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ABSTRACT BOOK

Oral Communications and Posters

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Contents

Chapter 1

Invited and Solicited Speakers

An Overview of Recent Results in the Galactic Center

Frederick Baganoff[1]
[1] *MIT Kavli Institute for Astrophysics and Space Research*

A brief summary is presented of recent results from observations of the Galactic Center and Sgr A* using various X-ray and Gamma-ray observatories, especially NuSTAR, and comparisons with observations at lower energies, such as the enhanced VLA, that are being used to determine the origins and dominant emission mechanisms of various objects in this region ranging from accretion onto the supermassive black hole to pulsar wind nebulae, CVs, compact binaries and magnetic flux tubes.

The X-ray Integral Field Unit of the Athena X-ray Observatory

Didier Barret[1], Jan Willem den Herder[2], Luigi Piro[3]
[1] *Institut de Recherche en Astrophysique et Planétologie, Toulouse*
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on behalf of the X-IFU consortium

The Athena X-ray observatory is proposed to the European Space Agency as the second large mission to specifically address the Hot and Energetic Universe science theme. The Athena science payload will carry the X-ray Integral Field Unit (X-IFU): a cryogenic X-ray spectrometer, based on a large array of Transition Edge Sensors (TES), providing a 2.5 eV spectral resolution, with 5 arcsecond pixels, over a field of view of 5 arc minutes in diameter. In this paper, we will briefly outline the science to be addressed by the X-IFU. The current instrument design will be presented, together with its anticipated performance. Finally, we will emphasize on the latest technology developments concerning TES array fabrication, spectral resolution and readout performance to demonstrate that significant progresses are being accomplished towards the demanding X-IFU requirements.

Magnetic energy dissipation and emission from magnetars

Andrei Beloborodov[1]
[1] *Columbia University, New York, USA*

Energy dissipation in magnetars will be discussed, including dissipation inside and outside the neutron star. Different modes of dissipation are responsible for various components of magnetar activity: persistent emission and bursts, thermal and nonthermal X-ray emission, and low-frequency emission.

Astro-H: science goals, development status, and European contribution

Matteo Guainazzi[1]
[1] *European Space Astronomy Centre of the European Space Agency on behalf of the Astro-H mission, JAXA/NASA and cooperating partners*

The joint JAXA/NASA ASTRO-H mission is the sixth X-ray mission initiated by the Institute of Space and Astronautical Science (ISAS). ASTRO-H allows a combination of wide band X-ray spectroscopy (5-80 keV) provided by multilayer coating, focusing hard X-ray mirrors and hard X-ray imaging detectors, and high energy-resolution soft X-ray spectroscopy (0.3-12 keV) provided by thin-foil X-ray optics and a micro-calorimeter array. The mission will also carry a X-ray CCD camera as a focal plane detector for a soft X-ray telescope (0.4-12 keV) and a non-focusing soft gamma-ray detector (40-600 keV). ASTRO-H is expected to provide breakthrough results in the large-scale structure of the Universe and its evolution, the behaviour of matter in the gravitational strong field regime, the physical conditions in sites of cosmic-ray acceleration, and the distribution of dark matter in galaxy clusters at different redshifts. I will also review the European contribution to Astro-H, both in terms of hardware development as well as in terms of prospective support for the European community.

The XMM-Newton survey of the Large (and Small) Magellanic Cloud

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

Between December 2011 and February 2014 we performed an X-ray survey of the Large Magellanic Cloud (LMC) using the XMM-Newton observatory. The LMC is the fourth largest galaxy in the Local Group and one of the closest to the Milky Way making it an ideal target to study its X-ray emission. The XMM-Newton large project comprises of 25 ks observations of 70 fields, which together with archival data cover an area of about 10 square degrees. The observations reach a limiting flux of about 2×10^{-14} erg/s/cm^2 which corresponds to $4\text{x}10^{33}$ erg/s at the distance of the LMC. The XMM-Newton survey provides a unique data set to investigate the X-ray source populations of the LMC. This comprises high mass X-ray binaries and supernova remnants, but also emission from the hot interstellar medium. In this talk I'll present on behalf of the XMM-Newton LMC-survey collaboration an overview of the LMC survey with some highlights from our first results while more specific projects are presented in other contributions to this conference.

The geometric origin of low frequency quasi-periodic oscillations in black hole binaries

Adam Ingram[1], Michiel van der Klis[1], Chris Done[2]
[1] *Anton Pannekoek Institute, University of Amsterdam*
[2] *University of Durham*

X-ray radiation from accreting black holes displays quasi-periodic oscillations (QPOs). This was discovered 30 years ago and the potential of the signal to provide insight into accretion physics was immediately recognised, however the QPO origin was not understood. Perhaps the most promising model to date associates the QPO with Lense-Thirring (LT) precession of the inner accretion flow. In general relativity, a spinning black hole drags the surrounding spacetime with it (frame dragging), causing LT precession in any particle orbit misaligned with the black hole equatorial plane. Determining the QPO phase dependence of the spectrum provides a powerful diagnostic tool to test this model against alternative interpretations. However, this poses a technical challenge because the QPO is quasi-periodic rather than purely periodic and so existing techniques are not suitable. I will describe a method designed to circumvent these problems and present the results of the first QPO phase resolved spectral analyses using archival data from the Rossi X-ray Timing Explorer (RXTE). We find, through variations in the equivalent width of the iron K alpha emission line, strong evidence that the accretion geometry changes on the QPO period, consistent with the predictions of the precession model.

XMM-Newton: Longevity through continued modification

Fred Jansen[1]
[1] *ESA-ESTEC, Noordwijk, The Netherlands*

While the XMM-Newton observatory was built with a design lifetime of 10 years, a number of activities have been necessary during recent years to guarantee, from a resource and hardware point of view, the extension of an, otherwise limited, lifetime. This has required involving the original designers, project team members and companies where the relevant hardware elements were built to define, test and upload on board software which had not been changed in some 14 years. This, amongst others, has led to the implementation of attitude control based on simultaneous use of 4 reaction wheels - a method which has not only generated significant fuel savings, but also helped to address some performance issues with one of the reaction wheels. In the next few years a few other projects/updates will need to be implemented on-board. Not only the hardware is an item to be addressed in trying to achieve mission longevity, but also analysis software changes and calibration consolidation are items which have to be considered to keep on operating under increasing budget pressure while maintaining scientific proficiency.

Tidal disruption events

Andrew Levan[1]
[1] *University of Warwick*

Tidal disruption events (TDEs) provide a powerful probe of many astrophysical processes. They occur when the powerful tidal field around a black hole disrupts a passing star which is subsequently accreted. The resulting signal is a powerful X-ray, UV/opt and possibly even radio source, that provides us with a view of accretion aroud supermassive black holes from switch-on to switch-off over the timescale of years. TDEs probe accretion physics, the ubquity of black holes in galactic nuclei and dynamics in their cores, offering a novel route to addressing these issues. I will review observations of TDEs over the past decade, outlining how samples of candidates have been gradually building, and how they can be identified against other more common transient events. I will also discuss the implications of the discovery of a population of TDEs apparently launching relativisitc jets, and how these powerful transients may be detected in upcoming X-ray to radio surveys.

Recent results on the X-ray emission of radio-quiet AGN

Giorgio Matt[1]
[1] *Dipartimento di Matematica e Fisica, Universita' Roma Tre, via della Vasca Navale 84, 00146 Roma, Italy*

I will review recent results on the X-ray emission of radio-quiet AGN, with particular emphasis on the importance of broad band observations.

New Constraints on Galaxy Cluster Evolution from Chandra Observations of SPT-Selected Clusters

Michael McDonald[1]
[1] *MIT Kavli Institute for Astrophysics and Space Research*

In the past 4 years, the number of known galaxy clusters at $z > 0.5$ has grown by a factor of > 5, thanks primarily to Sunyaev Zel'dovich surveys such as Planck, the Atacama Cosmology Telescope, and the South Pole Telescope (SPT). Here, I present several important results from the SPT 2500 deg^2 survey, which has discovered over 500 new galaxy clusters, more than 300 of which are at $z > 0.5$. Using data primarily from the Chandra X-ray Observatory, we determine evolutionary trends in the central cluster galaxy (inner $\sim$ 20 kpc), the cluster core (inner $\sim$ 100 kpc), and cluster outskirts ($>$ 1 Mpc) over the past 8 Gyr, addressing such outstanding issues as the cooling flow problem, the effects of AGN feedback, and subhalo accretion, or clumping, at the virial radius. These studies are providing the most detailed constraints to date on the evolution of galaxy clusters on all physical scales, and will continue to improve with the next generation of surveys already upon us.

Future of X-ray Astronomy

Paul Nandra[1]
[1] *MPE, Max-Planck-Institut für extraterrestrische Physik, Garching/Germany*

Missing Baryons and the WHIM: Current Evidence and Future Prospects

Fabrizio Nicastro[1]
[1] *INAF - Osservatorio Astronomico di Roma*

Baryons are missing at all astronomical scales in the Universe, from galaxies to the large scales of structure formation and the Universe as a whole. Hydro-dynamical simulations for the formation of structures, tend to re-concile the different "missing-baryon" problems and predict that most of the baryonic matter of the Universe is hiding in a hot and tenuous gaseous phase (dubbed the "Warm-Hot Intergalactic Medium, or WHIM), surrounding virialized structures and more at large in the low-redshift inter-galactic space. Here I will first summarize the current state of the art and show the current evidence of such matter in the local Universe, and will then focus on the short- and long-term future prospects for such a rich and still relatively unexplored field of research.

Galaxy Clusters: Trouble in the Periphery

Georgiana Ogrean[1], Marcus Bruggen[1], Reinout van Weeren[2], Huub Rottgering[3], Aurora Simionescu[4]
[1] *Hamburger Sternwarte, University of Hamburg, Hamburg, Germany*
[2] *Harvard-Smithsonian Center for Astrophysics, Boston, MA, USA*
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[4] *Japan Aerospace Exploration Agency, Tokyo, Japan*

Radio relics are Mpc-scale, steep-spectrum synchrotron sources in the periphery of merging galaxy clusters, which are most likely produced by particle acceleration at shocks. Two spectacular examples of relics are in the merging clusters CIZA J2242.8+5301 and 1RXS J0603.3+4214. Radio observations predict that the relics trace shocks with Mach numbers of ~ 4, under the assumptions of standard diffusive shock acceleration. We tested this prediction using deep XMM-Newton, Chandra, and Suzaku observations. Contrary to expectations, a shock of Mach number ~ 2.5 is present at the relic in CIZA J2242.8+5301, significantly weaker than predicted from the radio. Puzzlingly, there are also weaker inner shocks that have no corresponding radio emission. These shocks could be the consequence of violent relaxation of the dark matter cores of the clusters involved in the merger. Similarly to the case in CIZA J2242.8+5301, the Mach number we measure in X-ray at the radio relic in 1RXS J0603.3+4214 is also only ~ 2, significantly smaller than predicted by the radio observations. Moreover, the shock is spatially offset from the relic. I will detail these surprising results, and discuss their implications on our understanding of particle acceleration at merger shocks.

A Comparison of Weak-lensing and X-ray masses of Galaxy Clusters

Nobuhiro Okabe[1]
[1] *Kavli IPMU, The University of Tokyo*

Weak gravitational lensing effect on galaxies behind galaxy clusters is a powerful, unique tool to measure cluster masses out to virial radii, regardless of assumptions of dynamical state of matters. The weak-lensing study enables us to measure cluster masses even where hydrostatic equilibrium assumption is no longer valid, which is complementary to X-ray measurement. Recent optical observations using wide-field cameras of ground telescopes, such as the Subaru telescope, made remarkable progresses of the study.

The Suzaku X-ray satellite allows us to measure properties of intracluster medium (ICM) in cluster outskirts. By combining with Chandra/XMM-Newton observations of cluster central regions, we are able, for the first time, to investigate X-ray properties of the ICM in the entire region. Here, we are now ready to compare weak-lensing and X-ray masses out to virial radii. This talk gives a review of recent results of weak-lensing, X-ray and joint studies of galaxy clusters.

High-energy observations of novae

Julian Osborne[1]
[1] *University of Leicester*

I will review the lessons learned from the last few years of high-energy observations of classical and recurrent novae. Some observations have reinforced previous ideas (such as ejecta dispersion revealing the hot white dwarf, and ejecta shocks), while others have revealed new behaviours still in the process of being understood. XMM-Newton, Chandra, Swift and Fermi have led the way, MAXI and Suzaku have also contributed. Novae in our own Galaxy can be studied in great detail, and M31 provides a wonderful nova-rich laboratory. The mass of the white dwarf appears to dominate many aspects of nova outbursts, the density of a companion star wind is another significant variable. Even so, there remain very high energy gamma-rays, short period QPOs, and an early soft X-ray phase of huge variability with no obvious correlates or very convincing models.

X-ray emission of hot massive stars

Lidia Oskinova[1]
[1] *University of Potsdam, Germany*

Massive hot stars are important cosmic engines that severely influence their environment by powerful stellar wind and strong ionizing radiation. Modern observations of X-ray emission from massive stars provide deep insight into the structure and dynamics of their winds and allow to study the very hot gas in wind blown bubbles. I will review the recent findings on X-ray emission from OB and Wolf-Rayet stars and massive star clusters. While our knowledge about the X-ray emission from massive stars is increasing, a small fraction of massive stars that have strong magnetic fields are often unusual in their X-ray light. Massive star clusters provide an excellent opportunity to study stellar feedback and the hot gas filling the intracluster medium. The most massive stars are often binaries where the stellar winds collide and produce X-ray or even gamma-ray radiation. Finally, I will discuss the progress towards an unified view of stellar winds in single stars and in high mass X-ray binaries.

Swings between accretion and rotation power in binary millisecond pulsars

Alessandro Papitto[1]
[1] *Institute of Space Sciences (CSIC-IEEC)*

Neutron stars in low mass X-ray binaries can be spun-up to millisecond rotational periods by accreting the matter transferred by a companion star. When the rate of mass transfer decreases at the end of this Gyr-long X-ray bright phase, a radio pulsar powered by the rotation of the neutron star magnetic field turns on. Recently, the evolutionary link between these two classes of sources was finally proven by the XMM-Newton discovery of an accreting millisecond X-ray pulsar, previously seen as a rotation-powered radio pulsar. This source is the prototype of a new class of transitional systems that can alternate between accretion and rotation-powered states in response to variations of the rate of mass in-flow, on time scales as short as a couple of weeks. Observations of this and other similar systems indicate that transitions to the accretion phase not only involve bright X-ray outbursts, but also a fainter intermediate X-ray state, possibly caused by centrifugal inhibition of the matter in-fall. I will review the main observed properties, as well as prospects of finding more sources of this newly established class.

XXL: The ultimate XMM extragalactic survey

Marguerite Pierre[1], Florian Pacaud[2], The XXL consortium
[1] *CEA Saclay, Gif-sur-Yvette, France*
[2] *AIfA, Bonn, Germany*

At the end of 2010, a Very Large XMM programme - the XXL survey - was granted in order to map two regions of 25 deg2 each at medium sensitivity. This will lead to the detection of several hundreds of clusters of galaxies and of some 30 000 AGNs with well defined selection functions. The X-ray observations were completed in May 2013. After reviewing the scientific motivations, we describe the some 540 XMM observations, the associated multi-wavelength follow-up and simulation programmes. We especially underline the cosmological goals of the project involving cluster number counts, large-scale studies with clusters and AGNs as well as the systematic search for distant very clusters in a multi-lambda space. We present the first scientific results

Sunyaev-Zel'dovich effect: Recent results

Etienne Pointecouteau[1]
[1] *Institut de Recherche en Astrophyisque et Planétologie (Toulouse, France)*

The Sunyaev-Zel'dovich (SZ) effect provides an alternative and independent observable to X-rays to characterise the hot gas within groups and clusters. The quality of SZ observations has drastically improved over the past years with experiments such as the Planck satellite, the South Pole Telescope, the Atacama Cosmology Telescope, the CARMA observatory, the Mustang/GBT instrument. These SZ machines allow precise SZ measurements over a wide range of frequencies and spatial resolutions. They provide detailed views of the intra-cluster gas and cover huge volumes, competing with X-ray data. However, even more important are the combined SZ and X-ray analysis, which bear a tremendous scientific potential for groups and clusters studies in the framework of structure formation and evolution, and cosmology. I will review the recent results obtained from SZ observations, and joint SZ and X-ray analysis.

Extrasolar Planets and their Hosts: why exoplanet science needs X-ray observations

Katja Poppenhaeger[1]
[1] *Harvard-Smithsonian Center for Astrophysics*

The characterization and detection of exoplanet systems has become one of the most active fields in astronomy. A wide spectrum of observational tools is used for this, from high-precision photometry over optical and near-infrared spectra to microlensing experiments. Observations at short wavelengths are a powerful addition to the exoplaneteer's toolbox. I will discuss how short-wavelength data can enhance our understanding of exoplanets and their host stars; I will cover topics ranging from exoplanet atmospheres to coronal activity of exoplanet hosting stars.

Spectrum Roentgen Gamma

Peter Predehl[1], Mikhail Pavlinsky[2]
[1] *MPE, Max-Planck-Institut für extraterrestrische Physik, Garching/Germany*
[2] *IKI, Space Research Institute, Moscow/Russia*

Spectrum Roentgen Gamma (SRG) is an X-ray astrophysical observatory, developed by Russia in collaboration with Germany. The mission will be launched in 2016 into a 6-month-period halo orbit around L2. The mission lifetime is planned to be more than seven years. While the first four years of the mission are devoted to an all sky survey, the rest of the mssion will be used for pointed observations. The payload consists of two X-ray telescopes, eROSITA and ART-XC. The eROSITA sky survey will be about 30 times more sensitive than ROSAT at energies between 0.5 and 2 keV, while in the hard band (2-8 keV) it will provide the first ever true imaging survey of the sky. The design driving science is the detection of large samples of galaxy clusters out to redshifts z>1 in order to study the large scale structure in the universe and test cosmological models including Dark Energy. ART-XCs role is to extend the energy range of eROSITA alone, thereby doubling the effective area in the critical 4-7 keV range. The harder response of ART-XC also facilitates the x-ray detection of obscured AGN. Both instruments are currently in the flight model and calibration phase.

Magnetars: unique laboratories to study the physics of ultra-magnetized objects

Nanda Rea[1,2]
[1] *CSIC-IEEC, Barcelona, Spain*
[2] *University of Amsterdam, The Netherlands*

Neutron stars are unique laboratories to test the physics of matter embedded in strong gravitational and magnetic fields. Among the neutron star population there are a few strongly magnetic pulsars (aka magnetars): the most extreme magnetic fields known in the Universe. In this review I will report on the state-of-the-art results on these big "magnets", and on the physics driving their multi-band emission and long term evolution.

Relativistic Astrophysics in Active Galactic Nuclei

Christopher Reynolds[1]
[1] *University of Maryland*

X-ray spectroscopy and timing with XMM-Newton have given us an unprecedented view of general relativistic physics in the immediate vicinity of accreting supermassive black holes. In addition to firmly establishing the existence of black holes and allowing us to constrain their spin, we are now detecting reverberation effects from the innermost disk that will ultimately allow us to map the location of the enigmatic X-ray source. In this review talk, I shall begin by describing current status of black hole spin measurements and the tantalizing evidence for a mass dependence to the spin distribution. Building on from the previous talk, I shall then describe the general relativistic modeling of the detected reverberation delays as a means to map out the geometry of both the X-ray source and the inner accretion disk. I shall conclude by discussing the promise of ATHENA for these studies.

Reflection from the Strong Gravity Regime in a Lensed Quasar at z=0.658

Mark Reynolds[1], Rubens Reis[1], Jon Miller[1], Dominic Walton[2]
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[2] *Cahil Center for Astronomy & Astrophysics, California Institue of Technology, Pasadena, California, 91125, USA*

The co-evolution of a super-massive black hole with its host galaxy through cosmic time is encoded in its spin. At z>2, SMBHs are thought to grow mostly by merger-driven accretion leading to high spin. It is not known, however, whether below z<1 these black holes continue to grow by coherent accretion or in a chaotic manner, though clear differences are predicted in their spin evolution.

We will report an a recent analysis of archival Chandra data together with a new XMM-Newton observation of the gravitationally lensed quasar RX J1131-1231 at a redshift of z=0.658. The boost in S/N provided by the gravitational lens allows us to place strict constraints on the spin of the SMBH in a moderate redshift quasar for the first time, with implications for the growth of SMBHs.

X-rays from low and intermediate mass stars

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

In this review I will present selected science topics, challenges and future prospects in stellar X-ray astronomy. I discuss new X-ray observations of stars that have provided important insights into coronae of low mass stars, the X-ray properties of intermediate mass stars and the X-ray emission from pre-main sequence stars. Specifically, I cover magnetic activity and it's evolution over the stellar lifetime and discuss alternative X-ray generating processes including magnetically channelled winds and phenomena of young stellar objects like accretion shocks and jets.

X-ray time lags and reverberation from accreting black holes

Phil Uttley[1]
[1] *Anton Pannekoek Institute, University of Amsterdam, Amsterdam, Netherlands*

XMM-Newton's measurement of time-lags between X-ray variations at different energies has led to the discovery of the first clear signatures of X-ray reverberation in AGN, revealing the light-travel time delay between the corona and the innermost regions of the accretion disc. I will discuss the latest developments in this rapidly-evolving field, focussing on the observations of time-lags and other spectral-timing measurements of AGN, and also comparing the AGN behaviour with that seen in black hole X-ray binaries.

The X-ray afterglows of Gamma-Ray Bursts

Darach Watson[1]
[1] *Dark Cosmology Centre, Niels Bohr Institute, University of Copenhagen*

Gamma-ray bursts are renowned for being the brightest explosions since the Big Bang. They are extremely useful probes with which to study the cosmos, primarily because of their bright afterglows. While the afterglow is panchromatic, the X-ray afterglow has proved extremely useful: the first localisations of both short and long-duration GRBs were made via their X-ray afterglows, an X-ray afterglow is associated with almost every burst, and spectroscopy of the X-ray afterglow informs us of the material close to the GRB as well as providing an unobscured measurement of the afterglow flux for virtually every GRB. We now have an incredibly rich database of ten years worth of GRBs and their afterglows from the Swift satellite, where its rapid autonomous repointing has allowed its X-Ray Telescope to be on target only minutes after the GRB. Here I will review what we have learnt from the X-ray afterglows of GRBs and describe some exciting recent results.

Models of X-ray emission from black-hole binaries

Andrzej Zdziarski[1]
[1] *N. Copernicus Astronomical Center*

I will review the current status of models of X-ray emission from black-hole binaries with the emphasis of the contribution of jets. Some of other currently disputed issues are the extent of the accretion disc in the hard state and the location of the X-ray emitting hot accretion flow, and the distribution of the flow electrons, which can be either Maxwellian or hybrid.

Chapter 2

Stars and Star-forming Regions, Solar System Studies

XMM-Newton survey and multi-wavelength vision of the Chamaleon I star forming region.

Juan Facundo Albacete-Colombo[1], Javier Lopez-Santiago[2], Elisa Lopez de Castro[3]
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[2] *Instituto de Matemática Interdisciplinar, S. D. Astronomía y Geodesia, UCM, Madrid, España.*
[3] *Universidad Complutense de Madrid (UCM), Madrid, España.*

This work improves the knowledge of the Chamaleon I X-ray stellar content and describe the nature of 484 X-rays sources detected in the analysis of 8 XMM-Newton X-ray observations. We correlate its with optical, and mid- and near- infrared Spitzer and 2MASS counterparts. One third of X-ray sources shows 2MASS counterparts and 14 X-ray sources out of 54 Spitzer sources, exhibit mid-IR colors, as indicative of stars with circumstellar discs. The spread range of Av absorption is between 0.1 to 0.5 mag. We performed X-ray spectral analysis of X-ray sources with more than 300 X-ray photons in the spectrs. The extinction is highly variable over the whole stellar field. We estimates X-ray plasma temperatures, abundances and fluxes of stars. Typical X-ray spectral parameters are log(NH) $\sim$21.45 (cm^{-2}) with 1 sigma dispersion of 0.4 dex, and a not normal temperature kT $\sim$ 0.71 keV, with a hard tail temperature distribution towards 1.5 keV. The properties of the X-ray emitting plasma in these stars are similar to those found in other nearby young massive star-forming regions..

XMM-Newton view of eight young open star clusters

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The physical origin of X-ray emission from young stars (age<50 Myr) : massive (> 10M$\odot$), intermediate mass (10 - 2 M$\odot$) and pre-main-sequence (PMS) low mass (< 2M$\odot$) stars, and its evolution with time are poorly understood because X-ray studies of clusters with intermediate age (5 to 30 Myr) are few and far between. We investigate X-ray source contents of eight young open clusters with ages between 4 to 46 Myr using archival X-ray data from XMM-Newton, which provides a link between the X-ray properties of young clusters like the Orion ($\sim$5 Myr) and older clusters like the Pleiades ($\sim$100Myr). Overall 152 X-ray sources have been identified with low mass PMS stars, 36 with intermediate mass stars and 16 with massive stars on the basis of multi-wavelength data. Various properties of stars with different masses, like plasma temperatures, X-ray luminosity distributions and their evolution during 4 to 46 Myr, have been investigated. In addition, we have observed interesting flare-like features in the lightcurves of eight stars.The concomitant analysis of the large data sets and detailed X-ray spectral and temporal properties of the cluster members with different masses in these eight young open clusters will be discussed.

Accretion shocks in young stars: the role of local absorption on the X-ray emission

Rosaria Bonito[1,2], Costanza Argiroffi[1,2], Salvatore Orlando[2], Marco Miceli[2]
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We analyze the X-ray emission from accretion shocks formed where the infalling material impact the surface of young stars. Several aspects in observations and in models of accretion are still debated: the density vs temperature structure of the shocked plasma is opposite of what expected from simple accretion shock models and the X-ray luminosity detected from post-shock plasma is below the predicted value. To address these open issues we performed numerical simulations describing the impact of an accretion stream onto the stellar surface (exploring different configurations of the magnetic field) and taken into account the local absorption due to the surrounding medium. We investigated the effects of absorption for different viewing angles and wavelengths. From the model results we synthesize the X-ray emission from the accretion shock and perform density and temperature diagnostics on the synthetic spectra. By comparing our results with the observations, we find that the X-ray fluxes detected are lower than expected because of the local absorption. The emerging spectra suggest higher density for higher temperature as derived from the observations, proving that a detailed model accounting for a realistic treatment of the local absorption is needed to interpret the observations of X-ray emitting accretion shocks.

Solar system X-rays: What we know and what we are looking for

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X-ray emission in the context of the solar system is now recognised as a powerful diagnostic tool for the study of high energy phenomena associated with planetary environments and the heliosphere as a whole.

Scattering of solar X-rays in planetary atmospheres and from the surface of rocky bodies tells us about albedo characteristics and elemental compositions; auroral X-rays may reflect in some cases the interaction of the solar wind with planetary magnetospheres, and in others the internal dynamics and particle populations of a planet's surroundings. Charge exchange X-rays from comets, producing spectacular displays at their closest approach to the Sun, are remarkable probes of the solar wind conditions.

This talk will review how our understanding of the solar system has been advanced by X-ray observations, the vast majority of which so far have been carried out remotely from Earth's orbit; how multi-wavelength observing campaigns, as well as the combination of remote X-ray and in-situ plasma and magnetic field measurements, can enhance the scientific return of our studies; how planned and proposed future missions will expand our discovery horizon further, also by including the added potential of X-ray observations in-situ at the planets.

The X-ray bright massive stars in Cyg OB2

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As a complement to the results from the Cyg OB2 Chandra Legacy program, we present in this contribution the detailed analysis of the four X-ray bright massive stars dominating the cluster. Cyg OB2 #5, #8A, and #9 are binary or multiple massive stars in the Cyg OB2 association displaying several peculiarities, such as bright X-ray emission and non-thermal radio emission. Our X-ray monitoring of these stars reveals the details of their behavior at high energies, which can be directly linked to wind-wind collisions (WWCs). In addition, the X-ray emission of Cyg OB2 #12, an evolved massive star, shows a long-term decrease, which could hint at the presence of a companion (with associated colliding winds) or indicate the return to quiescence of the system following a recent eruption.

Puzzling fluorescent emission from Orion

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Fluorescent X-ray emission allows to study cool material surrounding active, young stars. We analyzed fluorescent iron Kalpha-line emission in a sample of 106 young stars in Orion with a special emphasis on its temporal behavior. Along with a total of 23 detections of fluorescent emission, we found a wide variety of temporal behavior: While the fluorescent emission is associated with soft X-ray flares in some cases, it also appears as a (quasi) persistent feature – sometimes in otherwise quiescent periods. This temporal behavior often challenges photoionization as the sole origin of the fluorescent emission. As alternative formation mechanisms demand, however, immense amounts of energy to explain the observations, we conclude that photoionization in combination with suitable source geometries represents the most plausible configuration to explain the observed fluorescent emission.

Ionization-Gasdynamics Modelling, and X-ray Spectral Calculations, of Wind-Bubbles around Massive Stars

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Using a code that employs a self-consistent method for computing the effects of photo-ionization on circumstellar gas dynamics, we model the formation of wind-driven nebulae around massive stars. Our algorithm incorporates a simplified model of the photo-ionization source, computes the fractional ionization of hydrogen due to the photo-ionizing flux and recombination, and determines self-consistently the energy balance due to ionization, photo-heating and radiative cooling. We take into account changes in stellar properties and mass-loss over the star's evolution. Our multi-dimensional simulations clearly reveal the presence of strong ionization front instabilities, similar to those seen in galactic ionization fronts. Using various X-ray emission models, we compute the X-ray flux and spectra from our wind bubble models, taking the absorption of the X-rays by the ionized bubble into account. Our simulated X-ray spectra compare reasonably well with observed spectra of Wolf-Rayet bubbles. They suggest that X-ray nebulae around massive stars may not be easily detectable, consistent with observations.

Magnetic coronae and circumstellar disks - new insights from the Coordinated Synoptic Investigation of NGC2264 (CSI-NGC2264)

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Proto-planetary disks are affected by radiative and magnetic interactions with the central object. X-ray/UV coronal and accretion-shock emission may drive gas ionization and heating and, consequently, photo-evaporation and disk dispersal. The magnetosphere connecting the star and inner disk mediates mass and angular momentum exchanges and modifies the disk structure. These interconnected processes are highly dynamic and involve material emitting in different bands: the inner disk dust (mIR), the stellar photosphere (optical), accretion shocks (UV/X-rays), and coronae (X-rays).

I will present selected results form the Coordinated Synoptic Investigation of NGC2264 (CSI-NGC2264), an unprecedented multi-wavelength month-long observing campaign of the NGC2264 region. Three space telescopes (Spitzer, CoRoT, and Chandra) simultaneously monitored a rich sample of 3Myr old stars in the mIR, optical, and X-ray bands, providing new insights on the dynamics of the respective emitting regions and their interactions. First, I will discuss magnetic flares: for the first time we observe the heating phase (in the optical), the decay (in X-rays), and, possibly, the disk response to the flare (in the mIR). I will then focus on the longer time-scale relation between X-ray (coronal) and optical (photospheric)/mIR(disk) emission, with particular reference to the obscuration of coronal plasma by temporally varying disk structures.

Hot-subdwarf stars: a new class of X-ray sources

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In the latest years, the X-ray observation of hot subdwarfs has provided several interesting results. New observations of HD 49798, for long time the only X-ray emitting sdO star known, allowed us to investigate the eclipse phase of the X-ray pulsar, its spin evolution and the intrinsic X-ray emission of the subdwarf star. Moreover, new X-ray emitting stars were discovered. On the one hand, the XMM-Newton observation of BD+37 442 revealed a soft and pulsed X-ray emission comparable to that of HD 49798, thus suggesting that also in this case there is a compact accreting companion. On the other hand, a Chandra survey of a complete flux-limited sample of sdO stars provided a clear detection of three of them: while one is a 'luminous' star similar to HD 49798 and BD+37 442, and its high luminosity ($L_{\rm X} > 10^{31}$ erg/s) is compatible with an accreting compact companion, the other two are 'compact' stars with a low luminosity ($L_{\rm X} < 10^{30}$ erg/s), most probably due to intrinsic emission. Finally, no detections were obtained in the X-ray observations of sdB stars with possible compact companions, strongly constraining the sdB mass-loss rate in the case of NS companion.

On the X-ray variability of HD 150136

Jean-Christophe Leyder[1], Andy Pollock[1]
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HD 150136 is a triple system harboring the nearest O3-type star. Its X-ray lightcurve shows variability, that could be due to the stellar winds colliding.

The first X-ray observation of HD 150136 over an entire orbital period of 2.7 days was recently secured by our team, with the main purpose of definitively identifying the origin of the X-ray variability.

We will share the first results of our in-depth X-ray study of HD 150136.

X-ray emission of the young stellar population of the Orion B molecular cloud

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We carried out an analysis of nine XMM-Newton archive observations covering a significant part of the Orion B molecular Cloud. We completed the analysis by using Infrared (Spitzer, WISE, and 2MASS) and Optical (Optical Monitor and UCAC4) photometry data. This work is focused on the classification and characterization of young stellar objects and the inhomogeneity along the cloud. From nine X-ray observations we detected 604 sources in which 490 of them have at least a counterpart. We obtained the X-ray coronal properties of 49 sources with more than 100 net counts, using the 1T or 2T-model of XSPEC. After rejecting the background sources we classified the sample in 332 Classes III, 141 Classes II and 11 Classes 0/I based on their infrared properties. We explored the differences along the cloud and discovered 5 different groups where Class 0/I and Class II objects are located, coincident with NGC2023, NGC2024, NGC2068, NGC2071 and around V1647-Ori. We compared the X-ray luminosity functions for the different classes obtained, and also the complete sample with the COUP distribution, which reveals similar populations.

A study of HD 161103: new pieces to the puzzle of γ Cassiopeiae-like stars

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The "γ Cassiopeiae-like stars" comprise a class of Be stars which are marked by unusual hard thermal and variable X-ray emission of unknown nature. Previous results reported by our group from XMM-*Newton* observations carried out in 2004 for one of them, HD 161103, revealed a $\sim$3.2 ks oscillation in its X-ray light curve. The XMM-*Newton* revisited the star in 2012 with the main goal of verifying the stability of such oscillation, whose results are presented in this work. Although strongly variable, including a strong drop in the brightness, there is no evidence of the 3.2 ks or other clear periodic oscillation in HD 161103. This result reinforces the scenario already inferred from γ Cassiopeiae itself: modulations "come and go", usually with different timescales. Although not conclusive, the absence of the modulation in the second observation poses serious trouble to the scenario in which the X-rays come from accretion onto a compact star. There is no significant variation in the intrinsic absorption of X-rays in the system but the temperature of the dominant thermal plasma is slightly higher (kT $\sim$ 7 keV in 2004, and $\sim$ 9 keV in 2012) while the flux is slightly lower in 2012, revealing changes in the production of the X-rays.

X-ray emission from magnetic massive stars

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Magnetically confined winds of early-type stars are expected to be sources of bright and hard X-rays. In an attempt to clarify the systematics of the observed X-ray properties, we have analyzed a large series of Chandra and XMM observations, corresponding to over 100 exposures of 60% of the known magnetic massive stars listed recently by Petit et al. (2013). We notably show that the X-ray luminosity is strongly correlated with mass-loss rate, in agreement with predictions of magnetically confined wind models. We also investigated the behavior of other X-ray properties (plasma temperature, absorption, variability), yielding additional constraints on models. This work not only advances our knowledge of the X-ray emission of massive stars, but also suggests new observational and theoretical avenues to further explore magnetically confined winds.

Modeling the non-thermal emission from bowshocks produced by runaway stars

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Runaway O- and early B-type stars passing throughout the interstellar medium at supersonic velocities and characterized by strong stellar winds, can produce bow shocks that can serve as particle acceleration sites. Previous theoretical models predict the production of high energy photons by non-thermal radiative processes, but their efficiency is still debated. We present a new insight in the non-thermal emission treatment by introducing new approaches, new formulae and exploring the computational method to search for sistematic errors, and we also test its feasibility. We applied our model to AE Aurigae, the first reported star with an X-ray detected bow shock (López-Santiago et al. 2012), and BD+433654, in which the observations failed in detecting high-energy emission. From our analysis, we confirm that the X-ray emission from the bow shock produced by AE Aurigae can be explained by inverse Compton processes involving the infrared photons of the heated dust. We also predict low high-energy flux emission from the bow shock produced by BD+433654, which explains its non detection in X-rays by Terada et al. (2012).

