corona undergoes during transient events, notably the collimation and ejection of the corona during X-ray flares, reminiscent of the aborted launching of a jet.

Recent reverberation studies, including those of the Seyfert galaxy I Zwicky 1 with XMM-Newton, are revealing structures within the corona for the first time. A persistent collimated core is found, akin to the base of a jet embedded in the innermost regions. The evolution of both the collimated and extended portions point to the mechanisms powering the X-ray emission and variability.

This gives us important constraints on the processes by which energy is liberated from black hole accretion flows and by which jets are launched, allowing us to understand how these extreme objects are powered.

Bow shocks as tracers of the environment and stellar outflows near the supermassive black hole.

Lydia Stofanova[1], Michal Zajacek[2,3,4], Vladimir Karas[4]
[1] *Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic*
[2] *1. Physikalisches Institut, Universität zu Köln, Germany*
[3] *Max Planck Institute for Radioastronomy, Bonn, Germany*
[4] *Astronomical Institute, Academy Of Sciences, Czech Republic*

Bow shocks develop near stars in the supersonic motion with respect to the surrounding interstellar environment. In particular, extended shocks emerge due to the interaction of stars with strong winds. We discuss the expected shape and orientation of bow shocks in the context of fast moving stars near a supermassive black hole (SMBH) embedded within Bondi-type accretion flow (Zajaček et al. 2016, MNRAS; Štofanová 2016, BSc. Thesis). We present models which take into account different velocities of the probe star and also consider various scenarios for the ambient medium near the vicinity of the black hole such as an inflow/outflow of the material towards/outwards SMBH or a model which considers inflow and outflow at the same time. Under suitable circumstances, a bow shock structure can be detected in infrared domain and their properties can trace the environment of the Galactic center. On the other hand, if density of the ambient medium is determined from mm/radio observations, bow shocks can be used to constrain mass-loss rates of massive OB/WR stars. X-rays can supplement the spectral evidence, though, the structures are below the angular resolution of the current instruments even in the most favourable case of the Milky Way's SMBH (Sgr A*).

Chapter 14

Groups of Galaxies, Clusters of Galaxies and Superclusters

Suzaku and XMM-Newton observations of the newly discovered early-stage cluster merger of 1E2216.0-0401 and 1E2215.7-0404

H. Akamatsu[1], L. Gu[1], T.W. Shimwell[2], F. Mernier[1,2], J. Mao[1,2], I. Urdampilleta[1,2], J. de Plaa[1], H.J.A Rottgering[2], J.S. Kaastra[1,2]
[1] *SRON the Netherlands Institute for Space Research*
[2] *Leiden University*

We present results from *Suzaku* and *XMM-Newton* X-ray observations of the cluster pair 1E2216.0-0401 and 1E2215.7-0404. We have discovered an X-ray bridge between the clusters which shows a remarkably high temperature. Furthermore, at the position of the bridge, we detected an enhancement in the wavelet-decomposed *XMM-Newton* image. This enhancement is most likely due to a compression of the intracluster medium as a consequence of the merging activity. The X-ray intensity and temperature enhancement are in agreement with the predictions from numerical simulations of an early phase merger. From the observations the Mach number is estimated to be $\mathcal{M} = 1.4$. From the shock properties, we estimate that the age of the shock structure is 50100 Myr. Combining the radio, X-ray, and optical image data, we conclude that 1E2216.0-0401 and 1E2215.7-0404 system is a new example of an early phase cluster merger with remarkable characteristics.

Properties of the cosmological filament between two clusters: detection of a large-scale accretion shock by Suzaku

Hiroki Akamatsu[1], Yutaka Fujita[2], Takuya Akahori[3], Yoshitaka Ishisaki[4], Kiyoshi Hayashida[2], Akio Hoshino[5], Francois Mernier[1,6], Koji Yoshikawa[7], Kosuke Sato[8], Jelle Kaastra[1,6]
[1] *SRON the Netherlands Institute for Space Research*
[2] *Osaka University*
[3] *Kagoshima University*
[4] *Tokyo Metropolitan University*
[5] *Rikkyo University*
[6] *Leiden University*
[7] *University of Tsukuba*
[8] *Tokyo University of Science*

We report on the results of a *Suzaku* observation of the plasma in the filament located between the two massive clusters of galaxies Abell 399 and Abell 401. Our analysis shows that filament plasma is present out to a radial distance of 1.3 Mpc from a line connecting the two clusters. The temperature profile is characterized by an almost flat radial shape with $kT{\sim}67$ keV within $\sim$0.8 Mpc. Across r=8' from the axis, the temperature of the filament plasma shows a drop from 6.3 keV to 5.1 keV, indicating the presence of a shock front. The Mach number based on the temperature drop is estimated to be $\mathcal{M} \sim$1.3. We also successfully determined the abundance profile up to 15' (1.3 Mpc), showing an almost constant value (Z=0.3 solar) at the cluster outskirt. The total mass of the filamentary structure is $\sim 7.7 \times 10^{13}$ Msolar. We discuss a possible interpretation of the drop of X-ray emission at the rim of the filament, which was pushed out by the merging activity and formed by the accretion flow induced by the gravitational force of the filament.

Using XMM and Chandra to probe the mass distribution in the most distant massive galaxy clusters

Iacopo Bartalucci[1]
[1] *DSM - IRFU - SAp, CEA Saclay, France*

We present a detailed study of the mass profiles of the five most massive clusters detected at $z \sim 1$ via the Sunyaev-Zel'dovich effect. These objects represent an ideal laboratory to test our models in a mass regime where structure formation is driven mainly by gravity. We present a method to study these objects that optimally exploits information from XMM-Newton and Chandra observations. The combination of Chandras excellent spatial resolution and XMM-Newtons photon collecting power allows us to investigate the properties of the hydrostatic mass profile from the core to the outskirts, for the first time in such objects. We contrast the optical and X-ray mass estimates by comparing our results with recently-published HST lensing values. Evolution properties are also investigated by comparison with the REXCESS local galaxy cluster sample. Finally, we discuss the current limitations of this method in the context of joint analysis of future Chandra and XMM large programs and, more generally, of multi-wavelength efforts to study high redshift objects.

The Presence of Thermally Unstable X-ray Filaments and the Production of Cold Gas in the NGC 5044 Group

Laurence David[1], Jan Vrtilek[1], Ewan O'Sullivan[1], Ming Sun[2], Christine Jones[1], William Forman[1]
[1] *Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA*
[2] *Univiersity of Alabama at Huntsville, Huntsville, AL, USA*

We present the results of a deep Chandra observation of the X-ray bright, cooling flow group NGC 5044 along with the observed correlations between the ionized, atomic, and molecular gas. The Chandra observation shows that the central AGN has undergone two outbursts in the past 100Myr, based on the presence of two pairs of bi-polar X-ray cavities. The molecular gas detected by ALMA is aligned with the orientation of the inner pair of X-ray cavities, suggesting that the most recent AGN outburst had a dynamical impact on the molecular gas. NGC 5044 hosts many X-ray filaments within the central 8kpc, but there are no obvious connections between the X-ray and Ha filaments; however, we find that the majority of the multi-phase, thermally unstable gas in NGC 5044 is confined within the X-ray filaments. We suggest that the variety of observed properties exhibited by the X-ray filaments are consistent with an evolutionary sequence where thermally unstable gas begins to cool, forms X-ray filaments, becomes multi-phased, develops Ha emitting plasma, and finally produces molecular gas. The combined mass cooling rate in the X-ray filaments is sufficient to supply the observed molecular gas within the time between the two AGN outbursts

Chemical Enrichment History Of Abell 3112 Galaxy Cluster Out To The Virial Radius

Cemile Ezer[1], Esra Bulbul[2], E. Nihal Ercan[1], Randall K. Smith[3], Mark W. Bautz[2], Mike Loewenstein[4,5], Mike McDonald[2], Eric D. Miller[2]
[1]*Department of Physics, Bogazici University, Istanbul, Turkey*
[2]*Kavli Institute for Astrophysics & Space Research, Massachusetts Institute of Technology, Cambridge, MA 02139, USA*
[3]*Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA*
[4]*NASA Goddard Space Flight Center, Greenbelt, MD, USA*
[5]*CRESST and X-ray Astrophysics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA*

The deep potential well of the galaxy clusters confines all metals produced via supernova explosions within the intra-cluster medium (ICM). The radial distributions of these metals along the ICM are direct records of the metal enrichment history. In this work, we investigate the chemical enrichment history of Abell 3112 galaxy cluster from cluster's core to out to radius R_{200} ($\sim$ 1470 kpc) by analyzing a deep 1.2 Ms *Suzaku* observations with overlapping 72 ks *Chandra* observations. The fraction of supernova explosions enriching the ICM is obtained by fitting the X-ray spectra with a robust snapec model implemented in XSPEC. The ratio of supernova type Ia explosions to the core collapse supernova explosions is found in the range 0.12 – 0.16 and uniformly distributed out to R_{200}. The uniform spatial distribution of supernova enrichment indicates an early metal enrichment between the epoch of z $\sim$ 2 – 3. We also observe that W7, CDD, and WDD SN Ia models equally better explain the highest signal-to-noise region compared to 2D delayed detonation model CDDT. We further report the first time temperature (3.37 $\pm$ 0.77 keV) and metallicity (0.22 $\pm$ 0.08 $Z_{\odot}$) measurements of this archetypal cluster at its virial radius.

Constraints on new spectral features and atomic modeling from the Hitomi spectrum of the Perseus cluster

Liyi Gu[1], Makoto Sawada[2], Jelle Kaastra[1], Adam Foster[3], Randall Smith[3], Grey Brown[4], Maurice Leutenegger[5], Naomi Ota[6], Hiroki Akamatsu[1], Hirokazu Odaka[7]
[1]*SRON Netherlands Institute for Space Research, Utrecht, the Netherlands*
[2]*Aoyama Gakuin University, Tokyo, Japan*
[3]*CfA, Harvard University, Cambridge, MA 02138, US*
[4]*Lawrence Livermore National Laboratory, Livermore, CA 94550, US*
[5]*NASA Goddard Space Flight Center, Greenbelt, MD 20771, US*
[6]*Nara Women's University, Nara, Japan*
[7]*Kavli Institute for Particle Astrophysics and Cosmology, Stanford University, Menlo Park, CA 94025, US*

The first high-resolution X-ray spectrum of the Perseus cluster has been obtained with the Soft X-ray Spectrometer on-board the Hitomi satellite. The main emission lines in 2-9 keV are clearly resolved for the first time from such a diffuse, highly-ionized object. This presentation addresses selected new spectral features and atomic modelling issues as impacts of the Hitomi observation. First, for elements such as Fe and S, lines from highly-excited levels are marginally detected, posing an upper limit on the charge exchange between hot and cold gas in Perseus. Second, the data provide a constraint on the non-thermal electron population in the plasma, as those electrons would affect the intensities of the characteristic satellite lines that become visible with the Hitomi.