The frequency of stellar X-ray flares from a large-scale XMM-Newton sample

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The XMM-Newton Serendipitous Source Catalogue has been used as the basis for a survey of X-ray flares from late-type (i.e. spectral type F-M) stars in the Hipparcos Tycho catalogue. The XMM catalogue and its associated data products provide an excellent basis for a comprehensive and sensitive survey of stellar flares - both from targeted active stars and from those observed serendipitously in the half-degree diameter field-of-view of each observation. Our sample contains ~ 130 flares with well-observed profiles; they range in duration from ~ 1000 s to $\sim 10,000$ s, have peak X-ray luminosities $\log(L\_x$, erg/s) from ~ 29 to ~ 32, and X-ray energy output $\log(E\_x$, erg) from ~ 32 to ~ 35. We present flare frequency distributions from both target and serendipitous observations. The latter provide an unbiased (with respect to stellar activity) estimate and allow us to predict numbers of stellar flares that may be detected in future X-ray wide-field surveys such as those based on Lobster-eye optics. We also compare the XMM-derived estimates with values derived from earlier X-ray transient surveys. Predictions for future wide-angle surveys are of value both for the study of the stellar energetics and for determining likely contaminant levels in programmes aimed at other types of transient event such as gamma-ray bursts.

X-raying the winds of the evolved massive binary HDE228766

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HDE228766 is an evolved massive binary hosting a rare Of-WN8ha transition object on a circular orbit about a normal O7 star. We have obtained XMM-Newton EPIC spectra of this system at three key orbital phases (two conjunctions and quadrature phase) that allow us to probe the absorbing column towards the wind interaction zone as seen through the wind of the O7 star and the Of-WN8ha star. We combine these observations with a simple model of the wind-wind collision to infer the properties of the wind interaction zone (opening angle of the shock cone) and constrain the properties of the stellar winds in this system.

The X-ray emission of the massive stars population in Cyg OB2

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Cygnus OB2 contains a wealth of massive stars of spectral types O, B and Wolf-Rayet. In the framework of a Chandra legacy program to study the X-ray emission from this important association, we have studied the X-ray properties of its massive stars population. We show that the O-stars in Cyg OB2 follow a well-defined scaling relation between their X-ray and bolometric luminosities: $\log(Lx/Lbol) = -7.2 \pm 0.2$. Except for the brightest O-star binaries, there is no general X-ray overluminosity due to colliding winds in O-star binaries. Roughly half of the known B-stars in the surveyed field are detected, but they fail to display a clear relationship between Lx and Lbol. Out of the three WR stars in Cyg OB2, probably only WR144 is itself responsible for the observed level of X-ray emission, at a very low $\log(Lx/Lbol) = -8.8 \pm 0.2$. The X-ray emission of the other two WR-stars (WR145 and 146) is most probably due to their O-type companion along with a moderate contribution from a wind-wind interaction zone.

The X-ray properties of λ Cep, a true twin of ζ Pup?

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Oef stars are O-stars that display a double-peaked He II λ 4686 line in their optical spectra, suggesting that the inner part of the stellar wind is co-rotating with the star. This hypothesis is also often used to explain their ubiquitous spectral variability in the optical domain. In this context, the fact that the high-resolution X-ray spectra of ζ Pup (O4Ief) meet the expectations of the wind-embedded shock model, assuming a spherically symmetric wind came as a surprise. To understand what is going on, we have obtained a 300 ksec observation of λ Cephei, the second brightest Oef star. This observation not only allows to collect the RGS high-resolution spectrum of the star, but further enables us to search for X-ray variability. To correlate the potential X-ray variability with that of the optical spectrum of λ Cep, we monitored the optical spectrum simultaneously with the TIGRE telescope. We present here the first results of this campaign, both in terms of the line profiles in the RGS spectrum and the search for X-ray variability in correlation with the optical variations.

Accretion impacts studied on the Sun

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Accretion in star-forming regions is a hot topic. The Sun has recently offered an interesting opportunity to study accretion impacts observed in great detail at high energies (Reale et al. 2013, Science, 341, 6143, 251). After the eruption of a dense filament triggered by an energetic flare on June 7, 2011 part of the ejected material falls back onto the solar surface. The impact of the downfalling plasma is similar to that of accretion flows on young stellar objects, and was imaged in the EUV by the Atmospheric Imaging Assembly (AIA) on-board the Solar Dynamics Observatory (SDO). Hydrodynamic simulations confirm that the high energy emission is produced by the impact of high-density plasma at the highest free-fall speeds and show the importance of the absorption in reducing the X-ray emission and of fragmentation in explaining the line broadenings. Impacts such as these present a laboratory for stellar astronomers to study the impact of dense (accreting) circumstellar material in unique detail.

X-ray studies of circumstellar material around classical T Tauri stars

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I will present recent XMM-Newton observations of accreting, young stars. These so-called classical T Tauri stars are surrounded by protoplanetary accretion disks and drive outflows or even powerful jets. Currently, the structure of these two components is not well understood, both observationally and theoretically. X-ray data are particularly useful to study these circumstellar structures as they provide complementary information to classical, longer wavelengths observations. I will show results of our new X-ray programs targeting prototypical young stellar systems and discuss them in the multi-wavelength context.

The stellar population in the XMM-Newton slew survey

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We study X-ray transients from the XMM-Newton slew catalog with focus on the identification of flare stars. We have selected 118 variable X-ray sources from the XMM-Newton slew catalog Delta-3 on the basis of at least 70-fold enhanced count rate with respect to ROSAT. Our characterization of the counterparts includes a systematic cross-match with optical and infrared photometric catalogs. The photometry was used to identify candidate stars for spectroscopic follow-up. Optical low-resolution spectra were obtained for 34 of those objects with OSIRIS@GranTeCan, most of them without any previous spectroscopic data. Among these objects we find many M-type stars, some giant stars and a small number of extragalactic sources. We present here the X-ray, optical and near-infrared properties of all slew transients from our sample together with the statistics of the various source populations.

X-rays from Magnetically Confined Wind Shocks: Effect of Cooling-Regulated Shock Retreat

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We use 2D MHD simulations to examine the effects of radiative cooling and inverse Compton (IC) cooling on X-ray emission from magnetically confined wind shocks (MCWS) in magnetic massive stars with radiatively driven stellar winds. For the standard dependence of mass loss rate on luminosity $\dot{M} \sim L^{1.7}$, the scaling of IC cooling with L and radiative cooling with $\dot{M}$ means that IC cooling become formally more important for lower luminosity stars. However, the overall effect of including IC cooling is quite modest. But for stars with high enough mass loss to keep the shocks radiative, the MHD simulations indicate a linear scaling of X-ray luminosity with mass loss rate; but for lower luminosity stars with weak winds, X-ray emission is reduced and softened by a *shock retreat* resulting from the larger post-shock cooling length, which within the fixed length of a closed magnetic loop forces the shock back to lower pre-shock wind speeds. A semi-analytic scaling yields X-ray luminosities that are in close agreement to time-averages computed from the MHD simulations. The results here provide a good basis for interpreting available X-ray observations from the growing list of massive stars with confirmed large-scale magnetic fields.

Chapter 3

Interacting Binary Systems, Galactic Black Holes, Micro-quasars

A Unified Model of Low Mass X-ray Binaries

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We present a unified physical model of Low Mass X-ray Binaries explaining the basic Atoll and Z-track types of source. In all LMXB with luminosity above 1-2.10^{37} erg/s, we have a new fundamental result that the temperature of the Comptonizing ADC corona equals that of the neutron star, i.e. there is thermal equilibrium. This equilibrium explains the properties of the basic Banana State of Atoll sources. Below this luminosity, equilibrium breaks down, T_ADC rising towards 100 keV by an unknown heating mechanism, explaining the Island State. Above 5.10^{37} erg/s flaring begins in the GX-Atolls which we show is unstable nuclear burning. Above 1.10^{38} erg/s, LMXB are seen as Z-track sources. Flaring in these and the GX-Atolls occurs when the mass accretion rate to the neutron star falls to the critical value for unstable nuclear burning on the star. Below 2.10^{37} erg/s, a different unstable burning: X-ray bursting, takes over. We show that the Normal Branch of the Z-track consists simply of increasing mass accretion rate, as is the Banana State in Atolls. In the Horizontal Branch, a measured, strongly increasing radiation pressure of the neutron star disrupts the inner disk launching the relativistic jets seen on this branch.

Predicting Jets in Cygnus X-2

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We describe simultaneous radio and X-ray observations of Cygnus X-2 that captured the launching of relativistic jets. Observations with the e-EVN, revealed the switch-on of radio while Swift showed the source to be on the Horizontal Branch of the Z-track. The evolution of the jet images in radio showed the velocity to be 0.33c. We have also analysed 16 years of RXTE pointed and ASM data. The 16-year ASM lightcurve shows strong aperiodic variability having about 10 large intensity peaks per year. All pointed data were analysed and correlated with the ASM light curve allowing us to recognize important features of the Z-track in ASM data, such as the hard and soft apex. The aim was to be able to predict jet formation using such monitoring data. All available radio data were used to obtain a relation between radio flux and ASM count rate. This showed that jet launching takes place at the hard apex which is seen at count rates in the ASM more than 40 counts per second, regardless of position in the long-term variability. This threshold can be converted to the equivalent, much lower count rate in MAXI

Luminous Supersoft X- ray sources: RXJO527, RXJ0513.9 - 6951, RXJ0537 and XMMUJ0520

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A steady state model has been considered to explain the observed characteristics of luminous supersoft X- ray sources RXJO527, RXJ0513.9-6951, RXJ0537 and XMMUJ0520. The model is of an accreting white dwarf (WD) in a close binary with a main-sequence star, subgiant, or giant. When accretion rate is ($\sim 1 \times 10^{-7}$ $M_\odot$ $yr^{-1} - 5 \times 10^{-7} M_\odot yr^{-1}$) hydrogen shell burning consumes hydrogen at the same rate as the white dwarf accretes it. The accreting matter containing small fraction of C, O, Ne, Mg will capture proton at high temperature and density condition leading to CNOF, NeNa, MgALSi cyclic reactions. Using most recent proton capturing reaction rates and beta-decay rates the cyclic reactions have been studied and examined about the energy generation during supersoft X-ray outburst time scale. The presently calculated values of effective temperature, luminosity etc tally well with the values observed by ROSAT and XMM-Newton observatories. Absorptive and electron-scattering opacities at layers of the envelope and color temperature near the photosphere have been determined. In the present work, possible absorption lines have been calculated and compared with the observed one.

The tormented quiescence of the low mass X-ray binaries Cen X-4 and V404 Cyg

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The majority of low mass X-ray binaries (LMXBs) spend the bulk of their time in the quiescent state, where their X-ray emission is a tiny fraction of the Eddington luminosity. However, the physical mechanisms involved during quiescence are still debated. So far, a unifying scenario that can systematically match the spectral energy distribution from optical up to the X-ray emission of both NS and BH quiescent LMXBs, is still missing. Moreover, an increasing number of LMXBs display variability in quiescence, the origin of which is still unclear. Residual accretion at very low Eddington luminosity rates could play an important role, however, there has lacked clear observational constraints on such processes. With the main goal of unveiling the nature of the quiescent variability in LMXBs we planned a unique study of the two best targets: the NS Cen X-4 and the BH V404 Cyg. We conducted a multi-wavelength (optical, ultraviolet, and X-ray) long-term monitoring (months) of the two sources on a daily basis. This allowed us for the very first time to accurately characterize their variability properties, find strong evidence of UV/X-ray correlation in the emission from Cen X-4, and show that both sources are very likely accreting also in quiescence.

Multi-component high-energy emission from gamma-ray binary LS 5039.

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LS 5039 is one of the few high-mass X-ray binaries for which the spectral energy distribution is dominated by emission in high-energy gamma-ray band. We perform orbital phase resolved spectral analysis based on the data of five year long monitoring of the system with Fermi telescope and supplement the high-energy gamma-ray data with the multi-wavelength data, from radio to very-high-energy gamma-rays. The orbital phase resolved spectra reveal the presence of two spectral components. One component is modulated in time, while the other component, dominating the flux above several GeV is (almost) not variable. The variability pattern of the modulated component dramatically changes below and above 100 MeV energy. This change is readily explained as being due to the orbital-phase dependent shift of the high-energy cut-off in the spectrum of the modulated component. We interpret this modulated component as the synchrotron emission from the interior of the binary system and the shift in high-energy cut-off as being due to the orbital modulation of the magnetic field strength.The non-variable component of the gamma-ray spectrum could be self-consistently explained as the high-energy IC counterpart of extended radio synchrotron emission originating from a region 1000 times larger than the binary system size.

New Results on Time lags of quasi-periodic oscillations in the low-mass X-ray binary 4U 1636–53

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We present an analysis of the energy and frequency dependence of the Fourier time lags of the hectoHertz QPOs and of the QPOs at the frequency at which the PDS shows a break in the NS–LMXB 4U 1636–53, using data obtained with the RXTE satellite.

We found that: (i) For the break frequency QPO: for low frequencies the lag is positive, but it is decreasing with increasing frequency, reaching zero lag at $\sim$ 20 Hz. Between 20 and 35 Hz there is some fluctuation around zero, then the lags become positive again increasing slightly above zero up to 65 Hz. (ii) For the hHz QPO: we see that when the frequency is $\sim$ 100 Hz the lag is negative, but it increases to zero at $\sim$ 110 Hz, being consistent with this value up to 130 Hz, increasing to 0.5 msec at $\sim$140 Hz. From 140 Hz the lag decreases being strongly negative for hHz $\geq$ 220 Hz. (iii) We see no significant dependence of the lags on energy for both QPOs studied here.

We compare these lags with our previous results for the lags of the kiloHertz QPOs in this system and discuss possible scenarios for producing the lags.

Low frequency QPOs and Variable Broad Iron line from LMC X-1

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We have performed temporal and energy spectral study of the persistent black hole X-ray binary LMC X-1 using XMM-Newton, Suzaku and RXTE observations. We report the discovery of low frequency (26-56 mHz) QPOs and variable broad iron line from LMC X-1. The QPOs are generally weak with rms amplitudes in the 1-6% range and coherence (quality factor Q∼2-10). The QPOs are accompanied by weak red-noise with rms variability in the 1.3-4% level. The energy spectra of LMC X-1 consist of three components - multicolor disk blackbody (kT∼0.7-0.9 keV), high energy power law tail (photon index ∼2.4-3.3), and broad iron line at 6.4-6.9 keV. The QPOs were detected only in the presence of a strong powerlaw component. The strong broad and relativistic iron line was observed in the presence of both the strong powerlaw and an accretion disk extending to the innermost regions. The iron line is found to be weaker when the disk is truncated and absent when the powerlaw component almost vanished. Our results imply that LMC X-1 does not always remain in the canonical soft state but also transits to the soft intermediate or the steep powerlaw state.

Probing black hole disk atmospheres in X-rays and UV: XMM and HST-COS observations of 4U 1957+11

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The black hole candidate 4U 1957+11 shows one of the cleanest examples of a disk spectrum in X-ray band with a disk temperature in the 1.3-1.8 keV range and therefore among the highest detected. Previous X-ray measurements indicate that the source is a maximally spinning black hole in the halo of our galaxy.

4U 1957+11 is the ideal test case for disk models and a unique opportunity for UV observations: it is the only known persistent low mass X-ray binary and therefore the only persistent source where the compact object dominates over the companion star. We have obtained XMM + HST/COS observations that allow us to study disk models over a wider bandpass than ever previously possible: do UV and X-ray measurements agree with each other? What can we learn about the physics underlying the spectral correction factor, i.e., the ratio of color to thermal temperature, from extending the measurements to lower energies? What does this imply for the physical size of the disk? Can the spin results be upheld when taking the UV signature of the disk into account?

Modeling the heartbeat state in the microquasar IGR J17091-3624

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Microquasar IGR J17091-3624 exhibits faint, quasi-periodical outbursts of the period between 5 and 70 seconds and regular amplitudes, frequently referred to as the 'heartbeat state'. These outbursts are plausibly explained by the accretion disk instability, driven by the dominant radiation pressure. Similar models have already been proposed to discuss the behaviour of another, much brighter microquasar, GRS 1915+105.

In the current work, we use our hydrodynamical code GLADIS (Global Accretion Disk Instability Simulation) to model these 'heartbeat' outbursts. We compare our results with the observational data from SWIFT XRT and we investigate the link between the development of the disk instability and strength of massive wind launched from the source. We discuss the properties of this wind and compare them with the results of spectral analysis.

Power Colours: Easy power spectral comparison

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Low mass black hole binaries are transient X-ray sources, transitioning through several states during an outburst. These states are classified using both the energy spectral and temporal properties within each observation and show clear similarities from source to source, despite differences in mass, inclination angle and binary separation. We present a model independent method of characterising the variability properties throughout outburst, by comparing ratios of temporal power over different frequency ranges. This has distinct advantages over current simple methods of classifying source state using timing statistics, as it retains information on the power spectral shape and shows a single evolutionary path for all objects studied. We expand on how this method can be used to easily compare other properties (such as the energy spectral hardness) between observations of multiple objects in the same temporal state, using it to demonstrate that the correlation between system inclination angle and hardness recently found in the soft states (Munoz-Darias et. al. 2013) also extends into the hard-intermediate states.

A Deep Census of Low-Luminosity X-ray Sources in Globular Cluster w Cen

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We report the results of an analysis of a 290 kilosecond observation of Omega Centauri with the Chandra X-ray Observatory aimed at studying this globular cluster's population of X-ray emitting binary stars. Combining ACIS-I data from 2000 and 2012, we obtain a deep exposure that reaches a limiting flux of $5 \times 10^{-16} erg/cm^2/s$, or a luminosity of $L_X \sim 1.6 \times 10^{30} erg/s$ for sources in the cluster. Given these limits, we expect to be sensitive to most cataclysmic variable stars and many coronally active stars (e.g., BY Draconis and RS CVn stars) in the cluster, as well as large numbers of active galactic nuclei in the background. We find a total of 302 sources in the 17'x17' field, 138 of which are newly reported here. We assess the fraction of these sources that are likely to be AGN by comparing our results to the Chandra Deep Field. We present an X-ray colour-magnitude diagram for all the sources and discuss its significance for distinguishing different types of X-ray emitting binary stars in the cluster. We also present some archival HST images of the brightest X-ray sources in this new sample.

X-ray binaries in the Local Universe

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In this talk I will present my research into extragalactic X-ray binaries (XRBs) in the Local Universe carried out during my Phd. This work consisted of a study of the XRB population of the elliptical galaxy NGC4472 as well as the discovery of a new black hole in a globular cluster of NGC1399. I will then discuss my current project: searching for low mass X-ray binaries (LMXBs) in the Small Magellanic Cloud (SMC) using X-ray, radio and optical data. Previous studies of the SMC revealed objects like accreting pulsars and supernova remnants within the SMC. These studies have mainly been sensitive to pulsating systems, like high mass X-ray binaries, leaving the galaxy's other populations of compact objects unstudied. The identification of LMXBs in the SMC would make it the first full external galaxy in which a clearly understood sample of quiescent XRBs had been discovered.

Accretion influences cooling of neutron star atmospheres during type-I X-ray bursts

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Observations of type-I X-ray bursts provide a way of measuring neutron star (NS) masses and radii. The derived mass-radius values depend on the colour-correction factor of the NS photosphere, the photospheric chemical composition and the distance.

We have studied 11 bursting low-mass X-ray binaries (LMXB) with RXTE/PCA. We find a correlation between the time evolution of the apparent NS radii during the early cooling phases of X-ray bursts and the spectral properties of the persistent emission before the bursts.

NS atmosphere models predict that the colour-correction factor decreases in the early cooling phases when the emitted luminosity drops from the Eddington value. Therefore, the apparent NS radii should be variable during this phase as it depends on this factor. We find that the model predictions agree with the data only when X-ray bursts occur during the hard (island) state of LMXBs. We take this as evidence that the accretion flow - that surrounds the NS - changes the photospheric colour-correction factor during the soft (banana) states, where the atmosphere model predictions never agree with the data. This finding is important as even slight variations in the colour-correction factors cause large errors in the derived neutron star radii.

The radio-quiet nature of Swift J1753-0127

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A lot of effort has gone into trying to explain the two radio/X-ray correlation tracks seen in the low/hard state of black hole binaries in recent years. The standard correlation of the form $L_R \propto L_X^{0.7\pm0.1}$ is clearly paired with a lower, radio-quiet track with a slope of ∼1-1.4, although a generally accepted cause for this remains unclear.

We present new simultaneous radio/X-ray observations of Swift J1753-0127, spanning over a year in time, which seem to confirm the steep-slope radio-quiet nature of the source. Our X-ray-faint sample complements previous higher luminosity observations, making Swift J1753 one of the best sampled sources in $L_X - L_R$. We find that the source has only very recently started showing possible signs of a dual track behaviour, moving from the radio-quiet track towards the standard correlation track with decreasing X-ray flux. If the source continues its current trend all the way down to X-ray quiescence, this will provide us with a unique opportunity to study the transition from a 'radio-quiet state' back to the standard correlation.

X-ray diagnostics of chemical composition of the accretion disk and donor star in UCXBs II: XMM-Newton observations

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Ultra-compact X-ray binaries are identified by their extremely short orbital periods of less than 1h. This implies such tight orbits that only H-deficient compact objects would fit. Most likely, UCXBs consist of a Roche lobe filling white dwarf that is accreting onto a neutron star companion. In our recently published paper (Koliopanos, Gilfanov & Bildsten 2013) we showed that X-ray reflection spectra, in particular the iron Ka line, can be used as a diagnostic of the chemical composition of the accretion disk in UCXBs. Specifically, we used Monte Carlo simulations to show that the most dramatic and easily observable consequence of a C/O-rich accretion disk is the more than tenfold attenuation of the Ka line of iron (consistently detected in the spectra of typical LMXBs with main sequence or red giant donors). On the other hand in the case of a He-rich donor (e.g. a helium-WD or helium-star) the iron line remains at its usually observed strength. In our most recent paper (Koliopanos et al. 2014, submitted) we applied our theoretical findings on XMM observations of well known UCXBs. In my talk I will present the results of our analysis as well as our predictions regarding their chemical composition.

Unsupervised spectral decomposition of X-ray spectra from galactic black hole X-ray binary GX 339–4

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Modelling the X-ray spectra of accreting black holes often leads to a problem of degeneracy, i.e. multiple distinct models fit the observed data equally well. Even if an apparently good fit is obtained between the data and the model, it does not necessarily imply a match between theory and physical reality. We separate a multivariate signal – a set of time series of X-ray spectra – into subcomponents, using linear unsupervised decomposition methods. This analysis will provide a better estimate of the X-ray continuum models needed to fit the X-ray spectra in these sources by taking into an account also the spectral variability in addition to the fitting of the individual spectra. A comparison with the different analysis methods are studied and suggestions made for the future use of these methods in the context of this study. We apply these analysis methods to an archival set of X-ray spectra from a stellar mass black hole X-ray binary GX 339–4. With a sufficiently long set of observations throughout the hardness-intensity diagram (HID) from GX 339–4, the use of unsupervised decomposition methods reveal how the spectral components change across the HID. We will discuss the ramifications of these results.

The multicolour optical monitoring of the High Mass X-ray Binary CI Cam/XTE J0421+560

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We analyse the photometric behaviour of the high-mass X-ray binary system CI Cam/XTE J0421+560. Our observations cover the time interval 1999-2014. The source was monitored with 70-cm AZT-8 (CrAO, Ukraine) and 0.4-m LX-200 (St.Petersburg, Russia) telescopes. During the monitoring period, CI Cam displayed two significant increases of brightness in the optical photometric bands. The first one follows the X-ray outburst that occurred in 1998 March. The second one started in 2013 and lasts until January - February of 2014.

The Galactic bulge as seen by INTEGRAL: it never looks the same

Erik Kuulkers[1], et al.
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The central region of our Milky Way, the Galactic bulge, is a rich host of variable high-energy X-ray and gamma-ray point sources. These sources include bright and relatively faint X-ray transients, X-ray bursters, persistent neutron star and black-hole candidate binaries, high-mass X-ray binaries, etc.. Since 2005 INTEGRAL monitors the Galactic bulge region regularly and frequently, whenever it is observable. As a service to the scientific community the high-energy light curves of sources in the field of view, as well as the images of the region are made available through the WWW at http://integral.esac.esa.int/BULGE/ as soon as possible after the observations have been performed. Moreover, the data are made publicly immediately. We show the ongoing results of this exciting program, and focus on the transient population. Since the bulge never looks the same, it stays a region to be watched.

INTEGRAL view of LS I +61 303 in orbital/superorbital phase space

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LS I +61 303 is one of the few high-mass X-ray binaries emitting high energy gamma-rays. Besides the orbital period of 26.496 days, LS I +61 303 is known to have a long-term (1667 days) superorbital modulation. The nature of its compact object is heavily debated. In this talk we will discuss new analysis of the years-long radio and hard X-ray data in the orbital/superorbital phase space of LS I +61 303. Even when non-simultaneous, enough data coverage at the same orbital and super orbital phases exist to consider possible relationships between the spectral indices in both bands. We also uncover hints for the superorbital variability in the hard X-ray flux and show how an orbital phase drift of radio peak flux and index along the superorbital period is observed in the radio data. We explore its influence on a previously reported double peak structure of radio orbital lightcurve, posing it as a plausible explanation.

The feedback of type-I bursts to the corona and the accretion process in X-ray binaries

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We discuss the interaction between the soft X-ray photons and the corona / accretion disk during type-I X-ray bursts. Up to date, a hard X-ray shortage and fast recovery during the evolution of bursts have been found in 6 sources. These observations promote a plausible interpretation based on the position and origin of the corona. We also note that type-I X-ray bursts embedded in the banana state of an outburst seem to deviate from a blackbody spectrum, which may hint for a temporary increased accretion rate in the accretion disk during type-I X-ray bursts. These results could be consistently explained by the feedback of type-I X-ray bursts to the accretion process.

Eighteen years of the life of the Be/X-ray binary XMMU J054134.7-682550

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We investigate the Be/X-ray binary XMMU J054134.7-682550 from 21 XMM-*Newton* observations and almost daily monitoring carried out by the ASM/RXTE and Swift/BAT satellites, in a total coverage of ~ 18 years. Its X-ray light curve is marked by the occurrence of several minor and three large outbursts, without clear recurrence that could be the signature of the (yet unknown) orbital period. Two minor outbursts were partially observed by the XMM-*Newton* and, as for one large outburst also observed by that satellite, they are followed by significant changes in the hardness ratio. Both soft and hard tails in the 0.5–12 keV band were more pronounced during the outbursts while the spectral shape in the 2–4.5 keV energy band remains essentially the same. Spin up episodes of the X-ray pulsar were observed during outbursts. The excess in low energy is more likely due to the prominence of a black body component during the outbursts. The spectral evolution and timing properties are discussed on the basis of the formation of a transient accretion disk and the geometry of the system. Finally, we present an optical characterization of the system from spectroscopy obtained with the 4.1m SOAR telescope and the 3.6m ESO/NTT.

Suzaku observations of ultraluminous X-ray sources in nearby galaxies

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Recent results indicate that the majority of ULXs are stellar remnant black holes accreting material at or above the Eddington rate, rather than sub-Eddington accretion onto intermediate mass black holes. However, precisely how these ULXs accrete material at a super-Eddington rate remains an open question. In this work, we present the results of an analysis of 21 high quality spectra (> 4000 counts) extracted from a sample of 15 ULXs detected in nearby galaxies ($D < 4.2$ Mpc), using Suzaku data. We confirm that these high quality datasets require two component models to provide an adequate description of the spectra. A disc plus Comptonised corona model suggests an anti-correlation between the corona's temperature and its optical depth, as found in previous ULX studies. Alternatively, fitting by a blackbody plus Comptonised corona model allows a simple calculation of an outflowing wind radius (assuming this provides the soft component) and we find that the wind becomes larger as the accretion rate increases, consistent with theoretical predictions of Super-Eddington accretion. Finally, we demonstrate that the mass of the black hole powering these ULXs can be constrained to 3-16 $M_{\odot}$ by modelling the hard spectral component using a Kerr black hole model.

The OmegaWhite Survey for Ultracompact Binaries

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The OmegaWhite Survey is a wide-field synoptic survey targeting 400 square degrees along the Galactic plane (|b| <5°), with high cadence exposures reaching $g = 22$ magnitude (10-σ). This survey aims to substantially increase our knowledge of the rare and faint ultracompact binary star systems. These binaries consist of two degenerate objects in compact orbits with periods less than 1 hour. This includes white dwarf−white dwarf systems (detached or semi-detached such as 'AM CVn' stars), or white dwarf−neutron star systems (ultracompact X-ray binaries). In order to reach this late stage of binary evolution, these binaries must have already gone through two common envelope stages, as well as a direct impact accretion stage. Therefore population studies of these objects are vital for a better understanding of the evolution physics experienced by all compact binary systems. I will present the results from analysis of the first 150 square degrees of OmegaWhite, including a look into the initial population study and some of the more interesting ultracompact sources detected.

Timing variability of Vela X-1 during a bright flare

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We present an in-depth analysis of the temporal behaviour of the HMXB Vela X-1 which exhibited strongly varying flux levels during an observation by XMM-Newton. During the 100 ks observation the source went from being in a highly absorbed initial state, to one of increased activity which was followed by a giant X-ray flare, before finally reaching a settled state with low absorption. The lower absorption state allows the normally absorbed pulse profile below 1 keV to be studied. Vela X-1 also showed multiple changes in the structure of the pulse profile including a phase lag with the harder photons leading the softer ones. A change in the pulse period, significant at approximately the 2σ level, was observed at the beginning of the powerful flare and is likely related to the large accreted mass. For comparison purposes, an earlier XMM-Newton observation in a lower active state is used to put the variations in pulse profile and phase lag in context.

Optical observations of the transiently accreting radio pulsar binary PSR J1023+0038

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PSR J1023+0038 is a rare example of a transiently accreting neutron star binary system, which occasionally also appears as a radio pulsar.

We present optical photometry and spectroscopy of J1023 from April 2009. The revised the orbital period of the system is P=0.19809655(14) days and the K_2 and vsini of the companion are $(286 \pm 2)km/s$ and $(71^{+6}_{-3})km/s$ respectively. We have modelled the lightcurve of the system, and find that a companion star with a Roche lobe filling factor of $f \sim 0.8$ gives the best fit to the data. The mass of the compact object and the companion star are found to be $(2.0 \pm 0.1)M_{\odot}$ and $(0.30 \pm 0.06)M_{\odot}$. The spectrum of the companion was found to match a G2V template, and optimum subtraction of the template revealed a $H\alpha$ emission line of $EW = (-1.3 \pm 0.2)\mathring{A}$. The filling factor of the companion is of particular interest as it suggests that the secondary is underfilling its Roche lobe. We also discuss the origin of the $H\alpha$ emission.

Gemini H-band spectroscopy of the Galactic microquasar GRS 1915+105

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Since its discovery in 1994 (Castro-Tirado 1994) GRS 1915+105 has become one of the most intensely studied of all the X-ray binaries in the Galaxy. This Galactic microquasar system is unique in that it has remained in outburst for the past 20 years: furthermore, initial measurements suggested a relatively high black hole mass of $14 \pm 4M_{\odot}$ (Greiner et al. 2001), outside the predicted mass range for such transients (Ozel et al. 2010).

Here we present new Gemini H-band observations, and discuss the degree to which they can be used to refine the black hole mass in comparison to more recent estimates (Hurley et al 2013, Steeghs et al 2013). In addition, previous work found phase dependent emission of the CO bandheads in the K-band, and we present evidence of double peaked emission lines, indicative of ongoing mass transfer via the accretion disk.

Quasi-Periodic Oscillations: Energy Dependent Time-lags

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We present a a generic model for alternating lags in QPO harmonics where variations in the photon spectrum are caused by oscillations in two parameters that characterize the spectrum. The model assumes that variations in one of the parameters are linearly driven by variations in the other after a time delay. We show that alternating lags will be observed for a range of time delays. We have further developed a phenomenological model based on this generic one that can explain the amplitude and phase lag variation with energy of the fundamental and the next three harmonics of the 67 mHz QPO observed in GRS 1915+105. The phenomenological model also predicts the variation of the Bicoherence phase with energy, which can be checked by further analysis of the observational data.

Multi-scale virtual view on the precessing jet SS433

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Observations of SS433 infer how an X-ray binary gives rise to a corkscrew patterned relativistic jet. XRB SS433 is well known on a large range of scales for wich we realize 3D simulation and radio mappings. For our study we use relativistic hydrodynamic in special relativity using a relativistic effective polytropic index. We use parameters extracted from observations to impose thermodynamical conditions of the ISM and jet. We follow the kinetic and thermal energy content, of the various ISM and jet regions. Our simulation follows simultaneously the evolution of the population of electrons which are accelerated by the jet. The evolving spectrum of these electrons, together with an assumed equipartition between dynamic and magnetic pressure, gives input for estimating the radio emission from our simulation. Ray tracing according to a direction of sight then realizes radio mappings of our data. Single snapshots are realised to compare with VLA observation as in Roberts et al. 2008. A radio movie is realised to compare with the 41 days movie made with the VLBA instrument. Finaly a larger scale simulation explore the discrepancy of opening angle between 10 and 20 degree between the large scale observation of SS433 and its close in observation.

Geometrical constraints on the origin of timing signals from black holes

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As it has been known for a long time, inclination strongly affect the observed properties of Active Galactic Nuclei. Over the last years it has become more and more clear that the same is true for galactic accreting BH binaries: above all, the disk and outflows properties largely depend on the inclination to the light of sight of the sources. We have systematically studied the effect of the orbital inclination on the fast time- variability properties of black-hole transients. We have considered the black-hole binaries observed by the RossiXTE satellite that have gone through all the canonical spectral states and we found that the amplitude of low-frequency quasi periodic oscillations (QPOs) strongly depends on the orbital inclination. Type-C QPOs are stronger for nearly edge-on systems, while type-B QPOs are stronger for nearly face-on ones. Furthermore, we found that the broad band noise associated to both types of QPOs is inclination-independent. I will discuss these results in the context of recently proposed theoretical models for low-frequency QPOs, showing how QPOs can be used as effective tools to study accretion close to a compact object, where the effects of General Relativity are expected to be strongest.

Spectroscopic evidences for a low-mass black hole in SWIFT J1753.5-0127

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The black hole (BH) candidate SWIFT J1753.5-0127 has remained active since the onset of its 2005 outburst. Emission lines in the optical spectrum were observed at the very beginning of the outburst, but since then the spectrum has been featureless making a precise BH mass estimation impossible. Here we present results from our optical and UV observations of SWIFT J1753.5-0127 taken in 2012-2013. Our new observations show extremely broad, double-peaked emission lines in the optical and UV spectra. A time-series analysis of these spectral data and our photometric data revealed a possible orbital periodicity of 2.85 hr, significantly shorter than the reported 3.2 hr periodic signal by Zurita et al. (2008). The observed variability properties argue against a very low orbital inclination angle and we present several observational arguments in favour of the BH interpretation. However, the measured velocity semi-amplitude of 382 $\mathrm{km\,s^{-1}}$ and the short period implies that the primary mass should not exceed 4.0 $M_\odot$. Thus, SWIFT J1753.5-0127 is a BH binary that probably has one of the shortest orbital period and hosts the smallest stellar-mass BH found to date.

4U1700+24: a puzzling symbiotic.

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Symbiotic X-ray binaries form a subclass of low-mass X-ray binary systems with a neutron star accreting material from a red giant donor object. Only a few confirmed members are currently known; 4U 1700+24 is a good candidate as it is a relatively bright X-ray object, possibly associated with the late-type star V934 Her. We analysed the archive XMM-Newton and Swift/XRT observations of 4U 1700+24 in order to have a uniform high-energy (0.3-10 keV) view of the source, and performed a detailed spectral and timing analysis. We confirmed the existence of a red-shifted O VIII Ly- transition (already observed in the 2002 XMM-Newton data) in the high-resolution spectra collected via the RGS instruments. The red-shift of the line was estimated to be 0.009. We also observed a modulation of the centroid energy of the line on short time scales (a few days). If the modulation is due to the gravitational red-shift of the neutron star, it might have its origin in a sudden re-organization of the emitting X-ray matter on the scale of a few hundreds of km. Alternatively, a uni-polar jet of matter with typical velocity of 1000-4000 km/s is emitted by the neutron star in an almost face-on system.

Searching for Gamma-Ray Binaries using the Fermi Second Source Catalog

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The Large Area Telescope (LAT) is an imaging high-energy gamma-ray telescope on the Fermi Gamma Ray Space Telescope spacecraft. The Fermi LAT Second Source Catalog contains 1873 gamma-ray sources. A large fraction of these sources remain unidentified.

Recently, a new class of gamma-ray source has emerged, the so-called gamma-ray binaries, composed of a compact object and a massive star, distinguished by their relatively high gamma-ray luminosity in the 0.1-100 GeV range. However, only 5 gamma-ray systems have been identified thus far.

Here we present an attempt to discover new gamma-ray binaries by studying unidentified Fermi LAT sources. First we identify radio sources from the NRAO/VLA Sky Survey which are positionally coincident with a Fermi source: the radio error circles are then searched for optical counterparts consistent with those of a gamma-ray binary (via optical/IR colors and spectroscopy). Here we present our attempts to identify 2 such systems - 2FGLJ0359.1+6003 and 2FGLJ0747.5-3305.

FABADA: Fitting Algorithm for Bayesian Analysis of DAta

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The extraction of any physical information from data has been generally made by fitting the data through a χ^2 minimization procedure. However, as pointed out by the pioneer work of Sivia D. S. et al. another way to analyze the data is possible using a probabilistic approach based on Bayes theorem. Expressed in a practical way, the main difference between the classical (χ^2 minimization) and the Bayesian approach is the way of expressing the final results of the fitting procedure: in the first case the result is expressed by values of parameters and a merit figure such as χ^2, while in the second case results are presented as probability distribution functions (PDF) of both. In the method presented here we obtain the final probability distribution functions exploring the combinations of parameters compatible with the experimental error, i.e. allowing the fitting procedure to wander in the parameter space with a probability of visiting a certain point P=exp(-χ^2/2), the so called Gibbs sampling. Among the advantages of this method, we would like to emphasize three.

First of all, correlation between parameters is automatically taken into account with the Bayesian method. This implies, for example, that parameter errors are correctly calculated, correlations show up in a natural way and ill defined parameters are immediately recognized from their PDF (i.e. parameters for which data only support the calculation of lower or upper bounds).

Secondly, it is possible to calculate the likelihood of a determined physical model, and therefore to select the one which best fits the data with the minimum number of parameters, in a correctly defined probabilistic way.

Finally, the last but not less, in the case of a low count rate, where the known low error=$\sqrt{counts}$ fails because Poisson distribution can no longer be approximated as a Gaussian, the Bayesian, method can also be used by simply redefining χ^2, which is not possible with the usual fitting procedure.

Revealing accretion onto black holes through X-ray reflection

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Understanding the dynamics behind black hole state transitions and the changes they reflect in outbursts has become long-standing problem. The X-ray reflection spectrum describes the interaction between the hard X-ray source (the power-law continuum) and the cool accretion disc it illuminates, and thus permits an indirect view of how the two evolve. We present a systematic analysis of the reflection spectrum throughout three outbursts (500+ RXTE observations) of the black hole binary GX 339-4, representing the largest study applying a self-consistent treatment of reflection to date. Particular attention is payed to the coincident evolution of the power-law and reflection, which can be used to determine the accretion geometry. The hard state is found to be distinctly reflection weak, however the ratio of reflection to power-law gradually increases as the source luminosity rises. In contrast the reflection is found dominate the power-law throughout most of the soft state, with increasing supremacy as the source decays. Using results from archival and AO-12 observations of GX 339-4 with XMM-Newton we reveal the dynamics driving this evolution and the nature of accretion onto black holes in outburst.

The 100-month Swift Catalogue of Supergiant Fast X-ray Transients

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We present the 100-month Swift Catalogue of Supergiant Fast X-ray Transients, a collection of over a thousand Swift/BAT flares from 11 Supergiant Fast X-ray Transients (SFXT), complete down to 15–150 keV fluxes of about $\sim 6 \times 10^{-10}$ erg cm^{-2} s^{-1} (daily timescale) and about $\sim 1.5 \times 10^{-9}$ erg cm^{-2} s^{-1} (orbital timescale, averaging about 800 s). This population is characterized by short (a few hundred seconds) and relatively bright (in excess of 100 mCrab, 15–50 keV) events, lasting much less than a day in the hard X-rays. The outbursts are a much longer phenomenon however, as testified by the clustering of flares in orbital phase-space. They last up to a few days, as previously discovered from Swift deeper soft X-ray observations. We use this large dataset to probe the properties of the high and intermediate emission states in SFXTs, and to infer the properties of these binary systems. We also present preliminary results from our analysis of spectral evolution dependent flux light curves and broad-band spectroscopy of the outbursts. Finally, we provide a recipe to estimate the number of flares per year each source is likely to produce as a function of the detection threshold and limiting flux.

Millihertz to hectohertz variability in low mass X-ray binaries as seen by XMM-Newton

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In the last two decades a detailed phenomenological picture of short-term variability in low-mass X-ray binaries has emerged mainly based on RXTE observations that cover energies above 3 keV. We are accomplishing a comprehensive study of archival XMM-Newton observations in timing or burst mode of more than ten black hole and more than thirty neutron star low-mass X-ray binaries to investigate the variability properties of these sources at softer energies.

Here we present some results of this study, which will comprise a summary of the power density spectra and related time lags for different black hole X-ray binaries; a discussion of the energy dependence of the power spectral state that we found in the plateau state of GRS 1915+105 and the implications of this finding for the picture of the accretion geometry in black hole X-ray binaries; a presentation of the results of our waveform analysis and phase resolved spectral investigations of the millihertz quasi-periodic oscillations in 4U 1636-536 and a discussion on the implication of the potential thermonuclear burning mode based on its phase-resolved energy spectra.

Irradiated accretion discs in ultraluminous X-ray sources

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Observations of optical counterparts to ultraluminous X-ray sources (ULXs) could provide critical clues to the physical nature of these extraordinary objects. Recently attempts have been made to constrain the stellar types of ULX counterparts, however the detection of optical variability suggests that they may actually be dominated by reprocessed X-ray emission. Here, we report on a combined XMM-Newton and HST study of ULXs with broadened disc-like X-ray spectra. We fit the data with a new spectral model of emission from an irradiated, colour-temperature-corrected accretion disc with a Comptonising corona, finding reprocessing fractions similar to the high/soft state black hole binaries (BHBs), but less than has been reported for some ULXs with soft, wind-dominated X-ray spectra. We suggest that X-ray emission may be scattered on to the outer disc by material in a natal super-Eddington wind, then the higher reprocessing fractions in some ULXs may be associated with stronger winds. Alternatively, these disc-like ULXs may be similar in geometry to the high/soft state BHBs.

Exploring the formation of binary systems of Ultraluminous X-ray Sources

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Ultraluminous X-ray sources (ULXs) are observationally defined as non-nuclear extragalactic X-ray point sources with luminosity exceeding the Eddington limit for a $\sim$10 solar mass compact object. They are the key to exploring extreme super-Eddington accretion regimes and the unknown distribution of black hole (BH) masses above $\sim$20 solar masses. To address these issues and shed light on the nature of ULXs, we started a systematic investigation of the dynamics and emission properties of BH binaries in young star clusters for different metallicities, computing optical colour-magnitude diagrams for all systems that enter an active Roche lobe accretion phase. The calculation accounts for the emission of both the donor star and the irradiated accretion disc, under different assumptions on the physical regime of the accretion disc. Comparison with the available X-ray data and HST photometry of ULX counterparts shows that binary systems hosting a rather massive stellar BH originating from the direct collapse of a massive low-metallicity star and formed through dynamical interaction in the cluster can produce a ULX with emission properties consistent with the observed ones. Important constraints on the range of allowed BH masses and on the properties of the accretion flow are also derived.

Probing the Geometry of the Comptonizing Coronae of Neutron Star LMXBs

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Neutron star (NS) low-mass X-ray binaries (LMXBs) are widely known to exhibit thermal Comptonization phenomena by hot electron coronae both in the low-hard and high-soft states. The Comptonizing coronae are considered to locate in the vicinity of the NS, with a disk-like shape in the soft state (e.g., Inogamov+1999), and nearly spherical in the hard state (e.g., Sakurai+2012). However, further details of the coronal geometry are not yet clear. In this study we aimed to probe possible anisotropy of the coronal shape, by comparing the Comptonization strength (namely the Compton y-parameter) of dipping and non-dipping LMXBs in the same spectral state. The difference of these two categories are, the former must be observed from higher inclinations. With a wide study of the broadband spectra of dipping and non-dipping LMXBs from Suzaku archived data, we found that the dippers, in general, exhibit larger Compton y-parameters. The results further indicate that the Comptonizing coronae may have oblate shapes which extends along the disk plane, thus their optical depths increase when viewed from higher inclinations (Zhang+2014, submitted to PASJ).

Chapter 4

Cataclysmic Variables and Novae

Soft Fourier time lags observed in the dwarf nova SS Cyg

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Accretion is a common phenomenon in active galactic nuclei (AGNs), X-ray binary systems (XRBs) and cataclysmic variables (CVs), providing different scenarios to study the physics involved in accretion discs. It has been shown that XRBs and CVs show similar observational properties such as recurrent outbursts, spectral state transitions and aperiodic variability. The latter has been extensively studied for XRBs, but only recently has the rms-flux relation and optical Fourier time-lags been observed in CVs. We present a broad-band Fourier analysis of the well-known cataclysmic variable SS Cyg in quiescence based on data collected by William Herschel Telescope using ULTRACAM. Lightcurves in SDSS filters u', g' and r' were taken simultaneously with sub-second cadence. The high sensitive camera allows us to study the broad-band noise of the source in a frequency range of $\approx 10^{-4} - 2$ Hz. We explored the coherence, cross spectra and the power spectral densities that are well described by a power law. Soft lags at lowest frequencies were observed indicating that the emission in the softer bands lags the emission in the harder bands. This can be possibly described by hard photons reprocessing created in the boundary layer close to the white dwarf.

Pre-outburst Chandra Observation of the Recurrent Nova T Pyxidis in Quiescence

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I present a total of 98.8 ksec observation of the recurrent nova T Pyx obtained with the Chandra ACIS-S. Spectral analysis gives a $kT_{max} > 37.0$ keV with (5.0-9.0)$\times 10^{-14}$ erg s^{-1} cm^{-2} and (0.8-1.4)$\times 10^{32}$ erg s^{-1} in the 0.2-10.0 keV range using a multi-temperature plasma emission model. The ratio L_x/L_{disk} is $\leq$(1-5)$\times 10^{-4}$ indicating considerable inefficiency of X-ray emission. There is no soft X-ray emission with a 2σ upper limit (using a blackbody model) of $kT_{BB} < 25$ eV and $L_{soft} <$ 2.0×10^{32} erg s^{-1} with only interstellar absorption. I suggest that T Pyx has an optically thin boundary layer merged with an ADAF-like flow and/or X-ray corona in the inner disk indicating ongoing quasi-spherical accretion at high rates during quiescent phases. An elaboration of advective accretion flows (in boundary layers) for some high state CVs (nova-likes) and occurance of recurrent novae will be included. Extended emission at S/N of 7-10 has been recovered from T Pyx using deconvolution at the subpixel level revealing an elliptical/ring-like shape with an outer radius $\sim$ 0.9 arc sec. The count rate in the extended emission is < 0.0025 c s^{-1}. The nebulosity seems consistent with an interaction of the outflow/ejecta from the 1966 outburst.

On Different Absorption Components in the X-ray Spectra of the Intermediate Polar Systems

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We present orbital phase-resolved spectroscopy of the Intermediate polars (IP) AO Psc, HT Cam, V1223 Sgr and XSS J0056+4548 using the XMM-Newton EPIC pn data. We detect increase of absorption by neutral hydrogen column density N_H during the phases corresponding to the orbital minima in a range $\sim$ (1.0-2.0)$\times 10^{22}$ cm^{-2}. AO Psc indicates spectral hardening in the soft plasma emission component. HT Cam, reveals an increase of N_H at the orbital minimum from 0.05×10^{22} cm^{-2} to 0.13×10^{22} cm^{-2}. These high N_H values are most likely a result of absorption by the bulge material at the accretion impact zone. We discuss implications of this interms of warmabsorbers in IPs and bulge temperatures. The four IPs reveal a second high absorption component that is constant over the orbital phase in a range (5.0-11.0)$\times 10^{22}$ cm^{-2}. We attribute this component to the accretion column/curtain. These results are in accordance with the orbital phase-resolved analysis presented in Pekon & Balman (2011) for EX Hya and (2012) for FO Aqr. We strongly suggest that absorption by the bulge at the accretion impact zone is a distinct component in the IP X-ray spectra.

Constraints on QPOs in accreting magnetic white dwarfs from XMM observations and simulations

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Magnetic cataclysmic variables ('Polars') are binary systems in which a highly magnetic white dwarf accretes matter from a dwarf secondary star, via a column. The gravitational energy is released through a stand-off shock close to the white dwarf surface, mainly via Bremsstrahlung X-ray emission and cyclotron visible radiation. Some of these Polars are known to show (0.3-1 Hz) quasi-periodic oscillations (QPOs) in visible light, which have been related to shock instabilities. No systematic search for QPOs has yet been done in the X-rays. We have analyzed a large sample of Polars observed with the XMM-Newton satellite and provide upper limits on QPOs in the range (0.1-5) Hz. These results are compared to theoretical predictions of 2D hydrodynamical models developed in the context of the POLAR project. This project aims at studying the formation and dynamics of accretion shocks by combining the astrophysical approach and laboratory experiments which use powerful lasers to generate physical conditions relevant for astrophysics. The comparison between observations and numerical simulations provides important constraints of the influence of the mass accretion rate and the magnetic field strength on the development of instabilities and damping processes.

Dwarf Novae of the Catalina Real-time Transient Survey

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Cataclysmic Variables (CVs) are binary systems wherein matter transfer takes place from a low-mass main-sequence secondary star to a white dwarf primary. CVs show brightness variations with a range of amplitudes and time-scales, which means that they are readily detected by transient surveys that search for variability. The Catalina Real-time Transient Survey (CRTS) is one such survey. With approximately 9 years worth of observations at a cadence of less than a month over most of the sky, they have detected more than 1100 CVs to date.

Here I will discuss the properties of this population and the implications it has for CV evolution models. The sample includes magnetic systems, novalikes and eclipsing systems, but the vast majority are dwarf novae (DN) - a subclass of CVs that brighten by 2-6 magnitudes on a semi-regular time-scale as a result of a disc instability. By correcting for selection effects and taking the CRTS sampling cadence into account, we compare the detected sample to theoretical predictions for the population. We subsequently derive an estimate for the duty cycle of DN and use it to constrain the long-term mass transfer rate - a value that is currently ill-constrained and yet necessary for evolutionary models.

X-ray properties of hard X-ray Cataclysmic Variables

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Among hard X-ray galactic sources detected by the INTEGRAL and SWIFT surveys, those identified as accreting white dwarf binaries recently boosted in number, representing 20% of the galactic sample. The majority are identified as magnetic Cataclysmic Variables (CVs) suggesting that this subclass is an important costituent of galactic population of X-ray sources. We will present the results of an on-going follow-up programme with XMM-Newton aiming at identifying the true nature of newly discovered hard X-ray CV candidates.

Early X-ray emission from novae: The case of the symbiotic recurrent nova RS Ophiuchi

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Novae can be sources of high-energy photons, reaching GeV energies. Such emission is a consequence of π^0 decay and/or Inverse Compton, which are related to particle (p and e^-) acceleration. The strong shock between matter ejected by the white dwarf and the circumstellar medium is responsible for this process. The 2006 outburst of RS Ophiuchi was the first nova for which particle acceleration was predicted. This prediction showed that the blast wave decelerated faster than expected as a consequence of acceleration of particles in the shock and their escape. RS Oph is a recurrent nova in a symbiotic system composed of a white dwarf and a red giant with a recurrence period of $\sim$ 21 years. Five novae have been detected by *Fermi/LAT* so far. Our aim is to understand the acceleration process through the analysis of contemporaneous X-ray emission. We present an analysis of the *XMM-Newton*'s observations of RS Oph early after its 2006 outburst both with RGS and EPIC-MOS, which have a broader energy range than RGS. We will compare with *RXTE*, *Swift/BAT* and *Chandra* observations, to get a global picture of VHE γ-ray emission in novae and its relationship with particle acceleration.

Novae as supersoft X-ray sources in the Andromeda galaxy

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Novae are the major class of supersoft X-ray sources (SSSs) in the central region of our neighbouring galaxy Andromeda (M31). From 2006 until 2012 we carried out a dedicated monitoring of the M31 central region with XMM-Newton and Chandra that was specifically designed to detect and characterise SSS states of novae. Only X-ray observations allow us to observe the hot post-nova white dwarf directly and study its physics. Here, I present new results based on an updated catalogue of 79 novae with SSS counterparts, which is by far the largest sample known in any galaxy, to date. Global trends and correlations were established between various multiwavelength nova parameters and there appear to be significant deviations from current models of Galactic novae. Furthermore, there is evidence for different X-ray parameters of sub-samples associated with the M31 bulge and disk, although the question whether both populations are inherently different is far from resolved. The sample contains several remarkable individual novae and I will discuss their peculiarities and importance. The X-ray monitoring of large, homogeneous samples of extragalactic novae is shown to be a powerful tool to study nova populations and the dependence of their observable characteristics on the underlying stellar population.

V2487 Oph 1998: a puzzling recurrent nova observed with XMM-Newton

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V2487 Oph exploded as a classical nova in 1998. Several years later it was identified as a recurrent nova, with a previous eruption in 1900. Most recurrent novae host massive white dwarfs (WDs), which could increase in mass after each eruption, finally reaching the Chandrasekar mass and exploding as type Ia supernovae, if CO WDs.

We observed V2487 Oph with XMM-Newton between 2 and 9 years after its explosion, to study its post-outburst behavior, and the WD and companion star properties. The emission revealed restablished accretion onto a magnetic WD in a cataclysmic variable of the intermediate polar (IP) type. Interestingly, V2487 Oph was also detected in hard X-rays with INTEGRAL/IBIS, and was again tentatively classified as IP. There's not yet a confirmation of $P_{spin}(WD) < P_{orbit}$, the defining property of IPs.

V2487 Oph is not the first nova exploding in a magnetic CV, but it is indeed challenging to reach explosive conditions without genuine accretion disks. Also, the type of binary system should be reconciled with the fact of being recurrent (where larger accretion rates than in CVs are required). It will be discussed how XMM-Newton observations (EPIC and RGS) provide insight into such a puzzling object.

Classical and Recurrent Novae as Quintessential Panchromatic Transients

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In classical and recurrent novae, thermonuclear runaway (TNR) of accreted material on the white dwarf surface results in ejection of 10^{-6} to 10^{-4} solar masses at velocities of order 1000 $\mathrm{km\,s^{-1}}$. They are routinely detected as transients from X-rays to radio, and 6 novae (so far) have also been detected in GeV gamma-rays with Fermi/LAT. It appears that all the nearby novae are detected with Fermi, suggesting gamma-ray emission to be a universal property of novae, while a few exceptional novae further away are also detected, indicating that the gamma-ray luminosity of novae varies from system to system. Here we present selected results from our multi-wavelength observations of recent classical and recurrent novae and discuss evidence for multiple, discrete mass ejection episodes driven by a single TNR. The collision among these shells create shocks that can be observed through synchrotron radio emission and optically thin, thermal, hard X-ray emission. We do not find obvious correlation between the X-ray flux and the GeV flux, even though the latter must also result from shocks. It is clear that shocks can either be efficient particle accelerator or efficient thermal X-ray emitter, but not necessarily both at the same time.

Transient short-period oscillations in Super Soft Sources

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Novae are powered by nuclear runaway reactions that take place on the surface of a white dwarf. The nova ejecta block all emission produced by nuclear burning until the start of the Super Soft Source (SSS) phase when X-rays become visible after the ejecta have cleared sufficiently. Recently, transient short-period (< 100s) oscillations have been found in Swift/XRT light curves taken during the SSS phase of three novae. We performed a systematic search for short-period oscillations in all available continuous XMM and Chandra SSS light curves and found short-period oscillation in LMC 2009a (33s), RS Oph (35s), KT Eri (35s), V339 Del (54s), and Cal 83 (67s). Period-time maps clearly illustrate the transient nature of the period both in terms of period value and signal strength. A similar systematic study of all Swift/XRT observations is under way (Beardmore et al.). If interpreted as g-mode oscillations, excited by the ϵ mechanism, theoretical relations between period, luminosity, and white dwarf mass can be explored to determine the white dwarf mass.

Suzaku observations of the peculiar cataclysmic variable FS Aurigae

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FS Aur is a peculiar cataclysmic variable containing a magnetic and freely precessing white dwarf. The system is known to exhibit three very coherent periodic signals in the optical photometric and spectroscopic data. The periods of these signals are the orbital period, the period of precession of the white dwarf and the beat period between former two. The previous X-ray observations made with Chandra and Swift, also revealed the presence of strong modulation with the orbital period. However, the existence of the precession and beat period signals in X-rays is not conclusive owing to insufficient data. Here we present the longest and the most sensitive X-ray observations of FS Aur made with the Suzaku observatory in 2013. We use these data to analyse temporal and spectral properties of X-ray emission from the object.

X-ray Grating Spectra of Classical and Recurrent Novae

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We present high resolution XMM-Newton RGS grating spectra of recent recurrent novae of the last 5 years, taken after the outburst in the supersoft X-ray phase. We show cases that can be fitted with white dwarf static atmospheric models and cother examples that should be fitted with white dwarf "wind" atmospheric models. We also show how to disentagle emission line spectra produced in he ejecta from the hot and luminous white dwarf atmosphere. We discuss innovative ways to examine the spectra taking into account the secular evolution, the accretion history, and optical observations done immediately after the outburst.

The space density of magnetic and non-magnetic cataclysmic variables, and implications for CV evolution

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I will present estimates of the space densities of both non-magnetic and magnetic cataclysmic variables (CVs), based on X-ray flux-limited samples. The measurements can be used to address several questions relevant to the evolution of CVs and to the makeup of Galactic X-ray source populations. I will discuss the implications of these results for the high predicted space density of non-magnetic CVs, the evolutionary relationship between intermediate polars and polars, the fraction of CVs with strongly magnetic white dwarfs, and for the contribution of magnetic CVs to Galactic populations of hard X-ray sources.

The grating spectra of the SSS classical novae V5116 Sgr and V5115 Sgr

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XMM-Newton observed novae V5116 Sgr and V5115 Sgr during their supersoft phases (SSS). V5116 Sgr showed a decrease of the flux by a factor around 8 during 2/3 of the orbital period. The 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. We obtain reasonable good fits with N rich NLTE atmosphere models, from which we determine $T_{eff} \sim 7 - 7.5 \times 10^5$ K. In contrast, during the low flux periods the spectrum is dominated by emission lines superimposed to the soft X-ray continuum, probably originated in the non-occulted ejecta. 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 emission lines in their spectra. V5115 Sgr RGS spectrum is also characteristic of a white dwarf atmosphere, while the EPIC spectra show a harder excess (1-5 keV), probably originated in the ejecta.

Timing HU Aqr

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We report XMM-Newton X-ray and ultraviolet observations of the bright eclipsing polar HU Aqr performed in October 2013. When discovered in the RASS, it was the brightest eclipsing AM Her star but in the XMM-Newton era it was encountered in low or intermediate states only. After recovery into a high state a triggered Swift/XMM-Newton accompanied by ground-based photometry could be arranged. The X-ray observations covered 5 orbital cycles of the 125min binary. The object was extremely bright at soft X-rays reaching >150 cts/s in 1s time bins. The X-ray light curve was found to be highly structured featuring an opaque accretion stream and a porous accretion curtain. We will present a multi-wavelength timing study to locate the X-ray emission region and determine its size. The relative timing of optical and X-ray eclipses and the use of either data searching for circumbinary planets via the Roemer delay is discussed.

Multi-Observation Identification for Studying the Evolution of Spin-up line

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Binaries that contain a White Dwarfs (WDs) star and a main-sequence companion may have interacted. This binary population has historically helped determine our understanding of binary stellar evolution. We use a collection of 180 well-measured WDs masses to strengthen the case that a substantial fraction of these systems could potentially evolve to reach Chandrasekhar limit, and undergo an Accretion Induced Collapse (AIC) and then produce millisecond pulsars. We focus our attention mainly on the massive WDs $\sim M > 0.9 M_{sun}$, that are able to grow further by mass-transfer phase, to reach the Chandrasekhar mass in stellar binary systems. We derive a mean value of $\sim M 1.15 + -0.2 M_{sun}$. We have also estimated the bottom magnetic field for the observed sample of WD. It is interesting to note that the most highly magnetized WDs are massive as well as isolated. The implications of the results presented here to our understanding of binary MSPs evolution are discussed.

CV Science with Athena: A case study of AM Herculis

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The proposed ESA large mission telescope Athena+ has recently been selected for launch in 2028. We investigate the capability of Athena+ with respect to spectral analyses of cataclysmic variables on the case of the prototype of magnetic CVs, AM Herculis. To simulate observations with the X-IFU calorimeter onboard Athena+, we model the emission line spectrum of AM Her as a combination of the multi-temperature plasma emission of the post-shock accretion column and reflection. We generate phase-resolved synthetic X-ray spectra for the models which are sensitive to changes in the accretion rate, the white dwarf mass, and the magnetic field strength. Line shifts due to gas infall in the accretion column, orbital velocity, and gravitational redshift are taken into account. A radial-velocity study of the Fe-line complex at 6.7 keV recovers those velocity components in the H- and He-like plasma lines and the neutral reflection line with 10% accuracy.

Model atmospheres for Novae in the SSS phase

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One of the fascinating things about novae is the diversity with which they appear in the sky. In X-rays, high-quality datasets obtained with XMM-Newton and Chandra present a wealth of detailed information about the physical conditions deep inside the nova. With all the diversity in the X-ray datasets, the grating spectra have one thing in common: they exhibit blue-shifted absorption lines. Apparently, these observations exhibit the basis of the nova where a mix of accreted, processed, and dredged-up material continues to leave the system. In this talk, I give an overview on different hydro-static and expanding model atmospheres that are used to interpret the X-ray data, and compare their synthetic spectra. I will show how the models are constrained by details in X-ray grating spectra and how they enable us to determine from the observations what the physical conditions are in deep layers of novae in outburst.

A systematic X-ray Study of Dwarf Novae with Suzaku

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Dwarf novae (DNe) are the type of cataclysmic variables that are characterized by outbursts, in which the optical brightness increases by 2–5 mag. Typically, they occur once in several months and continues for a few days, and are believed to be caused by the thermal instability of the accretion disk formed around the primary star. The accreting gas in the region between the white dwarf and the disk is heated to $\sim 10^8$ K by the dissipation of kinetic energy, from which X-ray light is emitted. It has been known that, although both optical flux increase during outbursts, there are two kinds of behavior in X-rays; the X-ray count rate increases or decreases. However, here have been few X-ray observations during outbursts, these differences are not well known yet.
To reveal the differences in the behavior of X-ray outburst, we analyzed 19 data sets of 13 DNe observed by the Suzaku satellite. These data include both quiescent and outburst states of several sources. We fitted successfully their spectrum with cooling flow model in quiescence. On the other hand, the spectrum in the outburst requires one or two thermal plasma models in addition to the cooling flow model. Furthermore, we found that the number of the thermal plasma components required differ depending on the two types of X-ray outburst.

X-ray observations of VY Scl-type nova-like binaries in the high and low state

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Four VY Scl-type nova-like systems were observed in X-rays both during the low and the high optical states. Having a high (10^{-8} $M_\odot$/year) mass transfer rate these objects could be pre-novae or pre-supernovae. We examined *Chandra*, *ROSAT*, *Swift* and *SUZAKU* archival observations of BZ Cam, MV Lyr, TT Ari, and V794 Aql. We also plan to use XMM Newton data for further analysis. No SSS was detected in the low state of the any of the systems. The best fit model to the *Swift* X-ray spectra is a multi-component plasma in collisional ionization equilibrium. The high state TT Ari spectra taken with *Chandra* ACIS-S and the HETG gratings show a rich emission line spectrum, with prominent lines of in Mg, Si, Ne, and S. The complexity of this spectrum seems to have origin in more than one region, or more than one single physical mechanism. Most of the emission lines are consistent with a cooling flow in an accretion stream, but there is an additional component, possibly due to a wind or accretion onto polar caps in intermediate polar systems, continuing even during the low optical state, while the accretion disk is not fed.

Chapter 5

Isolated Neutron Stars and Pulsars

Thermal properties of three Fermi pulsars

Andrey Danilenko[1], Anna Karpova[1,2], Aida Kirichenko[1,2], Yury Shibanov[1,2], Peter Shternin[1,2], Sergey Zharikov[3], Dmitry Zyuzin[1]
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We analysed thermal properties of the Fermi pulsars J0357+3205, J1741−2054, and J0633+0632 using data from the XMM-Newton and Chandra archives. The X-ray spectra of all three pulsars can be fitted by sum of thermal and power-law components. For J1741−2054, the thermal component is best described by a blackbody model whose normalization suggests that the thermal emission comes from the bulk of the neutron star surface. The effective temperature of 60 eV, which is rather large for a pulsar as old as J1741−2054, makes it similar to the well-studied pulsar B1055−52, one of "the three musketeers". The thermal components of PSRs J0357+3205 and J0633+0632 can be equally well described by blackbody or the hydrogen atmosphere models. In the former case the normalizations suggest hot polar cap as thermal emission origin and only upper limits on the neutron stars surface temperatures can be computed. For the hydrogen atmosphere models, the normalizations are in agreement with emission coming from a substantial part of neutron star surface. Thermal properties of the pulsars are confronted with similar data on other isolated neutron stars and predictions of the neutron star cooling theory.

Spectral analysis of the Double Pulsar PSR J0737-3039 with XMM-Newton

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Since its discovery in 2003, the first and unique Double Pulsar system PSR J0737-3039 retains all the attention. This exciting system is composed of two neutron stars: a recycled 23 ms pulsar and a younger pulsar with a period of 2.8 s, revolving in a tight orbit in 2.4 hr. It is the only binary system in which both neutron stars have been detected as radio pulsars.

The high-energy study of this system is extremely interesting to understand the physics of the magnetosphere emissions/interactions of both pulsars. We present the spectral analysis of the two XMM-Newton "Large Programs" performed in 2006 and 2011, which result in a total exposure time of about 600 ks.

The magnetic spectrum of X-ray pulsars

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We have developed a new model based on the solution of the radiative transfer equation exploiting the analytical formalisation of Becker & Wolff (2007, ApJ 654, 435). Our model overcomes the purely phenomenological approach that is usually adopted to describe the high energy emissions from these sources and allows us to better understand the state of the accretion column in terms of model parameters, such as the radius and height of the column, the magnetic field intensity, the plasma temperature.

We have successfully applied this model to several X-ray pulsars at different luminosity levels. One of our main findings is that the collisional excitation of electrons plays a key role in shaping the source X-ray spectrum and originates a broad line-like emission centred at the cyclotron energy of the accreting plasma. Such feature has been repeatedly modelled in the literature as a bump in the spectrum at ∼10-20 keV, but its physical origin was never clearly understood. Our study highlights that a broad-band energy coverage is fundamental to constrain the physics of accretion in highly magnetized pulsars. Promising new perspective will be provided by the instruments on-board the Astro-H mission, covering the energy range 0.3-600 keV.

NuSTAR pulsar discoveries: SGR J1745-2900 near the Galactic Center and PSR J1640- 4631 associated with HESS J1640-465

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Two young pulsars have been discovered using the NuSTAR observatory over the last year. **SGR J1745–2900:** this 3.76 s transient magnetar was detected during a NuSTAR ToO followup of a large flare observed by Swift towards the Galactic center. Its large, erratic spin-down implies a magnetic field $B_s \sim 1.6 \times 10^{14}$ G and characteristic age $\tau \sim 9$ kyr. We followed the magnetar's spectral and timing evolution 4 months post-outburst as its flux and temperature leveled off. In 2013 June, we observed an abrupt tripling of its spin-down rate, likely coincident with a bright Swift burst. We discuss implications of a magnetar near Sgr A*. **PSR J1640–4631:** This energetic 206 ms pulsar and its surrounding PWN lies within SNR G338.3–0.0 and is likely associated with the extreme gamma-ray sources HESS J1640–465 and 1FHL J1640.5–4634. Its spin-down rate implies a $B_s = 1.4 \times 10^{13}$ G, $\tau = 3350$ yrs, and $\dot{E} = 4.4 \times 10^{36}$ erg/s. The origin of the gamma-ray emission is difficult to discern given the complex local environment, both leptonic and hadronic model for the emission mechanism have been proposed. The present work supports an evolutionary PWN model for the spectrum energy distribution, provided that the pulsar's braking index is $n \approx 2$, and that its initial spin period was < 22 ms. A NuSTAR program to measure its braking index is underway.

Constraining parameters of the neutron star in the supernova remnant HESS J1731-347

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The Central Compact Object (CCO) in HESS J1731-347, presumably a neutron star, is one of the brightest sources in this class. Like other CCOs, it potentially provides an "undisturbed" view of thermal radiation generated at the neutron star surface. The shape and normalization of the corresponding X-ray spectrum depends on the emitting area, surface redshift, and gravity acceleration. Thus, its modeling under certain assumptions allows the mass and radius of the neutron star to be constrained. In our analysis, we model the spectrum of the CCO accumulated with XMM-Newton over ∼100 ksec exposure time in three observations. The exposure time has increased by a factor of five since our previous analysis of the source. For the spectral fitting, we use our hydrogen and carbon atmosphere models calculated assuming hydrostatic and radiative equilibria and taking into account pressure ionization and the presence of spectral lines (in case of carbon). We present the resulting constraints on the mass, radius, distance, and temperature of the neutron star.

X-ray observations of radio-quiet black widow-type millisecond pulsars

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Five years of observations with the Fermi Gamma-ray Space Telescope have revolutionized our knowledge of the gamma-ray pulsar population, leading to the discovery of over 40 millisecond pulsars (MSPs) by combining with deep radio observations. With this growing number of gamma-ray emitting MSPs and by combining multi-wavelength observing facilities, it is now possible to study their properties as a population. One of the successes is the discovery of radio-quiet gamma-ray MSP candidates and this opens a new window to study pulsars. Although radio-quiet gamma-ray MSPs are predicted by theories, they are observationally challenging and have never been detected. By combining X-ray and optical data, we have discovered the first candidate 2FGL J2339.6-0532 as a black widow-type MSP. In this presentation, we will present our new XMM-Newton, Suzaku, and JVLA follow-up observations of 2FGL J2339.6-0532. In particular, we will present the first millisecond pulsation search in the X-ray band and a detailed binary phase resolved X-ray spectroscopic study. We will also report preliminary results of a multi-wavelength search for other similar systems.

The most "magnificent" of the seven? A candidate spin and spin down for RX J1605.3+3249

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RX J1605.3+3249 is the third brightest source in the group of intriguing isolated neutron stars (INSs) known as the "Magnificent Seven" (M7). Crustal heating by means of magnetic field decay and an evolutionary link with magnetars may explain why these objects rotate slower and have higher thermal luminosities and magnetic field intensities than standard rotation-powered pulsars of similar age. A recent XMM-Newton observation of the source performed in AO11 finally revealed the neutron star spin period, $P = 3.387864(16)$ s. Very interestingly, the amplitude of the modulation was found to be energy-dependent and is more significantly detected when the search is restricted to photons with $E > 0.5$ keV. The coherent combination of the AO11 data with past observations of the source constrains the pulsar spin-down rate and dipolar magnetic field at the $\sim 3\sigma$ confidence level, at a value that is the highest amongst the M7, $B_{\rm dip} \sim 8.1 \times 10^{14}$ G. Further observations are extremely important to determine a precise timing solution, as well as to perform phase-resolved spectroscopy. These will give invaluable constraints on the neutron star geometry and will allow one to confirm the high value of spin down, which would place the source closer to a magnetar than any other M7 INS.