The Hitomi spectrum offers an unprecedented benchmark of the atomic modeling. We test the latest APEC/SPEX/Chianti codes on the data, and for the first time, we compare systematically the atomic data in these codes. An important lesson is that the atomic data uncertainty contributes one of the main errors in the data analysis; even for the simplest H-like ions, the line errors can sometimes reach 20%. The atomic uncertainty also potentially affects the results with the current XMM-Newton/Chandra data.

Gas motions in the Perseus galaxy cluster observed with Hitomi

Yuto Ichinohe[1], The Hitomi collaboration[2]
[1] *Department of Physics, Tokyo Metropolitan University, Tokyo, Japan*

We present the results associated with gas motions in the core of the Perseus galaxy cluster observed with Hitomi. We searched for spatial variations in the bulk velocity as well as the line-of-sight (LOS) velocity dispersion of the gas in the Perseus cluster out to 100 kpc from its center. After correcting for the PSF scattering effect, we find no significant radial gradient, with the LOS velocity dispersion at radii of 50-100 kpc being consistent with the value reported previously for the region close to the cluster core (Hitomi collaboration 2016, Nature, 535, 117). Overall shapes of well resolved emission lines agree with Gaussian, whereas there are hints of non-Gaussianity in the wings of He-like and H-like Fe lines. Combining the widths of the lines originating from various elements, we investigate the constraints on the thermal motion of ions in the intra-cluster medium; we find no evidence of deviation between the temperatures of ions and electrons in the core of the Perseus cluster.

Detection of the second shock in the merging cluster of galaxies Abell 754

Shota Inoue[1], Maxim Markevitch[2], Kiyoshi Hayashida[1], Daniel R. Wik[2], Hiroshi Tsunemi[1]
[1] *Department of Earth and Space Science, Osaka University, Toyonaka, Japan*
[2] *NASA/Goddard Space Flight Center, Greenbelt, USA*

Abell 754 is the recent merging galaxy cluster. At the southwestern region of the cluster, Macario et al. (2011) detected the shock front with Chandra data. Inoue et al. (2016) reported the region with high temperature ($\sim$13 keV) and the hint of the non-equilibrium ionization feature around this region using the Suzaki data, which imply the region heated by the shock separated from Macario et al. (2011) detected. In this presentation, we report the detection of this second shock. Using the data observed by XMM-Newton in 2001 and 2002, we find the surface brightness discontinuity around this region. Our results of the spectrum analysis using the XMM-Newton and Suzaku data show the temperature drop, which support our hypothesis that the discontinuity indicates the shock front, not cool core. We also find this discontinuity strongly correlates with the edge of the radio emission, which is the similar profile with another shock reported by Macario et al. (2011). The Mach number of the shock is $\sim$1.4, similar number of another shock ($\sim$1.57). It is very rare that two shock fronts are detected in one merging cluster, while the numerical simulation of the merging cluster always shows two shock waves.

XMM-Newton Observations of the Toothbrush and Sausage Clusters

Sinancan Kara[1], Francois Mernier[2], Cemile Ezer[1], Hiroki Akamatsu[2], Jelle de Plaa[2], Enise Nihal Ercan[1]
[1] *Bogazici University, Istanbul, Turkey*
[2] *SRON Netherlands Institute for Space Research, Sorbonnelaan, Utrecht, Nederlands*

Galaxy clusters are the largest gravitationally-bound objects in the universe. The member galaxies are embedded in a hot X-ray emitting Intra Cluster Medium (ICM) that has been enriched with metals produced by supernovae over the last billion years. Here we report new results from XMM-Newton archival observations of the merging clusters 1RXSJ0603.3+4213 and CIZA J2242.8+5301. These two clusters, also known as the Toothbrush and Sausage clusters, respectively, show a large radio relic associated with a merger shock North of their respective core. We show the distribution of the metal abundances with respect to the merger structures in these two clusters. The results are derived from spatially resolved X-ray spectra from the EPIC instrument on board XMM-Newton.

CXB surface brightness fluctuations: A new frontier of ICM structure and outskirts studies of (un)resolved galaxy clusters?

Alexander Kolodzig[1,2], Marat Gilfanov[2,3], Gert Hütsi[2,4], Rashid Sunyaev[2,3]
[1] *Kavli Institute for Astronomy and Astrophysics (KIAA), Peking University, Beijing, China*
[2] *Max-Planck Institute for Astrophysics, Garching, Germany*
[3] *Space Research Institute, Russian Academy of Sciences, Moscow, Russia*
[4] *Tartu Observatory, Tõravere, Estonia*

Surface brightness fluctuations of the cosmic X-ray background (CXB) carry unique information about the intracluster-medium (ICM) structure of galaxy clusters and groups up to the virial radius, which is inaccessible by conventional observations of selected nearby resolved clusters.

We present results of our CXB fluctuation analysis of the ∼5ks-deep, ∼9deg^2-large Chandra survey XBOOTES.

We find that our fluctuation signal of resolved clusters is dominated by nearby, high-luminosity sources. The shape of its power spectrum suggests that for the brightest cluster we are sensitive to the ICM structure up to $\sim 2 \times R_{500}$ ($\sim 2\,\mathrm{Mpc/h}$). The energy spectrum of the fluctuation signal from resolved and unresolved clusters follows a typical ICM spectrum, where redshifts and temperatures are consistent with expectations. It also demonstrates that fluctuations of our unresolved CXB are dominated by unresolved clusters with an average z∼0.4 and T∼1.6keV, suggesting an average $L_{500,0.5-2keV} \sim 6 \times 10^{42}\,\mathrm{erg/s}$ and $M_{500} \sim 6 \times 10^{13}\,\mathrm{M}_{Sun}/\mathrm{h}$. Comparison with modeling suggests, that our fluctuation signal can be described with the one-halo-term of clusters and that it might be sensitive to the presence of substructures. Discrepancies between model and measurement could be utilized to improve our understanding of the ICM structure in a statistical manner. We briefly discuss the potential of larger surveys (e.g. Stripe82, XXL, SRG/eRosita).

X-ray morphological study of the ESZ sample

Lorenzo Lovisari[1], William Forman[1], Christine Jones[1], Felipe Andrade-Santos[1], Jessica Democles[2], Gabriel Pratt[2], Stefano Ettori[3], Monique Arnaud[2]
[1] *Harvard-Smithsonian Center for Astrophysics, Cambridge, USA*
[2] *Commissariat à l'énergie atomique Saclay, Gif sur Yvette, France*
[3] *INAF, Osservatorio Astronomico di Bologna, Italy*

An accurate knowledge of the scaling relations between X-ray observables and cluster mass is a crucial step for studies that aim to constrain cosmological parameters using galaxy clusters. The measure of the dynamical state of the systems offers important information to obtain precise scaling relations and understand their scatter. Unfortunately, characterize the dynamical state of a galaxy cluster requires to access a large set of information in different wavelength which are available only for a few individual systems. An alternative is to compute well defined morphological parameters making use of the relatively cheap X-ray images and profiles. Due to different projection effects none of the methods is good in all the cases and a combination of them is more effective to quantify the level of substructures.

I will present the cluster morphologies that we derived for the ESZ sample. I will show their dependence on different cluster properties like total mass, redshift, and luminosity and how they differ from the ones obtained for X-ray selected clusters. Finally, I will discuss how we used the morphological parameters to investigate the influence of substructures on the scaling relation and their scatter.

XMM-Newton Observations of Galaxy Cluster MKW3s

Muhammet Memic[1], E. Nihal Ercan[1], Cemile Ezer[1]
[1] *Department of Physics, Bogazici University, Istanbul, Turkey*

Clusters of galaxies are sensitive probes of history of structure formation of the universe and elemental abundance measurements since their strong gravitational potential wells enable us to investigate their physical properties in X-Ray band. In this work, we present a study of the galaxy cluster MKW3s ($z \sim 0.045$) using a 2014 XMM-Newton observational archive data. Radial distributions of temperature and metallicity are investigated in order to reexamine the properties of the intra-cluster medium. We further discuss the effects of the substructures on pressure and entropy profiles.

Radial distribution of metals in the hot intra-cluster medium as observed by XMM-Newton

Franois Mernier[1,2], Jelle de Plaa[1], Jelle Kaastra[1,2], Yu-Ying Zhang[3], Hiroki Akamatsu[1], Liyi Gu[1], Junjie Mao[1,2], Ciro Pinto[4], Thomas Reiprich[3], Jeremy Sanders[5]
[1] *SRON Netherlands Institute for Space Research, Utrecht, The Netherlands*
[2] *Leiden Observatory, Leiden, The Netherlands*
[3] *Argelander Institut für Astronomie, Bonn, Germany*
[4] *Institute of Astronomy, Cambridge, United Kingdom*
[5] *Max-Planck Institut für Extraterrestrische Physik, Garching, Germany*

The hot intra-cluster medium (ICM), which accounts for ∼80% of the baryonic content in galaxy clusters, is rich in heavy elements. Since these metals have been produced by stars and supernovae before enriching the ICM, measuring metal abundance distributions in galaxy clusters and groups provides essential clues to determine the main astrophysical source(s) and epoch(s) of the ICM enrichment. In this work, we present radial abundance profiles averaged over 44 nearby cool-core galaxy clusters, groups, and massive ellipticals (the CHEERS sample) measured with XMM-Newton EPIC. While most of the Fe of the Universe is thought to be synthesised by Type Ia supernovae (SNIa), lighter elements, such as O, Mg, Si or S, are mostly produced by core-collapse supernovae (SNcc). The derived average radial profiles of the O, Mg, Si, S, Ar, Ca, Fe, and Ni abundances out to $\sim 0.5r_{500}$ allows us to accurately compare the distributions of SNIa and SNcc products in clusters and groups. By comparing our results with recent chemo-dynamical simulations, we discuss the interpretation of the profiles in the context of early and late ICM enrichments.

Hitomi observation of the Perseus cluster: temperature and metal abundance in the cool-core region

Shinya Nakashima[1], Hitomi collaboration[2]
[1] *ISAS/JAXA, Sagamihara, Japan*

We observed the core of the Perseus cluster with the Soft X-ray Spectrometer (SXS) on-board Hitomi. The unprecedented energy resolution of the SXS enables us to resolve the Fe and Ni lines which are degenerated in CCD spectra. We also detect weak emission lines of other elements including Cr and Mn. Utilizing flux ratios of these emission lines, we measure electron and ionization temperatures of each element independently. We find that 2-temperature or 1-temperature equilibrium plasma model explains the obtained line flux ratios in most of the regions, but the non-equilibrium ionization model also gives nearly the same goodness-of-fit as the 2-temperature model in some regions. In addition, high-temperature plasma ($kT > 8$ keV), which is suggested in the previous studies, is not detected in the SXS spectra. We also measure the metal abundances of Si, S, Ar, Ca, Cr, Mn, and Ni relative to Fe. The obtained abundances are consistent with the solar values, and different from the previous study in which Cr, Mn, and Ni are over-solar abundances. This inconsistency shows the importance of high-resolution spectroscopy to determine metal abundances precisely.