The X-ray timing behaviour of gamma-ray pulsars

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The Fermi launch revolutioned our comprehension of high-energy emission from pulsars, mainly thanks to the comparison between their radio and gamma-ray profiles. The analysis of the relative shape and peaks separation of light curves in different energy bands appears to be the only way to build a comprehensive emission model but only few pulsars can account for observations able to test X-ray emission models. After a review of the state of the art of the X-ray behaviour of Fermi pulsars, we'll focus on three pulsars we recently observed with XMM-Newton. We'll show some of the best ever collected X-ray non-thermal lightcurves and detailed phase-resolved spectroscopies. We extended the public ephemeris by covering 5 years and we'll compare the obtained curves and phase-resolved spectroscopies with the ones from X. The low-energetic J1741 shows (¿20sigma) two single-peaked pulsed spectral components, with a pulsed fraction of 35% and a photon index varying with phase - the only one known apart from Crab. The bright, energetic J1813 has a 100% pulsed fraction, with two very sharp non-thermal X-ray peaks in opposition - in quadrature with the gamma-ray ones. We'll give results from our recent, orbit-long XMM observation of the oldish and possibly nearby J2055.

X-ray tails powered by gamma-ray pulsars

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The Large Area Telescope onboard the Fermi mission discovered gamma-ray pulsations from about 150 rotation-powered neutron stars, one third of which are young, energetic pulsars not detected at radio wavelengths. X-ray observations of Fermi pulsars unveiled the existence of unusual, very peculiar structures of diffuse emission. We will focus on the cases of two middle-aged, likely nearby, radio-quiet pulsars with low spin-down luminosity, sporting surprisingly long, collimated and bright X-ray tails. Such elongated tails challenge standard models for ram-pressure dominated pulsar wind nebulae and point to alternative explanations. We will discuss possible solutions, including e.g. thermal emission from the interstellar medium shock-heated by the fast-moving neutron star. Implications of such interpretations for the system geometry, pulsar space velocity and properties of the intestellar medium will also be described.

X-ray observations of Fermi LAT gamma-ray pulsars and pulsar candidates

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Since the launch of Fermi, in 2008, the population of known gamma-ray pulsars has exploded from just a handful, to over 150. X-ray observations have been crucial in both the discovery and the understanding of this new pulsar population. I will discuss our ongoing program of XMM, Chandra, and Swift observations of Fermi-LAT pulsars and pulsar candidates and present some of the latest results we have obtained.

Measuring the strongest magnetic fields in the Universe

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Magnetars are neutron stars powered by their own magnetic energy and are believed to host the strongest magnetic fields in the Universe. The magnetar model was proposed to explain the sources of peculiar gamma-ray bursts, the soft gamma repeaters (SGRs), and then extended to interpret a subclass of X-ray pulsars, the anomalous X-ray pulsars (AXPs). Various observational properties of SGRs and AXPs are well consistent with such a picture, but a direct measurement of their surface magnetic field through the detection of a cyclotron line in their spectra has been searched for many years without success. We have recently discovered a phase-variable absorption line in the X-ray spectrum of SGR 04181+5729, which is the first narrow feature significantly detected in a magnetar spectrum and the most variable line ever observed in a neutron star. If interpreted as a proton cyclotron line, it implies the presence of a super strong magnetic field in this object and constitutes a striking confirmations for the magnetar model.

XMM-Newton observations of SNR G350.0-2.0

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Only about ten Central Compact Objects (CCOs), a peculiar manifestation of isolated neutron stars (NS) associated with young supernova remnants (SNRs), have been detected in X-rays. This is too few to address fundamental questions such as the equation of state of superdense matter in extreme conditions inside NSs. To expand this sample we observed Galactic SNR G350.0−2.0 using the XMM-Newton observatory. Here we report on the analysis of the CCO candidates detected in the SNR field, and on the thermal emission spectrum of the remnant.

Chapter 6

Planetary Nebulae, SN, SNR, PWN, Gamma-ray Bursts and Afterglows

The X-ray Lightcurves of Young Supernovae, and Implications for the Supernova Progenitors

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We have aggregated together data available in the literature, or analysed by us, to compute the X-ray lightcurves of almost all young supernovae (SNe). We use this to explore the diversity of SN X-ray lightcurves, the expansion of the SN into the surrounding medium, the characteristics of the medium into which they are expanding, and the implications for their progenitors. In this talk we focus on Type IIP and Type IIn SNe. IIPs have the lowest luminosities, which is surprising given the high mass-loss rate winds expected from their red supergiant (RSG) progenitors, and therefore the high density medium into which IIP SNe are expected to expand into. We show that the low X-ray luminosity sets a limit on the mass-loss rate, and thereby initial mass of a RSG star which can become a Type IIP progenitor. This initial mass limit, of about 19 solar masses, is consistent with that obtained via direct optical progenitor identification. IIns are observed to have very high X-ray luminosities in general, but some of the light curves tend to fall off very steeply. We explore the implications of this behaviour.

SN 1993J - The X-ray Story of a Supernova Slowly Transitioning to a Remnant

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Supernova 1993J in the nearby galaxy M81 is one of the best observed supernovae (SNe) in X-rays, with better long-term X-ray time-sampling than any other SN. We re-analysed most of the available archival data on SN 1993J, combined with a 79ks Chandra observation obtained by our group in Aug 2010. Together, the data constitute a veritable history of a Type IIb SN from its explosion, through its outward journey into the surrounding medium, and on its way to becoming a remnant. The X-ray emission probes the characteristics of the surrounding medium, and the kinematics of the SN shock wave(s). In this project we explore the evolution of these quantities in SN 1993J, together with the evolution of its X-ray spectrum.

Gamma Ray Bursts from Binary Black Holes

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We consider a scenario for the longest duration gamma ray bursts, resulting from the collapse of a massive rotating star in a close binary system with a companion black hole (BH). The primary BH born during the core collapse is first being spun up and increases its mass during the fallback of the stellar envelope just after its birth. As the companion BH enters the outer envelope, it provides an additional angular momentum to the gas. After the infall and spiral-in toward the primary, the two BHs merge inside the circumbinary disk. The second episode of mass accretion and high final spin of the postmerger BH prolongs the gamma ray burst central engine activity. The observed events should have two distinct peaks in the electromagnetic signal, separated by the gravitational wave emission. The gravitational recoil of the burst engine is also possible.

Nucleosynthesis of elements in the outflows from gamma ray bursts

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We consider the outflows from gamma ray bursts central engines resulting from the collapse of a massive rotating star or compact binary mergers. The engine is composed of free nucleons, helium nuclei, electron-positron pairs and cooled by neutrino emission. The significant number density of neutrons in the outflowing material and interactions with neutrinos will lead subsequent formation o heavier elements. We study the process of nucleosynthesis and observational consequences of the engine physical properties.

XMM-Newton observations of 30 Dor C in the Large Magellanic Cloud

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The 30 Dor C superbubble (SB) in the Large Magellanic Cloud is notable for its bright shell of non-thermal X-ray emission. The southeastern region is also known to exhibit significant thermal emission with metal enhancements indicating the presence of a supernova remnant (SNR). However, a detailed treatment and characterisation of the thermal emission has not yet been performed. In this work, we present the analysis of the ample *XMM-Newton* data available for 30 Dor C (flare-filtered exposure times of 420 ks EPIC-pn, 556 ks EPIC-MOS1, 614 ks EPIC-MOS2) to attempt to isolate and identify any X-ray emission due to an SNR. In addition, an analysis of the non-thermal emission will be presented and discussed in the context of emission mechanisms previously suggested in the literature (i.e., non-thermal bremsstrahlung and synchrotron). Two SNRs were found to be contributing to the thermal emission in 30 Dor C. The most apparent is manifest as a prominent arc in the 1-2 keV energy range, which shows strong emission lines of α-process elements in its spectrum, consistent with a core-collapse remnant. Its X-ray morphology points to a location outside the SB. The second SNR is likely an interior SNR interacting with the shell wall.

Synchrotron X-ray radiation in highly turbulent fields

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Synchrotron radiation is considered to be the main channel for the production of non-thermal emission in the energy band from radio to soft gamma rays. This emission component emerges from interaction of high energy electrons with magnetic field, and its spectral properties have been studied in detail both in the context of theoretical physics and astrophysics. However, to a large extend this concerns only the case when the magnetic field is homogeneous. Properties of emission which is produced when electrons interact with turbulent (or simply chaotic) magnetic field still remains a subject for theoretical and numerical studies. Here we focus on the implications of this radiation regime on production of X-ray emission in different astrophysical sources. We discuss the difference in the X-ray spectral slope and flux level as compared to the "conventional" one-zone model. In particular, it was found that the standard relations used to link the X-ray and gamma-ray components in synchrotron–inverse Compton models can be significantly disturbed by the chaotic nature of magnetic field. Also, we discuss how a case of chaotic magnetic field can be distinguished from the emission produced in several active zones characterised by different strength of magnetic field.

Constraints on the rate of particle acceleration using late X-ray observations of GRB afterglows

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In gamma-ray burst (GRB) afterglows, particle acceleration may be produced through diffusive shock acceleration in weakly magnetised relativistic collisionless shocks. The rate of acceleration affects the maximum energy of the accelerated electrons and therefore, the maximum energy of the observed photons. When the synchrotron frequency of the maximally accelerated electrons crosses the X-ray band, a sharp steepening of the X-ray light curve accompanied by a spectral softening is expected 10 or more days after the trigger time. This is in contrast to the so-called jet-break when the decay slope steepens achromatically at late times due to the drop in Lorentz factor revealing the full jetted emission. We present here a direct comparison between the expected properties of these breaks including viewing angle effects. We put the results in the context of the X-ray afterglows of GRB 080411 and GRB 120711A for which very late X-ray data are available.

Shock-cloud interaction in the southwestern limb of SN 1006, observations and models

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The historical supernova remnant SN 1006 is a powerful source of high-energy particles showing a characteristic bilateral morphology in its nonthermal emission (from radio to TeV gamma-rays). By analyzing the observations of the XMM-Newton Large Program (LP) on SN 1006, together with archive HI observations, we found evidence that clearly indicates that an atomic cloud is interacting with the southwestern rim of the remnant, which is dominated by nonthermal synchrotron emission (Miceli et al. 2014). The southwestern limb therefore presents a unique combination of efficient particle acceleration and high target density, thus being the most promising region for gamma-ray hadronic emission in SN 1006. We further investigate the shock-cloud interaction by analyzing the Chandra LP observations of SN 1006 to obtain dedicated measurements of the proper-motion in the interaction region (Katsuda et al. 2014 in preparation). We finally perform detailed 3-D MHD simulations describing the remnant-cloud interaction and present the comparison between observables synthesized from the model and actual X-ray data. We estimate that hadronic gamma-ray emission from the southwestern limb of SN 1006 will be detectable with the Fermi telescope within a few years.

Filling the gap between supernova explosions and their remnants: the Cassiopeia A laboratory

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Supernova remnats (SNRs) show a complex morphology characterized by an inhomogeneous spatial distribution of ejecta, believed to reflect pristine structures and features of the progenitor supernova (SN) explosion. Filling the gap between SN explosions and their remnants is very important for a comprehension of the origin of present-day structure of ejecta in SNRs and to probe and constraint current models of SN explosions. The SNR Cassiopeia A (Cas A) is an attractive laboratory for studying the SNe-SNRs connection, being one of the best studied SNRs for which its 3D structure is known. We present a three-dimensional hydrodynamic model describing the evolution of Cas A from the immediate aftermath of the SN explosion to its expansion through the interstellar medium, taking into account the distribution of element abundances of the ejecta, the backreaction of accelerated cosmic rays at the shock front, and the deviations from equilibrium of ionizazion for the most important elements. We use the model to derive the physical parameters characterizing the SN explosion and reproducing the today morphology of Cas A.

Three-dimensional hydrodynamic modeling of SN 1987A from the supernova explosion till the Athena+ era

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The proximity of SN 1987A and the wealth of observations collected at all wavelength bands since its outburst allow us to study in details the evolution of a supernova remnant (SNR) from the immediate aftermath of the SN explosion till its expansion through the highly inhomogeneous circumstellar medium (CSM). We investigate the interaction between SN 1987A and the surrounding CSM through three-dimensional hydrodynamic modeling. The aim is to determine the contribution of shocked ejecta and shocked CSM to the detected X-ray flux and to derive the density structure of the inhomogeneous CSM and clues on the early structure of ejecta. Our model describes the evolution of supernova shocks from the breakout of the shock wave at the stellar surface till its transition from SN to SNR. Our best-fit model reproduces the bolometric lightcurve of SN 1987A during the first 150 days of evolution and the X-ray lightcurves in the [0.5-2] keV and [3-10] keV bands derived during the first 26 years of evolution, providing an accurate description of the structure of ejecta and of the CSM around the progenitor. Also remnant evolution is followed for 40 years, providing predictions on the future of SN 1987A until the advent of Athena+.

An Archival X-ray Study of the Large Magellanic Cloud Supernova Remnant N132D

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We present the results of an analysis of the archival XMM-Newton EPIC data (382ks for pn and 514ks for MOS) and the Chandra X-ray Observatory ACIS data (89ks) of the brightest X-ray supernova remnant (SNR) in the Large Magellanic Cloud (LMC) N132D. N132D has been routinely observed by XMM-Newton over its 14 year mission as a calibration target. We have combined the data from all calibration observations suitable for scientific analysis to create the deepest X-ray images of N132D. N132D has been classified as an "O-rich" remnant based on the UV and optical spectra which show emission from C, O, Ne, Mg, and Si. These spectra of the central optical knots do not show any emission from elements with Z higher than Si, yet the nucleosynthesis models predict significant quantities of these higher Z elements. Our spectral analysis of the deep XMM data clearly shows emission lines from S, Ar, Ca, and Fe, with indications of other possible features between Ca and Fe. We discuss the interpretation of the emission from the high Z elements as a "hot ejecta" component or a high temperature shell component and the implications for the progenitor.

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Supernova remnant candidates in the ROSAT All-Sky Survey

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Radio supernova remnants (SNRs) in the Galaxy comprise an incomplete sample of the SNR population due to various selection effects. ROSAT performed the first All-Sky Survey (RASS) with an imaging X-ray telescope and thus provided another window for finding SNRs. Schaudel (2003) searched the RASS for unknown SNRs and pinpointed about 210 candidates. Meanwhile, 14 new SNRs of his list were identified (cf. Prinz & Becker 2013 for a summary). Revisiting the RASS SNR candidates and applying more stringent selection criteria as well as taking archival XMM-Newton, Chandra and Fermi data into account the current list of RASS SNR candidates still comprises 73 sources. These sources are promising SNR candidates and studying them with e.g. eRosita will help to reveal their true nature. eRosita is an X-ray telescope which is supposed to be launched in 2016. It will perform an X-ray all-sky survey with a sensitivity of more than 10 times of what was available with ROSAT. It supports to continue the previous SNR identification campaign and may reveal other candidates not seen with ROSAT. We report on the current status of our supernova identification campaign, characterize the most promising candidates and give prospects for eRosita.

New findings on the X-ray emission from Wolf-Rayet nebulae

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We present the most recent results from *XMM-Newton* and *Chandra* observations on the only 4 Wolf-Rayet (WR) nebulae observed to date. Given the limited number of observations and different morphological and spectral characteristics, there still no fully understanding of the reason why only two of them harbor diffuse X-ray emission. There is an apparent correlation between the central star properties and the existence of hot gas inside the nebulae but strong statements cannot be done.

XMM-Newton observations of the newly confirmed X-ray supernova remnants 1RXS J053353.6-720404 and [HP99] 1139 in the Large Magellanic Cloud

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Supernova remnants (SNRs) are of vital importance to the physical and chemical evolution of the interstellar medium (ISM). The expanding shell of the remnants imparts kinetic energy to the surrounding ISM as well as enriching it with the metals fused in the cores of their progenitor stars. Thus, an understanding of these objects is crucial to the understanding of star formation and matter recycling in galaxies. We have been studying SNRs in the Magellanic Clouds (MCs) in greater detail using combined optical, radio, and X-ray observations. The X-ray selected candidate SNRs 1RXS J053353.6-720404 and [HP99] 1139 were observed by XMM-Newton in May 2012. Both candidates are readily confirmed as bona fide X-ray SNRs due to their soft thermal emission and morphology. [HP99] 1139 is also notable due to the bright Fe-rich gas in its interior, a feature observed in several evolved LMC SNRs and is typical of a Type Ia SN progenitor. In this poster we present the detailed analysis of these remnants, including a comparison of the X-ray emission to multiwavelength data to better understand their spectral and morphological properties.

A Deep Chandra Observation of SN 1006

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The supernova of 1006 C.E. was the brightest stellar event in human history, yet ironically, its remnant is the faintest—in all wavelengths—of the historical supernova remnants. The properties that contribute to the remnant's faintness—its location in a relatively pristine low-density environment—make it extremely valuable for probing diffusive shock acceleration and the physics of nonradiative shocks. We will discuss results from the most detailed view of SN 1006 yet obtained, a mosaic of 10 overlapping fields, obtained with Chandra totaling 700 ks, as well as a deep optical image that reveals extremely faint H-alpha emission around the complete 30-arcmin shell in far greater detail than seen previously. Measurement of proper motions gives the shock velocity around the entire shell, which varies from 3000 to 7400 km/s (for a distance of 2.2 kpc). The very thin filaments along the synchrotron-dominated northeast and southwest limbs have widths that shrink rapidly with rising X-ray energy, indicating limitation by synchrotron losses on the electrons, rather than by magnetic damping, and confirming strong magnetic field amplification. The rapid shrinkage may require sub-Bohm diffusion. In addition to the X-ray images, we will discuss data from other bands that enhance our understanding of SN 1006.

Chapter 7

Galaxies, Galaxy Surveys, Population Studies, ISM and Diffuse Galactic Emission

A Search for Periodicities from a ULX in the LINER Galaxy NGC 4736

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We present our results from the timing analysis of the transient Ultraluminous X-ray Source (ULX) X-2 in nearby galaxy NGC 4736 based on the *Chandra* and *XMM-Newton* archival data. The power density spectrum (PDS) of the source have been obtained using Fast Fourier Transform and examined to search periodicities. The PDS of X-2 reveals a QPO peak at $0.73^{+0.16}_{-0.14}$ mHz with an fractional rms variability of 16 percent using the *Chandra* data (ObsID 808) and the PDS obtained by using *XMM-Newton*-pn data (ObsID 0404980101) shows a peak at $0.53^{+0.09}_{-0.35}$ mHz with a fractional rms variation of 5 percent. These QPOs overlap within error limits and may be the same oscillation. Also, we detect a long periodicity or a QPO in the *Chandra* data of about $(5.2 \pm 2.0) \times 10^{-5}$ Hz ($\sim$ 5.4 hrs) over 3 σ confidence level. If this is a QPO, it is the lowest QPO detected from a ULX. The mass of the compact object in ULX X-2 is estimated from Eddington luminosity and disk blackbody model in the range of (10−80) M_{sun}.

The second ROSAT All-Sky Survey source catalogue: the deepest X-ray All-Sky Survey before eROSITA

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We present the second ROSAT all-sky survey source catalogue (RASS2, (Boller, Freyberg, Truemper 2014, submitted)). The RASS2 is an extension of the ROSAT Bright Source Catalogue (BSC) and the ROSAT Faint Source Catalogue (FSC). The total number of sources in the second RASS catalogue is 124489. The extensions include (i) the supply of new user data products, i.e., X-ray images, X-ray spectra, and X-ray light curves, (ii) a visual screening of each individual detection, (iii) an improved detection algorithm compared to the SASS II processing. This results into an as most as reliable and as most as complete catalogue of point sources detected during the ROSAT Survey observations. We discuss for the first time the intra-day timing and spectral properties of the second RASS catalogue. We find new highly variable sources and we discuss their timing properties. Power law fits have been applied which allows to determine X-ray fluxes, X-ray absorbing columns, and X-ray photon indices. We give access to the second RASS catalogue and the associated data products via a web-interface to allow the community to perform further scientific exploration. The RASS2 catalogue provides the deepest X-ray All-Sky Survey before eROSITA data will become available.

The X-ray Evolution of Young Post-Merger Galaxies

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Studies of elliptical galaxies have revealed an intriguing population of young merger-remnant galaxies, which are found to be X-ray faint when compared to mature ellipticals. Here I will present Chandra observations of two young post-merger galaxies (1-2 Gyr since coalescence) and discuss how these merger-remnants have allowed us to probe an important gap in the evolution of elliptical galaxies. Specifically, from these observations we can place constraints on the growth of post-merger X-ray luminosity per unit mass, investigate the point source population and observe how the diffuse emission evolves through the regeneration of hot gas haloes. Further, I will also compare these observed X-ray haloes with hydrodynamical simulations of decoupled hot gas within elliptical galaxies.

X-rays as a tool to reveal the interstellar dust chemistry

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We present the latest results on absorption by diffuse interstellar dust (ID) as seen in the X-rays, using high-resolution data from both XMM-Newton RGS and the Chandra gratings. The X-rays have unique advantages which makes these studies fundamental to acquire a complete picture on the ID chemistry. For example sharp and deep absorption features of Mg, Si, O and Fe, which are the building blocks of silicates, fall in the X-ray band. Therefore X-ray spectroscopy is also a powerful tool to unveil the Fe inclusion in dust. High quality data have already revealed that Mg-rich silicates are favored with respect to the Fe-rich population and that Fe is most likely in metallic form (Costantini et al. 2012). We present results on both diffuse and dense ID in our Galaxy and in nearby galaxies. This large project, which considers various lines of sight, is taking also advantage of our new laboratory absorption-measurements of several dust samples. This allows us to confront the data of present and future X-ray observatories with a complete data base of dust species.

XMM-Newton study of the interacting galaxies NGC1512 and NGC1510

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We present an analysis of an XMM-Newton observation of the interacting galaxies NGC1512 and NGC1510 with the aim of gaining information on the population of X-ray sources and diffuse emission. Spectral analysis, hardness-ratios, X-ray variability, and cross-correlations with catalogues in other wavelengths, allowed us to identify and classify the observed sources as X-ray binaries in the NGC1512/1510 system, background objects and foreground stars. We detected 106 sources in the energy range of 0.2-12 keV, 15 within the D25 ellipses of NGC1512 and NGC1510. The properties of the most interesting sources are discussed.

A new X-ray Absorption Model for the Interstellar Medium

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Absorption from the interstellar medium (ISM) affects every X-ray observation. Its effects are usually removed or studied using models which assume that the gas is neutral. However, spectra show that ions are present in most or many lines of sight. We present a model for interstellar X-ray absorption, which we call ismabs, that includes both ions and neutral elements and which uses the most accurate atomic data available for abundant elements. We have benchmarked ismabs using high-resolution spectra from X-ray binary sources obtained with the High Energy Transmission Grating Spectrometer (HETGS) on the Chandra X-ray observatory. The oxygen and neon K edge absorption regions as well as the iron L edge absorption region have been studied in detail. Although the neutral component is dominant in these spectra, the inclusion of ions leads to better fits to observed data, compared with previous work which only included neutral elements. The use of ismabs allows the determination of column densities of abundant elements, and their mean ionization states. Ismabs is fast and has relatively few free parameters. It has been developed for use with common X-ray spectral fitting packages such as XSPEC or ISIS.

Abundance patterns in the Interstellar Medium of early-type galaxies observed with Suzaku

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We investigated the metal abundances/abundance ratios of the hot interstellar medium (ISM), in 17 early-type galaxies with Suzaku (Konami et al. 2014). The derived O and Mg abundances in the ISM within 4 times effective radius, which include most of stars, agree with the stellar metallicity within a one effective radius derived from optical spectroscopy. Because the O and Mg in the ISM have been provided by stellar massloos, the results are very reasonable and indicates relatively small systematic errors in the measurements with these optical and X-ray observations. The abundance ratios of O/Fe, Mg/Fe and Si/Fe in the ISM of almost galaxies are close to the solar ratio. Since the abundances/abundance ratios show no significant dependence on the morphology and environment, the major star formation history should be similar among these objects. Furthermore, the Fe in the ISM have been provided by stellar massloos and present SN Ia. The Fe abundance in the ISM is significantly smaller than the expected value derived from optical observations, indicates a low present SN Ia rate. From these results, we discuss the past and present SN Ia rates and star formation histories in early-type galaxies.

Discovering Rare AGN with Stripe 82X

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We have begun a wide-area survey overlapping the Sloan Digital Sky Survey (SDSS) region Stripe 82 which contains extensive multi-wavelength coverage from both ground- and space-based observatories. With the initial data release of Stripe 82X, covering 16.5 deg^2 from XMM-Newton and Chandra, we identified ∼3300 X-ray sources, including the highest spectroscopically confirmed X-ray selected quasar to date (z = 5.86). I will review the science highlights of this survey so far, including the space density of high luminosity AGN and results from our ground-based campaign to target optically dull, infrared bright targets, which are prime candidates for obscured AGN at high redshift. I will conclude with a discussion of what we expect to learn with the additional 20 deg^2 of coverage with XMM-Newton awarded to us in AO 13, which will more than double our current survey area.

Direct Constraints on the Evolution of LMXBs from Deep Chandra and HST Observations of Nearby Early-Type Galaxies

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Studies of X-ray binary populations in galaxies allow us to gain insight into the key factors contributing to the formation and evolution of compact objects, the stars involved in the accreting binary phase, and their associated remnants (e.g., millisecond pulsars and compact-object binaries). Early-type galaxies contain predominantly old stars (3-12 Gyr) and have X-ray emission dominated by low-mass X-ray binary (LMXB) populations. I will present results from deep Chandra and HST observations of three nearby early-type galaxies (NGC 3115, 3379, and 3384) that have luminosity-weighted stellar ages covering the range of 3-10 Gyr. These data allow for the clean identification of field LMXB populations (i.e., sources not coincident with globular clusters), and provide unique measurements for how the field LMXB X-ray luminosity function evolves with time. Leading X-ray binary population synthesis models predict that field LMXB populations will be more prevalent and luminous in the younger early-type galaxies. For the first time, we can unambiguously confront these models and provide important new insight into the formation and evolution of LMXBs.

A Hard X-ray View of Starburst Galaxies with NuSTAR

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We are observing six nearby starburst galaxies jointly with NuSTAR and the soft (0.3-10 keV) X-ray imaging telescopes Chandra and XMM-Newton. These observations are providing crucial new input on disentangling the key mechanisms that dominate the hard (¿10 keV) X-ray emission from star-forming galaxies, as well as the balance between accretion onto supermassive black holes and that onto stellar-mass black holes and neutron stars. I will highlight recently published results on the nuclear region of NGC 253 (Lehmer et al. 2013), which demonstrated that the hard X-ray emission is dominated by X-ray binaries (stellar mass black holes and neutron stars) and not an accreting supermassive black hole. I will present additional results from NGC 253 including the first measurements of the accretion states of the brightest X-ray binaries in a starburst galaxy based on their hard X-ray spectra and new constraints on the inverse Compton emission associated with starburst outflows. I will describe the NuSTAR, Chandra, and XMM-Newton observations of two additional galaxies (M83 and Arp 299) that have been recently completed, as well as plans for the remaining three galaxies (M82, NGC 3310, and NGC 3256).

A deficit of ultraluminous X-ray sources in luminous infrared galaxies

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Luminous infrared galaxies (LIRGs) are amongst the most energetic star-forming galaxies, producing total infrared luminosities $> 10^{11}$ $L_{\odot}$ that imply star formation rates (SFR) in excess of 10 $M_{\odot}$ yr^{-1}. Given the close relationship between the number of ultraluminous X-ray sources (ULXs) and SFR, we might therefore expect to find larger populations of ULXs in LIRGs than in field galaxies. Here, we present the results of a study of the ULX population in 17 nearby ($D < 60$ Mpc) LIRGs, using Chandra data. Only 53 ULXs have been detected, compared to an expectation of ∼500 ULXs from studies of field galaxies (Swartz et al. 2011). We investigate the origin of this large deficit in the number of ULXs by several means. For instance, X-ray luminosity functions confirm the deficit and also reveal a possible break at a luminosity of $\sim 2\times10^{39}$ erg s^{-1}. The physical interpretation for the deficit will be discussed. In addition, a study of the evolution of the ULX spectra with luminosity based on stacked X-ray spectra shows a possible transition from ∼Eddington to super-Eddington states, consistent with the ULXs being a population of ∼10 solar mass black holes.

New X-ray lights on the supernova remnant population of the Large Magellanic Cloud

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Supernova remnants (SNRs) mark the end point of stellar evolution. They return nucleosynthesis products to the interstellar medium (ISM), enriching and mixing it with freshly-produced heavy elements. Studying SNRs in general, and their X-ray emission in particular, is crucial to advance our understanding of many important astrophysical processes. With an XMM-Newton Very Large Programme (PI: F. Haberl), we conducted an X-ray survey of the Large Magellanic Cloud (LMC). As opposed to the Milky Way, the LMC offers an ideal target, at a well-constrained distance with small absorption column densities. Thus, X-ray properties of the evolved end of the SNR population of a galaxy can be studied.

I will present the characteristics of the newly X-ray-discovered SNRs, with emphasis on the discovery of several iron-rich SNRs, which are the most evolved remnants of type Ia (i.e. thermonuclear) supernovae. I will take advantage of the high level of completeness of our sample of SNRs to *i)* present the X-ray luminosity function (XLF) of LMC SNRs, extended towards lower-luminosity objects, comparing it to the XLF of SNRs in other galaxies; and *ii)* compare the spatial distribution of SNRs and star formation histories in the LMC.

Dwarf spheroidal galaxies in X-rays

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We report the results of archive XMM-Newton and Chandra observations of some dwarf spheroidal galaxies (Draco, Fornax, Leo I, Leo T, Ursa Major II and Ursa Minor) that stand in Milky Way neighbourhood. Their X-ray source population is fully characterized and cross-correlated with the available databases. Data analysis of the deep X-ray observations allows us to infer the possible nature for the sources. We also search for the intermediate-mass black holes (IMBHs) expected to be hosted in the centre of this kind of galaxies. At least in one case (Ursa Minor), we identify an X-ray object at the galaxy centre and classify it as an IMBH since it also correlates with a radio source.

The Warm-hot Gaseous Halo of the Milky Way

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It is well-known that most galaxies are missing most of their baryonic mass. Perhaps more surprisingly, they also seem to be missing most of their metals. I will present Chandra, XMM-Newton and Suzaku observations probing our Milky Way halo in absorption and emission. Our results show that the Milky Way halo contains a huge reservoir of warm-hot gas that may account for a large fraction of missing baryons and metals. I'll review current status of this field, discuss implications of our results to models of galaxy formation and evolution and outline paths for future progress.

A thin diffuse component of the Galactic Ridge X-ray emission contributed by the radiation of Galactic X-ray binaries

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The apparently diffuse X-ray emission characteristically concentrated in the plane of our Galaxy, the Galactic Ridge X-ray emission (GRXE), is currently believed to result from the superposition of a large number of faint Galactic X-ray sources. Evidence of this includes the resolution of over 80% of the emission in a small region of the sky, the similarity of the emission with the Galactic near-infrared surface brightness distribution, and the similarity of the GRXE spectrum with the combined spectra of the sources expected to contribute to the emission.

We argue that the GRXE should also have an additional truly diffuse component, arising from the scattering of the radiation of bright X-ray binaries (XBs) by the interstellar medium. This may be the dominant contribution to the GRXE in the inner 1 degree latitude of the Galactic plane. We estimate the contribution of this component using both known Galactic XBs and a simulated population of XBs, which takes into account the possibility of a higher average Galactic X-ray luminosity in the past 30000 years. I will discuss how comparing future observations of the GRXE with these predictions can allow us to study the past X-ray activity of Galactic XBs.

The ARCHES project

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ARCHES (Astronomical Resource Cross-matching for High Energy Studies) is a FP7-Space funded project started in 2013 and involving the Observatoire Astronomique de Strasbourg including the CDS (France), the Leibniz-Institut fuer Astrophysik Potsdam (Germany), the University of Leicester (UK), the Universidad de Cantabria (IFCA, Spain) and the Instituto Nacional de Técnica Aeroespacial (Madrid, Spain).

ARCHES aims at providing the international astronomical community with well-characterised multi-wavelength data in the form of spectral energy distributions (SEDs) for large sets of objects extracted from the 3XMM catalogue. The project develops new tools implementing fully probabilistic simultaneous cross-correlation of several catalogues. SEDs are based on an enhanced version of the 3XMM catalogue and on a careful selection of the most relevant multi-wavelength archival catalogues. In order to ensure the largest audience, SEDs will be distributed to the international community through CDS services and through the Virtual Observatory. These enhanced resources are currently tested in the framework of several science cases. An integrated cluster finder is developed at Potsdam, AGN science is studied at Leicester and IFCA while populations of Galactic X-ray sources are investigated at Strasbourg and Madrid.

Infrared identification of hard X-ray sources in the Galaxy

Ada Nebot[1], Christian Motch[1]
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The nature of the low-to-intermediate X-ray luminosity ($L_X < 10^{34}$ erg/s) source population revealed in hard band (2-10keV) X-ray surveys of the Galactic Plane by ASCA, Chandra and XMM-Newton is poorly understood, partly due to the difficulty of optically identifying highly extinct sources. To overcome such a problem we cross-correlated the XMM-Newton 3XMM-DR4 survey with 2MASS and GLIMPSE catalogues. The cross-matching tool used has the advantage of providing the user with association probabilities based on local source densities and position errors. Among the 779 X-ray sources with a statistically significant identification in 2MASS and GLIMPSE, about 25% are hard X-ray (>2keV) sources. We distinguished low mass stars from high-mass stars based on their X-ray and infrared colors and comparing with those of previously classified sources. In this conference we present the results from a pilot study in which we carried out spectroscopic follow-up observations at the WHT for five of the high-mass star candidates. We positively classified four of the five sources, three sources are either wind colliding binaries or supergiant fast X-ray transient and one is likely a symbiotic binary. The work presented here forms part of the Galactic Science Case of the ARCHES consortium (see C.Motch contribution).

Superbubbles in the Large Magellanic Cloud

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Massive stars inject energy into the ambient interstellar medium (ISM) through their radiation, stellar winds, and finally by supernova explosions. These processes are often correlated in space and time, generating interstellar bubbles and superbubbles filled with hot gas with sizes of typically 100 – 1000 pc. Due to the expansion of superbubbles, surrounding cold interstellar gas can break and hot gas can escape the galactic disk. Therefore, the hot gas inside superbubbles may eventually form galactic winds and fountains, which feed the galactic corona. Bubbles and superbubbles can be studied best in soft X-ray line and continuum emission, since the plasma in their interiors is very hot ($10^6 - 10^7$ K). We will present recent results of our studies of superbubbles in the Large Magellanic Cloud and discuss their evolution and energetics.

The diffuse X-ray emission of the Small Magellanic Cloud

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The Small Magellanic Cloud (SMC) is the second-nearest star-forming dwarf galaxy, and has low abundances ($\sim 0.2 Z_\odot$) like galaxies in the early universe. The complete coverage with the XMM-*Newton* survey of the SMC allows a detailed analysis of the diffuse X-ray emission with a reliable separation of point and extended sources. We present the mosaic image of the diffuse X-ray emission, compare it with Hα and HI emission and show that X-ray emission is mainly found in regions with high Hα and low HI emission.

Spectral and spatial decomposition yields emission by a plasma with a characteristic temperature of $kT = 0.2$ keV, an observed luminosity of $L_{\rm obs} = 7.1 \times 10^{36}$ erg s^{-1} and an estimate of the intrinsic luminosity of $L = 4 \times 10^{37}$ erg s^{-1} integrated over the whole galaxy. In the northern part of the bar, the intrinsic luminosity correlates well with star formation $\sim$40 Myr ago, whereas in the southern part no significant X-ray emission is detected, which we attribute to photoelectric absorption. We discuss the hot interstellar medium as the origin of the diffuse X-ray emission and the possibility of outflows into the Galactic halo.