Galaxy clusters from eeHIFLUGCS, to eROSITA, to Athena

Thomas H. Reiprich[1]
[1] *Argelander Institute for Astronomy, Bonn University*

The latest results from detailed X-ray follow-up observations of large X-ray selected galaxy cluster samples are discussed, in particular from eeHIFLUGCS. An outlook is given to expected cosmological constraints from eROSITA, in particular on dark energy and neutrino masses. The possible significant role of XMM-Newton to improve on these constraints is highlighted. Finally, the expectations for Athena to discover and characterize the first galaxy groups, massive and evolved enough to contain $\gg$10 million Kelvin gas, around redshift 2.5 are quantified.

XMM Cluster Survey: Project update, with a Dark Energy Survey Focus.

Kathy Romer[1], XCS Collaboration[2]
[1] *University of Sussex, Brighton, UK*
[2] *xcs-home.org*

The XMM Cluster Survey (XCS) has analysed the entire XMM public archive with the primary aim of producing a large catalogue of X-ray selected clusters. To date, over 5,000 (or 11,000) extended sources have been identified as clusters of galaxies. Most of those have associated redshift and X-ray temperature ($T_{\rm X}$) information. In this presentation we will preview the second XCS data release, and describe a series of recent science results that include: the evolution and interpretation of various scaling relations (optical richness to $T_{\rm X}$; $L_{\rm X}$ to $T_{\rm X}$, $M_{\rm X}$ to $T_{\rm X}$; σ_v to $T_{\rm X}$; $M_{\rm lens}$ to $T_{\rm X}$; $Y_{\rm SZ}$ to $T_{\rm X}$); the evolution of the red sequence; constraints on modified gravity models. The presentation will feature several joint XCS-DES (Dark Energy Survey) results.

Measurements of resonant scattering in the Perseus cluster core with Hitomi SXS

Kosuke Sato[1], Irina Zhuravleva[2]
[1] *Tokyo University of Science, Tokyo, Japan*
[2] *Stanford University, Stanford, U.S.A*

Hitomi (ASTRO-H) SXS allows us to investigate fine structures of emission lines in extended X-ray sources for the first time. Thanks to its high energy resolution of 5 eV at 6 keV in orbit, Hitomi SXS finds a quiescent atmosphere in the Intra cluster medium of the Perseus cluster core where the gas has a line-of-sight velocity dispersion below 200 km/sec from the line width in the spectral analysis (Hitomi collaboration, Nature, 2016). The resonant scattering is also important to measure the gas velocity as a complementary probe of the direct measurement from the line width. Particularly in the cluster core, resonant scattering should be taken into account when inferring physical properties from line intensities because the optical depth of the He-alpha resonant line is expected to be larger than 1. The observed line flux ratio of Fe XXV He-α resonant to forbidden lines is found to be lower in the cluster core when compared to the outer region, consistent with resonant scattering of the resonant line and also in support of the low turbulent velocity.

NGC 741 – Mergers and AGN feedback on galaxy groups scale

Gerrit Schellenberger[1], Jan Vrtilek[1], Laurence David[1], Ewan O'Sullivan[1], Simona Giacintucci[2], Melanie Johnston-Hollitt[3,4], Stefan Duchesne[3,4]
[1] *Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA*
[2] *Naval Research Laboratory, 4555 Overlook Avenue SW, Code 7213, Washington, DC 20375, USA*
[3] *School of Chemical & Physical Sciences, Victoria University of Wellington, Wellington, 6140, New Zealand*
[4] *Peripety Scientific Ltd., PO Box 11355, Manners Street, Wellington, 6142, New Zealand*

Low mass galaxy cluster systems and groups play an essential role in upcoming cosmological studies like those to be carried out with new instruments such as eROSITA. A detailed understanding of the astrophysical processes taking place in these systems is crucial before using them as cosmological tools. The effects of active galactic nuclei (AGNs) and merging processes, although of special importance to quantify biases like selection effects or deviation from hydrostatic equilibrium, are poorly understood on the galaxy group scale. We present an analysis of recent deep Chandra and XMM-Newton integrations of NGC 741, which provides an excellent example of a group with multiple concurrent phenomena: both an old central radio galaxy and a spectacular infalling head-tail source (only 17 kpc from the BCG), strongly-bent jets and a 130 kpc radio trail, intriguing narrow X-ray filaments, and gas sloshing features. Supported principally by X-ray and radio continuum data, we address the merging history of the group, the nature of the X-ray filaments, the extent of gas stripping from NGC 742, the character of (ghost) cavities in the group, and the roles of the central AGN and infalling galaxy in heating the intra-group medium.

Groups and clusters in the 3XMM-Stripe 82 zone

Ali Takey[1], Florence Durret[2], Amael Ellien[3], Isabel Marquez[4], Mona Molham[1], Adele Plat[2]
[1]*NRIAG, 11421 Helwan, Cairo, Egypt*
[2]*Sorbonne Universites, UPMC Univ. Paris 6 et CNRS, UMR7095, IAP, 98bis Bd Arago, 75014 Paris, France*
[3]*Observatoire de Paris, UFE, 61 avenue de l'Observatoire, 75014 Paris, France*
[4]*Instituto de Astrofisica de Andalucia, c/ Bajo de Huetor 24, 18008 Granada, Spain*

We conducted a survey of galaxy clusters detected from XMM-Newton observations covering an area of 11.25 deg^2 in the Stripe 82 region of the Sloan Digital Sky Survey (SDSS). We found 94 X-ray cluster candidates from the third XMM-Newton serendipitous source catalogue (3XMM-DR5) and correlated this list with recently published X-ray and optically selected cluster catalogues to obtain optical confirmations and redshifts (between 0.05 and 1.19, with a median of 0.36) for 54 galaxy groups/clusters. Of these, 17 are newly X-ray discovered clusters and 45 systems with spectroscopic confirmations. Among the remaining candidates, 25 sources are distant cluster candidates (beyond a redshift of 0.6). We will present results on the X-ray and optical properties of these clusters: luminosities and temperatures of the X-ray gas, morphological and luminosity functions of the galaxies.

Radial Profiles of PKS 0745-191 Galaxy Cluster with XMM-Newton X-Ray Observations

Aysegul Tumer[1], Cemile Ezer[1], Enise Nihal Ercan[1]
[1]*Bogazici University, Istanbul, Turkey*

Since clusters of galaxies are the largest comprehensive samples of the universe, they provide essential information on the most basic physical mechanisms such as nucleosynthesis. Some of these information are supplied by the X-ray emission from Intra Cluster Medium (ICM) which contains hot dilute gas. Recent observation of the X-Ray spectrum of the cooling flow galaxy cluster PKS 0745-191 provided by XMM-Newton is subjected to data analysis where background subtracted, exposure corrected maps are obtained. In this work we present the results of the radial profiles of temperature and metallicity from the core to the outskirts of brightest distant cluster (z $\sim$ 0.102) PKS 0745-191. The radial distrubution of pressure and entropy is also investigated and preliminary results of the effect of X-ray cavities found in the core of the cluster due to the AGN Feedback and cold fronts will be presented.

Embedded spiral patterns in the massive galaxy cluster Abell 1835

Shutaro Ueda[1], Tetsu Kitayama[2], Tadayasu Dotani[1,3]
[1]*Institute of Space and Astronautical Science, JAXA, 3-1-1 Yoshinodai, Chuo Sagamihara, Kanagawa, Japan*
[2]*Department of Physics, Toho University, 2-2-1 Miyama, Funabashi, Chiba, Japan*
[3]*SOKENDAI (The Graduate University for Advanced Studies), 3-1-1 Yoshinodai, Chuo Sagamihara, Kanagawa, Japan*

We report on the properties of the intracluster medium (ICM) in the central region of the massive galaxy cluster, Abell 1835, obtained with the data from the Chandra X-ray Observatory. We find distinctive spiral patterns in the cool core in the residual image of the X-ray surface brightness after its nominal profile is subtracted. The spiral patterns consist of two arms. One of them appears as positive, and the other appears as negative excesses in the residual image. Their sizes are $\sim$ 70 kpc and their morphologies are consistent with each other. We find that the spiral patterns extend from the cool core out to the hotter surrounding ICM. We analyze the X-ray spectra extracted from both regions. We obtain that the ICM properties are similar to those expected by gas sloshing. We also find that the ICM in the two regions of spiral patterns is near or is in pressure equilibrium. Abell 1835 may now be experiencing gas sloshing induced by an off-axis minor merger. These results have been already published (Ueda, Kitayama, & Dotani 2017, ApJ, 837, 34).

X-ray study of the merging double-radio-relic cluster Abell 3376 with Suzaku

Igone Urdampilleta[1,2], Hiroki Akamatsu[1], Francois Mernier[1,2], Jelle Kaastra[1,2], Jelle de Plaa[1], Tayaka Ohashi[3], Yoshitaka Ishisaki[3], Hajime Kawahara[4]
[1]*SRON, Netherlands Institute for Space Research, Utrecht, The Netherlands*
[2]*Leiden University, Leiden, The Netherlands*
[3]*Tokyo Metropolitan University, Tokyo, Japan*
[4]*University of Tokyo, Tokyo, Japan*

In this work, we present an X-ray analysis of the nearby merging double-radio-relic cluster Abell 3376 (z= 0.046), observed with the Suzaku XIS instrument. These deep observations ($\sim$380 ks) cover the entire double-relic region in the outskirts of the cluster. The mentioned diffuse radio structures are one of the largest arc-shaped relics known ($\sim$Mpc) and are co-spatially located with large-scale X-ray shocks (Mach number M$\leq$2-3). We confirm the presence of a prominent shock (M$\sim$3) in the western periphery, derived from a sharp temperature drop across the shock. This is one of the strongest shocks ever detected in a merging galaxy cluster. In addition, we have preliminary indications of a shock present in the eastern outskirts. In our analysis, we are able to constrain the Cosmic Xray Background fluctuations and limit the systematic uncertainties on the temperature in the outer regions to 20-30%. These data allow us to study the connection between shocks and radio relics as well as the particle acceleration mechanism in strong shocks. We also estimate the dynamical age of the shock front, which provides us with a better understanding of the evolution of the merging cluster.

Is there a giant Kelvin-Helmholtz instability in the sloshing cold front of the Perseus cluster?

Stephen Walker[1], Julie Hlavacek-Larrondo[2], Marie-Lou Gendron Marsolais[2], Andy Fabian[3], Huib Intema[4], Jeremy Sanders[5], Tom Bamford[6]
[1] *NASA Goddard Space Flight Center*
[2] *Universite de Montreal*
[3] *University of Cambridge*
[4] *Leiden Observatory, Leiden University*
[5] *Max-Planck-Institute fur extraterrestrische Physik*
[6] *University of Leeds*

Deep observations of nearby galaxy clusters with Chandra have revealed concave 'bay' structures in a number of systems (Perseus, Centaurus and Abell 1795), which have similar X-ray and radio properties. These bays have all the properties of cold fronts, where the temperature rises and density falls sharply, but are concave rather than convex. By comparing to simulations of gas sloshing, we find that the bay in the Perseus cluster bears a striking resemblance in its size, location and thermal structure, to a giant (≈50 kpc) roll resulting from Kelvin-Helmholtz instabilities. If true, the morphology of this structure can be compared to simulations to put constraints on the initial average ratio of the thermal and magnetic pressure, $\beta = p_{\rm th}/p_{\rm B}$, throughout the overall cluster before the sloshing occurs, for which we find $\beta = 200$ to best match the observations. Simulations with a stronger magnetic field ($\beta = 100$) are disfavoured, as in these the large Kelvin-Helmholtz rolls do not form, while in simulations with a lower magnetic field ($\beta = 500$) the level of instabilities is much larger than is observed. We find that the bay structures in Centaurus and Abell 1795 may also be explained by such features of gas sloshing.

Angular power spectra of eROSITA mock cluster all-skymaps

Fabio Zandanel[1], Mattia Fornasa[1], Florian Pacaud[2], Thomas Reiprich[2], Francisco Prada[3], Anatoly Klypin[4]
[1] *GRAPPA Institue, University of Amsterdam*
[2] *Argelander-Institut für Astronomie, University of Bonn*
[3] *Instituto de Astrofisica de Andalucia (CSIC)*
[4] *Astronomy Department, New Mexico State University, Las Cruces*

We developed a phenomenological model to generate mock galaxy cluster catalogues from the MultiDark N-body simulations that reproduce current X-ray and Sunyaev-Zel'dovich observations. We generated many mock all-sky maps and light-cone cluster catalogues and use them to simulate complete realizations of the eROSITA all-sky survey. We will present the analysis of the corresponding angular power spectra and cross-correlation with the Sunyaev-Zel'dovich signal showing the potential of the eROSITA survey in improving our current understanding of clusters of galaxies both for astrophysics and cosmology.

Chapter 15

Special Session: AGN and Cluster Feedback

Understanding AGN Feedback in SZ-Selected Clusters

Laura Birzan[1], David Rafferty[1], Marcus Brueggen[1], Huib Intema[2]
[1] *Hamburger Sternwarte, Hamburg, Germany*
[2] *Leiden Observatory, Leiden, The Netherlands*

The Chandra X-ray Observatory has revealed X-ray cavities in the hot atmospheres of many nearby giant ellipticals, groups and clusters. The work done by the buoyantly rising cavities can stabilize cooling cores in clusters and govern the growth of massive galaxies. However, there is little understanding of how AGN feedback operates at higher redshift ($z > 0.5$), where the bulk of galaxy and cluster formation occurs. We present results from a study of AGN feedback at $0.3 < z < 1.2$ using SZ-effect selected samples of clusters. In contrast to studies of nearby systems, we do not find a separation between cooling flow clusters and non-cooling flow clusters based on the radio luminosity of the central radio source. This lack may be due to the increased incidence of galaxy-galaxy mergers at higher redshift that triggers AGN activity. In support of this scenario, we find evidence for evolution in the radio luminosity function of the central radio source. Additionally, we use local radio-to-jet power scaling relations to estimate feedback power and find that half of the cooling flow systems in our sample probably have enough heating to balance cooling.

X-raying massive outflows in high-z QSOs

Massimo Cappi[1]
[1] *INAF/IASF-Bologna*

After highlighting some of the latest results on massive outflows in nearby AGNs and QSOs, I will review the state-of-the-art of X-ray studies on high-z QSOs, and will discuss their potential interest for AGN feedback.

The case of the galactic wind in the bright quasar 1H 0419-577

Laura Di Gesu[1], Elisa Costantini[2]
[1]*ISDC/University of Geneve*
[2]*SRON, Netherlands Institute for Space Science*

We present the analysis of the first Chandra image ever obtained of the Seyfert 1 galaxy 1H 0419-577. This intriguing AGN is known to host a galactic-extended outflow, that is seen in the O III image, in the UV, and in the X-ray spectrum (Di Gesu et al. 2013). Using Chandra ACIS-S, we were also to observe extended X-ray emission. Ionized gas emitting at soft X-ray energies is detected with Chandra up to a distance of $\sim$10 kpc from the bright Seyfert nucleus. We will discuss possible scenarios for the physical nature of the extended emission, focusing on how it could be related to the galactic wind.

Buoyancy, Uplift, and AGN Feedback - Deep Chandra and XMM-Newton Observations of the Radio Outbursts in NGC 4472 and NGC 1399

Ralph Kraft[1], Yuanyuan Su[1], Marie-Lou Gendron Marsolais[2,1], Elke Roediger[3], Paul Nulsen[1], Julie Hlavacek-Larrondo[2], William Forman[1], Christine Jones[1], Scott Randall[1], Marie Machacek[1]
[1]*Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge, MA 02138*
[2]*Department of Physics, Universite de Montreal, Pavillion Roger Gaudry, Montreal, QC Canada H3C 3J7*
[3]*E. A. Milne Center for Astrophysics, Department of Physics and Mathematics, University of Hull, Hull UK HU6 7RX*

We present results from deep Chandra and XMM-Newton observations of the AGN outbursts in the nearby early-type galaxies NGC 4472 and NGC 1399. Both pairs of radio bubbles are surrounded by rims of enhanced X-ray emission. Spectral analysis shows that the temperatures of these rims are less than that of the surrounding medium, suggesting that they are gas uplifted from the group center by the buoyant rise of the radio bubbles and not shocks due to the supersonic inflation of the lobes. The energy required to uplift these shells can be a significant fraction of the total outburst energy, and thus may play an important role in the thermodynamic evolution of the galaxy core. Buoyant uplift could also be a very efficient means of transporting metals from the galaxy core to the halo.

Using X-ray velocity measurements as a new probe of AGN feedback in massive galaxies

Anna Ogorzalek[1,2], Irina Zhuravleva[1,2], Steve Allen[1,2,3], Ciro Pinto[4], Norbert Werner[5,6], Adam Mantz[1,2], Rebecca Canning[1,2], Andrew Fabian[4], Jelle Kaastra[7,8], Jelle de Plaa[7]
[1] *Department of Physics, Stanford University, Stanford, USA*
[2] *Kavli Institute for Particle Astrophysics and Cosmology, Stanford, USA*
[3] *SLAC National Accelerator Laboratory, Menlo Park, USA*
[4] *Institute of Astronomy, Cambridge, United Kingdom*
[5] *MTA-Eötvös University, Lendület Hot Universe Research Group, Budapest, Hungary*
[6] *Department of Theoretical Physics and Astrophysics, Masaryk University, Brno, Czech Republic*
[7] *SRON Netherlands Institute for Space Research, Utrecht, The Netherlands*
[8] *Leiden Observatory, Leiden University, Leiden, The Netherlands*

A key missing piece in our understanding of galaxy formation and mechanical AGN feedback in massive galaxies is knowledge of the velocity structure within their host gaseous halos. Using deep XMM-Newton Reflection Grating Spectrometer observations and a combination of resonance scattering and direct line broadening methods, we have obtained significantly improved measurements of turbulent velocities in the cores of 13 nearby giant early-type galaxies. Our study offers the first possibility for population studies of hot gas motions in such systems. I will present our measurements, highlight the main systematic (modeling and observational) effects, discuss the insights our study provides into the physics of kinetic AGN feedback, and outline future directions.

Turbulence in the Intracluster Medium: XMM-Newton legacy

Ciro Pinto[1], Andrew Fabian[1], Jeremy Sanders[2], Jelle De Plaa[3]
[1] *University of Cambridge, Institute of Astronomy, Cambridge, UK*
[2] *Max-Planck-Institut fur extraterrestrische Physik, Garching, Germany*
[3] *SRON Netherlands Institute for Space Research, Utrecht, The Netherlands*

The kinematics structure of the Intracluster Medium (ICM) in clusters of galaxies is heir of their past evolution. AGN feedback, sloshing of gas within the potential well, and galaxy mergers are thought to generate turbulence of several hundred km/s into the ICM. Accurate measurements of velocity widths provide the means to understand the effects of these energetic phenomena onto the evolution of the clusters. In this talk I will review our recent measurements of turbulence using the high-resolution grating and microcalorimeter spectrometers on board XMM-Newton and Hitomi, respectively. Most recently, we have produced the largest XMM-Newton/RGS grating catalogue totalling about a hundred objects, which merge the recent CHEERS campaign and the efforts of the last decade as well as the newest observations of clusters and groups of galaxies. This catalogue includes all high-quality grating spectra publicly available by January 2017 and provides the XMM-Newton legacy for the future work. In this talk, I will discuss the first results with particular focus on the measurements of velocity broadening and the new constraints on turbulence.

Feeding and feedback in radio galaxies and mergers: an X-ray perspective

Francesco Tombesi[1,2,3], Richard Mushotzky[2], Christopher Reynolds[2], James Reeves[4], Timothy Kallman[1], Ehud Behar[5], Valentina Braito[6], Yoshihiro Ueda[7], Massimo Cappi[8], Lukasz Stawarz[9]
[1] *NASA/Goddard Space Flight Center, USA*
[2] *University of Maryland, College Park, USA*
[3] *University of Rome Tor Vergata, Italy*
[4] *Keele University, UK*
[5] *Technion, Israel*
[6] *INAF/OA Brera, Italy*
[7] *Kyoto University, Japan*
[8] *INAF/IASF Bologna, Italy*
[9] *Jagiellonian University, Poland*

Observations performed in the last decades have shown that supermassive black holes (SMBHs) and cosmic structures are not separate elements of the Universe. While galaxies have sizes roughly ten orders of magnitude larger than SMBHs, black holes would not exist without matter feeding them, and cosmic structures would not be the same without feedback from SMBHs. Powerful winds/jets in active galactic nuclei (AGN) may be the basis of this co-evolution. X-ray observations trace both the cold/feeding and hot/ionized feedback phases. We show the Chandra HETG spectral analysis of two radio galaxies, 3C 390.3 and 3C 120. Complex emission/absorption features are present in the soft X-rays and Fe K band. We detect a hot gas with temperature kT 0.5-1keV from broad ionized Fe L-shell lines which may originate from a kpc scale shocked bubble inflated by the wind/jet. This is reminiscent of supernova bubbles. The shape and strength of the neutral Fe K line suggest that the material feeding the accretion disk, or torus, may be in the form of Compton-thick, clumpy clouds. Such systems may likely be late stage mergers and they allow us to extend the parameter space traced by winds in Seyferts and ULIRGs.

Chapter 16

Cosmological Structure Formation, Extragalactic Deep Fields and Area Surveys

Compton-thick AGN at high and low redshift

Athanasios Akylas[1], Ioannis Georgantopoulos[1], Amalia Corral[1], Piero Ranalli[1], Giorgio Lanzuisi[2]
[1]*National Observatory of Athens*
[2]*Bologna Observatory*

The most obscured sources detected in X-ray surveys, the Compton-thick AGN present great interest both because they represent the hidden side of accretion but also because they may signal the AGN birth. We analyse the NUSTAR observations from the serendipitous observations in order to study the Compton-thick AGN at the deepest possible ultra-hard band (¿10 keV). We compare our results with our SWIFT/BAT findings in the local Universe, as well as with our results in the CDFS and COSMOS fields. We discuss the comparison with X-ray background synthesis models finding that a low fraction of Compton-thick sources (about 15 per cent of the obscured population) is compatible with both the 2-10keV band results and those at harder energies.