Half-megasecond Chandra X-ray Spectral Imaging of the Nebula around Quasar Mrk 231

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In the past few years, Mrk 231 has become the best laboratory to study quasar feedback in action due to the galaxy's proximity. Recent observations have revealed that Mrk 231 is host to a powerful, spatially resolved wind with velocities in excess of -1000 km/s. This wide-angled outflow, in both neutral and molecular phases, extends over a few kpc and is thought to be a quasar wind. This may be evidence that quasar mechanical feedback is important and can transform gas-rich mergers such as Mrk 231 into red and dead galaxies. We present the results from our analysis of 500+ ks of Chandra ACIS-S new and archival data on the X-ray faint nebula surrounding the quasar.

Low-luminosity X-ray sources and the Galactic ridge X-ray emission

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We make a new determination of the hard-band (2–10 keV) X-ray luminosity function (XLF) of relative low-luminosity Galactic X-ray sources based on a source sample derived from the XMM Slew Survey (XSS). The source population is comprised of coronally-active late-type stars and binaries with hard-band X-ray luminosities in the range 10^{28-32} erg s^{-1} and cataclysmic variables (magnetic and non-magnetic) with X-ray luminosities spanning the range 10^{30-34} erg s^{-1}. We use this new estimate of the XLF, to predict the 2–10 keV X-ray source counts on the Galactic Plane at faint fluxes and show that the result is fully consistent with the available observational constraints. Similarly the predicted surface brightness, both in the full 2–10 keV band and in a restricted 6–10 keV bandpass, due to the integrated emission of faint unresolved Galactic sources, is well matched to the observed intensity of the Galactic ridge X-ray emission (GRXE). We find that the coronally-active sources make the dominant contribution to both the faint Galactic X-ray source counts and the GRXE.

Hot gas and the "magnetic arms" of NGC 6946

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The grand-design face-on spiral galaxy NGC 6946 is remarkable due to its high star formation activity, its massive northern spiral arm and the "magnetic arms", visible in radio continuum polarization and located between the optical arms. Strong Faraday depolarization of the polarized radio emission from the disk indicates also an extended halo of ionized gas around NGC 6946.

We used X-ray observations of NGC 6946 performed with the EPIC-pn camera of the XMM-Newton telescope 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.

We study relations between thermal energy densities in different regions of NGC 6946 and compare them with energies of the magnetic fields. This allows to start mapping the distribution of the energy budget of NGC 6946.

XCHANGES: XMM-Newton data on CHANG-ES spiral galaxies

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The CHANG-ES survey of galaxies provides a unique sample of edge-on spiral galaxies with deep radio observations, that allow detailed analysis of their magnetic fields. Since the co-existence of halo magnetic fields and hot gas is likely to greatly influence the dynamics of the galactic halo, we analyse diffuse X-ray emission for the sample galaxies. Here, we present preliminary results of the imaging of the soft X-ray emission (0.2-1 keV) from selected galaxies of the sample using archive data of the XMM-Newton X-ray telescope.

Populations of accreting, nuclear-burning white dwarfs and the origin of type Ia supernovae

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Type Ia supernovae (SNe Ia) arise from the thermonuclear explosion of a white dwarf, however the evolutionary channel by which this comes about remains unknown. In the single degenerate (SD) scenario, a white dwarf (WD) grows through nuclear burning of hydrogen accreted from a companion prior to explosion. This suggests that SD progenitors should be extremely luminous sources in the EUV and soft X-ray bands, possibly observable as supersoft X-ray sources (SSSs). Recently, we demonstrated that if the SD model is correct, then accreting, nuclear-burning white dwarfs should provide the dominant source of ionizing radiation in passively-evolving galaxies, 40% of which are known to host extended emission-line nebulae. Therefore, one can search for the presence of any high-temperature SD progenitor population in these galaxies by looking for emission lines characteristic of ionization by very high-temperature (10^5 K - 10^6 K) sources. In this contribution, I will present our first such constraints on the contribution of the SD channel to the SN Ia rate in nearby early-type galaxies (<10%). I will then discuss how combined optical spectroscopy and soft X-ray observations of nearby galaxies reveal fundamental problems in our present understanding of the evolution of SSSs and other accreting WD binaries.

Investigating dense interstellar environments in the X-rays

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We present the modelling of the silicon and magnesium absorption edges due to dust absorption along the line of sight of bright X-ray sources. The shape and observed energy of these edges may indeed reveal the composition and abundance of the intervening dust grains in different environments of our Galaxy. Here we present, as a test case, the interpretation of a high-quality spectrum of a bright X-ray binary, GX5-1, located in the vicinity of the Galactic Center. This spectroscopic study, performed using data from the Chandra-HETG, benefits from new laboratory data in the X-ray band of several silicate compounds, taken at the Soleil synchrotron facility in Paris.

The deep census of the X-ray source populations in the Small Magellanic Cloud

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We present the first results from the Chandra Deep Survey of the Small Magellanic Cloud (SMC). The goal of this project is to characterize the X-ray sources detected in the 1.1 Ms Chandra survey of the SMC, which provides a census of their populations down to a luminosity of 10^32 erg/s in 11 fields sampling young (10-100 Myr) stellar populations of different ages. We detect between 50-90 X-ray sources in each field, for which we measure their photometric and spectroscopic parameters. Analysis of their light-curves is used to identify accreting pulsars and flaring objects. The initial X-ray source lists have been cross-correlated with optical and IR photometric and spectroscopic catalogs (such as the OGLE and SAGE). We have determined the most likely optical counterpart for those sources, and based on the combination of their X-ray and multiwavelength properties, we identify candidate Be-XRBs and interlopers (foreground stars and AGN). The X-ray luminosity function of the Be-XRBs shows clear evidence for a break at low luminosities that is consistent with the onset of the propeller effect. Finally we present the first results from an analysis of the clustering of the X-ray binaries in the SMC with stellar populations of different ages.

Constraining X-ray binary formation and evolution parameters

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We present results from a systematic study of the X-ray binary (XRB) populations in a sample of 12 nearby late-type galaxies from the Spitzer Infrared Nearby Galaxy Survey (SINGS). Comparisons of their X-ray luminosity functions (XLF) with predictions from populations synthesis models are used to constrain binary formation and evolution parameters such as the common envelope ejection efficiency and the initial mass ratio distribution. Based on these results we also calculate the contribution of different sub-populations such as neutron-star and black-hole binaries, and Low-Mass and High-Mass XRBs. Finally, based on fits of the XLFs from a larger sub-set of the SINGS galaxy sample, we calculate scaling relations between the number of XRBs, and the SFR and stellar mass, and we compare them with predictions from populations synthesis models.

A search for hyperluminous X-ray sources in the *XMM-Newton* source catalog

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We present a method to search for off-nuclear X-ray sources in the *XMM-Newton* source catalog by cross-matching it with large spectroscopic galaxy catalogs (e.g. SDSS) using special non-central match condition. Known distances to expected host galaxies then allow to select X-ray sources from their outskirts within specific luminosity range, $10^{41} < L_{\rm X} < 10^{44}$ erg s^{-1}. We attempt to discard various possible contaminating foreground and background object classes such as AGN, BL Lacs, Galactic stars and compact objects by analyzing broadband radio-to-X-ray spectral energy distribution properties of selected sources available from other public wide area surveys. As an early result of our method we present several candidates to hyperluminous X-ray sources with high X-ray-to-optical flux ratios that can hardly be explained by invoking any conventional object type.

Chapter 8

Active Galactic Nuclei

ESO 362-G18: black hole spin and the size of the X-ray emitting region

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The variability of Seyfert galaxies in the X-ray and optical energy domain represents a powerful tool to probe the regions around supermassive black holes at all spatial scales. We present results from an X-ray monitoring campaign of the Active Galactic Nucleus (AGN) ESO 362-G18 performed between November 2005 and June 2010. When X-ray unabsorbed, ESO 362-G18 exhibits the typical X-ray spectrum of Seyfert 1 galaxy with a highly significant soft excess below 1 KeV, which is very well described with a relativistically distorted X-ray disc-reflection component. From our best-fitting, we infer that the accreting black hole powering the AGN is a very rapidly spinning Kerr black hole with a spin greater 0.9 with high statistical significance. One of the monitoring observations reveals, however, a heavily X-ray absorbed state, which follows an unabsorbed observation performed only 2 months earlier. Clear UV variability between the absorbed observation and the others suggests to identify the variable absorber with a dusty cloud of the clumpy torus transiting the line-of-sight. Moreover, two optical spectroscopic observations separated by about 2 years show a type 2 to type 1 transition, confirming the clumpy nature of the dusty absorber.

Clustering of moderate luminosity X-ray selected Type 1 and Type 2 AGNs in COSMOS

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Measurement of the spatial distribution of AGN in the Universe provides a unique way to study the typical environment in which AGN preferentially reside and to address which physical processes are triggering AGN activity. In this talk we'll present the clustering properties of 348 moderate luminosity X-ray selected Type 1 and Type 2 AGNs with known spectroscopic or photometric redshifts in the range $2.2<z<6.8$, from Chandra and XMM-Newton data in the COSMOS field. We found indication that unobscured AGN reside in more massive halos compared to obscured AGN. This result extends to $z\sim3$ the $z<2$ findings in COSMOS and rules out the picture in which obscuration is purely an orientation effect. Following the BH accretion history, we argue that the decreasing redshift evolution of the bias between z=2 to 3 for Type 1 COSMOS AGN provide indications that, at $z\sim3$, we are picking up AGN with fast growing BHs with masses of $\sim 10^8$ $M_\odot$ that reside in DMHs with typical mass of $\sim 10^{12.8}$ h^{-1} M$\odot$. The difference in the bias between bright quasars and Type 1 COSMOS AGN at $z\sim3$ marginally suggests a luminosity-dependent bias such as predicted by major merger models.

Towards A Complete Cencus of Compton-thick AGN and N_H Distribution in the Local Universe

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Many studies have shown that Compton-thick AGNs (CTAGNs) provide important contribution to the cosmic X-ray background spectrum (∼25% at 20keV). They are expected to dominate the Seyfert 2 population in the local universe, yet only ∼20 bona fide CTAGNs are known. We present an updated census of CTAGN population in the local universe using a volume-limited AGN sample complete to D=15Mpc. Intrinsic relations between 2-10keV X-ray luminosity and mid-IR emission at 12μm, [OIV]λ25.68μm and [NeV]λ14.32μm are investigated, and it is found that the emission at 12μm has the tightest correlation with the X-ray luminosity.Candidates for CTAGN are then selected using this relation and by comparing their 12μm luminosity with the observed X-ray luminosity.We also investigate the Compton-thick nature of these sources using the optical [OIII]λ5007Å:X-ray diagnostic for comparison, and find that $35-50\%$ of the sample are Compton-thick,of which $10-20\%$ would be missed with the optical approach.Finally, we estimate the intrinsic N_H distribution of AGN population in the local universe from this analysis, and show that up to 70% of the sources are heavily obscured ($N_H > 10^{23}\ cm^{-2}$), with ≥50% lying in the Compton-thick regime ($N_H > 10^{24}\ cm^{-2}$).This work provides a well-defined local benchmark for AGN obscuration studies.

On the cosmological bias of the excess variance as a variability estimator

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We discuss the use of the normalized excess variance in the variability analyses of samples of X-ray sources. This variability measure depends on the rest-frame duration of the observed light-curves, and is therefore affected by a bias which is especially important for high redshift sources. Many authors apply this variability indicator to samples of low redshift active galactic nuclei (AGN), while in some cases the same approach is used in wide redshift intervals. We show that a better approach is the use of the structure function, which estimates the variability as a function of the time delay between the observations, and we propose a formula to correct the excess variance, taking into account such dependence. We use an AGN sample extracted by the XMM-Newton Serendipitous Source Catalogue for comparing these two approaches.

Modeling Active Galactic Nuclei in Cosmological Simulations

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It is generally accepted that black holes play an essential role in the formation and evolution of galaxies. Resolving galaxies and AGN feedback in cosmological simulations allows us to investigate the current understanding of galaxy formation, black hole growth, gas accretion and the origin of AGN. Due to the limited resolution of the simulations, a simplified sub-scale model for AGN feedback is commonly used. Such a model usually depends on various parameters, for which true values are highly uncertain.
I present a new advanced model and a more detailed description of AGN feedback, where such nuisance parameters reflect recent observations. The model takes into account the dependency of these parameters on the properties of the black hole and describes a continuous transition between the feedback processes acting in the so called radio-mode and quasar-mode. I will show that with these new implementations, our simulations are now very successful in reproducing observed properties of AGN and their host galaxies, such as the relation between the black hole mass and the stellar mass of the bulge, the stellar mass function and the black hole luminosity function.

Probing the X-ray absorber structure in the AGN population through fast spectral variability

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One of the hot topics in modern astrophysics is the variability of absorbers in Seyfert 2 galaxies, suggesting that these structures could be more complex and located at much smaller distances than the conventional obscuring torus. However, in this framework a statistically representative sample of well-studied sources is still missing. We recently started a project aimed at finding more examples of these objects in order to study the physical properties of the X-ray absorber on a larger statistical basis, and to evaluate the frequency of rapid absorption variability among the active galactic nuclei (AGN) population.

Here I will present our project: the source selection, based on the exploitation of the BAT AGN catalogue plus the XRT data archive; few preliminary results on particularly significant individual objects; and the future developments, in particular the expectations for Mrk 915, for which new XMM-Newton + NuSTAR observations have been awarded in the last XMM-Newton call.

A Variable-Density Absorption Event in NGC 3227 mapped with Suzaku and Swift

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We present new time-resolved spectroscopy of an eclipse event in NGC 3227 from a Swift and Suzaku campaign over several weeks in 2008. Observations of variable X-ray absorption over the past decade support the paradigm of clumpy circumnuclear gas. Eclipse events across multiple Seyferts and timescales allow us to explore the properties of the clumps over a wide range of radial distances from BLR scales to beyond the dust sublimation radius. Time-resolved density profiles so far are rare, but suggest a range of shapes, including centrally-peaked, comet-shaped, or doubly-peaked ones. In the case of the 2008 event, we resolve the density profile to be highly irregular and variable in contrast to a previous symmetric and centrally-peaked event mapped with RXTE. The data indicate a filamentary, moderately ionized cloud that covers 90% of the line of sight to the central engine. Our results for the first time show a variety of profile shapes within the same source and thus provide an excellent opportunity to further test models describing the formation and dynamics of individual clouds or filaments as well as their distances from the SMBH.

A new cosmological distance measure using AGN X-ray variability

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We report the discovery of a luminosity distance estimator using Active Galactic Nuclei (AGN). We combine the correlation between the X-ray variability amplitude and the Black Hole (BH) mass with the single epoch spectra BH mass estimates which depend on the AGN luminosity and the line width emitted by the broad line region. We demonstrate that significant correlations do exist which allows one to predict the AGN (optical or X-ray) luminosity as a function of the AGN X-ray variability and either the HBeta or the PaBeta line widths. In the best case, when the PaBeta is used, the relationship has an intrinsic dispersion of 0.6 dex. Although intrinsically more disperse than Supernovae Ia, this relation constitutes an alternative distance indicator potentially able to probe, in an independent way, the expansion history of the Universe. With this respect, we show that the new mission concept Athena should be able to measure the X-ray variability of hundreds of AGN and then const! rain the distance modulus with uncertainties of 0.1 mag up to z 0.6. We also discuss how, using a new dedicated wide field X-ray telescope able to measure the variability of thousands of AGN, our estimator has the prospect to become a cosmological probe even more sensitive than current Supernovae Ia samples.

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

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An excess of X-ray emission below 2 keV, called soft-excess, is detected in many Seyfert 1-1.5s spectra. The origin of this feature remains debated, as several models have been suggested to explain it, including warm Comptonization and blurred ionized reflection. In order to constrain the origin of this component, we use the fact that these models predict different behaviors in the hard X-rays. Ionized reflection indeed covers a broad energy range, from the soft X-rays to the hard X-rays around a few tens of keV, while Comptonization drops very quickly in the soft X-rays. We present here the results of a study of the hard X-ray characteristics of objects with and without soft-excess, using a sample of 72 sources observed with XMM-Newton, INTEGRAL and Swift/BAT, and show which constraints can be set with current hard X-ray observations.

Evolution and Geometry of obscured AGN: Bayesian model selection for X-ray spectra

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I will present a novel method for selecting among different plausible spectral models based on X-ray spectra of AGN. I will demonstrate the advantages of the method when applied to deep surveys. Despite the low counts, our method can draw strong conclusions on e.g. the geometry of the obscuring region ("torus"). Going further, using the estimated luminosity and column density from the analysis of COSMOS, AEGIS and CDFS fields, we derive the X-ray luminosity function of high-redshift (z=0.5-4) AGN. The self-consistent approach allows the determination of the evolution of obscured AGN, including the most heavily obscured, Compton-thick objects. I will discuss these results in the context of the co-evolution of AGN and galaxies and the growth of supermassive black holes across cosmic time.

Origin of the high energy emission from the Galactic Center

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In the talk I will present the new results from more than 5 years of Fermi/LAT observations of the Galactic center region. I will discuss constraints on the diffuse spatial morphology of the central high-energy source and whether the observed spectrum above 60 MeV favors hadronic or leptonic models.

Absorption at the Dust Sublimation Radius and the Dichotomy Between X-ray and Optical Classification in the Seyfert Galaxy H0557-385

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In this work, the analysis of multi-epoch (1995-2010) X-ray observations of the Seyfert 1 galaxy H0557-385 is presented. The wealth of data presented in this analysis show that the source exhibits dramatic spectral variability from a typical unabsorbed Seyfert 1 type spectrum to a Compton-thin absorbed state on time scales of ~ 5 years. This extreme change in spectral shape can be attributed to variations in the column density and covering fraction of a neutral absorbing medium attenuating emission from the central continuum source. Evidence for both Compton reflection and warm absorption have also been detected in the spectra. Optical spectroscopy observations concurrent with a 2010 *XMM-Newton* observation campaign have detected the presence of broad optical emission lines during an X-ray absorption event. From the analysis of both X-ray and optical spectroscopic data, it has been inferred that the X-ray spectral variability is a result of obscuration of the central emission region by a clumpy absorber, located outside the broad line region, which covers ≥ 80 per cent of the source with an average column density of $N_H \sim 7 \times 10^{23}$ cm^{-2}.

Long Term X-ray Spectral Variability of PDS 456 with Suzaku, XMM-Newton and NuSTAR

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We present the recent Suzaku and simultaneous XMM/NuSTAR observations of PDS 456 (z=0.184) taken in 2013 each with a 500ks exposure. PDS 456 is an object which shows strong X-ray spectral variability, varying from bright/soft (with $\Gamma > 2$) to low/hard (with $\Gamma < 1$). The 2013 Suzaku observations catches PDS 456 in a low flux (2.1×10^{-12}ergs cm^{-2} s^{-1}) with a hard X-ray spectrum. In contrast, the XMM/NuSTAR observations in August/Sept 2013 were at a much was a higher flux (7.0×10^{-12}ergs cm^{-2} s^{-1}), with an overall soft X-ray spectrum. When compared to prevous observations, PDS 456 seems to vary in two distinctive ways.

In the low flux Suzaku observations, most of the spectral changes are due to a variable X-ray absorber, with a high covering fraction for the absorber. In contrast the XMM/NuSTAR observations, which were brighter and less absorbed, appear to require intrinsic continuum changes to the hard X-ray powerlaw account for the spectral variations. We also discuss whether changes in an innermost accretion disk reflector could account for the spectral variability instead of a partial covering absorber.

The X-ray view of the γ-ray emitting narrow-line Seyfert 1 galaxies

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[5] *U.S. Naval Research Laboratory*
[6] *INAF-OA To*

The discovery by *Fermi*-LAT of variable γ-ray emission from radio-loud narrow-line Seyfert 1 galaxies revealed the presence of a possible third class of AGNs with relativistic jets in addition to blazars and radio galaxies. This finding opened new challenging questions about the production of relativistic jets, the disk/jet connection, the Unification model for AGNs and the evolution of radio-loud AGNs.

High quality spectra obtained by XMM-*Newton* are important to determine if the X-ray spectrum of these sources is completely dominated by the jet emission or there is some contribution from the accretion flow, such as the soft X-ray excess and the Fe K line. In this talk I discuss the XMM-*Newton* data of three γ-ray emitting NLSy1s: PMN J0948+0022, PKS 1502+036 and PKS 2004-447. Moreover the combination of XMM and *Swift* observations allows us to study the source variability in optical, UV and X-rays on different time scales, which can be compared with the γ-ray variability observed by LAT. Owing to quasi-simultaneous XMM-*Newton* and *Fermi*-LAT observations, we are also able to construct detailed SEDs in order to study the relation between the accretion flow and the jet, and the emission mechanisms in these NLSy1s.

Simultaneous UV/X-ray observation of the Seyfert 1 galaxy 1H 0419-577

Laura Di Gesu[1], Elisa Costantini[1]
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We present the results of a 170 ks-long XMM-Newton observation of the bright Seyfert 1 galaxy 1H 0419-577, that was taken simultaneously to a HST-COS spectrum. The study of the UV and X-ray features (Di Gesu et al 2013, A&A, 556A, 94D), both in absorption and in emission, allowed us to depict a likely scenario for the geometry of this AGN. The source hosts a galactic scale AGN wind, located at a distance of at least 3 kpc from the nucleus. For the first time we were able to detect the X-ray counterpart of such a large scale AGN outflow. The NLR emitting region is located much closer to the black hole and it consists of complex medium, stratified both in ionization and in density. The broadband optical-to-X-ray spectrum is best fitted by a Comptonization model (Di Gesu et al 2014, A&A, in press, arxiv/1401.5614). This model offers also a simple explanation for the variability of this source, provided a partially-covering neutral absorber with a variable opacity. We suggest that the obscuring medium may be associated with the innermost dust-free region of the obscuring torus.

Anatomy of the AGN in NGC 5548: the short-term variability.

Laura Di Gesu[1], Jelle Kaastra[1], and the NGC 5548 collaboration
[1] *SRON, Netherland Institute for Space Research*

After a very successful multi-satellite campaign on Mrk 509 in 2009, we conducted a similar campaign on the AGN NGC 5548 in 2013. During the latter the source appeared unusually strongly absorbed in the soft X-rays, and signatures of strong outflows were also present in the UV. While a talk giving an overview of the campaign (PI: J. Kaastra) is also proposed at this conference, here we focus on the short term (∼months) variability of the source during the campaign. The short time-scale behaviour of the source is likely due to variations in the obscuring wind, that may consist of two gas phases. This study allows us to investigate the geometry of the system around the black hole.

Relativistic reflection from accretion disc ionised due to illumination from on-axis compact corona

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We re-visit the relativistic (light bending) reflection scenario of AGN spectra in the lamp-post geometry. We compute the ionisation of the disc consistently with the amount of illumination from the on-axis compact corona. In this model the ionisation pattern of the disc is dependent on the distance from the centre according to astrophysically-motivated assumptions. We investigate the complementarity of different model parameters like: a) the intrinsic primary flux and the height of the corona, both affecting the normalization of the observed primary power-law; b) the height of the corona and the black hole spin, both affecting the amount of radiation emitted from the innermost regions of the disc; and c) the intrinsic primary flux, the height of the corona and the density of the disc, the three parameters that affect the ionisation state of the disc. We examine how these complementarities manifest themselves when fitting X-ray broadband spectra of the Seyfert 1 Galaxy MCG-6-30-15.

X-ray polarization in the lamp-post model of non-smooth black-hole accretion discs

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Theoretical computations show that significant polarization of X-ray radiation should be present in the emission from an accretion disc of AGN. This is due to the reflection of the primary power-law coronal emission by the disc. The polarization in this scenario is produced mainly by Compton scattering of the primary photons in the disc which depends heavily on geometry of scattering. In this contribution we re-visit the polarization in the lamp-post geometry and we investigate how much the polarisation properties change if the geometry of scattering is not from a perfectly smooth disc, on the contrary, we assume that the disc surface has random irregularities so that the final results are averaged over a range of scattering geometries.

Origin of the Seemingly Broad Iron-Line Spectral Feature in Seyfert Galaxies

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A seemingly broad iron K- and/or L-line spectral feature is observed from MCG-6-30-15, 1H0707495 and other Seyfert galaxies. Some interpret these spectral features as due to extremely relativistic distortion of iron emission lines from the innermost region of the accretion disk. We show that these characteristic spectral features are more simply explained by "double-partial covering" of two absorption layers with the same covering fraction such that the thick and low-ionized layer is responsible for the iron K-edge and the thin and high-ionized layer is responsible for the iron L-edge. Most observed spectral variation below a time-scale of a day is caused by change of the partial covering fraction, while the X-ray source luminosity and the spectral shape are not significantly variable. We show that this "Variable Partial Covering model" (Miyakawa, Ebisawa and Inoue 2012) is successful to explain spectral variation and the seemingly broad iron-line structures in 20 Seyfert 1 galaxies including MCG-6-30-15 and 1H0707-495. Variation of the partial covering fraction causes such an anti-correlation between the direct component and the transmitted component that cancels each other at the iron K-edge. This explains the significantly small fractional variations in the iron K-energy band, a well-known observational fact in Seyfert galaxies.

Anatomy of the AGN in NGC 5548: long-term variability of the warm absorber

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After a very successful multi-satellite campaign on Mrk 509 in 2009, we conducted a similar campaign on the AGN NGC 5548 in 2013. During the latter the source appeared unusually strongly absorbed in the soft X-rays, and signatures of strong outflows were also present in the UV. While a talk giving an overview of the campaign (PI: J. Kaastra) is also proposed at this conference, we will focus here on the analysis of the archival high-resolution X-ray spectra of NGC 5548.

Previous grating observations of this source with XMM-Newton RGS, Chandra LETGS and Chandra HETGS were reanalyzed using up-to-date atomic physics and photoionization codes, revealing that the warm absorber (WA) consists of 6 distinct ionization components. The observations, taken between 1999 and 2007 when the source was consistently unobscured, allow us to probe variations in the WA components at time scales ranging from 2 days to 3000 days. We used such variations to derive limits on the gas density and thus on the distance of these components to the central source. The picture derived here is key to interpret the 2013 observations, when the source experienced heavy absorption in the soft X-rays domain.

Distant and disk reflection in the average X-ray spectrum of AGN in the Véron-Cetty-Véron catalogue

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We present our study of X-ray spectra of Active Galactic Nuclei (AGN). Compton reflection and iron fluorescence are two of the most important processes of interaction of the primary X-ray radiation with circum-nuclear material because their study allows to explore material far away from the central engine (e.g. the torus) and close to it (e.g. the accretion disk). We study the average X-ray spectrum of 263 unabsorbed AGN with average z=0.8. This XMM-Newton sample was selected from the cross-correlation between the 2XMM X-ray source catalogue and the Vèron-Cetty-Vèron sample. The most significant fits to the average spectrum were made considering the interaction of the primary radiation (a basically unabsorbed powerlaw) with matter located far away from the central engine and with material in the accretion disk. The disk reflection component, smeared by relativistic effects, is significantly required in the spectral fitting (at 6 sigma) and accounts for about 70% of the total reflected flux. In conclusion, we detect distant reflection in the average spectrum of unabsorbed AGN. Adding the disk-reflection improves our data description significantly, suggesting that both components are present.

Active galactic nuclei synapses: X-ray versus optical classifications using artificial neural networks

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Optical and X-ray data of AGN classes show many discrepancies not fully understood yet. We have studied the 'synapses' between them using artificial neural networks (González-Martín+14). To do so, we used flux-calibrated X-ray spectra of a sample of 90 emission line nuclei (ELN) observed with XMM-Newton. It includes starbursts (SB), transition objects (T2), LINERs (L1.8 and L2), and Seyferts (S1, S1.8, and S2).

The ELN can be classified into six classes, based on the shape of their X-ray spectra. These classes are associated with most of the optical classes. Moreover, the ELN X-ray spectra are simply the product of two components, an AGN-like component and a second component which is due to the host-galaxy emission in X-rays. Furthermore, an AGN-like nucleus may be present in all of them. Its strength, relative to the host-galaxy component, determines the average X-ray spectrum for these X-rays classes. A third physical parameter could be the amount of obscuration. This parameter almost certainly drives the Type-1/Type-2 dichotomy, but may also explain why L1.8 show a S1-like component while L2/T2 show a S1.8-like component.

Discovery of Relativistic Outflows in the Seyfert Galaxies Ark 564 and Mrk 590

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Outflows are ubiquitous in AGNs, manifested by blueshifted absorption lines in the soft X-ray and UV bands and have outflow velocities of $100-1000$ km s^{-1}. The discovery of ultra-fast outflows ($0.1\ c$) exhibited by blueshifted absorption lines in the hard X-ray band has added an intriguing aspect to the rich field of AGN outflows. The significance of these absorption line detections is often questioned and with only a few lines observed, accurate parametrization of the photoionized plasma becomes difficult.

We recently discovered relativistic outflows in the soft X-ray band in two Seyfert galaxies; these detections are robust and alleviate earlier concerns about statistical significance of the lines in the hard X-ray band. I will discuss the our recent results on the discovery of high velocity outflows in the narrow line Seyfert 1 galaxies Ark 564 and Mrk 590. These absorbers are identified through multiple absorption lines at blueshift of $0.1c-0.17c$ detected in the Chandra HETG-MEG spectra. These high-velocity outflows have ionization parameter and column density typical of low-velocity outflows, but much higher velocity, probing a distinct region in the velocity versus ionization/column parameter space. The presence of such relativistic outflows in Seyfert galaxies poses a challenge to theoretical models of AGN winds. I will briefly discuss existing models and future prospects.

Constraining physical parameters of ultra-fast outflows in PDS 456 with Monte Carlo simulations

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Deep absorption lines with extremely high velocity of $\sim$0.3c observed in PDS 456 spectra strongly indicate the existence of ultra-fast outflows (UFOs). However, the launching and acceleration mechanisms of UFOs are still uncertain. One possible way to solve this is to constrain physical parameters as a function of distance from the source. In order to study the spatial dependence of parameters, it is essential to adopt 3-dimensional Monte Carlo simulations that treat radiation transfer in arbitrary geometry.

We have developed a new simulation code of X-ray radiation reprocessed in AGN outflow. Our code implements radiative transfer in 3-dimensional biconical disk wind geometry, based on Monte Carlo simulation framework called MONACO (Watanabe et al. 2006, Odaka et al. 2011).

Our simulations reproduce FeXXV and FeXXVI absorption features seen in the spectra. Also, broad Fe emission lines, which reflects the geometry and viewing angle, is successfully reproduced. By comparing the simulated spectra with Suzaku data, we obtained constraints on physical parameters. We discuss launching and acceleration mechanisms of UFOs in PDS 456 based on our analysis.

X-ray spectral variability of LINERs selected from the Palomar sample

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Variability in active galactic nuclei (AGN) has been discovered at X-ray, UV, and radio frequencies on timescales from hours to years, being one of their most important features. Among the AGN family and according to theoretical studies, low-ionization nuclear emission line region (LINER) nuclei would be variable objects at long timescales because of their large black hole masses and low accretion rates. Our aim is to investigate the spectral X-ray variability in LINERs, leading to an understanding of the nature of this kind of objects, including their accretion mechanism. We selected 18 LINERs from the Palomar sample, and used *Chandra* and *XMM*-Newton public archives to analyze their X-ray spectral properties at different epochs with timescales of years. Spectral modeling allowed us to investigate the parameter(s) responsible for the variations. The main result from the analysis is that long term spectral variability is very common, mostly related to the nuclear power at hard (2-10 keV) energies.

CANDELS/GOODS-S, CDFS, ECDFS: Photometric Redshifts For X-Ray Detected AGNs

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We present photometric redshifts for X-ray sources, as well as new multi-wavelength identifications in the 4Ms-CDFS/ECDFS. To find counterparts of the X-ray sources efficiently, we use a new method based on Bayesian statistics with priors on magnitudes and position errors, making associations with optical and near/mid-infrared data simultaneously. Specifically taking advantage of high-resolution HST/WFC3 data in the Cosmic Assembly Near-IR Deep Legacy Survey (CANDELS) and homogeneous data from the Taiwan ECDFS Near-IR Survey (TENIS), 97% of X-ray sources have multi-wavelength counterparts. To compute photo-z, in addition to the CANDELS data, the de-blended intermediate-band photometry (by TFIT method) is used for the first time in this field. Furthermore, we adopt a new set of AGN-galaxy hybrid templates which are more representative of population. These hybrids are composed of semi-empirical galaxy templates that include emission lines, in addition to type1/2 AGNs. In the entire field, we achieve a photo-z accuracy of 0.014 with 5.3% outliers. The WFC3/NIR data allow us to reach more accurate redshifts up to 7. The results are particularly accurate when incorporating the intermediate bands and emission lines that pinpoint strong line features from AGNs. The photo-z accuracy is three times better when including them in the fitting.

Anatomy of the AGN in NGC 5548: Discovery of a fast and massive outflow

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After a very succesfull multi-satellite campaign on Mrk 509 in 2009, we conducted a similar campaign on the AGN NGC 5548 in 2013. This archetype Seyfert 1 galaxy NGC 5548 has been studied for decades, and high-resolution X-ray and UV observations have previously shown an outflow with standard physical characteristics. However, our recent observing campaign with six space observatories (XMM-Newton, HST, Swift, NuSTAR, Chandra and INTEGRAL) shows the nucleus to be obscured by a stream of new ionized gas never seen before in this source. The gas with hydrogen column densities of 1E26-1E27 per m2 blocks 90% of the soft X-ray emission and causes deep and broad UV absorption troughs. The outflow velocities are up to five times faster than the persistent normal outflow. It is located at a distance of only a few light days from the nucleus close to the broad line region; this might indicate an origin from the accretion disk.

VERITAS observations and spectral energy distribution of H 1426+428 BL Lac

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The VERITAS array of 12-m atmospheric-Cherenkov telescopes in southern Arizona is one of the world's most sensitive detectors of astrophysical very high energy (VHE) γ-rays above 100 GeV. We present results from VERITAS observations of the BL Lac object H 1426+428. The VERITAS array has been monitoring this source since 2007 and has accumulated over 35 hours of data. The source was first detected in the VHE range by the Whipple 10-m γ-ray telescope in 2002 during a flaring state. It is classified as an extreme high-frequency peaked BL Lac (HBL), with the peak of the synchrotron emission lying above 100 keV, even during low states. The spectral energy distribution of H 1426+428, including contemporaneous VERITAS, Fermi-LAT, Swift XRT/UVOT and optical data, will be presented.

Tidal Disruption Events (TDEs) as Probes of Single and Binary SMBHs

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Stars tidally disrupted and accreted by supermassive black holes (SMBHs) produce luminous X-ray flares, first seen in the ROSAT all-sky survey. Tidal disruption events (TDEs) will be detected in the thousands in upcoming transient surveys, opening up a new window of probing the intermediate-mass BH populations, and providing new probes of accretion physics under extreme conditions, and of the mechanisms of launching jets. I will discuss new results on TDEs, and present the first candidate binary SMBH detected using characteristic features in a TDE outburst lightcurve

Ernie and Bert in the Radio: The TANAMI view of the IceCube PeV Neutrino events

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The IceCube Collaboration has published their first results on an excess neutrino flux above the atmospheric background. Due to low atmospheric background at PeV energies, the highest energy events ("Ernie" and "Bert") are the most likely ones to be of extraterrestrial origin. We study the multiwavelength properties of AGN from the TANAMI sample that are positionally coincident with the two neutrino events. We combine multiwavelength data, including X-ray data from the *XMM-Newton* and the *Swift* satellite to construct broadband spectra.