Deep X-ray spectroscopy of obscured AGN in the Chandra Deep Field South

Andrea Comastri[1], Kazushi Iwasawa[2,3]
[1]*INAF-Osservatorio Astronomico di Bologna, via Gobetti 93/3, 40129 Bologna, Italy*
[2]*Institut de Ciències del Cosmos (ICCUB), Universitat de Barcelona (IEEC-UB), Martí i Franquès, 1, 08028 Barcelona, Spain*
[3]*ICREA, Pg. Lluís Companys 23, 08010 Barcelona, Spain*

According to the recent models for the joint evolution of Super Massive Black Holes (SMBH) and their Host Galaxies, heavy obscuration represents an important phase and is expected to play a key role in the feedback mechanisms self regulating the SMBH growth. The smoking gun signature of heavy absorption is the presence of a heavily absorbed or reflected X-ray spectrum plus a strong iron line at 6-7 keV. X-ray spectroscopy thus represents an extremely efficient method to uncover the most obscured AGN at cosmological distances. We will present the results of a systematic analysis of a flux limited sample of X-ray selected AGN in the deep (3 Ms) XMM observations in the Chandra Deep Field South (CDFS). We will focus on the absorption distribution of the sources responsible for the bulk of the X-ray background, with particular emphasis on the fraction of Compton thick AGN. We will highlight the power of deep spectroscopy to obtain redshift estimates more accurate and reliable than available photo-z. Synergies with the ultra deep (7 Ms) Chandra observations in the same field, along with the perspectives for future observations with current (XMM & Chandra) and future (i.e. ATHENA) facilities will be also presented.

Searching for faint AGN in the CDFS: an X-ray (Chandra) vs optical variability (HST) comparison.

Ioannis Georgantopoulos[1], Ektoras Pouliasis[1], Alceste Bonanos[1], Kiril Sokolovsky[1], Min Yang[1], Despina Hatzidimitriou[2], Ioannis Bellas[1], Panos Gavras[1], Zoi Spetsieri[1]
[1] *National Observatory of Athens*
[2] *University of Athens*

X-ray surveys are believed to be the most efficient way to detect AGN. Recently though, optical variability studies are claimed to probe even fainter AGN. We are presenting results from an HST study aimed to identify Active Galactic Nuclei (AGN) through optical variability selection in the CDFS.. This work is part of the "Hubble Catalogue of Variables"project of ESA that aims to identify variable sources in the Hubble Source Catalogue." In particular, we used Hubble Space Telescope (HST) z-band images taken over 5 epochs and performed aperture photometry to derive the lightcurves of the sources. Two statistical methods (standard deviation & interquartile range) resulting in a final sample of 175 variable AGN candidates, having removed the artifacts by visual inspection and known stars and supernovae. The fact that the majority of the sources are extended and variable indicates AGN activity. We compare the efficiency of the method by comparing with the 7Ms Chandra detections. Our work shows that the optical variability probes AGN at comparable redshifts but at deeper optical magnitudes. Our candidate AGN (non detected in X-rays) have luminosities of $L\_x < 6 \times 10^{40}$ erg/sec at $z \sim 0.7$ suggesting that these are associated with low luminosity Seyferts and LINERS.

The relation between nuclear obscuration, galaxy interactions and accretion properties of AGN

Claudio Ricci[1], Mike Koss[2], Benny Trakhtenbrot[2], Franz Bauer[1], Ezequiel Treister[1], Yoshihiro Ueda[3], Kevin Schawinski[2], Kyuseok Oh[2], Isabella Lamperti[2]
[1] *Pontificia Universidad Catolica de Chile, Santiago, Chile*
[2] *ETH, Zurich, Switzerland*
[3] *Kyoto University, Kyoto, Japan*

Most of the accretion onto supermassive black holes (SMBHs) happens during a phase in which the AGN is obscured. However, to date it is not clear what is the mechanism regulating the amount of obscuration around supermassive black holes, and how obscuration is related to the host galaxy and to the accretion properties of the SMBH.

Our group has carried out the multi-wavelength study of a large sample of local AGN selected in the hard X-ray band (14-195 KeV), where obscuration does not play a strong role. This includes detailed broad-band X-ray spectroscopy for ∼830 sources, and optical and near-IR spectroscopy for ∼640 AGN. This allowed us to measure, for the first time, black hole masses and Eddington ratios of a large number of obscured AGN. In my talk I will show how obscuration is related to the Eddington ratio and black hole mass of the accreting system, and discuss our results in the frame of an evolutionary scenario for the growth of supermassive black holes. I will also discuss some recent results obtained with NuSTAR, showing the relation between galaxy mergers and nuclear obscuration.

X-Ray Bright Optically Faint AGNs Found in XMM-Newton and Subaru Hyper Suprime-Cam Surveys

Yuichi Terashima[1], Makoto Suganuma[1], Masayuki Akiyama[2], Jenny Greene[3], Toshihiro Kawaguchi[4], Kazushi Iwasawa[5], Tohru Nagao[1], Yoshiki Toba[6], Yoshihiro Ueda[7], Takuji Yamashita[1]

[1] *Ehime University*
[2] *Tohoku University*
[3] *Princeton University*
[4] *Sapporo Medical University*
[5] *Universitat de Barcelona*
[6] *Academia Sinica Institute of Astronomy and Astrophysics*
[7] *Kyoto University*

We present a new sample of X-ray bright optically faint active galactic nuclei selected by combining XMM-Newton and Subaru Hyper Suprime-Cam surveys. 53 X-ray sources satisfying i band magnitude fainter than 23.5 mag and X-ray counts with EPIC-PN detector larger than 70 are selected from 9 deg^2 in the XMM-XXL field, and their spectral energy distributions (SEDs) and X-ray spectra are analyzed. 46 objects with an X-ray to i band flux ratio $F_{\rm X}/F_i > 10$ are classified as extreme X-ray-to-optical flux sources. SEDs of 48 among 53 are represented by templates of type 2 AGNs or starforming galaxies and show signature of stellar emission from host galaxies in the optical in the source rest frame. X-ray spectra are fitted by an absorbed power law model, and the intrinsic absorption column densities are modest (best-fit $\log N_{\rm H} = 20.5 - 23.5$ cm^{-2} in most cases). The absorption corrected X-ray luminosities are in a range of $6 \times 10^{42} - 2 \times 10^{45}$ erg s^{-1}. 20 objects are classified as type 2 quasars. The optical faintness is explained by a combination of redshifts (mostly $z > 1.0$), strong dust extinction, and in part a large ratio of dust/gas.

The search for heavily obscured AGN in the Chandra deep fields

Cristian Vignali[1,2], Maria Elisabetta Dalla Mura[1], Ivan Delvecchio[3], Giorgio Lanzuisi[1,2], Fabio Vito[4,5], Francesca Pozzi[1,2], Carlotta Gruppioni[2]

[1] *Dipartimento di Fisica e Astronomia, Università di Bologna, Italy*
[2] *INAF - Osservatorio Astronomico di Bologna, Italy*
[3] *Department of Physics, University of Zagreb, Croatia*
[4] *Department of Astronomy & Astrophysics, The Pennsylvania State University, University Park, USA*
[5] *Institute for Gravitation and the Cosmos, The Pennsylvania State University, University Park, USA*

Among the possible methods to select heavily obscured AGN, one of the most efficient combines the strength of SED fitting with deep X-ray spectroscopy in the Chandra deep fields (North and South). In the sample of sources characterised by powerful mid-infrared AGN emission and relatively faint X-rays we discovered nine heavily obscured AGN, some of which having a column density above 10^{24} cm^{-2}. We also provide constraints from X-ray stacking analysis for the IR-luminous sources whose individual X-ray emission is undetected even in the 7Ms exposure of the CDF-S. Finally, prospects for forthcoming X-ray and mid-IR facilities will be also highlighted.

Characterizing the AGN populating the NuSTAR Extragalactic Survey fields

Luca Zappacosta[1], Andrea Comastri[2], Francesca Civano[3], Simonetta Puccetti[4], Fabrizio Fiore[1], James Aird[5], Agnese Del Moro[6], George Lansbury[5], Giorgio Lanzuisi[7], David Alexander[8]
[1]*INAF-Osservatorio Astronomico di Roma, Monte Porzio Catone, Italy*
[2]*INAF-Osservatorio Astronomico di Bologna, Bologna, Italy*
[3]*Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA*
[4]*ASI Science Data Center, Rome, Italy*
[5]*Institute of Astronomy, University of Cambridge, Cambridge, UK*
[6]*Max-Planck-Institut fur Extraterrestrische Physik, Garching, Germany*
[7]*Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italy*
[8]*Centre for Extragalactic Astronomy, Department of Physics, Durham University, Durham, UK*

I will present a spectroscopic analysis of a sample of 63 AGN detected in the NuSTAR Extragalactic Survey fields and selected to have bright fluxes in the 8-24 keV energy range. I will report on their properties measured through a broad-band joint NuSTAR+Chandra/XMM spectral analysis. In particular I will discuss on the derived observed/intrinsic column density distribution, Compton Thick and absorption fractions comparing them with Cosmic X-ray Background population synthesis model predictions.

Chapter 17

Cosmology, Dark Matter and Dark Energy

The status of the 3.5 keV line

Joseph Conlon[1], Francesca Day[1], Nicholas Jennings[1], Sven Krippendorf[1], Markus Rummel[2]
[1] *University of Oxford, UK*
[2] *Perimeter Institute for Theoretical Physics, Waterloo, Canada*

In 2014, an anomalous 3.5 keV line was observed in the spectra of galaxy clusters by Bulbul et al and Boyarsky et al. Numerous explanations of this feature, both dark matter based and astrophysical, have been proposed. I will review the observational status of the 3.5 keV line and its potential as a dark matter signal. I will discuss our recent discovery of an absorption feature at 3.5 keV in the AGN at the centre of the Perseus galaxy cluster, and how these anomalies may be linked. In particular, our result means that the non-observation of the 3.5 keV line with Hitomi is fully consistent, and could be explained in a two-state Fluorescent Dark Matter model for the 3.5 keV line.

Cosmological constraints from X-ray all sky surveys, from CODEX to eROSITA

Alexis Finoguenov[1,2]
[1] *MPE, Garching, Germany*
[2] *University of Helsinki, Finland*

Large area cluster cosmology has long become a multiwavelength discipline. Understanding the effect of various selections is currently the main path to improving on the validity of cluster cosmological results. Many of these results are based on the large area sample derived from RASS data. We perform wavelet detection of X-ray sources and make extensive simulations of the detection of clusters in the RASS data. We assign an optical richness to each of the 25,000 detected X-ray sources in the 10,000 square degrees of SDSS BOSS area. We show that there is no obvious separation of sources on galaxy clusters and AGN, based on distribution of systems on their richness. We conclude that previous catalogs, such as MACS, REFLEX are all subject to a complex optical selection function, in addition to an X-ray selection. We provide a complete model of identification of cluster counts are galaxy clusters, which includes chance identification, effect of AGN halo occupation distribution and the thermal emission of ICM. Finally we present the cosmological results obtained using this sample.

Bounds on Axion-like Particles from X-ray observations of AGNs and quasars

Sven Krippendorf[1], Joseph Conlon[1], Francesca Day[1], Nicholas Jennings[1], Markus Rummel[2]
[1] *University of Oxford*
[2] *McMaster University, Perimeter Institute*

Axion-like particles are a well-motivated extension of the Standard Model. They arise generically in string theory and they can be (part of) dark matter. Axion-like particles can induce localised oscillatory modulations in the spectra of photon sources passing through astrophysical magnetic fields, in particular through magnetic fields in galaxy clusters. By the absence of modulations in AGN/Quasar spectra (in particular from observations of the central AGN of NGC1275 in the Perseus Cluster) we are able to place world-leading bounds on light axion-like particles: $g_{a\gamma\gamma} < 1.4 - 4.0 \times 10^{-12} GeV^{-1}$ for $m_{axion} < 10^{-12} eV$. I will present how we obtain these bounds from Chandra observations, how they compare to direct (upcoming) experimental searches (e.g. IAXO) and how future observations (for instance with Athena) could improve these bounds. This talk will be based on 1605.01043 and work in progress to be published soon.

HICOSMO – X-ray analysis of a complete sample of galaxy clusters

Gerrit Schellenberger[1,2], Thomas Reiprich[2]
[1] *Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA*
[2] *Argelander-Institut für Astronomie, Universität Bonn, Auf dem Hügel 71, 53121 Bonn, Germany*

Galaxy clusters are known to be the largest virialized objects in the Universe. Based on the theory of structure formation one can use them as cosmological probes, since they originate from collapsed overdensities in the early Universe and witness its history. The X-ray regime provides the unique possibility to measure in detail the most massive visible component, the intra cluster medium. Using Chandra observations of a local sample of 64 bright clusters (HIFLUGCS) we provide total (hydrostatic) and gas mass estimates of each cluster individually. Making use of the completeness of the sample we quantify two interesting cosmological parameters by a Bayesian cosmological likelihood analysis. We find $\Omega_{\rm M} = 0.3 \pm 0.01$ and $\sigma_8 = 0.79 \pm 0.03$ (statistical uncertainties) using our default analysis strategy combining both, a mass function analysis and the gas mass fraction results. The main sources of biases that we discuss and correct here are (1) the influence of galaxy groups (higher incompleteness in parent samples and a differing behavior of the $L_x - M$ relation), (2) the hydrostatic mass bias (as determined by recent hydrodynamical simulations), (3) the extrapolation of the total mass (comparing various methods), (4) the theoretical halo mass function and (5) other cosmological (non-negligible neutrino mass), and instrumental (calibration) effects.

Chapter 18

Special Session: Athena

Calibrating the Athena telescope

Jos de Bruijne[1], Matteo Guainazzi[1], Jan-Willem den Herder[2], Marcos Bavdaz[1], Vadim Burwitz[3], Philippe Ferrando[4], David Lumb[1], Lorenzo Natalucci[5], Francois Pajot[6], Giovanni Pareschi[7], Steven Sembay[8], Daniele Spiga[7], Richard Willingale[8], Hironori Matsumoto[9], Takashi Okajima[10]
[1] *European Space Agency, Directorate of Science, Noordwijk*
[2] *SRON Netherlands Institute for Space Research, Utrecht*
[3] *Max-Planck-Institut fuer extraterrestrische Physik, Garching*
[4] *CEA, Saclay*
[5] *INAF-IAPS, Roma*
[6] *IRAP, Toulouse*
[7] *INAF, Brera*
[8] *University of Leicester, Leicester*
[9] *Nagoya University, Nagoya*
[10] *NASA, Goddard Space Flight Center, Greenbelt*

Athena is ESA's upcoming, large X-ray mission, currently set for launch in 2028. With two state-of-the-art instruments (a high-resolution spectrograph named X-IFU and a wide-field imager named WFI), and a telescope collecting area of 2 m^2 at 1 keV, the calibration of the spacecraft is a challenge in itself. This poster presents the current plan of how to calibrate the Athena telescope. It is based on a hybrid approach, using manufacturing and integration data as well as dedicated calibration measurements plus a refined model to simulate the full response of the optics.

Athena's Constraints on the Dense Matter Equation of State from Quiescent Low Mass X-ray Binaries

Sebastien Guillot[1]
[1] *Pontificia Universidad Católica de Chile*

Athena's observatory science goal R-SCIOBJ-331 states that Athena shall constrain the equation of state of neutron stars by obtaining X-ray spectra of 7 quiescent low mass X-ray binaries with a good distance estimate. Indeed, the study of the soft X-ray thermal emission from the neutron star surface in qLMXBs is a crucial tool to understand the interior structure of neutron stars and to place constrains on the dense matter equation of state. I will briefly review this method, its strengths and current weaknesses and limitations, as well as the current constraints on the equation of state from qLMXBs. The superior sensitivity of Athena will permit obtaining unprecedentedly high signal-to-noise spectra from these sources. I will present and discuss the expected constraints on the dense matter equation of state that will be obtained from observations of multiple qLMXBs with the Athena X-ray Observatory.

Projected bounds on ALP-photon coupling from simulated ATHENA data

Nicholas Jennings[1], Francesca Day[1], Joseph Conlon[1], Francesco Muia[1], Sven Krippendorf[1]
[1] *University of Oxford*

ALPs (Axion-Like Particles) are light pseudo-scalars that are a well motivated extension of the Standard Model. These particles couple to photons in the presence of a magnetic field, and ultralight ALPs are converted particularly efficiently in galaxy clusters. At X-ray energies this coupling will induce quasi-sinusoidal oscillations in the spectrum of any object in or behind the cluster, allowing us to place bounds on this interaction from observations of AGNs in galaxy clusters. The X-IFU instrument on ATHENA will represent a huge leap forward in our ability to constrain ALP-photon interactions in this way, due to its predicted energy resolution of 2.5 eV. In this talk I will present bounds derived from simulated Athena data and discuss how different design configurations will affect these bounds.

Surveys with Athena: results from detailed SIXTE simulations

Giorgio Lanzuisi[1,2], Andrea Comastri[2]
[1] *Dipartimento di Fisica e Astronomia, Università di Bologna, Italy*
[2] *INAF-Osservatorio Astronomico di Bologna, Italy*

"Formation and early growth of BH" and "Accretion by supermassive BH through cosmic time" are two of the scientific objectives of the Athena mission. To these and other topics (i.e. first galaxy groups, cold and warm obscuration and feedback signatures in AGN at high z), a large fraction (20-25%) of the Athena Mock Observing Plan is devoted, in the form of a multi-tiered (deep-medium-wide) survey with the WFI. We used the flexible SIXTE simulator to study the impact of different instrumental configurations, in terms of WFI FOV, mirror psf, background levels, on the performance in the three layers of the WFI survey. We mainly focus on the scientific objective that drives the survey configuration: the detection of at least 10 AGN at z=6-8 with Log(LX)=43-43.5 erg/s and 10 at z=8.10 with Log(LX)=44-44.5 erg/s. Implications for other scientific objectives involved in the survey are also discussed.

An end-to-end X-IFU simulator: constraints on ICM kinematics

Mauro Roncarelli[1,2]
[1] *Università di Bologna - Dipartimento di Fisica e Astronomia*
[2] *INAF - Osservatorio Astronomico di Bologna*

In the next years the study of ICM physics will benefit from a completely new type of observations made available by the X-IFU microcalorimeter of the ATHENA X-ray telescope. X-IFU will combine energy and spatial resolution (2.5 eV and 5 arcsec) allowing to map line emission and, potentially, to characterise the ICM dynamics with an unprecedented detail. I will present an end-to-end simulator aimed at describing the ability of X-IFU to characterise ICM velocity features. Starting from hydrodynamical simulations of ICM turbulence (Gaspari et al. 2013) we went through a detailed and realistic spectral analysis of simulated observations to derive mapped quantities of gas density, temperature, metallicity and, most notably, centroid shift and velocity broadening of the emission lines, with relative errors. Our results show that X-IFU will be able to map in great detail the ICM velocity features and provide precise measurements of the broadening power spectrum. This will provide interesting constraints on the characteristics of turbulent motions, both on large and small scales.

Chapter 19

Current and Future X-ray Missions

The Transient High-Energy Sky and Early Universe Surveyor (THESEUS)

Lorenzo Amati[1]
[1] *INAF - IASF Bologna*

The Transient High Energy Sky and Early Universe Surveyor (THESEUS) is a mission concept developed by a large international collaboration aimed at exploiting Gamma-Ray Bursts for investigating the early Universe. The main scientic objectives of THESEUS, currently under evaluation by ESA within the selection process for next M5 mission, include: investigating the star formation rate and metallicity evolution of the ISM and IGM up to redshift 10, detecting the first generation (pop III) of stars, studying the sources and physics of re-ionization, detecting the faint end of galaxies luminosity function. These goals will be achieved through a unique combination of instruments allowing GRB detection and arcmin localization over a broad FOV (more than 1sr) and an energy band extending from several MeVs down to 0.3 keV with unprecedented sensitivity, as well as on-board prompt (few minutes) follow-up with a 0.7m class IR telescope with both imaging and spectroscopic capabilities. Such instrumentation will also allow THESEUS to perform a monitoring of the X-ray sky with unprecedented sensitivity, which will provide a perfect service and sinergy to next generation multi-wavelength (e.g., E-ELT, SKA, CTA, ATHENA) and multi-messenger (aLIGO, aVIRGO, eLISA, ET, neutrino detectors, ...) facilities.

SMILE: Novel and global X-ray imaging of the Sun-Earth connection

Graziella Branduardi-Raymont[1], Chi Wang[2], SMILE Collaboration[3]
[1] *Mullard Space Science Laboratory, UCL, Holmbury St Mary, UK*
[2] *National Space Science Center, CAS, Beijing, China*
[3] *ESA, CAS and European, Canadian, USA, China institutions*

SMILE (Solar wind Magnetosphere Ionosphere Link Explorer) is a novel space mission, under development, dedicated to study the dynamic coupling of the solar wind with the Earths magnetosphere in a global way never attempted before. From a highly elliptical Earth polar orbit SMILE will obtain X-ray images of the dayside magnetosheath and polar cusps simultaneously with UV images of the Northern aurora, while making in situ solar wind/magnetosheath plasma and magnetic field measurements.

X-ray imaging of the dayside magnetosheath and cusps is now possible thanks to the advanced development of wide field of view and low mass X-ray optics, which enable us to map the solar wind charge exchange X-ray emission found to occur in the vicinity of the Earths magnetosphere. SMILE will turn this unwanted background for astronomical observations into a diagnostic tool for the study of solar-terrestrial interactions, making it possible to trace and link the processes of solar wind injection in the magnetosphere with particle precipitation into the cusps and the aurora.

SMILE is the first fully collaborative space mission from design to flight operations between ESA and the Chinese Academy of Sciences. Its scientific motivation and impact, as well as the payload development, will be presented.