The X-ray view of the γ-NLS1 galaxy PKS 2004-447

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The five most enigmatic members of the class of narrow-line Seyfert1 galaxies are five objects which exhibit both, bright radio and gamma-ray emission (hereafter γ-NLS1s). This demonstrates the existence of powerful relativistic jets similar to blazars and radio galaxies but whether γ-NLS1s really define a distinct sub-class of active galaxies is still under debate. As the radio-loudest of all γ-NLS1s, PKS 2004−447 plays a key role in settling this debate. We scrutinize the radio and X-ray properties of PKS 2004: the TANAMI VLBI program finds a high brightness-temperature core and a one-sided parsec-scale jet while Swift and XMM-Newton observations reveal a moderately variable unobscured X-ray spectrum, which is dominated by a flat power-law component. Radio-quiet NLS1s often show a soft X-ray excess, but this feature is missing in two deep XMM-Newton observations of PKS 2004−447 in 2012. We compare our results to the other four known γ-NLS1: moderate flux variability is always observed, while only some exhibit additional weak spectral variability. A strong soft excess is found in only one object. The main difference among the five γ-NLS1 is their X-ray luminosity, which spans almost two orders of magnitude.

More massive SMBHs reside in more massive dark matter halos

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We are investigating the spatial clustering properties of AGN identified in the ROSAT All-Sky Survey (RASS) and Sloan Digital Sky Survey (SDSS). We previously found a positive X-ray luminosity dependence in the clustering of broad-line AGN at $0.16 < z < 0.36$ (Krumpe et al. 2010), over the X-ray luminosity range of $43 < \log L\_X < 45$. Here we investigate this trend by fitting H-alpha line profiles in the SDSS spectra for all X-ray and optically selected broad-line AGN, in order to determine the black hole mass and infer the accretion ratio relative to Eddington. Since M_BH and L/L_EDD are anti-correlated, we create AGN subsamples with a difference in one parameter while maintaining identical distributions in the other parameter. We find that the weak X-ray luminosity clustering dependence previously observed is caused by a difference in M_BH and not L/L_EDD. Consequently, on average, more massive dark matter halos harbor more massive active SMBH in our observed redshift and luminosity ranges. These results support the idea that high Eddington ratio does not necessarily require dense environments, and mergers can play only a minor role in the accretion processes in the low redshift Universe.

Warm Absorbers in X-rays (WAX), a comprehensive high resolution grating spectral study of a sample of Seyfert galaxies

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We present results from a homogeneous analysis of the broadband 0.3-10 keV CCD resolution as well as of soft X-ray high-resolution grating spectra of a hard X-ray flux-limited sample of 26 Seyfert galaxies observed with XMM-Newton. We could put a strict lower limit on the detection fraction of 50%. We find a gap in the distribution of the ionisation parameter in the range $0.5< \log\xi <1.5$ which we interpret as a thermally unstable region for WA clouds. This may indicate that the warm absorber flow is probably constituted by a clumpy distribution of discrete clouds. The distribution of the WA column densities for the sources with broad Fe K-alpha lines are similar to those sources which do not have broadened emission lines. Therefore the detected broad Fe K lines are bonafide and not artefacts of ionised absorption in the soft X-rays. The WA parameters show no correlation among themselves, except for one case. The shallow slope of the $\log\xi$ versus $\log v_{\rm out}$ linear regression (0.12 ± 0.03) is inconsistent with the scaling laws predicted by radiation or magneto-hydrodynamic-driven winds. Our results suggest also that WA and Ultra Fast Outflows (UFOs) do not represent extreme manifestation of the same astrophysical system.

A Hard X-Ray Survey of Radio-Selected Blazars

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The MOJAVE and TANAMI programs comprise a large sample of the full sky, representative of the radio-brightest blazars with synchrotron peaks at low energies. Blazars are notoriously difficult to study in the hard X-ray regime: only 50 out of 1500 known BAT catalog sources belong to this source class. A targeted BAT survey reveals that about 2/3 of the radio-selected MOJAVE/TANAMI sample are significantly detected hard X-ray emitters, which more than doubles the number of blazars known to emit in the 20-100 keV regime. This unique and well-defined new sample of the blazar population provides a starting point for new hard X-ray observatories, and is of great importance to related modern topics such as studies of the blazar sequence.

Heavily Obscured AGN in the XMM-COSMOS survey

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Heavily obscured, possibly Compton Thick (CT) AGN are thought to represent an important, early phase in the AGN/Galaxy co-evolution. However, clearly identify CT beyond the local Universe is a challenging task even for the deepest X-ray surveys, while, given their low number density, large area surveys are needed to collect sizable samples. Through direct X-ray spectral analysis, pushed to the very low counts regime, we selected a small sample ($\sim$ 45 sources out of 1800) of heavily obscured AGN (Log(NH)$>$ 23.5 cm^{-2}) at bright fluxes (F(2-10keV) $> 1 \times 10^{-14}$ erg s^{-1} cm^{-2}) in the XMM-COSMOS catalog. A dozen of them are CT candidates. Trough deeper Chandra data in the same field, we tested "a posteriori" hour selection method, confirming the CT nature of 10 sources. We analyzed the distribution of BH masses and Eddington Ratios, finding significant differences between CT and non obscured sources, with the former having smaller masses and larger accretion rates, as expected in evolutionary scenarios. We also compared our results with predictions from the latest X-ray background synthesis models, finding very good agreement between the two.

The X-Ray Emission of Water Maser and Non-Maser Galaxies

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Water maser galaxies are a rare subclass of Active Galactic Nuclei (AGN). They play a key role in modern cosmology, since they provide a significant improvement for measuring geometrical distances with high precision. Therefore, they allow a determination of H_0 with accuracy of better than 3%, providing powerful constraints on the equation of state of dark energy (Braatz 2008, ASPC, 395, 103B). Measurements for every single object are independent, the uncertainty consequently decreases with increasing detections of suitable water masers. We have studied the X-ray properties of a unique and homogeneous sample of Type 2 AGN with water-maser activity observed by *XMM-Newton* to investigate the properties of AGN hosting mega-masers compared to a control sample of non-maser AGN, both analysed in a uniform way. A comparison of the spectral shape of water-maser and non-maser AGN indicates that water-maser X-ray spectra tend to be more complex than non-maser spectra. This suggests that also the physical processes in maser sources are more complex. Here we present a unique, systematically-analyzed sample of maser and non-maser AGN that have been observed by *XMM-Newton*.

Hard X-ray Properties of Water Maser Galaxies

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The Megamaser Cosmology Project (MCP) uses VLBI observations to measure distances for a sample of galaxies showing maser emission and to derive the Hubble Constant with an accuracy of 3 %. A knowledge of the properties of known maser galaxies can lead to a better physical understanding of the maser phenomenon and the development of successful search strategies to increase source-number statistics. The hard X-ray properties of megamaser galaxies are largely unexplored. Based on 70 months of Swift/BAT survey data, we detect a substantial fraction of 40 % of the megamaser galaxy sample at energies between 14 keV and 195 keV.
From studies of the soft X-ray band (2–10 keV), a connection between X-ray absorbing column densities and the maser phenomenon have been established. Hard X-rays are virtually unaffected by absorption. We compare the hard X-ray properties of the maser sample with their radio luminosities to study relations between these emissions.
The BAT spectra in a range of 20–100 keV can be described by simple power laws. For the sources in the maser sample we determined X-ray fluxes and photon indices, or alternatively upper flux limits. We present comparisons of these results with properties of non-maser sources from the BAT catalog.

X-ray spectroscopic study of the largest X-ray selected spectroscopic AGN sample in the XMM-XXL north

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The XMM-XXL survey is a large public XMM survey which covers two ∼25 deg^2 sky regions with rich multi-wavelength coverage. In the northern field, we have extracted about ∼8000 unique point-like sources, identified their optical counterparts in SDSS imaging, and obtained spectroscopic redshift for ∼2400 AGN (with high completeness down to r-band optical magnitude of r∼22) thanks to a dedicated ancillary program of the SDSS-III/BOSS survey. This is to date the largest contiguous X-ray selected AGN sample with spectroscopic redshift information. Here we present the overall X-ray spectral properties of these ∼2400 reliable AGN. We fitted each X-ray spectrum with a simple power law model, modified by Galactic and intrinsic absorption. By dividing the sample into different redshift and luminosity bins, it possible to study the average X-ray spectrum properties of AGN in different cosmic epoch. We can also study the correlations between the X-ray spectrum and the optical spectrum parameters, and how those correlations change with redshift and the other physical parameters of the source (e.g. BH mass, accretion disc luminosity, broad emission line shapes etc.). Using the X-ray spectrum stacking method, we also study the properties of the iron K line in different redshift and luminosity bins.

The First Clear Detection of a Hard X-Ray Lag in a Seyfert 2

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We present the results of a new 200ks XMM-Newton observation of IRAS 18325-5926 (taken in late September 2013); one of the brightest obscured / type-2 Seyfert galaxies in the sky. This source displays significant X-ray variability (by a factor of 5) and we will hereby report the first clear detection of a hard X-ray lag in a Seyfert 2. In addition, these new data show that the lags display a highly significant log-linear energy dependence - quite possibly the cleanest and clearest detection of such a relationship in any Seyfert galaxy to date. The existence of such lags may have significant implications for the corona / inner accretion-flow / geometry in accreting black hole systems. We will also discuss the highest signal-to-noise view of the interesting Fe K emission profile, which has previously been claimed to be one of the few relativistically-broadened iron lines in a Seyfert 2, in addition to the interesting broad-band spectral properties / spectral variability.

The story of Seyfert galaxy RE J2248-511: from intriguingly ultrasoft to unremarkably average

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RE J2248-511 is one of only 14 non-blazar active galactic nuclei (AGN) detected in the far-ultraviolet (FUV) by the ROSAT Wide Field Camera implying a large ultrasoft X-ray flux. This soft X-ray excess is strongly variable on year time-scales, a common property of narrow-line Seyfert 1s, yet its optical line widths classify this source as a broad-lined Seyfert 1 (BLS1). We use four nearly simultaneous optical-X-ray spectral energy distributions (SEDs) spanning 7 yr to study the spectral shape and long-term variability of RE J2248-511. Here we show that the continuum SED for the brightest epoch data set is consistent with the mean SED of a standard quasar, and matches well to that from an XMM-Sloan Digital Sky Survey sample of AGN with mean $M/M_{\odot} \sim 10^8$ and $L/L_{\rm Edd} \sim 0.2$. All the correlated optical and soft X-ray variability can be due entirely to a major absorption event. The only remarkable aspect of this AGN is that there is no measurable intrinsic X-ray absorption column in the brightest epoch data set. The observed FUV flux is determined by the combination of this and the fact that the source lies within a local absorption 'hole'. RE J2248-511, whose variable, ultrasoft X-ray flux once challenged its BLS1 classification, demonstrates that characterization of such objects requires multi-epoch, multiwavelength campaigns.

Broad Line Radio Galaxies with NuSTAR

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The formation of relativistic jets is an open question in AGN physics. Despite significant observational efforts it is still unclear why some AGN show strong radio jets while others do not. Of particular interest to answer this question are broad line radio galaxies, which do show a strong jet but otherwise show an X-ray spectrum similar to their radio-quiet kin. While studies of the standard X-ray band (0.5-10 keV) have not yielded any significant insights, the newly launched X-ray mission NuSTAR offers the possibility to also study the hard X-ray spectra of these sources. In combination with coordinated XMM-Newton and Suzaku observations this provides the best broad-band X-ray spectra of broad line radio galaxies to-date. In this talk I will discuss the first results from the NuSTAR Radio Galaxy program and their implications for our understanding of jet formation.

The Extreme X-ray/UV Flux Dips in Fairall 9

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The luminous Seyfert 1 galaxy Fairall 9 harbors a black hole of about $3x10^8$ solar masses. Nevertheless it displays very rapid dips in its X-ray flux, which last for only a few days. While we were able to detect these dips with RXTE their nature remained an open question. Their short duration excludes many possibilities, viable options are rapidly variable absorption, the failed formation of radio jets or a sudden disruption of the corona. In this talk I will present results from new observations in the UV and X-ray band, aimed at resolving this mystery. In particular, I will discuss two XMM observations, one in a dip state and one in a high flux state, triggered off a Swift monitoring of Fairall 9. Utilizing this unprecedented view of the dips, we are, for example, able to discover that the dips are not just present in the X-ray but also in the UV band, excluding simple absorption as a possibility.

Relativistic iron Kα line detection in the Suzaku spectra of IC4329a

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Broad iron lines are expected, and observed, to be a widespread feature in bright AGN. Still unclear is why some AGN miss a disk line component and if, as expected, the Fe Kα emission is varying in a correlated way with the associated hard X-ray reflection continuum. We investigated the hypothesis of an always present broad line emitted close to the black hole and rendered indistinguishable from the continuum by relativistic effects. We also looked at a direct correlation of this component with the emission at higher energies. I will present the analysis of Suzaku observations of the bright Seyfert1 galaxy, IC4329a. The broad energy band of Suzaku allows us to constrain the continuum and better fit the Iron Kα feature. A resolved peak at 6.4 keV consistent with neutral material is detected. The analysis of the spectra with a physical and self-consistent model reveals also the presence of a broad Iron Kα line. This component is consistent with being produced in the inner part of the accretion disk and to be highly blurred by gravitational redshift and Doppler effects. We also detected a narrow Fe XXVI emission line peaking at 6.94 keV, consistent with being produced by distant material.

Revealing the coronal properties of Seyfert galaxies with NuSTAR

Andrea Marinucci[1], The NuSTAR Team
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The Nuclear Spectroscopic Telescope Array, or NuSTAR, launched on June 13, 2012, is the first orbiting telescope to focus high energy X-ray light above 10 keV. Compared to the previous generation of coded aperture observatories, this change in technology provides NuSTAR with 10x sharper images and 100x improved sensitivity. We will present and discuss the key parameters describing the hot corona of AGN that have been recently measured, with unprecedented accuracy, in a number of Seyfert galaxies.

First Statistical Tests for Clumpy Tori Models: Constraints from RXTE monitoring of Seyfert AGN

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We present an analysis of multi-timescale variability in line-of-sight X-ray absorbing gas as a function of optical classification in a large sample of Seyfert AGN to derive the first X-ray statistical constraints for clumpy-torus models. We systematically search for discrete absorption events in the vast archive of RXTE monitoring of 55 nearby type Is and Compton-thin type IIs. We are sensitive to discrete absorption events due to clouds of full-covering, neutral/mildly ionized gas with columns $>\sim 10^{22-25}$ cm^{-2} transiting the line of sight. Our results probe model parameter space complementary to that for eclipses observed with XMM-Newton, Suzaku, and Chandra.

We detect 12 eclipse events in 8 objects, roughly tripling the number previously published from RXTE. Peak column densities span $4-26\times10^{22}$ cm^{-2}. Event durations span hours to years. The column density profile for a cloud in NGC 3783 is doubly spiked, possibly indicating a cloud that is being tidally sheared.

We infer clouds' distances from the black hole to span $0.3-140\times10^{4}R_{\rm g}$. Most clouds' distances are commensurate with the outer portions of the BLR, or the inner regions of infrared-emitting dusty tori. We discuss implications for cloud distributions in the context of clumpy-torus models.

Short term X-ray spectral variability of the strong iron-k absorption feature in PDS 456

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We present a recent 500 ks *Suzaku* and a simultaneous 500 ks *XMM-Newton* & *NuSTAR* observations, carried out in 2013, of the nearby ($z = 0.184$) luminous ($L_{bol} \sim 10^{47}$ erg s^{-1}) quasar PDS 456. Short term X-ray spectral variability, including the presence of a strong and rapidly variable iron-K absorption feature, is observed and subsequently investigated. Here, our attention is focused on the physical interpretation of the short term variability where two models are adopted in the spectral analysis (partial covering vs coronal changes), leading to two valid interpretations. In the partial covering scenario, rapidly varying absorption is due to inhomogeneous dense material and such short timescale changes also entail that that the absorption is due to gas located in the vicinity of the black hole possibly shielding part of the outflow. In the second scenario, the complex spectral variability is due to variations in the intrinsic continuum observed as changes in the soft X-ray spectrum leading subsequent changes in the hard X-ray power-law, possibly induced by Comptonisation in the disc corona. Furthermore it was possible to extrapolate the size and the location of the absorber, its outflowing velocity and a direct estimation of the size of the X-ray emitting region ~ 20 R$_g$.

Anatomy of the AGN in NGC 5548: tracking long-term evolution of a new massive outflow with Swift

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After a very successful multi-satellite campaign on Mrk 509 in 2009, we conducted a similar campaign on the AGN NGC 5548 in 2013. The source was heavily absorbed in the soft X-rays in 2013, with signatures of new strong outflows also present in the UV. While a proposed talk by the PI (J. Kaastra) gives an overview of the results of this campaign, we will focus here on how the newly discovered outflow (the X-ray obscurer) varies on long timescales. In 2013 and continuing in 2014 Swift has been observing NGC 5548 on average every other day, with archival observations reaching back to 2005, enabling us to obtain a precise characterisation of the X-ray and UV variability on various timescales. Using our combined analysis of the Swift and XMM-Newton data, we disentangle the X-ray and UV variability caused by absorption (due to the obscurer and the de-ionised warm absorber) from intrinsic UV and X-ray continuum components variability originating from the accretion disk/corona. We determine how the properties of the obscurer (apparent in the Swift data since Feb 2012) change over time, which sheds light on its physical structure and origin: a persistent stream of ionised gas from the accretion disk.

Using Doppler Tomography to constrain the spin of a low mass AGN

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Determining the spin of SMBHs, particularly at the low mass end, is vital in order to distinguish between SMBH growth paths (prolonged or chaotic) and for obtaining a full understanding of feedback. Traditional approaches make use of time-averaged spectroscopy: modelling the relativistically broadened Fe line or more recently modelling the disc continuum in those few cases where this is cleanly identified. I will present the first application of Doppler Tomography in the case of an unusual and very low mass AGN, where an inhomogeneous, optically thick wind provides a changing view of the emission, allowing us to directly model the approaching and receding sides of the accretion disc in turn. This phase-resolved spectroscopy allows us to constrain the spin to < 0.6 at > 5-sigma and rule out maximal spin assuming standard caveats. I will discuss potential future applications of this method and the important implications of this result for SMBH growth and feedback.

Radio-loud AGN through the eyes of 3XMM, WISE and FIRST/NVSS

Beatriz Mingo[1]
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We present the results from a new radio-loud AGN sample, obtained through the cross-correlation between the 3XMM, WISE and FIRST/NVSS catalogues. The radio selection allows us to eliminate the restrictions traditionally associated with mid-IR and X-ray sample selections, and to explore the population of lower luminosity AGN, in which the host galaxy contribution is substantial. We investigate the correlations between radio, mid-IR and X-ray emission associated to both stellar and AGN activity, and whether they can be disentangled. This work has been carried out as part of the ARCHES project. ARCHES (Astronomical Resource Cross-matching for High Energy Studies), funded within the EU/FP7-Cooperation Space framework, is a project which aims to produce well-characterised multi-wavelength data for large samples of sources drawn from the 3XMM serendipitous source catalogue.

The X-ray continuum and soft excess emitting region sizes from occultation events

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We present recent results of X-ray absorption variability events in two Seyfert galaxies on a series of different timescales. In one case, remarkable spectral variability from months to years timescales is clearly associated with clumpy absorbers crossing the line-of-sight to the nuclear X-ray emitting region. The observed variability enables us to identify two absorbing systems whose properties (density, column density, typical cloud velocity) suggest an identification with clumpy structures associated with both the broad line region and with the dusty, clumpy torus. On the other hand, an occultation event is followed from ingress to egress in the second Seyfert galaxy whose unabsorbed X-ray spectrum is typical of Seyfert 1 objects, comprising a power-law-like X-ray continuum and a clear soft excess. The detailed analysis of the occultation event in both X-ray and UV energy ranges enables us to constrain the size of the X-ray continuum as well as that of the soft X-ray excess emitting region, providing strong support for an origin in X-ray reflection off the inner accretion disc for the soft X-ray excess.

The New Spectral Picture of Seyfert 1 AGNs

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X-ray spectra of active galactic nuclei (AGNs) were so far considered to consist of a single power-law (PL) like primary component and a reflection component accompanied by an FeK line. However, the assumption of "single primary component" has not been confirmed observationally. To overcome this limitation, we developed a method that can decompose observed AGN spectra model-independently using time-variability (Noda et al. 2011, 2013). We applied it to the bright and variable Seyfert 1 AGN, IC4329A. It was observed by Suzaku 5 times in 2007, and once in 2012. Using our method, the time-averaged spectra have been successfully decomposed into a fast-variable component and a slowly-variable one. While the former can be regarded as a PL with photon index 2.1, the latter is explained as a sum of the distant reflection component and a harder PL with 1.4. This harder PL component, observed in all observations of IC 4329A and in many other AGNs (Noda et al. 2011, 2013), can be interpreted neither as partially-covered 2.1 PL, nor relativistic reflection that varies with the primary. Therefore, the 1.4 PL is considered to be another primary component. Its recognition has a big impact on our understanding of the AGN central engine.

Relativistic model of disk-jet variability

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We present a relativistic model of disk-jet variability in the optical/UV and X-ray wavelengths from AGN. The model treats the kinematics of a bulk inflow in orbital motion in a relativistic thin disk. A part of the advected plasma continues in a helical orbital motion onto a relativistic jet shaped by a magnetic surface with foot points near the innermost stable circular orbit. The model, cast in Kerr geometry includes Doppler and gravitational shifts, aberration, light bending and time delay effects on the outgoing radiation. Light curves are simulated for studying effects of the relativistic beaming and the quasi-periodic oscillation (QPO) phenomena with resulting typical timescales ranging between a few 1000 s and a few days. A power law power spectral density shape results with a typical slope of ~ -2.5. Also, using a model for the quality factor of the QPO, we place constraints on black hole mass, spin and the size of the emission region.

The Compact Symmetric Radio Structure of the Peculiar Gamma-Ray Source PMN J1603−4904

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The Southern Hemisphere AGN monitoring program TANAMI, provides regular VLBI monitoring and multiwavelength coverage of extragalactic jets south of −30° declination. We focus on our latest results on the bright hard-spectrum gamma-ray source PMN J1603−4904. Our VLBI observations reveal a symmetric brightness distribution with the brightest, most compact component at the center of the emission region. Its broadband spectral energy distribution and other multiwavelength properties point to either a very atypical blazar or can be explained as a young radio galaxy with possible starburst contribution. The latter would make PMN J1603−4904 the first young radio galaxy detected in gamma-rays, so additional confirmation is sought. Our recent Suzaku and XMM observations detect a narrow iron line, which allows us a first measurement of the redshift of the system ($z \sim 0.179$) and to constrain the linear extent of the arcsec-scale structure to be smaller than ∼3kpc, which in the two-sided jet scenario is in agreement with the small linear scales known from young radio galaxies.

High-Resolution Observations of Centaurus A

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The closest active galaxy Centaurus A is regularly observed at milliarcsecond resolution within the framework of the Southern Hemisphere AGN monitoring program TANAMI. Additional multiwavelength observations up to gamma-ray energies allow us to study the time evolution of the broadband spectrum, providing crucial information on the emission mechanisms. We present recent TANAMI results on the jet properties at sub-parsec scales. In addition, first results of an XMM and Suzaku monitoring campaign (2013-2014) of Cen A's nucleus are shown. The combination of both analyses sheds light on the production sites of high-energy photons and allows us to disentangle emission components.

Understanding X-ray Spectral and Timing Characteristics of Active Galactic Nuclei by a Novel Picture with Multiple Primary Emission

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Our understanding of the central engine of type I Active Galactic Nuclei (AGNs) has been hampered by spectral ambiguity among different X-ray components: e.g., Comptonized primary emission, secondary components possibly affected by strong relativistic effects (e.g., Miniutti et al. 2007), and/or complex partial absorption (e.g., Miller et al. 2008). With a variability-assisted spectral analysis method developed in Noda et al. (2011, 2013), we succeeded in model-independently decomposing the AGN spectra, and establishing a novel view of the engine, that it consists of multiple primary X-ray continua with distinct spectral shapes, variability timescales, and Eddington-ratio dependences (Noda et al. 2013).

The novel view with the multiple primary X-ray components can explain several long-lasting problems with the AGN central engine. The hardest of the primary components can now partially explain the "too strong hard X-ray hump", and make the secondary reflection strength moderate. The well-known X-ray spectral softening, when a source brightens, can be successfully reproduced by an increasing dominance of a softer-slope primary component towards higher Eddington ratios. Furthermore, the puzzling lack of good optical vs. X-ray intensity correlation, in some AGNs, can be solved by considering that the optical emission is correlated only with some of the primary X-ray components.

The energy dependence of the AGN X-ray power spectra

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Characteristic time scales in the X-ray variations of AGN have been detected the last 10 years in X-ray bright AGN. They correspond to frequencies at which the slope of the X-ray power spectrum changes from ~ -1 (at lower frequencies) to a slope steeper than ~ -2 at higher frequencies. These time scales depend on the black hole mass of the source, and (maybe) on its accretion rate as well. I will present results from a recent work to investigate whether these time scales depend on energy as well, using archival data of seven X-ray bright AGN, which have been observed for more than ~ 0.5 Msec (each) by XMM-Newton. I will discuss the implications of these results on the scaling of these time scales with BH mass, as well on ideas that have been put forward to explain the X-ray variability properties of AGN. I will also present results regarding the dependence of the power spectrum amplitude and slope on energy, and will discuss briefly their implications on our understanding of the X-ray variability properties of these objects.

Principal Component Analysis: Revealing AGN spectral variability

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We present results from a study of spectral variability in a large sample of AGN, revealing model independent spectral components. We use principal component analysis to decompose the spectra of 26 bright, variable AGN, finding a large variety of different variability patterns, including strong evidence of both partial covering absorption and relativistic reflection. We demonstrate, using simulations, that different physical models give clearly distinct predictions for the results of such an analysis, including models that cannot be distinguished by spectral fitting alone. We then compare the results from these simulations to the variable components found in the real data, qualitatively matching the models to the data. This method can offer a clear way of distinguishing between different variability mechanisms, and can now be effectively used with the large amounts of high quality archival data freely available from multiple instruments.

New insights into optically elusive AGN

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We present a study of "optically elusive" AGN drawn from a large new X-ray selected sample (over 900 objects) obtained from a cross-match between the 3XMM catalogue and narrow-line SDSS-DR9 spectroscopic galaxies. Our study focuses on those galaxies which have the high hard X-ray luminosities expected for AGN ($L_{HX} > 10^{42}$ erg.s^{-1}), but which are nevertheless optically classified as star-forming galaxies through their emission line ratios. The nature of these objects is investigated through a detailed analysis of their optical/IR and X-ray properties. We find that our sample contains not only AGN whose misclassification can be readily understood (NLS1s and AGN with large host galaxy contamination), but also a number of objects that are new candidate *true* Seyfert 2 galaxies, i.e. objects which lack significant absorption and do not have a hidden broad-line region.

The XMM-Newton view of the Central degree of the Galaxy

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We will present new soft and hard X-ray mosaics, including over 100 XMM-Newton observations pointed within 1degree of SgrA*. Both soft X-ray continuum and emission lines (Sixiii, Sxv, Arxvii and Caxix) maps will be described. We will discuss the nature of several extended features in the vicinity of SgrA*. This includes the 20-pc scale bipolar lobes, a super bubble candidate and the soft emission peaking around G0.11-0.11. The data reveal several features having considerable extents in Galactic latitude, suggesting the presence of hot plasma overlying the Central Molecular Zone (CMZ). We will discuss the spatial relationship of this plasma to known radio/mid-IR features as well as the question of whether this hot gas is an inhomogeneous "atmosphere" over the CMZ or whether it is a reservoir for much larger-scale-features that represent continuous/episodic outflows of mass and energy from the Galactic center.

We will also present the FeKalpha, Fexxv and hard X-ray continuum maps. By examining X-ray reflecting clouds of the CMZ and their fluorescent FeKalpha emission, we can place constraints on SgrA*'s X-ray activity during the past millennium. The comparison between surveys performed between 2000 and 2012 shows a general decay of the reflected emission over the past decade.

Revealing Massive Black Holes in Dwarf Galaxies with X-rays

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Supermassive black holes (BHs) live at the heart of essentially all massive galaxies, power AGN, and are thought to be important agents in the evolution of their hosts. However, the origin of these monster BHs is largely unknown. While direct observations of the first "seeds" of supermassive BHs in the infant Universe are unobtainable with current telescopes, finding and studying dwarf galaxies hosting massive BHs today can provide valuable constraints on the masses, host galaxies, and formation mechanism of supermassive BH seeds. We have recently completed the first systematic search for AGN in dwarf galaxies using optical spectroscopy, increasing the number of known dwarfs with massive BHs by more than an order of magnitude (Reines et al. 2013). However, this optical search is biased towards BHs radiating at high fractions of their Eddington limit in galaxies with little on-going star formation. Alternative search techniques and diagnostics at other wavelengths are necessary to make further progress. I will discuss our efforts to find and study massive BHs in dwarf galaxies using observations at X-ray wavelengths. These observations are more sensitive to weakly accreting massive BHs and are already beginning to reveal massive BHs hidden at optical wavelengths in star-forming dwarf galaxies.

Probing the unification of AGN using the narrow Fe Kalpha line

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The narrow iron Kα line is the most distinctive feature in the X-ray spectra of AGN, and with the advent of the X-ray calorimeter on board ASTRO-H will become the most important tracer of neutral matter around super massive black holes. One of the most interesting characteristics of the narrow Fe Kα line is the decrease of its equivalent width with the continuum luminosity: the X-ray Baldwin effect (Iwasawa & Taniguchi 1993). This trend has been found by many studies of large samples of type-I AGN, and very recently also in type-II AGN (Ricci et al. 2014b, submitted to MNRAS). The slope of the X-ray Baldwin effect in type-II AGN is the same as that of their unobscured counterparts, which implies that the mechanism at work is the same. In my talk, I will review the main characteristics of the narrow Fe Kα line, and present the results of our recent works aimed at explaining the X-ray Baldwin effect (Ricci et al. 2013a,b, 2014b), and at understanding the origin of the narrow Fe Kα line by combining infrared and X-ray observations (Ricci et al. 2014a, submitted to A&A).

Suzaku observation of IRAS 00521−7054, a peculiar type II AGN with a very broad feature at 6 keV

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IRAS 00521−7054 is a Seyfert 2 that has been recently proposed to show an extremely large Fe Kα line. We report here the results obtained by a 100 ks *Suzaku* observation of the source. We confirm the existence of a very strong excess over the power-law X-ray continuum at $E \sim 6$ keV ($EW \simeq 860$ eV), extending down to ~ 4.5 keV, and found that the X-ray spectrum of the source can be explained by two different models. i) An absorption scenario, in which the X-ray source is obscured by two layers of ionized absorption, with a strong reflection component from neutral material ($R \sim 1.7$), a black body component and four narrow Gaussian lines (corresponding to Fe Kα, Fe Kβ, Fe XXV and Fe XXVI). ii) A reflection scenario, in which the X-ray spectrum is dominated by blurred reflection produced in an ionized disk around a supermassive black hole rotating with a spin of $a \geq 0.72$, and affected by light-bending ($R \sim 2.6$). While the X-ray continuum varies significantly during the observation, the intensity of the broad feature appears to be constant, in agreement with both the absorption and the reflection scenario. For both scenarios we obtain a steep power-law emission ($\Gamma \sim 2.3$). We speculate that the source might be an obscured narrow-line Sy1, and in particular, given its characteristics at 6 keV, it might be the obscured counterpart of objects such as IRAS 13224−3809 and 1H 0707−495.

Absorption Variability in NGC 1365 seen with XMM-Newton and NuSTAR

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Between July 2012 and February 2013, XMM-Newton and NuSTAR performed four long-look joint observations of the type 2 Seyfert NGC 1365 with the aim of measuring relativistic reflection from the inner region of the accretion disk. Fortuitously, two of observations caught the source in an unusually low absorption state, and one of these observation actually showed an uncovering of the central source. We have analyzed the variable absorption seen in these observations in order to characterize the geometry of the absorbing material in this source. In addition to a constant (likely distant) absorber with a column density of N_H $\sim 1 \times 10^{22}$ cm^{-2}, we find a variable absorber with a range of N_H from 5–25 $\times 10^{22}$ cm^{-2} and a range of covering fractions from $\sim$0.5–1 over the course of the four observations. This is consistent with the picture of a clumpy torus/BLR with the clumps embedded in a smoother, more diffuse medium.

A Catalogue of XMM-Newton BL Lacs

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A catalogue of XMM-Newton BL Lac is presented based on a cross-correlation with the 1374 BL Lac objects listed in the 13th edition of the Veron-Cetty and Veron (2010) catalogue. X-ray counterparts were searched for in the field of view of more than 10000 pointed observations available in the XMM-Newton Archive (XSA) that were public before June 2012. The cross-correlation yielded around 250 XMM-Newton observations, which correspond to 162 different sources. X-ray data from the three EPIC cameras and Optical Monitor data were uniformly analyzed using the latest XMMNewton Science Analysis System (SAS) version. The catalogue collects X-ray spectral properties, including flux variability, of the sample in the 0.2 - 10 keV energy band.

A wide search for obscured Active Galactic Nuclei using XMM-Newton and WISE

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We use a combination of the XMM-Newton serendipitous X-ray survey with the optical SDSS, and the infrared WISE all-sky survey in order to check the efficiency of the low X-ray to infrared luminosity selection method in finding obscured AGN. We select the sources which are detected in the hard X-ray band (2-8 keV), and also have a redshift determination in the SDSS catalogue. We match this sample with the WISE catalogue, and fit the spectral energy distributions (SEDs) of 2844 sources. We then select the heavily obscured AGN candidates by comparing their 12 micron AGN luminosity to the observed 2-10 keV X-ray luminosity. With this approach we find 20 candidate heavily obscured AGN and we then examine their X-ray and optical spectra. Of the 20 initial candidates, we find nine, out of the 14, for which X-ray spectra could be fit, based on the X-ray spectra, and seven, out of the nine detected spectroscopically in the SDSS, based on the [OIII] line fluxes. Combining all criteria, we determine the final number of heavily obscured AGN to be 12-19, and the number of Compton-thick AGN to be 2-5, showing that the method is reliable in finding obscured AGN, but not Compton-thick.

Red Quasars in the 2XMMi/SDSS Cross-Correlation

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Several studies strongly suggest that red quasars are a significant fraction of the quasar population ($\sim 20-30\%$). Although they are usually explained as dust-reddened sources, some studies based on small samples of red quasars find no evidence of dust for $\sim 40-50\%$ of them, suggesting a substantial population of intrinsically-red quasars. The joint use of SDSS and XMM-Newton data allows assembling a large sample of red quasars with optical and X-ray observation, which can provide strong constrains on the amount of dust present in these sources.

We studied a sample of 145 SDSS DR7 red quasars at moderate redshift ($0.5 < z < 2.5$) lying on 2XMMi fields (79 of them with a detected counterpart in the 2XMMi catalogue). 104 objects ($\sim 70\%$) showed signs of dust or X-ray absorption and were classified as dust-reddened quasars. For 13 sources ($\sim 10\%$) we found no conclusive evidence of neither dust obscuration nor X-ray absorption and were classified as intrinsically-red quasars. Our results suggest that intrinsically-red quasars represent a small fraction of the global population of quasars, significantly lower than that pointed out in previous studies.

X-ray wind variability in ESO 323-G077

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We present results on multi-epoch X-Ray spectral analysis of the Seyfert 1 galaxy ESO 323-G077, based on two observations performed with XMM-Newton in February 2006 and January 2013 respectively, and four with Chandra HETG in April 2010. The spectral variability shown by the source in the lapse of those seven years is extraordinary. All of the spectra show prominent emission and absorption features. We interpret the absorption lines as the signature of three different absorbers. Two of them are highly ionised outflowing warm absorbers, the third one being lowly ionised. The outflow velocities are of the order of v = 1000 - 2000 km/s, which is consistent with the Keplerian/escape velocity at typical BLR radii. Finally, the study of the absorption variability allows us to study the regions where the previously reported relativistically broadened iron emission line originates. This line profile is evident in the data obtained during the two XMM-Newton observations. The broad iron line is consistent with an origin in the inner accretion disc around a Kerr black hole viewed with an inclination of ∼25 degrees.