XMMFITCAT-Z: The enhanced XMM-Newton spectral-fit database by the inclusion of photometric redshifts

Amalia Corral[1,2], Ioannis Georgantopoulos[1], Francisco J. Carrera[2], Simon R. Rosen[3], Natalie Webb[4], Michael G. Watson[3], Angel Ruiz[1], Sotiria Fotopoulou[5]
[1] *IAASARS (NOA), Athens, Greece*
[2] *IFCA (CSIC-UC), Santander, Spain*
[3] *University of Leicester, Leicester, UK*
[4] *IRAP, Toulouse, France*
[5] *University of Geneva, Geneva, Switzerland*

I will present XMMFITCAT-Z, an unique tool for the astronomical community to construct large and representative samples of X-ray sources by selecting them according to their spectral properties. XMMFITCAT-Z is an enhanced version of XMMFITCAT, the XMM-Newton spectral-fit database, which contains automated spectral-fitting results for the X-ray sources within the XMM-Newton serendipitous source catalogue for which spectral data were pipe-line extracted, $\sim$ 120,000 source detetections corresponding to $\sim$ 80,000 unique sources. XMMFITCAT-Z is aimed to the derivation of photometric redshifts and redshift-dependent spectral fits by using up to 10 photometric points, from the optical to the mid-infrared, and machine learnig techniques. We have already made use of the photometric data from the SDSS, UKIDSS, 2MASS and WISE surveys to evaluate the reliability of our photometric redshifts, and we are currently implementing the recently released data from the Pan-STARRS survey to further increase the number of X-ray sources with optical counterparts. The final database will contain photometric redshifts for more than 40,000 extragalactic X-ray sources, and redshift-dependent spectral fits for those with extracted spectra.

EXTraS: Exploring the X-ray Transient and variable Sky

Andrea De Luca[1], Ruben Salvaterra[1], Andrea Tiengo[2], Daniele D'Agostino[3], Mike Watson[4], Frank Haberl[5], Joern Wilms[6]
[1] *INAF/IASF Milano, Milano, Italy*
[2] *IUSS, Pavia, Italy*
[3] *CNR/IMATI, Genova, Italy*
[4] *University of Leicester, Leicester, UK*
[5] *MPG/MPE, Garching, Germany*
[6] *ECAP, Bamberg, Germany*

The EXTraS project extracted all temporal domain information buried in the whole database collected by the EPIC cameras onboard the XMM-Newton mission. This included a search and characterisation of variability, both periodic and aperiodic, in hundreds of thousands of sources spanning more than eight orders of magnitude in time scale and six orders of magnitude in flux, as well as a search for fast transients, missed by standard image analysis. Phenomenological classification of variable sources, based on X-ray and multiwavelength information, has also been performed. All results and products of EXTraS are made available to the scientific community through a web public data archive. A dedicated science gateway will allow scientists to apply EXTraS pipelines on new observations. EXTraS is the most comprehensive analysis of variability, on the largest ever sample of soft X-ray sources. The resulting archive and tools disclose an enormous scientific discovery space to the community, with applications ranging from the search for rare events to population studies, with impact on the study of virtually all astrophysical source classes. EXTraS, funded within the EU/FP7 framework, is carried out by a collaboration including INAF (Italy), IUSS (Italy), CNR/IMATI (Italy), University of Leicester (UK), MPE (Germany) and ECAP (Germany).

Influence of a polarized primary source on the X-ray polarization resulting from disc reflection in AGN

Michal Dovciak[1], Rene Goosmann[2], Vladimir Karas[1], Niccolo Di Lalla[3], Frederic Marin[2], Giorgio Matt[4], Fabio Muleri[5], Jiri Svoboda[1]

[1] *Astronomical Institute of the CAS, Prague, Czech Republic*
[2] *Observatoire Astronomique de Strasbourg, Strasbourg, France*
[3] *Istituto Nazionale di Fisica Nucleare, Pisa, Italy*
[4] *Universita degli Studi Roma Tre, Rome, Italy*
[5] *Istituto di Astrofisica Spaziale e Fisica Cosmica, Rome, Italy*

Theoretical computations showed that the reflection of X-ray radiation from the accretion disc in AGN should result in significant (detectable) polarization signals. Originating from a primary power-law coronal emission situated above the disc surface, X-ray photons are partially reprocessed by Compton scattering in the disc material and show a polarization level that heavily depends on geometry of scattering. In this contribution, we examine the polarization that can be obtained in the lamp-post geometry scenario, where a compact patch of corona is positioned on the axis above the black hole. The influence of differently polarized primary source will be presented and simulated AGN observation with the proposed XIPE X-ray polarimetry mission shown.

XMM-Newton Science Analysis System (SAS): medium and long term strategy

Carlos Gabriel[1]

[1] *XMM-Newton SOC, European Space Astronomy Centre, ESA*

The Science Analysis System (SAS) is so far the only analysis software able to process the data taken with all the scientific instruments on board the XMM-Newton satellite. It also represents the core of the Pipeline Processing System (PPS), the system used to reduce all XMM-Newton observations for providing final calibrated products to the observers, and to populate the XMM-Newton Scientific Archive (XSA), as the source of data for the whole community. While maintaining and extending SAS, recognised as a fundamental component of optimising the mission's science output, we are in the process of simplifying it, modernising its code, and maximising its longevity for post-mission times.

Derivation of photometric redshifts for the 3XMM catalogue

Ioannis Georgantopoulos[1], Amalia Corral[2], George Mountrichas[1], Angel Ruiz[1], Vasilia Masoura[1], Sotiria Fotopoulou[3], Michael Watson[4]
[1] *National Observatory of Athens*
[2] *University of Santander*
[3] *University of Geneva*
[4] *University of Leicester*

We present the results from our ESA Prodex project that aims to derive photometric redshifts for the 3XMM catalogue. The 3XMM DR-6 offers the largest X-ray survey, containing 470,000 unique sources over 1000 sq. degrees. We cross-correlate the X-ray positions with optical and near-IR catalogues using Bayesian statistics. The optical catalogue used so far is the SDSS while currently we are employing the recently released PANSTARRS catalogue. In the near IR we use the Viking, VHS, UKIDS surveys and also the WISE W1 and W2 filters. The estimation of photometric redshifts is based on the TPZ software. The training sample is based on X-ray selected samples with available SDSS spectroscopy. We present here the results for the 40,000 3XMM sources with available SDSS counterparts. Our analysis provides very reliable photometric redshifts with sigma(mad)=0.05 and a fraction of outliers of 8% for the optically extended sources. We discuss the wide range of applications that are feasible using this unprecedented resource.

Arcsecond and Sub-arcsedond Imaging with X-ray Multi-Image Interferometer and Imager for (very) small sattelites

Kiyoshi Hayashida[1], Tomoki Kawabata[1], Hiroshi Nakajima[1], Shota Inoue[1], Hiroshi Tsunemi[1]
[1] *Osaka University, Osaka, Japan*

The best angular resolution of 0.5 arcsec is realized with the X-ray mirror onborad the Chandra satellite. Nevertheless, further better or comparable resolution is anticipated to be difficult in near future. In fact, the goal of ATHENA telescope is 5 arcsec in the angular resolution. We propose a new type of X-ray imager (or interferometer) consisting simply of an X-ray absorption grating and an X-ray spectral imaging detector, such as X-ray CCDs or new generation CMOS detectors. Arcseconds resolution is expected for very small satellites of 50cm size, and sub-arcseconds resolution for small sattellites. We have performed ground experiments, in which a micro-focus X-ray source, grating with pitch of 4.8um, and 30 micrometer pixel detector placed about 1m from the source. We obtained the self-image of the grating with this settings for wide band pass around 10keV. In some cases, the image should be called interference fringe. This result corresponds to about 2 arcsec resolution for parrallel beam incidence.

This system is usefull for high angular resolution imaging of relatively bright sources. Search for super massive black holes and resolving AGN torus would be the targets of this system.

Cross-calibrating XMM-Newton's EPIC effective areas for a default empirical correction

Cornelia Heinitz[1], Michael Smith[2], Chris Tenzer[1], Martin Stuhlinger[2], Andrea Santangelo[1]
[1] *Institute for Astronomy and Astrophysics Tübingen (IAAT)*
[2] *European Space Astronomy Centre (ESAC)*

Since SAS version 14.0, there is an option available to XMM-Newton users to apply an empirical on-axis effective area correction to reconcile the three EPIC cameras amongst themselves via an energy-dependent multiplicative factor. However, CORRAREA, which is the corresponding extension in the XMM calibration files, is currently only implemented as a non-default tool as it is not yet considered fully validated and requires recalibration. The goal is to make CORRAREA a default correction, for which we perform the necessary data reduction, spectral fitting and analysis, including an automation of the process as far as possible for testing purposes and future updates. This poster introduces the project and shows the current status of the recalibration. Further development of the tool is intended to bring the EPIC cameras in line with instruments on other observatories.

XMM-Newton mission operations - ready for its third decade

Marcus G. F. Kirsch[1], Timothy Finn[2], Thomas Godard[3], Nikolai v. Krusenstiern[2], Norbert Pfeil[4], David J. Salt[2], Liviu Toma[2], Detlef Webert[2], Uwe Weissmann[2]
[1] *ESA/ESOC*
[2] *Telespazio Vega*
[3] *Rhea*
[4] *Terma*

The XMM-Newton X-ray space observatory is approaching its third decade of operations. The spacecraft and payload are operating without major degradation and scientific demand is continuously very high. With the change to a new way of using the Attitude and Orbit control System in 2013 the fuel consumption was reduced by a factor of two, additionally this has reduced stress on the reaction wheels. The challenge for the next decade is now to ensure that the saved fuel is available for continuous usage.

We will describe the process of the so called "fuel migration and replenishment" activities needed to keep the spacecraft operational potentially up to 2029+.

We provide as well an overall health status of the mission, the evolution of the ground segment and concepts on streamlining mission operations with continued high safety requirements using automation tools.

A Novel Approach to model EPIC variable background

Martino Marelli[1], Andrea De Luca[1], David Salvetti[1], Andrea Belfiore[1]
[1] *IASF-INAF Milano - Italy*

One of the main aim of the EXTraS (Exploring the X-ray Transient and variable Sky) project is to characterise the variability of serendipitous XMM-Newton sources within each single observation. Unfortunately, 164 Ms out of the 774 Ms of cumulative exposure considered (21%) are badly affected by soft proton flares, hampering any classical analysis of field sources. De facto, the latest releases of the 3XMM catalog, as well as most of the analysis in literature, simply exclude these 'high background' periods from analysis. We implemented a novel SAS-indipendent approach to produce background-subtracted light curves, which allows to treat the case of very faint sources and very bright proton flares. EXTraS light curves of 3XMM-DR5 sources will be soon released to the community, together with new tools we are developing.

What can X-ray polarization tell us about accreting black hole systems?

Frederic Marin[1]
[1] *Astronomical observatory of Strasbourg*

With the launch of the Imaging X-ray Polarimetry Explorer (IXPE) by the year 2020/21, X-ray polarimetry will open a new window in astrophysics. Dedicated to high energy sources with sufficient X-ray luminosity, IXPE will target both stellar-mass black holes in binary systems and supermassive black holes in active galaxies. In this talk, I intend to review the main questions to be solved or constrained by X-ray polarimetry. I will show how polarimetric observations in the 2-8 keV band will measure the spin, disk inclination and mass of the black hole. Additional information about the surrounding medium, such as the amount of circumnuclear gas in active galactic nuclei (AGN) or the composition of outflowing polar winds will be derived simultaneously. By probing the iron Kalpha line band, X-ray polarimetry will also constrain the importance of General Relativity effects that are supposed to shape the spectra of pole-on objects. Finally, I will introduce how IXPE will map the Galactic Center in search of past activity.

Automated source classification of new transient sources

Mirjam Oertel[1], Annika Kreikenbohm[2], Jörn Wilms[1], Andrea DeLuca[3]
[1] *ECAP and Remeis Observatory, Erlangen and Bamberg, Germany*
[2] *ITAP, Univ. Würzburg, Germany*
[3] *INAF/IASF, Milano, Italy*

The EXTraS project harvests the hitherto unexplored temporal domain information buried in the serendipitous data collected by the European Photon Imaging Camera (EPIC) onboard the ESA XMM-Newton mission since its launch. This includes a search for fast transients, missed by standard image analysis, and a search and characterization of variability in hundreds of thousands of sources. We present an automated classification scheme for new transient sources in the EXTraS project. The method is as follows: source classification features of a training sample are used to train machine learning algorithms (performed in R; randomForest (Breiman, 2001) in supervised mode) which are then tested on a sample of known source classes and used for classification.

Overview of science results from Hitomi

Takaya Ohashi[1], Hitomi collaboration[2]
[1] *Tokyo Metropolitan University, Hachioji, Japan*

We will report on the overview of science results obtained from Hitomi. The satellite observed six targets (Perseus cluster, N132D, IGR J16318-4848, G21.5-0.9, RXJ 1856.5-3754, and Crab nebula) during its operation for about a month in the orbit. Observing instruments have been turned on in the course of these observations, and they functioned properly. Results from the Perseus cluster and the Crab nebula will be reported in this conference separately as several papers. We will summarize Hitomi results with emphasis on other sources.

Characterizing the Aperiodic Variability of 3XMM Sources using Bayesian Blocks

David Salvetti[1], Andrea Belfiore[1], Martino Marelli[1], Andrea De Luca[1]
[1]*INAFIstituto di Astrofisica Spaziale e Fisica Cosmica - Milano, via E. Bassini 15, I-20133 Milano, Italy*

I will present Bayesian blocks algorithm and its application to XMM sources, statistical properties of the entire 3XMM sample, and a few interesting cases. While XMM-Newton is the best suited instrument for the characterization of X-ray source variability, its most recent catalogue (3XMM) reports light curves only for the brightest ones and excludes from its analysis periods of background flares. One aim of the EXTraS ('Exploring the X-ray Transient and variable Sky') project is the characterization of aperiodic variability of as many 3XMM sources as possible on a time scale shorter than the XMM observation. We adapted the original Bayesian blocks algorithm to account for background contamination, including soft proton flares. In addition, we characterized the short-term aperiodic variability performing a number of statistical tests on all the Bayesian blocks light curves. The EXTraS catalogue and products will be released soon to the community, together with tools that will allow the user to replicate EXTraS results and extend them through the next decade.

The stellar content of soft all-sky X-ray surveys

Jürgen Schmitt[1], Sebastian Freund[1], Jan Robrade[1], Christian Schneider[1]
[1]*Hamburger Sternwarte, Hamburg Germany*

Wide angle soft X-ray surveys such as the ROSAT all-sky survey, the XMM slew survey, or the upcoming eROSITA all-sky survey(s) produce – more or less homogeneous – data sets with tens and hundreds of thousands of X-ray sources. The counterparts of typically about a third of these X-ray sources are stars, mostly of late spectral type. With the availability of genuine all-sky surveys at optical (GAIA) and infrared wavebands (2MASS) with reliable positions and multiband fluxes and in particular with the (eventual) availability of GAIA parallax information down to v = 15 mag and below, the automatic extraction and identification of the stellar content of soft X-ray surveys becomes feasible and doable. Distance information and hence accurate X-ray luminosities are available for the full data set, the counterparts can be accurately placed in the HR diagram and the local stellar volume X-ray emissivity can be measured. We discuss optimal identification strategies, the potential arising from future GAIA data releases and apply our methods to the XMM slew survey data. Our results suggest that 30.7% of the XMM slew survey entries can be identified with (non-accreting) stars.

The X-ray Astronomy Recovery Mission

Makoto Tashiro[1], Richard Kelley[2]
[1]*Saitama University, ISAS/JAXA*
[2]*NASA/GSFC*

On 25 March 2016, the Japanese 6th X-ray astronomical satellite ASTRO-H (Hitomi), launched on February 17, lost communication after a series of mishap in its attitude control system. In response to the mishap the X-ray astronomy community and JAXA analyzed the direct and root cause of the mishap and investigated possibility of a recovery mission with the international collaborator NASA and ESA. Thanks to great effort of scientists, agencies, and governments, the X-ray Astronomy Recovery Mission (XARM) are proposed. The recovery mission is planned to resume high resolution X-ray spectroscopy with imaging realized by Hitomi under the international collaboration in the shortest time possible, simply by focusing one of the main science goals of Hitomi Resolving astrophysical problems by precise high-resolution X-ray spectroscopy". XARM will carry a 6 x 6 pixelized X-ray micro-calorimeter on the focal plane of an X-ray mirror assembly, and an aligned X-ray CCD camera covering the same energy band and wider field of view, but no hard X-ray or soft gamma-ray instruments are onboard. In this paper, we introduce the science objectives, mission concept, and schedule of XARM.

Digging deeper: Towards a catalogue of detections from stacked XMM-Newton observations

Iris Traulsen[1], Axel Schwope[1], Georg Lamer[1], on behalf of the XMM-Newton Survey Science Centre Consortium[2]
[1]*Leibniz-Institut fuer Astrophysik Potsdam (AIP)*
[2]*IRAP, Toulouse, & consortium institutes*

About one third of the sky area covered by the XMM-Newton X-ray telescopes was observed more than once. The XMM-Newton Survey Science Centre Consortium (SSC) has been generating catalogues of individual detections in all publicly available XMM-Newton observations and matched catalogues of unique sources from them. The most recent incarnation is 3XMM-DR6. We present a new standardized approach to source detection on stacked images of multiple pointings. It aims at achieving ultimate sensitivity on repeatedly observed sky areas. The method has entered the Science Analysis System (SAS) as a new task and will be used to publish a catalogue of stacked detections involving all overlapping observations. Our first proto-catalogue is based on 736 individual observations grouped into 278 stacks with a minimum overlap of 50% in area between contributing observations. It comprises approximately 26000 unique sources, an increase of about 20% over the summed detections in individual pointings, and shows that the new approach gives higher sensitivity, improved source parameters, and fewer spurious detections.

MAXI/GSC 7-year Source Catalog

Yoshihiro Ueda[1], Taiki Kawamuro[1], Takafumi Hori[1], Megumi Shidatsu[2], Atsushi Tanimoto[1], the MAXI team[3]

[1] *Department of Astronomy, Kyoto University*

[2] *RIKEN*

[3] *JAXA, RIKEN, Tokyo Tech, Nihon U., AGU, Osaka U., Kyoto U., Chuo U., Miyazaki U., Nagoya U.*

Monitor of All-sky X-ray Image (MAXI) on the International Space Station has been continuously observing the X-ray sky since its launch in 2009. The MAXI survey has achieved the best sensitivity in the 4–10 keV band as an all sky X-ray mission, and is complementary to the ROSAT all sky survey (<2 keV) and hard X-ray (>10 keV) surveys performed with Swift and INTEGRAL. Here we present the latest source catalog of MAXI/Gas Slit Camera (GSC) constructed from the first 7-year data, which is an extension of the 37-month catalog of the high Galactic-latitude sky (Hiroi et al. 2013). We summarize statistical properties of the X-ray sources and results of cross identification with other catalogs.

The 3XMM catalogue

Natalie Webb[1], on behalf of the XMM-Newton Survey Science Centre[2,3]

[1] *IRAP, Toulouse, France*

[2] *OAS, Strasbourg, France; AIM, Saclay, France; University of Leicester, UK; MSSL, UK; AIP, Potsdam, Germany*

[3] *MPE, Garching, Germany; IFCA, Santander, Spain, OAB, Milan, Italy*

The latest release of the 3XMM X-ray catalogue, 3XMM-DR6, produced by the XMM-Newton Survey Science Centre (SSC) contains 678680 X-ray detections across 982 square degrees of sky and 468440 unique X-ray sources. A more comprehensive version, 3XMM-DR7 will be released in 2017. Data in this new version span 16 years and some sources have been pointed more than 50 times, providing well sampled lightcurves over long timescales. We present the latest version of the catalogue along with some of the rarest and most fascinating objects found in this resource. We also discuss future developments that will allow us to maximise the scientific return from this huge repository of X-ray data.

Exploring transient X-ray sky with Einstein Probe

Weimin Yuan[1], Chen Zhang[1], Zhi-Xing Ling[1], Donghua Zhao[1], Yong Chen[2], Fangjun Lu[2], Shuang-Nan Zhang[2]
[1]*National Astronomical Observatories, Chinese Academy of Science, Beijing, China*
[2]*Institute of High-Energy Physics, Chinese Academy of Science, Beijing, China*

The Einstein Probe is a small satellite in time-domain astronomy to monitor the soft X-ray sky. It is a small mission in the space science programme of the Chinese Academy of Sciences. It will carry out systematic survey and characterisation of high-energy transients at unprecedented sensitivity, spatial resolution, Grasp and monitoring cadence. Its wide-field imaging capability is achieved by using established technology of micro-pore lobster-eye X-ray focusing optics. Complementary to this is X-ray follow-up capability enabled by a narrow-field X-ray telescope. It is capable of on-board triggering and real time downlink of transient alerts, in order to trigger fast follow-up observations at multi-wavelengths. Its scientific goals are concerned with discovering and characterising diverse types of X-ray transients, including tidal disruption events, supernova shock breakouts, high-redshift GRBs, and of particular interest, X-ray counterparts of gravitational wave events.

On-the-fly Data Reprocessing and Analysis Capabilities from the XMM-Newton Archive

Aitor Ibarra[1], María Sarmiento[2], Elena Colomo[2], Nora Loiseau[1], Jesús Salgado[2], Carlos Gabriel[1]
[1]*XMM-Newton SOC- ESAC/ESA, Spain*
[2]*ESDC- ESAC/ESA, Spain*

The XMM-Newton Science Archive (XSA) includes since last release the possibility to perform on-the-fly data processing with SAS through the Remote Interface for Science Analysis (RISA) server. It enables scientists to analyse data without any download and installation of data and software.

The analysis options presently available include extraction of spectra and light curves of user-defined EPIC source regions and full reprocessing of data for which currently archived pipeline products were processed with older SAS versions or calibration files. The current pipeline is fully aligned with the most recent SAS and calibration, while the last full reprocessing of the archive was performed in 2013.

The on-the-fly data processing functionality in this release is an experimental version and we invite the community to test and let us know their results. Known issues and workarounds are described in the 'Watchouts' section of the XSA web page. Feedback on how this functionality should evolve will be highly appreciated.

Name Index