Investigating an extreme transient AGN from the XMM-Newton slew survey

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Over the last few years, several AGN have been discovered in the XMM-Newton slew survey with a flux >100 times higher than that seen in ROSAT 10-20 years earlier. After explanations, such as tidal disruption events or changes in line-of-sight absorption are excluded, it seems unavoidable that the flux change is due to an increase in the intrinsic emission from the nucleus. Most of these objects display very soft X-ray spectra and are clearly related to similar objects discovered during the ROSAT mission. One object, 2MASX 0619-65, has a hard, typical SY-I spectrum and yet appears to have increased its bolometric output by a factor 10,000 compared with that inferred from the optical emission lines. We present detailed X-ray, UV and optical monitoring of this AGN and attempt to provide a physical mechanism for its variability.

AGNs in Dwarf Galaxies? Evidence from WISE and XMM-Newton

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Whereas supermassive black holes (SMBHs) are ubiquitous in most major galaxies, evidence for the presence of SMBHs in dwarf galaxies is extremely rare. We present our XMM-Newton analysis of three dwarf galaxies out of a large population of optically-quiescent dwarf galaxies revealed by the Wide-field Infrared Survey Explorer (WISE) to have extreme mid-infrared colors indicative of the presence of accreting SMBHs. Our observations reveal the presence of X-ray point sources with spectral properties characteristic of active galactic nuclei in at least two of the three dwarf galaxies observed. This finding represents a major step in the understanding of SMBHs in dwarf galaxies, and potentially opens a new avenue into the study of AGNs in this rare class of objects.

Exploratory X-ray Monitoring of Luminous Radio-Quiet Quasars at High Redshift

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We present new results from an ongoing X-ray monitoring project of two groups of comparably luminous radio-quiet quasars (RQQs). The first consists of four sources at $4.10 \leq z \leq 4.35$, monitored by *Chandra*, and the second is a comparison sample of three sources at $1.33 \leq z \leq 2.74$, monitored by *Swift*. Together with archival X-ray data, the total rest-frame temporal baseline spans $\sim 2-4$ yr and $\sim 5-13$ yr for the first and second group, respectively. The main finding is that luminous RQQs at the highest accessible redshifts exhibit pronounced X-ray variability, above that expected from their luminosities, which is quite similar to many of their nearby and far less luminous counterparts. We show that this surprising result may be attributed to luminous sources at the highest redshifts having relatively high accretion rates. Complementary UV–optical monitoring of the two groups of sources shows that variations in their optical–X-ray spectral energy distribution are dominated by the X-ray variations. This project is designed to provide a basic assessment of the X-ray variability properties of RQQs at the highest accessible redshifts that will serve as a benchmark for more ambitious and systematic monitoring of such sources with future X-ray missions.

On the origin of X-ray spectra in luminous blazars

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Gamma-ray luminosities of some quasar-associated blazars imply jet powers reaching values comparable to the accretion power. With much lower radiative efficiencies of protons than of electrons and the recent reports of very strong coupling of electrons with shock-heated protons indicated by Particle-in-Cell simulations, the leptonic, rather than hadronic models seem to be strongly favored. However, the electron-proton coupling combined with the External-Radiation-Compton (ERC) models of gamma-ray production in leptonic models predict much harder X-ray spectra than observed. This problem can be resolved by assuming that the X-ray spectra up to 30 keV are dominated by SSC radiation. We show that such SSC component can be produced co-spatially with the observed synchrotron and ERC components in the hot-dust-region, or beyond that region but then with the synchrotron and ERC components dominated by radiation in the broad-line-region. Verification of these scenarios is possible by studies of correlations of X-ray flares with the optical and gamma-ray events. Both models imply very high radiative efficiency of blazar jets and a rather modest electron-positron pair content.

Timing warm absorbers in AGN

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Active Galactic Nuclei (AGN) are powered by accretion onto a supermassive black hole. These systems are also associated with ejection of matter, either in the form of relativistic jets and/or outflows of gas rich in metals. The impact of such outflows in the surrounding environment, so-called AGN feedback, is of crucial importance in modeling the evolution of black holes across cosmic time and their host galaxies. The assessment of AGN feedback is dependent on constraints on the geometry and location of these outflows, that can enable the quantification of the wind energetics. However, the wind is multicomponent, presenting a wide range in outflow velocities and densities, complicating the determination of its distance to the central source. In this work, we use archival data from XMM-Newton of the highly variable source NGC4051. We combine spectral and timing analysis to distinguish/characterize the different components of the gas. In particular, we analyse X-ray time lags corresponding to the response of the ionized gas relative to variations in the flux of the central source. This enables an estimation of the recombination time, which is a function of the gas density, consequently allowing us to determine the distance of the outflow to the central source.

Anatomy of the AGN in NGC 5548: A twin of NGC 4151?

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After a very successful multi-satellite campaign on Mrk 509 in 2009, we conducted a similar campaign on the AGN NGC 5548 in 2013. During the latter the source appeared unusually strongly absorbed in the soft X-rays, and signatures of strong outflows were also present in the UV. While a talk giving an overview of the campaign (PI: J. Kaastra) is also proposed at this conference, I will present a comparison between the new state of NGC 5548 with the X-ray spectrum of the well-known absorbed Seyfert 1 galaxy NGC 4151. Due to its brightness NGC 4151 has several high signal-to-noise X-ray spectra, allowing for a detailed modelling of the different absorption components, the coronal emission lines and radiative recombination continua. Due to their obscured state, both sources are ideal to compare the emission features in Seyfert 1 galaxies with those observed in Seyfert 2 galaxies.

The Global Implications of the Hard X-Ray Excess in Type 1 Active Galactic Nuclei

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The Suzaku observations of 1H 0419-577 and PDS 456 revealed a marked excess of flux above 10 keV, dubbed a 'hard excess'. In both sources, the high PIN-band flux was explained by the presence of a Compton-thick absorber covering $> 70\%$ of the continuum source. These results motivated an exploratory study of the hard excess phenomenon in the local type 1 AGN population, using the Swift Burst Alert Telescope (BAT). We selected all type 1 AGN, including intermediates up to type 1.9, from the 58-month BAT catalog. To understand the sample properties, we required simultaneous medium (2-10 keV) and hard X-ray (>10 keV) data. Therefore, we cross-correlated those selected sources with the Suzaku archive. From our sample, we extracted the observed energy density fluxes for the 2-10 keV and 15-50 keV bandpasses to determine the hardness ratio, Flux(15-50)/Flux(2-10), and extracted the equivalent width of the narrow core of Fe K alpha emission for each observation. We found that a partial-covering, Compton-thick absorber model is the most consistent with the observational result. In this talk, we discuss our methodology, the observational finding, and the location of the Compton-thick gas and its relationship to the optical broad-line region.

XMM-Newton and AKARI Selection of Obscured AGNs

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Obscured AGNs are an essential population to understand various aspects of the structure and evolution of AGNs. The combination of X-ray and infrared (IR) is often employed to find obscured AGNs utilizing absorbed X-ray spectra and infrared reemission from dust. We matched X-ray sources in the XMM serendipitous source catalogue and the IR all sky surveys with AKARI, and developed diagrams using X-ray to IR ratio, X-ray hardness, and IR color to efficiently select obscured AGNs. We analyzed XMM spectra of 49 candidates for obscured AGN with detected counts greater than 60. 17 and 10 objects among them turned out to be AGNs absorbed by Compton thin ($N_{\rm H} \sim 10^{22-24}$ cm^{-2}) and Compton thick material ($N_{\rm H} > 10^{24}$ cm^{-2}), respectively. Obscured AGN activity in 14 sources are found in this work for the first time. Three obscured AGNs we selected are classified as an HII nucleus based on their optical spectra, and are examples of elusive AGNs found by our technique. We report the details of our diagrams and X-ray spectral analysis.

The importance of nuclear winds in shaping the X-ray properties of AGN

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Feature-rich X-ray spectra of AGN trace the circumnuclear reprocessing gas, which spans a wide range of column density and ionization state in the local population. Combining spectral information with X-ray time lag signatures indicates that the nuclear regions have a high covering fraction of absorbing, Compton-scattering gas, existing on scales of light-hours. Grating spectroscopy indicates that the X-ray reprocessor is part of a nuclear outflow, whose details are key to understanding the accretion process, and the influence of the nuclear black hole upon its host galaxy.

Anatomy of the AGN in NGC 5548: the XMM/NuSTAR/INTEGRAL view

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After a very successful multi-satellite campaign on Mrk 509 in 2009, we conducted a similar campaign on the AGN NGC 5548 in 2013. During the latter the source appeared unusually strongly absorbed in the soft X-rays, and signatures of strong outflows were also present in the UV. While a talk giving an overview of the campaign (PI: J. Kaastra) is also proposed at this conference, we will focus here on the part of the campaign where XMM/NuSTAR and INTEGRAL operated simultaneously. It appears that the reflection component is consistent with being constant during the campaign, then originating from remote material at least a few light months away from the central X-ray source. The primary continuum above 5 keV is well fitted by a power law with standard value (1.7-1.8) with only lower limits on the presence of a high energy cut-off. The use of the XMM/OM as well as simultaneous HST/COS observations allow us also to compare the broad band UV/X-ray spectra with realistic comptonisation models. The physical interpretation will be discussed.

The 58-month BAT AGN catalogue: results from the Northern Galactic Cap

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The ongoing Swift/Burst Alert Telescope (BAT) all-sky survey is providing the most complete, hard X-ray selected census of local AGN activity, continually probing to deeper flux limits. I will present recent results from the 58-month BAT catalogue in the Northern Galactic Cap (Galactic latitude $b > 50°$), probing deeper than previous analyses of the 9-month and 36-month AGN catalogues. Our work includes a comprehensive analysis of the 0.1-200 keV properties (luminosity, absorption, spectral shape, Iron line and reflection properties) of 100 AGN in this sky region. This sample has excellent potential for further multi-wavelength study due to a wide range of archival data already available in other bands, and we propose it as a low-redshift analog to the "deep field" observations of AGNs at higher redshifts (e.g., CDFN/S, COSMOS, Lockman Hole). The stacked spectrum from this representative AGN sample looks remarkably like the Cosmic X-ray background (CXB) spectrum, albeit with a different underlying absorption and Compton reflection distributions than previous CXB synthesis models. I will outline various possibilities of how this sample can be used to further our understanding of local supermassive black hole accretion.

An X-ray outflow in a luminous obscured quasar at z=1.6 in the Chandra Deep Field-South

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In the AGN-galaxy co-evolution models, AGN winds and outflows are often invoked to explain why super-massive black holes and galaxies stop growing at a certain phase of their life. They are commonly referred to as the leading actors of feedback processes, which have been recently observed in both neutral/ionized and molecular gas up to very high redshifts. Evidences for ultra-fast outflows in X-rays have been collected in the last decade of sensitive XMM-Newton, Chandra and Suzaku observations for a sizable sample of AGN, mostly at low redshift. These observations have provided important test cases for wind and feedback models. Here we present 3Ms XMM-Newton coupled to 4Ms Chandra data of an obscured luminous quasar at z=1.6 in the Chandra Deep Field South, where an outflow of velocity about 0.15c has been significantly detected.

Variability of Sgr A*, Monte Carlo code for X-Ray Emission

Michael Walls[1], Masha Chernyakova[1]
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In the centre of our galaxy lies a super-massive black hole, identified with the bright radio source Sagittarius A* (Sgr A*). This black hole has an estimated mass of around 4 million solar masses, however excluding the radio, Sgr A* is quite dim in other wavelengths. Recently XMM-Newton has quite intensively observed the central region of our Galaxy in order to find out whether the current dim state is normal or as is suspected Sgr A* undergoes periods of far higher activity. The answer to this question can be found from the study of the delayed emission, e.g. reflected X-ray emission from the molecular clouds in the Galactic Centre. The interpretation of these results largely depends on the real position of the clouds. To approach this we have run a set of Monte Carlo simulations, showing very different spectra depending on the relative position of the molecular cloud. In my poster I will present these results and compare it with the observational data.

NuSTAR and XMM-Newton Observations of NGC 1365: Extreme Absorption Variability and a Constant Inner Disc

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Measurement of black hole spin in active galactic nuclei has the potential to enhance our understanding of how the black holes powering these sources grew to be so massive. To date, the best methods for measuring AGN spin are anchored in X-ray spectroscopy, and primarily involve studying relativistic reflection features from the inner accretion disc. However, there has been a long-standing debate surrounding such measurements, with models dominated by absorption and reprocessing in distant structures proposed as alternative interpretations of the observed X-ray spectra. We present the results from a series of four coordinated NuSTAR+XMM-Newton observations of the Seyfert galaxy NGC 1365, which has recently become central to this debate. Despite exhibiting an extreme range of absorption states, each of the observations displays the same characteristic signatures of relativistic reflection from the inner accretion disc. Through time-resolved spectroscopy, we find a clear link between the broad iron emission and the Compton reflection hump, and that each of the observations independently gives consistent parameters for the inner disc. These results strongly support the view that such regions are both observationally accessible and influence the observed spectra, and confirm that NGC 1365 hosts a rapidly rotating black hole.

Anatomy of the AGN in NGC 5548: the X-ray narrow emission lines

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After a very successful multi-satellite campaign on Mrk 509 in 2009, we conducted a similar campaign on the AGN NGC 5548 in 2013. During the latter the source appeared unusually strongly absorbed in the soft X-rays, and signatures of strong outflows were also present in the UV. While a talk giving an overview of the campaign (PI: J. Kaastra) is also proposed at this conference, we will focus here on the data obtained from the XMM-RGS, resulting in a stacked spectrum of 660 ks. Narrow emission lines, including He-like triplets of Oxygen, Nitrogen and Neon, and radiative recombination (RRC) features dominate this spectrum due to the low soft X-ray continuum flux. All emission features are consistent with having constant flux over our campaign. The O VII triplet has been one focus of our analysis, especially due to unexpected differences of $\sim$300 km s^{-1} among the measured outflow velocities of its individual lines. The RRCs allow us to directly calculate a temperature of the emitting gas of a few eV ($\sim 10^4$K), favouring photoionised conditions. We have modelled the emission lines and features using the photoionisation code Cloudy, to attempt to construct a self-consistent picture of the physical environment of the AGN.

A multi-wavelength study of the radio-loud Narrow-line Seyfert 1 galaxy RXJ23149+22

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We present a multi-wavelength analysis of a radio-loud narrow-line Seyfert 1 (NLS1) galaxy, including optical spectroscopy, Swift UV and X-ray data, and radio observations obtained at Effelsberg. The NLS1 galaxy exhibits some intriguing multi-wavelength characteristics, including an unusually flat X-ray spectrum, optical [OIII] emission that is exceptionally blueshifted, a tentative detection at gamma-rays, and luminous infrared emission. We discuss the nature of this source, and implications for the NLS1 phenomenon.

Chapter 9

Clusters of Galaxies

The X-ray view of high-redshift clusters: ICM and AGN contribution

Veronica Biffi[1]
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X-ray observations still represent a very powerful strategy to investigate the properties of galaxy clusters through their formation history. Current and up-coming X-ray telescopes, from Chandra to eRosita and Athena, are able in fact to track the properties of the most important contributor to the cluster baryonic budget: the intra-cluster medium (ICM). ICM thermo-dynamical properties can be reconstructed from its X-ray emission and theoretical models can be evaluated against the observational evidences. Especially at high-redshift, forthcoming X-ray instruments will allow to investigate clusters at the dawn of their assembly. This will help to unveil the details of metal production and diffusion, of the interplay between cooling and feedback mechanisms and of the interaction of the ICM with member galaxies. Predictions for this can already be anticipated via state-of-the-art numerical hydro-simulations, where a vast variety of physical processes (from star formation and cooling to AGN feedback) is carefully treated. In particular, I will show results on the contribution of AGN sources to the ICM X-ray properties, from synthetic observations of the simulated clusters. This will be an important issue to tackle in future observations, aiming at detecting high-redshift clusters and studying their baryonic features.

Cosmological implications from the eROSITA all-sky survey

Katharina Borm[1], Thomas Reiprich[1], Lorenzo Lovisari[1]
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eROSITA (extended ROentgen Survey with an Imaging Telescope Array) is the German core instrument aboard the Russian Spektrum-Roentgen-Gamma satellite which is scheduled for launch in 2015. The main driver for eROSITA is studying the nature of dark energy, which is especially imprinted in the redshift and mass distribution of galaxy clusters. eROSITA is expected to detect around 100 thousand clusters of galaxies in X-rays up to redshifts of z$\sim$2.0. We present forecasts for the observation power of this instrument and introduce the distribution of galaxy clusters with mass and redshift as it is expected to be observed during the all-sky survey. By means of simulations of galaxy cluster spectra, we quantify the accuracy and the precision with which eROSITA will determine the temperature of the intra-cluster medium and the cluster redshift directly from the survey data. According to these predictions, eROSITA will increase the current cluster sample with precise temperatures by a factor of 5-10. Based on the above computations and results, the constraints eROSITA will place on the cosmological parameters are predicted by means of Markov-Chain Monte Carlo simulations.

X-ray morphology and cool core state in galaxy clusters

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The dominant mechanism invoked to explain this bimodality relates the presence or absence of a CC to the recent merging history of the cluster. We tested this hypothesis on a sample of 100 local clusters observed with Chandra finding a clear correlation between an indicator of a thermodynamical CC state (central entropy) with several morphological indicators of the cluster dynamical state (center shift, concentration parameter and cuspiness). We found a significant correlation with all three parameters. We also show that cuspiness and concentration parameter are powerful indicators to select CC: more than 94% of the relaxed clusters selected according to these indicators are classified as cool core also from the thermodynamical point of view. Since these indicators can be easily measured also with poor quality data, we suggest to use them to identify relaxed objects for cosmological studies.

Characterising our Universe with the REFLEX II cluster survey

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Galaxy clusters are important cosmological probes and they are in particular useful to constrain the parameters for the matter density and the density fluctuation amplitude in the Universe. The currently largest uncertainties in using galaxy clusters for cosmological tests originate in our imperfect knowledge of scaling relations between cluster observables and the masses of galaxy clusters. Using well defined statistical samples constructed from our REFLEX and NORAS survey of X-ray luminous clusters in the ROSAT All-Sky Survey, we aim for a comprehensive characterization of the statistical properties of the structure of galaxy clusters in the nearby Universe. We will discuss scaling relations, morphological distributions and the effect of the enviroment on these properties. For the first time we compare such results for flux- and volume-limted samples of galaxy clusters.

A Wild Ride for Abell 2443: A High Impact Velocity Merger with a Shock, Cold Front, and Relic

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The dynamical state of galaxy clusters is revealed through X-ray features such as shocks and cold-fronts as well as radio features such as diffuse synchrotron emission. Abell 2443 is host to a shock edge, cold-front contact discontinuity, and ultra-steep spectrum radio relic. These features all point toward a cluster undergoing a significant merger but our recent deep Chandra data have revealed a more complex picture. We see a double-tailed X-ray tail reminiscent of that in 'El Gordo'. This structure appears to trace the trajectory of the merging subcomponent and suggests that it is highly inclined with respect to the line of sight. Separating the X-ray emission of the merging tailed component from that of its surroundings (the main cluster) suggests, through spectral fits, that the two components of Abell 2443 have a relative line of sight velocity difference of over 3000 km/s. Ahead of the merging component is where the ultra-steep spectrum radio relic appears co-spatial with the outgoing shock edge from this violent collision.

Chemical evolution and cluster physics with the CHEERS sample

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Last year, we obtained deep XMM-Newton observations of 11 $z < 0.2$ clusters for a total of 1.6 Ms. The clusters in this Very Large Program were selected based on good feasibility with the Reflection Grating Spectrometer (RGS). Using this legacy high spectral resolution cluster sample and additional cluster data from the XMM-Newton archive, we study the chemical enrichment, thermodynamic structure, and turbulence in the hot Intra-Cluster Medium (ICM). The observations with typically 130 ks exposure times provide spectra with excellent statistics, allowing an accurate determination of the widths and strengths of the spectral lines. The measured abundances are used to constrain models for the enrichment of the gas by type Ia and core-collapse supernovae. The EPIC data provide maps of the thermodynamic structure of the gas and the spatial distribution of the metallicity. We will show the first results extracted from these deep data and also look forward to the potential of future Astro-H SXS observations of clusters of galaxies.

The 100 XXL brightest clusters: morphological study

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The XXL survey is the largest XMM-Newton cluster survey, covering an area of 50 deg^2 in two 25 deg^2 regions of contiguous 10ks pointings. We use this to study the properties and evolution of the cluster population, for comparison with realistic cosmological simulations incorporating AGN feedback. We will present results from an analysis of the dynamical state of the 100 brightest clusters from the survey, based on the surface brightness concentration parameter, the centroid-shift and the offset between X-ray peak and brightest cluster galaxy. We relate those parameters to the cluster scaling relations, and use them to test the realism of our simulated clusters.

Substructures in DAFT/FADA survey clusters based on XMM and optical data

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The DAFT/FADA survey was initiated to perform weak lensing tomography on a sample of 90 massive clusters in the redshift range [0.4,0.9] with HST imaging available. The complementary deep multiband imaging constitutes a high quality imaging data base for these clusters. In X-rays, we have analysed the XMM-Newton and/or Chandra data available for 32 clusters, and for 23 clusters we fit the X-ray emissivity with a beta-model and subtract it to search for substructures in the X-ray gas. This study was coupled with a dynamical analysis for the 18 clusters with at least 15 spectroscopic galaxy redshifts in the cluster range, based on a Serna & Gerbal (SG) analysis. We detected ten substructures in eight clusters by both methods (X-rays and SG). The percentage of mass included in substructures is found to be roughly constant with redshift, with values of 5-15%. Most of the substructures detected both in X-rays and with the SG method are found to be relatively recent infalls, probably at their first cluster pericenter approach.

Hot gas accretion in cluster outskirts

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The baryonic content of galaxy clusters grows through the accretion of hot gas over cosmic time. Still at the present epoch accretion processes should be important in the outer regions of clusters, rendering the distribution of X-ray emission clumpy and asymmetric. We present a method based on the azimuthal median to estimate the gas clumping factor and recover unbiased density profiles. We apply this method to a sample of 31 clusters observed with ROSAT/PSPC, and compare with the expectations of hydrodynamical simulations. We also present the results of an XMM mosaic program of the clusters A2142 and Hydra A, in which we discovered accreting substructures around the cluster's virial radius. In particular, we report the XMM discovery of a spectacular X-ray tail in A2142, which we use to set constraints on thermal conduction in the ICM.

The ICM power spectrum: probing the gas physics of galaxy clusters

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Exploring the power spectrum of fluctuations in the intracluster medium can deeply improve our knowledge of galaxy cluster physics, in analogy to what the cosmology field has experienced with CMB studies during the last decade. The normalization of the ICM spectrum (related to density, entropy, or pressure fluctuations) is linearly linked to the level of large-scale motions, which excite gravity and sound waves. The slope of the spectrum reflects instead the competition between the turbulence cascade and diffusive processes, which act to damp fluctuations and smooth the X-ray surface brightness images. Using high-resolution 3D plasma simulations in realistic galaxy clusters, we probe the behavior of the ICM power spectrum under different physics, such as turbulence and thermal conduction. We test our spectral modeling on deep X-ray observations of Coma cluster, retrieving mild subsonic turbulence and strongly suppressed conduction. Being able to probe the (astro)physics of the diffuse medium or, for instance, to easily retrieve the gas motions from the thermodynamic fluctuations, is a powerful tool with profound implications for the evolution of baryons in the universe, which can be exploited by the current (XMM-Newton, Chandra) and future (e.g. Astro-H, Athena+) generation of X-ray telescopes.

The Bullet Group

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We report on a XMM observation of a strong lensing selected group, SL2S J08544-0121, with a total mass of $2.4 \pm 0.6 \times 10^{14}$ $M_{\odot}$ which revealed a separation of 124 ± 20 kpc between the X-ray emitting collisional gas and the collissionless galaxies and dark matter (DM), traced by strong lensing. This source allowed to put an upper limit to the interaction cross section of DM of 10 cm^2 g^{-1}. It is the lowest mass object found to date showing a DM-baryons separation and it reveals that the detection of bullet-like objects is not rare and confined to mergers of massive objects opening the possibility of a statistical detection of DM-baryons separation with future surveys.

Metal distribution in sloshing galaxy clusters

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Cold fronts in cool-core clusters are thought to be induced by minor mergers and to develop through a sloshing mechanism. While thermodynamical properties (e.g. temperature and surface brightness) have been widely measured and studied in many systems, a detailed characterization of the metal distribution and its relation with the sloshing is only available for a handful of objects. This is a significant limitation as the sloshing may play a crucial role in carrying metals from the core to the outskirts. Since cool-core clusters have prominent metallicity peaks in their centers, the metal distribution may trace the history of the central gas motions and provide important informations on the sloshing mechanism. We analyzed a long (120 ksec) XMM-Newton observation of A496 to study the metal distribution and its correlation with the cold fronts. We find a correlation between the metal abundance and the entropy distribution. We use this correlation to put limits on the dynamical mechanisms (such as thermal conduction and convection) at work in the ICM and find that all these processes should cooperate and be highly fine-tuned or, more simply, should be heavily suppressed. We extend this analysis to a small cluster sample.

The Luminosity-Temperature Relation of Clusters Detected in the XXL Survey

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The XXL survey is the largest observing programme undertaken with XMM-Newton, covering 50deg^2 to 10ks depth (split over two areas of 25deg^2 each). We will present the first sample of galaxy clusters from XXL, comprising the 100 brightest clusters. We will discuss the selection function of the sample, and present the luminosity-temperature relation of the clusters, demonstrating the importance of modelling the selection effects to recover the true relation of the population. We will show new constraints on the evolution of the LT relation, and discuss the implications of the results for cluster feedback models.

Probing of Interactions between the Hot Plasmas and Galaxies in Clusters over a Cosmological Timescale

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After reionization the Universe can no longer be considered as neutral fluids, but must be treated as ionized media which are ubiquitously threaded by magnetic fields. It remains still unexplored how the magneto-plasma nature of matter affects the formation and evolution of galaxies and galaxy clusters, and how the galaxies and cluster plasmas interact each other.

We consider a unique scenario, galaxies moving through the cluster will interact strongly with the ICM, transfer their free energies to the ICM, and will gradually fall to the cluster center". To verify this scenario, the key is to compare the spatial extents of galaxy and ICM at different redshifts.

In Gu et al. 2013, ApJ 767 157, we studied the expected galaxy infall using a sample of 34 massive clusters with redshift range of 0.1 to 0.9. We have detected, for the first time, a significant evolution spanning 6 Gyr; while the galaxy component was as spatially extended as the ICM at z$\sim$0.9, towards the lower redshifts, it has indeed become more centrally-concentrated relative to ICM/DM. Recently we confirm this discovery by a new complete sample of 316 clusters. This reveals the presence of strong ICM drag on galaxies over cosmological timescale.

Galaxy Cluster Substructure Study

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The hot intracluster medium in galaxy clusters often shows significant two-dimensional structure generated by mergers and AGN feedback.

We analysed a sample of X-ray bright, nearby Galaxy clusters, most of which have been observed for more than 20 ks with Chandra. Using the Chandra ACIS data, we mapped various properties of the intracluster medium, identifying substructure at high spatial resolution. These maps enabled us to study asymmetries in the projected pressure and density. We present the detailed analysis of these profiles for the best-observed clusters in our sample.

From the Chandra data we derive 2D cluster models, which we use as input for eROSITA simulated observations. The aim of the simulations is to investigate possible biases in the determination of cluster properties such as temperature or mass, when a large sample of clusters are analysed in the eROSITA cluster survey.

Dynamical History of the A1589 Cluster of Galaxies

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We have analyzed XMM-Newton archival data of nearby (z=0.0704) cluster of galaxies A1589. The extend plasma is elongated NW-SE direction which is probably effected by the gravitational potential of massive A1569 at the south east. The cluster ICM parameters are estimated as 4.2 keV average temperature and 0.2 solar metalicity. Produced temperature and metal abundance maps reveal patchy clumps. There is a significantly hot 5.1 keV jet like small-scale plasma. Around the central region chemical abundance value is about 0.5 which is significantly higher than the average. This metal rich region locates at the head of the hot elongation. If this is not a chance location, the picture looks like a hot sub-cluster is entered and it high metal core is survived. Based on the results, we try to understand dynamical history of the cluster.

Weak lensing calibrated scaling relations for galaxy groups and clusters in the COSMOS and CFHTLS fields

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The outstanding problem in galaxy cluster count cosmology is to determine accurate scaling relations between survey observables and cluster mass. As indicated by the tension between Planck CMB and Sunya'ev-Zeldovich cluster count cosmology, the robustness of the cluster count results are dominated by the mass measurements used to calibrate the scaling relations. Here we present our work on the scaling of X-ray observables obtained with XMM-Newton to unbiased weak lensing masses in the COSMOS and CFHTLenS survey fields.

Our recently published mass-temperature relation for low mass systems in the COSMOS field extended the mass range of the lensing calibrated M-T relation an order of magnitude lower than any previous study. It showed that previous X-ray mass estimates can be biased low by up to 30-50%, which is the level required to bring Planck cosmology into consistency. We showed that the bias is not attributable to uncertainties in X-ray cross-calibration. Our recent inclusion of low mass clusters from CFHTLenS allows us to improve the constraint on the M-T relation and to study the effects of substucture. With the CFHTLenS extension, we also include the first lensing calibrated mass-luminosity relation for individual low mass systems.

Taking a census of the Oxygen abundance and distribution in galaxy groups and clusters

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Oxygen is the most abundant of the elements produced after Big Bang nucleosynthesis. Its abundance carries information about the formation and evolution of stars and galaxies. Furthermore its spatial distribution in galaxy clusters encodes the metal enrichment history of the ICM. Despite the importance of Oxygen, its abundance and distribution in the Universe is still a matter of debate. We present measurements of the oxygen abundance and radial distribution for a large sample of galaxy groups and clusters. In addition we compare the radial distribution of oxygen with Silicon, Sulfur, and Iron, to identify the combination of processes involved in the ICM enrichment. Finally, we use metal abundances and ratios, in particular the O/Fe ratio, to constrain the relative ratios of supernovae types.

An XMM-Newton view of Abell 4059

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We present a deep 200 ks XMM-Newton observation of the nearby galaxy cluster A4059 ($z = 0.046$). We focus on measuring the cluster temperature profile and the abundances of 9 key-elements (O, Ne, Mg, Si, S, Ar, Ca, Fe and Ni) from EPIC spectra. A careful modelling of the EPIC background allows us to derive temperature and abundance radial profiles from the core up to a radius of ~ 10 arcmin (0.6 Mpc). Temperature and abundance maps are also presented and confirm the structures and the asymmetry of the Intracluster Medium (ICM) in the core, previously observed by Chandra, while the outskirts appear quite relaxed. RGS values of the core confirms the complex temperature structure and provide us constraints on the abundances in the cluster. The observed abundances will be compared with supernovae yields from theoretical models.

Exploring the Outskirts of Galaxy Clusters

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A number of recent studies have traced the hot intracluster medium (ICM) to the virial radius in a sizeable sample of galaxy clusters. These results have begun to clarify the thermodynamic conditions at the edge of clusters, constraining models of cluster growth and evolution, yet the observations are challenging and bedeviled by a host of systematic issues due to the very low ICM surface brightness in the cluster outskirts. We are currently embarked on a program to observe a sample of about ten relaxed clusters with Suzaku, fully imaging each cluster to beyond R_{200}, and leveraging complementary data from XMM-Newton and Chandra. Our results support the idea that the ICM is not in hydrostatic equilibrium in the cluster outskirts, where we see indications of low-entropy substructures and some evidence for azimuthal variations in temperature and surface brightness. I will present the latest results from this project, explore the possible sources of systematic error, and discuss the remarkable "universality" of thermodynamic profiles to the outer limits of galaxy clusters.

The ARCHES Integrated Cluster Finder

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We are developing a tool to search for galaxy clusters associated with X-ray sources from the 3XMM catalog within the ARCHES project (Astronomical Resource cross-matching for High-Energy Studies). We make use of the new cross-matching tool developed for ARCHES to select galaxies in different catalogs around X-ray positions and then try to find clusters by searching for overdensities in the multi-color space. Colors are related to redshifts using spectroscopic data for passively evolving galaxies from the BOSS and VIPERS catalogs. So far we are making use of SDSS, UKIDSS, WISE, and CFHTLS photometric catalogs, but the method can easily be expanded to other data as well (e.g. Pan-STARRS and DES). We present test results of our tool performed on reference samples from the XMM/SDSS cluster survey (Takey et al 2012) and the NORAS/REFLEX surveys.

Exploring Hot Gas at Junctions of Galaxy Filaments with Suzaku

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Galaxies are forced to form filamentary structure reflecting the underlying cosmic web of the dark matter. In particular, at junctions of galaxy filaments, one can naturally expect that intense structure formation has high chances to occur. We identified the galaxy filaments by making use of our original method (Sousbie (2011) & Sousbie et al. (2011)) in conjunction with SDSS spectroscopic galaxies. We performed X-ray pointing observations for six fields locating in the junctions of the galaxy filaments where no specific diffuse X-ray emissions had previously been detected so far. We discovered significant X-ray signals in their images and spectra of the all regions compared to a background region. Spectral analysis revealed that six sources originate from diffuse emissions associated with optically bright galaxies, group-scale, or cluster-scale X-ray halos with temperautres of 1-4 keV, while the others are compact object origin. Interestingly, the observed three intracluster media possess peculiar signatures such as complex or elongated morphologies in X-ray and/or optical and hot spot, suggesting that all of the systems are experiencing an ongoing merger (Kawahara et al. (2011) & Mitsuishi et al. (2014)). In this conference, results of follow-up radio observations to search for merger-induced diffuse radio emissions will be reported.

Turbulence measurements in clusters of galaxies with XMM-Newton

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The kinematics structure of the intracluster medium (ICM) in clusters of galaxies is related to the their evolution. AGN feedback, sloshing of gas within the potential well, and galaxy mergers are thought to generate ICM velocity widths of several hundred km/s. Appropriate determinations of turbulent broadening are crucial not only to understand the effects of the central engine onto the evolution of the clusters, but are also mandatory to obtain realistic (emission) line fits and abundances estimate. We have analyzed the data from the CHEERS catalog which includes 1.5 Ms of new observations (PI: Jelle de Plaa) and archival data for a total of 29 clusters and groups of galaxies, and elliptical galaxies. This campaign provided us with a unique database that significantly improves the quality of the existing observations and the measurements of chemical abundances and turbulent broadening. We have applied the continuum-subtraction spectral-fitting method of Sanders and Fabian and measured turbulence, temperatures, and abundances for the sources in the catalog. For some sources we obtain tight estimates of velocity broadening which is related to the past AGN activity and mergers. We will show our results at the conference and their relevance in the context of future missions.

LBT/MODS spectra of distant X-ray selected galaxy clusters

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We present a sample of distant clusters of galaxies selected from the 2XMM catalogue. Extended X-ray sources with no visible counterpart in the SDSS were chosen for deep imaging with the LBT/LBC. The most promising fields, showing overdensities of red galaxies in pre-imaging, were selected for spectroscopic follow-up with LBT/MODS. We were able to derive redshifts for seven galaxy clusters ($0.75 < z < 1.0$) and present X-ray and optical properties as well as mass estimations. Carried by our previous success and triggered by the availability of WISE survey, we use IR data to support the selection of distant ($z > 1$) clusters. The first promising fields have received deep pre-imaging and await spectroscopic follow-up.

eROSITA Cluster Cosmology – Statistics and Challenging Systematics

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eROSITA is expected to revolutionize galaxy cluster cosmology by discovering 100,000 clusters, including all massive (few times 1e14 Msun) ones in the entire observable Universe (that are not projected onto our Galaxy). This vast increase in statistics has to be accompanied by a significantly improved understanding of several systematic uncertainties of physical and technical nature. Progress on this subject will be described, paying particular attention to cluster outskirts, galaxy groups, non-thermal pressure support, low scatter mass proxies from eROSITA, X-ray cross calibration, weak lensing mass calibration, and SZ/X-ray/weak lensing comparison of low and high redshift clusters. Robust combination of eROSITA cluster data with cosmic microwave background data then promises exciting surprises for the future of cosmology.

Optical and near-infrared follow-up of the XMM Cluster Archive Super Survey (X-CLASS): Preparing for eRosita

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The XMM Cluster Archive Super Survey (X-CLASS) is a serendipitous, X-ray selected cluster catalogue, containing 850 galaxy clusters, extracted from 2774 observations from the XMM archive following the methodology of the XMM-LSS/XXL. I will present details of an optical and near-infrared follow-up of 160 members of the sample with the simultaneous, seven-channel (grizJHKs) imager GROND on the MPG 2.2m telescope at La Silla. These clusters form a part of the extended X-CLASS cosmological sample, which benefits from a uniquely well-controlled selection function over 90 deg^2. I will show that GROND provides an efficient tool for the identification of red sequence member galaxies and photometric redshifts. This in turn allows for the characterization of the clusters for future cosmological analyses. I will also present preliminary results and follow-observations of 900 newly processed XMM observations making up XCLASS-II. These observations will assist with the refining of observational and analytical strategies for future eRosita cluster studies, as the X-CLASS sample is a good representation of the expected eRosita cluster catalogue (launch in 2015).

Fluid flow experiments in galaxy clusters: Using cluster galaxies and minor mergers as probes for transport coefficients of the intracluster medium

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The intra-cluster medium (ICM) fills galaxy clusters and constitutes the bulk of the cosmic baryons. The ICM transport properties (viscosity, thermal conductivity) and magnetic field structure are still ill-constrained. We use the ICM flows around gas-stripped elliptical cluster galaxies and in merging clusters as direct probes of these ICM properties. Galaxies moving through the ICM experience a head wind that strips off their gaseous atmospheres. The structure of the galaxy-ICM interface and of the stripped gas tails depends on ICM transport coefficients and magnetic field structure, but also on the galaxy infall dynamics. Minor mergers drive gas sloshing motions that create cold fronts, whose fine-structure depends on the ICM properties. We have deep high resolution X-ray data with sufficient quality to distinguish different ICM properties – if we can disentangle the effects of ICM transport properties and ICM dynamics. We do so by one-to-one comparisons between observations and specifically tailored numerical simulations of these galaxies and merging clusters. We report on first evidence for a highly suppressed ICM viscosity in the Virgo cluster.

Beyond the (cool) cores: large scale sloshing in the ICM

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One of the main results of the Chandra/XMM-Newton era has been the discovery of cold fronts in galaxy clusters. They have been interpreted as contact discontinuities between gas with different thermo-dynamical properties and they are often generated by sloshing gas motions of the ICM, following the perturbation of the gravitational potential due to a minor merger. I will report on the recent discovery of a cold front at 1 Mpc from the center in A2142 with XMM-Newton (Rossetti et al 2013), which is revolutionizing our understanding of these features: from small disturbances in the central regions of relaxed clusters to a cluster-wide phenomenon, involving the ICM up to almost half of the virial radius. I will also report some preliminary results on a systematic search for large scale sloshing in the XMM-Newton and ROSAT/PSPC archives, providing indications of sloshing features beyond 0.3 r200 in five other clusters.

MBPROJ: MultiBand X-ray Surface Brightness PROJector applied to the PKS 0745191 galaxy cluster

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Measuring the radial properties of galaxy clusters is important for understanding both AGN feedback in cluster cores and examining clusters in a cosmological context. We discuss a new multi-band surface brightness deprojection method for determining cluster profiles. The aim of this code is to measure cluster radial properties without the need for spectral analysis and requiring the minimum number of photons. The method uses a Markov Chain Monte Carlo analysis of surface brightness profiles in multiple bands with mass and temperature models, assuming hydrostatic equilibrium. The analysis produces several other useful quantities for measuring cluster properties, including entropy, pressure, cooling time and gas mass. With the aid of a deep Chandra observation of PKS 0745-191, we compare the results of our method to other currently used tools (e.g. projct and dsdeproj) and discuss how useful it is in the low count regime, for example examining clusters in larger X-ray surveys such as will be created by eROSITA.

XMM-Newton and Chandra Observations of the Remarkable Dynamics of the Intracluster Medium and Radio Sources in the Clusters Abell 2061 and 3667

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XMM-Newton and Chandra observations of remarkable dynamic structures in the X-ray gas and connected radio sources in three clusters are presented. Abell 2061 is a highly irregular, merging cluster in the Corona Borealis supercluster. X-ray observations show that there is a plume of very cool gas ($\sim$1 keV) to the NE of the cluster, and a hot (7.6 keV) shock region just NE of the center. There is a very bright radio relic to the far SW of the cluster, and a central radio halo/relic with an extension to the NE. Comparison to SLAM simulations show that this is an offset merger of a $\sim 5 \times 10^{13}\, M\odot$ subcluster with a $\sim 2.5 \times 10^{14}\, M\odot$ cluster seen after first core passage. The plume is the cool–core gas from the subcluster, which has been "slingshot" to the NE of the cluster. The plume gas is now falling back into the cluster center, and shocks when it hits the central gas. The model predicts a strong shock to the SW at the location of the bright radio relic, and another shock at the NE radio extension. Time permitting, the observations of Abell 2626 and Abell 3667 will also be presented.

Mapping fossil and non-fossil systems out to their virial radii

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As the largest gravitational bound systems in the Universe, galaxy clusters are very valuable cosmological probes. Among them, fossil systems are supposed to be more evolved and relaxed while non-fossil systems are more disturbed and dynamically younger. With high quality Suzaku and Chandra observations, we studied the gas properties such as entropy, pressure, and baryon fraction profiles as well as their azimuthal variations out to the virial radii of a typical fossil system RXJ1159+5531 and a typical non-fossil system MKW4. The comparison of these two systems allows us to put constraints on the role played by non-gravitational processes and the evolution of galaxy clusters.

Extending the bolometric L-T relation from galaxy clusters to groups: Impact of ICM cooling, AGN feedback and selection effects

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With a sample of 26 galaxy groups with Chandra data, we endeavour to construct the bolometric luminosity-temperature relation. We fit the relation for five different cases; the complete sample, sub-samples which factor the presence/absence of a strong cool core (SCC), and the presence/absence of a central radio source (CRS). To correct for malmquist bias, we undertook simulations and determined the bias corrected slopes, normalisations and the intrinsic scatter in luminosity. Important similarities and differences of the relation on the group scale vis-a-vis clusters is presented and we try to come up with a cohesive picture of the impact of ICM cooling and AGN feedback on the group regime.

Plasma physics in the outskirts of the nearest, X-ray brightest galaxy clusters

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Over the past several years, the comparatively low background of the Suzaku satellite has enabled measurements of the thermodynamic properties of the faint cluster outskirts, opening a new window for the exploration of the ongoing virialization and equilibration processes that occur as part of large-scale structure formation. This has been complemented by several subsequent studies with Chandra, XMM-Newton, and Sunyaev-Zeldovich experiments such as Planck. I will briefly summarize the highlights from recently finalized Key/Large programs with the Suzaku satellite on the Perseus and Coma clusters, before discussing new results from the Key Project targeting the Virgo Cluster. These nearest, brightest clusters of galaxies are ideal targets for studying in detail the physics of the hot X-ray emitting plasma near their virial radii. I will compare and contrast the results from these different projects in order to shed light on how the thermodynamic properties in the cluster outskirts depend upon the cluster mass, dynamical state, and large-scale structure environment. I will furthermore show that the metal distribution in the intra-cluster medium provides important constraints on an early phase of chemical enrichment in the history of the Universe.

Discovery of a Nearby, Massive Galaxy Cluster Behind the Galactic Bulge with the XMM-Newton Observatory

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We report on the discovery of a heretofore unknown, nearby galaxy cluster behind the Galactic plane as part of a 43 ks follow-up XMM-Newton observation of the IGR J17448-3232 field. This source was first discovered by INTEGRAL and was subsequently observed for 5 ks with Chandra, which revealed a source of extended emission. Given its angular proximity to the Galactic center, and the poor statistics of the short Chandra observation, the object was initially interpreted as a supernova remnant (Tomsick et al. 2009). The XMM-Newton EPIC data, however, establishes that the extended emission is in fact a galaxy cluster (Barrière et al. 2014). The emission-weighted temperature of the cluster within the field of view is 8.5 keV, with parts of the cluster reaching temperatures of up to 12 keV; no cool core is evident. At a redshift of 0.054, the cluster is somewhat underluminous relative to the X-ray luminosity-temperature relation, which may be attributable to its dynamical state. We present an analysis of temperature, abundance, and surface brightness profiles as well as maps of the temperature and morphological structure that reveal the mass and likely late stage post-merger nature of this new cluster in the constellation of Scorpius.

Multi-wavelength mass calibration of galaxy clusters for cosmology

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We present the X-ray luminosity versus dynamical mass relation for a flux-limited sample of more than 60 nearby clusters of galaxies, taking into account the survey selection, based on 1.3 Msec clean XMM-Newton data and optical spectroscopic redshifts of more than 13 thousand cluster galaxies. To investigate the potential of spectroscopic surveys to follow up high-redshift galaxy clusters/groups observed in X-ray surveys for mass calibration, we carried out Monte-Carlo re-sampling of the cluster galaxy redshifts and calibrated the redshift and dynamical mass estimates. The re-sampling considers the eBOSS/SPIDERS and 4MOST configurations, designed for the follow up of the eROSITA clusters, and was carried out for the sample at the cluster redshifts as well as at the assigned input cluster redshifts of 0.2, 0.4, 0.6, and 0.8. Our results demonstrate the power and limit of combining upcoming X-ray and optical surveys for the mass calibration of galaxy clusters for cosmology.

The Effect of Viscosity on Sloshing Cold Fronts in Galaxy Clusters

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Cold fronts, which are contact discontinuities in the intracluster medium of galaxy clusters, should be disrupted by Kelvin-Helmholtz instabilities. However, most cold fronts appear to be very smooth and the signatures of significant disruption by instabilities appear to be absent. Therefore, cold fronts may be used to place constraints on ICM viscosity. We perform numerical simulations of gas sloshing in galaxy cluster cores using the Athena MHD code, comparing the effects of isotropic Spitzer viscosity and anisotropic Braginskii viscosity on the gas properties. We find that simulations with anisotropic Braginskii viscosity or isotropic Spitzer viscosity with a suppression factor of $f \sim 0.1$ give results that are very close to the observations in terms of suppressing K-H instabilities. Using synthetic X-ray observations, we show it is difficult to distinguish between these two models. This suggests that the combination of magnetic fields and Braginskii viscosity is sufficient to explain the observed smoothness of sloshing cold fronts. We find that sloshing-driven turbulence is only modestly reduced by Braginskii viscosity. We also perform simulations including anisotropic thermal conduction. We find that including Braginskii viscosity in these simulations has no effect on the evolution of cold fronts; they are smeared out by thermal conduction.

Chapter 10

Extragalactic Surveys and Population Studies, the CXB, WHIM and Cosmology

New constraints on the evolution of the X-ray luminosity function of AGN out to $z \sim 5$

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Determining the distribution and evolution of accretion activity in Active Galactic Nuclei (AGN) throughout the history of the Universe, traced by their luminosity function, is essential to constrain models of supermassive black hole formation and growth and their role in the evolution of galaxies. I will present new measurements of the X-ray luminosity function of AGN, combining data from all major deep and wide Chandra surveys (including the AEGIS-deep and wide surveys, the Chandra Deep Field North, Chandra Deep Field South and E-CDFS, C-COSMOS and the XBootes survey) to accurately trace the evolution of the low-luminosity AGN population out to $z \sim 5$. We construct a sample of over 4000 sources selected at soft (0.5-2keV) X-ray energies and over 2500 sources selected at hard (>2keV) X-ray energies. We adopt a sophisticated Bayesian methodology to account for the effects of absorption on these samples, as well as accounting for uncertainties in their photometric redshifts, flux uncertainties, incompleteness, and Eddington bias. Using this method, we carefully assess the evidence for any redshift- and luminosity-dependence of the absorbed AGN fraction as well as any change in the shape of the X-ray luminosity function out to high redshifts.

Signature of Early Black holes in Cosmic Backgrounds.

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I will present our recent discovery of significant coherent fluctuations in the unresolved Cosmic IR and X-ray Backgrounds on arcminute scales. We modeled such a signal and we were not able to reproduce the observations when including known source populations like AGN, Galaxies and Clusters emissivity folded with their clustering properties below z∼6. The remaining excess signal has a similar shape to the already known excess in the large scale CIB fluctuations. I will present some possible interpretations which point toward abundant populations of black holes in the early Universe, likely Direct Collapse Black Holes or POPIII Stars remnants. Finally I will show some predictions for the detection of the first black holes in the Universe in the eROSITA, Athena, Euclid and JWST cosmic backgrounds.

Completing the census of heavily obscured AGN with Athena

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Athena is a space observatory proposed to ESA to implement the science theme "The hot and energetic Universe", via high-troughput X-ray imaging and spectroscopy. Among the many topics in which Athena will provide a quantum leap, is uncovering the "hidden" population of highly obscured Active Galactic Nuclei (AGN), thought to be the sites of most of the energy emitted by accretion throughout the history of the Universe.

We concentrate on AGN at z=1-3 and with 2-10keV luminosities close to L*∼5e44erg/s, at the heyday of black hole growth and star formation. We show that Athena will be able to recognize and parameterise by itself a good fraction of the moderately Compton-Thick AGN (CT, N_H >1.5e24cm-2) detected in 1Ms exposures, effectively constraining the properties of many more, including their CT nature and their X-ray luminosities. With the proposed multi-tiered survey strategy, Athena will also be able to distinguish accurately between different models for X-ray evolution of AGN. The dependence of this performance on several de-scoping options is also explored and quantified.

Athena will revolutionize by itself our understanding of the darkest side of the AGN Universe and, in collaboration with other upcoming facilities, unveil currently hidden connections between AGN growth and galaxy formation.

The cosmological analysis of large X-ray galaxy cluster surveys

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Large samples of galaxy clusters collected in X-ray observations are able to tightly constrain cosmological scenarios by probing the mass function of large structures and its evolution with time. Current surveys with XMM (XMM-XXL, 50 deg^2 at 10ks depth) and the future eROSITA all-sky survey will deliver sizable samples ($10^3 - 10^5$) of objects showing a wide range of signal-to-noise ratios in the X-ray bands. We will present the CR-HR method, particularly suited to capturing the cosmological signal in such samples. By modeling the observed population of cluster properties down to the instrumental level (Count Rates and Hardness Ratios), it self-consistently includes the various model uncertainties and selection biases. We will demonstrate its applicability by presenting the results we obtained from a sample of clusters collected in XMM archival data (X-CLASS, 100 deg^2 at 10-20ks depth). These results will be compared to findings we independently derived from studying the redshift distribution (dn/dz) of a complete cluster sample in the XMM-LSS area (11 deg^2 at 10ks depth), which in particular appeal for a non self-similar evolution in the X-ray Luminosity-Temperature scaling relation and question several detection biases.

Deep X-ray spectroscopy of obscured AGN in the XMM-CDFS

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Heavy obscuration represents an important phase of AGN evolution and is expected to play a key role in the feedback mechanisms self regulating the SMBH growth. The signature of absorption is the presence of an exponential cut-off at low energy and/or a reflected X-ray spectrum plus a strong Iron line. The results of a systematic analysis of the brightest 200 sources in the deep XMM survey of the CDFS will be be presented, namely: the distribution of power law spectral indices and iron line equivalent widths, the absorption distribution and the evolution of obscured fraction and, in particular the properties of Compton thick AGN up to redshifts of about 4. The power of deep spectroscopy to obtain more reliable redshifts estimates than currently available for optically faint sources will be highlighted, along with a few examples of synergies between ultra-deep Chandra (7 Ms) and XMM observations.

The NuSTAR hard X-ray view on quasars

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I will present the hard X-ray properties (E∼3-30 keV) of the AGN population seen in the NuSTAR extragalactic survey. In particular, I will highlight the NuSTAR observations of NuSTAR J033202-2746.8, a heavily obscured, radio-loud quasar detected in the Extended Chandra Deep Field South (E-CDF-S). Combining the NuSTAR data, with existing very deep Chandra and XMM-Newton observations, we constrained the broad-band X-ray spectrum of NuSTAR J0332022746.8; this source is a heavily obscured quasar at redshift z≈2, with $N_H \approx 6 \times 10^{23}$ cm^2 and 10-40 keV luminosity $L_X \approx 6 \times 10^{44}$ erg/s. The NuSTAR spectrum shows a significant reflection component (R∼0.6), which was not constrained by previous analyses of Chandra and XMM-Newton data alone. Our results show the importance of NuSTAR in accurately characterising the broad-band spectral properties of quasars out to high redshift.

Galaxy groups in deepest XMM fields

Alexis Finoguenov[1]
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Ultra-deep observations of CDFS with Chandra and XMM-Newton enable a search for the extended X-ray emission down to a unprecedented flux level of 10^{-16} ergs s^{-1} cm^{-2}. In parallel, extensive imaging surveys and large spectroscopic surveys at VLT and Magellan have been completed, providing photometric and spectroscopic identification of galaxy groups to high redshifts. We present the search for the extended emission on spatial scales of $32''$ in both Chandra and XMM data, covering 0.3 square degree. We report on our efforts on the spectroscopic identification of sources, which result in a catalog of 40 spectroscopically identified groups, reaching a redshift of 1.6. We present one and two point statistics of galaxy group catalog. We demonstrate that extrapolation of the scaling relations derived on COSMOS is capable to describe the statistical properties of the groups, constraining departures from the relation to be within 30

The X-ray signature of the solar axion flux observed by XMM Newton?

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Solar axions interacting with the Earth's magnetic field are predicted to produce X-rays in the 0.2-10 keV band. The intensity of these X-rays should be greater in the sunward magnetosphere than in the magnetotail. This asymmetric source, viewed from the highly elliptical orbit of XMM Newton, could produce an apparent seasonal modulation in the cosmic X-ray background, with a minimum count rate in Winter. We report the results of a search for such a seasonal modulation in stacked blank sky data sets from the EPIC pn and EPIC MOS cameras. We describe both the internal consistency checks and the methods of screening against focused soft protons which must be applied to the detected data sets before the axion mass and values for the axion-photon and axion-electron coupling constants can be reliably derived.

Investigating different AGN fuelling modes since z=1

Antonis Georgakakis[1]
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I will present observational constraints on (i) the large scale clustering of X-ray selected AGN as a function of accretion luminosity and redshift to z=1 and (ii) the Eddington ratio distribution of X-ray AGN as a function of the level of star-formation and morphology of their host galaxies. The results will be discussed in the context of semi-analytic models for the formation and co-evolution of AGN and galaxies to argue that they are consistent with two modes for the fuelling of supermassive black holes to z=1. The first mode dominates the accretion density at all redshifts since z=1 and is associated with high specific star-formation galaxies. The second accretion mode is sub-dominant and takes place in quiescent, low specific star-formation systems. The results and conclusions are based on multi-wavelength observations in the 4Ms Chandra Deep Field South, the 800ks survey of the AEGIS field and the Chandra COSMOS sample.

Compton-thick AGN in the 3XMM spectral survey

Ioannis Georgantopoulos[1], Amalia Corral[1], Mike Watson[2], Simon Rosen[2]
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In the framework of an ESA Prodex project, we have derived X-ray spectral fits for a large number (120,000) of 3XMM sources. We focus our study on the 120 square degrees that overlap with the SDSS survey. For about 1,100 AGN there are spectroscopic redsifts available. We automatically select candidate Compton-thick sources using simple spectral models. Various selection criteria are applied including a) a high equivalent width FeK line b) a flat spectrum with a photon index of 1.4 or lower at the 90% confidence level or at higher redshift an absorption turnover consistent with a column density of logNh=24. We find 30 candidate Compton-thick sources. More detailed spectral models are applied trying to secure the Compton-thick nature of these sources. We compare our findings with X-ray background synthesis models as well as with Compton-thick surveys in the COSMOS and XMM/CDFS areas.

Testing the unified model of Active Galactic Nuclei in X-ray selected type 1 and type 2 quasars

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We have investigated whether the dusty tori invoked in the standard orientation-based unified scheme of Active Galactic Nuclei (AGN) is valid for all AGN types at both low and high luminosities. We used the Bright Ultra-hard XMM-Newton Survey (BUXS), one of the largest flux-limited samples of bright AGN selected above 4.5 keV with XMM-Newton, and the Wide-field Infrared Survey Explorer (WISE). BUXS includes 255 AGN detected over 44 deg2 of which to date 161 are identified as type 1 AGN and 89 as type 2 AGN and 98% are detected with WISE. We determined the distribution of covering factors of the obscuring region in X-ray type 1 and type 2 AGN by computing the AGN power re-processed into the IR (apparent covering factors) and the torus geometrical covering factor (i.e. the relative fraction of obscured AGN) using the clumpy torus models of Nenkova et al. We have also investigated whether our results favor the so-called receding torus scenario. Finally, I will discuss the possibility of using the spectral energy distributions of the sources in the 3XMM-DR4 catalogue, produced by the Astronomical Resource Cross-matching for High Energy Studies (ARCHES) project, to extend such studies over a broader range of AGN parameters.

The host galaxies of X-ray selected AGN: feeding and feedback

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Using the rich multi-band photometry in the COSMOS field we explore the host galaxy properties of a large, complete, sample of X-ray and spectroscopically selected AGN. Based on a two-components fit to their Spectral Energy Distribution, we derive rest-frame magnitudes, colors, stellar masses and star formation rates up to z$\sim$3, and we study the connection between these host galaxy properties, accretion luminosity and obscuration in galactic nuclei across more than 2/3 of the age of the Universe. Although AGN activity and star formation appear to have a common triggering mechanism, we do not find any strong evidence signaling the influence of luminous AGN on the global properties of their host galaxies. Conversely, we found that the central black hole activity have profound effects on the surrounding matter on scales comparable to the gravitational sphere of influence of the black hole. We discuss the implication of our findings for the nature of the long sough-after 'Quasar mode' feedback from AGN.

Obscured accretion history from the spectrum of the unresolved Cosmic X-ray background

Alberto Moretti[1]
[1] *INAF Brera*

We present a study of the the unresolved X-ray background spectrum in the 1.5-7.0 keV energy band. Combining Swift and Chandra observations of the Chandra Deep Field South, we exploited the deepest observation ever performed and the lowest instrument background today available. This allowed us to measure the unresolved emission at the deepest level and with the best accuracy today available. We find that unresolved XRB emission can be modeled by a very hard power law (photon index 0.1) with a flux corresponding to 20% of the total X-ray background in the 2-10 keV band, being 95% and 70% at 2 keV and 7 keV respectively. We use this measure to place a firm upper limits on the global accretion history of massive black holes at z $>$ 5 and to constrain the redshift evolution of the obscured AGN population luminosity function.

The 2–10 keV luminosity function of AGN in the XMM-LSS and XMM-CDFS surveys

Piero Ranalli[1], Ioannis Georgantopoulos[1], Elias Koulouridis[1], Andrea Comastri[2]
[1] *IAASARS, National Observatory of Athens*
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The XMM-Newton LSS and CDFS surveys probe complementary regions of the flux-redshift plane, and together they provide one of the largest samples of AGN available to study their luminosity function (LF), with approx. 2900 objects with 75% redshift completeness.

I will present the redshift-dependent 2–10 keV LF, estimated using different methods: a binned LF, a maximum-likelihood fit using the LDDE and LADE models for its evolution, and a Bayesian analysis with the same models. The LDDE model performs better than LADE, but there is space for improvement especially at low-redshift and high-luminosity.

For all three methods, the 2–10 keV luminosities have been corrected for absorption taking into account the complete probability distribution of spectral slopes and column densities. Photometric redshifts have been included with their probability distributions. I will show how to include this information in the LF computation.

Finally, the LF will be compared to previous determinations and models.

Reflection in obscured Seyfert galaxies and the CXB

Roland Walter[1], Valentino Esposito[1]
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We present a study of the average hard X-ray spectra of Seyfert galaxies obtained accumulating one billion seconds of Swift/BAT data and reaching a sensitivity of 20 micro-Crab in the hard X-rays.

As already suggested by INTEGRAL data, this analysis confirms that midly obsured Seyfert 2 galaxies feature much more reflection than unabsorbed sources. The ratio of the average spectra of obscured and unobscured sources, derived with high accuracy, is characteristic of a reflection hump with a broad excess peaking at 40 keV.

This large reflection cannot be explained easily by the unified model and points towards the clumpy torus model. It also provides a natural explanation for the peak of the cosmic X-ray background without requiring a large population of Compton thick sources.

Chapter 11

Future of X-ray Astronomy

European user support activities for ASTRO-H

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The Japanese mission ASTRO-H will be the next major X-ray satellite to operate after its launch in 2015. ASTRO-H will carry several instruments observing simultaneously that will provide broad-band coverage from 0.3 to 600 keV, while the Soft X-ray Spectrometer will offer high spectral resolution in the soft X-ray domain. Europe actively participates in the ASTRO-H mission, and European astronomers will have access to observing time. The European user support activities will be spread across two centers: The Science Operations Center (SOC), located at ESAC (Spain), and the European Science Support Center (ESSC), located at the University of Geneva (Switzerland).

The tasks of the SOC will be focussed on supporting the European user community in the use of the allocated time for ASTRO-H, through handling annual calls for observing proposals and related activities. The tasks of the ESSC will be focussed on supporting the European scientific community with respect to the analysis of ASTRO-H data.

The activities of the European ASTRO-H SOC and ESSC, together with a summary of ASTRO-H and its capabilities, will be presented at a booth at the X-ray Universe 2014 conference.

Atlas of High Resolution X-ray spectra: a Diagnostic Tool of the Hot Universe

Katarzyna Bensch[1], Maria Santos-Lleo[1], Rosario Gonzalez-Riestra[1]
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We present an Atlas of High Resolution X-ray spectra obtained with the Reflection Grating Spectrometer, RGS, on-board XMM-Newton. All the public RGS1 and RGS2 exposures have been analysed in order to identify those containing useful data and classified according to some pre-defined quality criteria. We found that out of 18000 RGS1&RGS2 exposures, about 4300 are useful, of which 220/2300 provide very-good/good quality spectra. The spectra are grouped according target Simbad Object Class. The spectra are plotted and information is provided about important properties point-like or extended emission and presence or absence of emission lines and line identification if applicable. The Atlas clearly shows differences when comparing different object classes, but not only that, differences are also found among different objects in an individual class and even among different spectra of an individual object. Spectral properties that characterize the different object classes as well as their variability properties are discussed.

The XMM-Newton spectral-fit database

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I will present the XMM-Newton spectral-fit database, 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. The XMM-Newton spectral-fit database is a publicly available catalogue, constructed in collaboration with the XMM-Newton Survey Science Centre, of 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. The database has been constructed by making use of automated spectral fits for six different spectral models. These models were selected and implemented according to the most common spectral shapes displayed by different astronomical sources. The automated process has been extensively tested and scientifically validated in order to derive the most relevant spectral information for every X-ray source. I will also present some recent results showing the potential of this database in selecting samples of Active Galactic Nuclei.

The EXTraS project: Exploring the X-ray Transient and variable Sky

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Modern X-ray observatories can yield unique insights into time domain astrophysics. Indeed, a huge amount of information is already stored – and largely unexploited – in data archives. The EXTraS project will harvest the hitherto unexplored temporal domain information buried in the serendipitous data collected by the European Photon Imaging Camera (EPIC) instrument onboard the ESA XMM-Newton mission since its launch. This will include a search for fast transients, missed by standard image analysis, and a search and characterization of variability (both periodic and aperiodic) in hundreds of thousands of sources spanning more than nine orders of magnitude in time scale (from <1 s to >10 yr) and six orders of magnitude in flux (from 10^{-9} to 10^{-15} erg cm^{-2} s^{-1} in 0.2-12 keV). X-ray results will be complemented by multiwavelength characterization of new discoveries. Phenomenological classification of variable sources will also be performed. Our final catalogue and results will be made available to the community, together with new analysis tools, at the end of the project (late 2016). EXTraS is funded within the EU/FP7-Cooperation Space framework and is carried out by a collaboration including INAF (Italy), IUSS (Italy), CNR/IMATI (Italy), University of Leicester (UK), MPE (Germany) and ECAP (Germany).

XMM Future Operational Ground Segment

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XMM-Newton has been operating for 14 years which have been characterised by an extraordinary scientific return leading to it being considered as one of the most important scientific missions operated by ESA.

XMM-Newton has outlived its original operating lifetime and this has led to a new array of technical challenges which new software and operating strategies have greatly mitigated and have enabled XMM-Newton to continue to perform optimally.

XMM-Newton relies on reaction wheels and thrusters to manoeuvre consuming on -board fuel and limiting XMM-Newtons operating life. As a result a new operating concept for the reaction wheels has been devised and reduces the fuel consumption by approximately 50% potentially allowing XMM-Newton to operate until 2028.

This extension leads to a new set of challenges; firstly, a change in the orbital inclination causes XMM-Newtons ground station Kourou to develop a gap in coverage around perigee for a period of 5 years from mid-2014 and secondly, XMM-Newtons second prime ground station, Perth, is to be decommissioned at the end of 2015 due to regulation governing civil spectrum usage. This paper illustrates how these issues are resoled from a ground segment perspective and when implemented will ensure XMM-Newtons continuance into the next decade.

The eROSITA/SRG All-Sky Survey: A new era of large-scale structure studies with AGN

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The four-year X-ray all-sky survey (eRASS) of the eROSITA telescope aboard the Spektrum-Roentgen-Gamma (SRG) satellite will detect $\sim$ 3 million active galactic nuclei (AGN) with a median redshift of $z \approx 1$ and typical luminosity of $L_{0.5-2.0keV} \sim 10^{44}$ erg s^{-1}. We show that this unprecedented AGN sample, complemented with redshift information, will supply us with outstanding opportunities for large-scale structure research.

For the first time with a sample of X-ray selected AGN, it will become possible to perform detailed redshift- and luminosity-resolved studies of the linear bias factor. These studies will dramatically improve our understanding of AGN environment, triggering mechanisms, growth of super-massive black holes and their co-evolution with dark matter halos.

The eROSITA AGN sample will become a powerful cosmological probe. It will become possible to convincingly detect baryonic acoustic oscillations (BAOs) with $\sim 8\sigma$ confidence in the $0.8 < z < 2.0$ range, currently uncovered by any existing BAO surveys.

To exploit the full potential of the eRASS AGN sample, photometric and spectroscopic surveys of large areas and a sufficient depth will be needed.

The new SCOS-based EGSE of the EPIC flight-spare on-ground cameras

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After almost 15 years since its launch, the instruments on-board the XMM-Newton observatory continue to operate smoothly. However, since the mission was originally planned for 10 years, progressive ageing and/or failures of the on-board instruments can be expected. Dealing with them could require substantial changes in the operating software and the command & telemetry database, which shall be tested with the on-ground flight-spare cameras. To this aim, the original Electrical Ground Support Equipment has been replaced with a new one based on SCOS2000, the same tool used by ESA for controlling the spacecraft. This was a demanding task, since it required both the recovery of the specialised knowledge regarding the original EGSE and need to adapt SCOS for a special use. Very recently this work has been completed by fully replacing the EGSE of one of the two cameras, which is now ready to be used by ESA. Here we describe the scope and purpose of this activity, the problems faced during its execution and the adopted solutions, and the tests performed to demonstrate the effectiveness of the new EGSE.

Status of ESA developments for the L2 X-Ray Observatory Mission

David Lumb[1]
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ESA has selected a high energy astrophysics theme for the 2nd Large mission of the Cosmic Visions programme. The key milestones for the development of this mission are described. The successful implementation of a high energy astrophysics theme for the ESA L2 mission depends upon the availability of key technologies. These include the X-ray optics, with unprecedented combination of effective area and angular resolution, as well as system-related developments for fast response, focal plane deployment, thermal sub-systems etc.. We describe progress in activities to secure these critical aspects, with prospects for enhancing the science return for the mission.

On the importance of polarimetry for the future of X-ray astronomy

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The first measurement of extra-terrestrial, soft X-ray polarization goes back to the 1970s, with the detection of linear polarization coincident with the Crab Nebula, strengthening the idea of a possible synchrotron origin of the X-ray polarization. But, since the launch of the 8th Orbiting Solar Observatory in 1975, that put upper limits on several, other X-ray bright objects, the enthusiasm for X-ray polarization measurement decreased. It is surprising as an increasing number of studies show that, from X-ray binaries to active galactic nuclei, the resulting X-ray emission should be polarized up to 70%. Polarization being highly sensitive to the source morphology, the geometry of the reprocessing material, the spacetime through which the X-rays propagate, and the strength of local magnetic fields, it becomes feasible to probe the vicinity of energetic targets using X-ray polarimetry in association with spectral and timing analyses. Hence, this talk will investigate the topic of X-ray polarimetry as an important instrument for future X-ray campaigns. The physical processes responsible for polarized emission will be reviewed to show examples of how X-ray polarimetric measurement could be used to constrain the close environment of compact objects and bring crucial informations to topical debates.

Constraining the layout of circumnuclear clouds with respect to the supermassive black hole in the Galactic center: outlook of X-ray polarimetry

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Despite past panchromatic observations of the innermost part of the Milky Way, the overall structure of the Galactic Center (GC) remains enigmatic in terms of geometry. Here we aim to show how polarimetry can probe the three-dimensional position of the molecular material in the central 100 pc of the GC. We investigate a model where the central supermassive black hole Sgr A* is radiatively coupled to a fragmented circumnuclear disc (CND), an elliptical twisted ring representative of the central molecular zone (CMZ), and the two main, bright molecular clouds Sgr B2 and Sgr C. Results indicate that Sgr B2 and Sgr C, situated at the two sides of the CMZ, present the highest polarization degrees (66.5% and 47.8% respectively), both associated with a polarization position angle $\psi = 90°$ (normal to the scattering plane). We also consider a range of spatial locations for Sgr A* and the reprocessing media, and investigate how the modeled three-dimensional geometry influences the resulting GC polarization. The two reflection nebulae are found to always produce high polarization degrees ($\gg 10\%$) and are thus prime targets for polarization measurement. We show that a 500 ks observation with a broadband polarimeter could constrain the location and the morphology of the scattering material with respect to the emitting source.

Stability of the XMM-Newton EPIC-pn and Variability of X-ray Sources

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XMM-Newton observations of the LMC supernova remnant N132D at intervals throughout the mission have provided the means to make an assessment of the long-term stability of the instruments. A set of data in EPIC-pn small-window mode taken under identical or almost identical geometrical conditions suggests that the instrument has been stable to about 0.1% once background variations have been taken into account. The establishment of the firmest temporal reference system in X-ray astronomy then allows unbiased measurements of the instrinsic variability of objects of both calibration and more general physical interest. Here we discuss the isolated neutron star RXJ1856-3754 and the supergiant O star zeta Puppis.

`cdfs-sim`, `cdfs-extract`, `LFtools`: new software tools for XMM-Newton and other missions

Piero Ranalli[1]
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With the increasing size and complexity of data in modern astrophysics, software is playing a major role among the astronomer's tools. The public availability of code is key to allow a faster advancement of science, and to guarantee the reproducibility of published results.

In this poster I will present a collection of programs which I have been developing as part of my research, which are being successfully used by different groups for their publications (XMM-CDFS, Stripe-82, XXL), and which I have publicly released as free software. While currently tuned to XMM-Newton, all of them are extensible to other missions. The list includes:

- `cdfs-sim`: a simulator of X-ray astronomical observations. It can simulate an arbitrary set of point sources and reproduce the XMM-Newton background, giving an event file which can be analyzed with SAS.
- `cdfs-extract`: a program to extract spectra for multiple sources in multiple XMM-Newton observations.
- `LFtools`: a set of programs to compute luminosity functions, with binned estimates, maximum likelihood fits and Bayesian parameter exploration.

The Wide Field Imager for the Athena X-ray Observatory

Arne Rau[1]
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The Wide Field Imager (WFI) is one of the two scientific instruments of the Athena mission concept proposed for ESA's next large X-ray Observatory. The instrument will make optimal use of the grasp provided by the Athena mirror system, by combining a sensitive 40' diameter field of view DEPFET detector with an excellent spectral resolution and a pixel size properly sampling the angular resolution of 5" on-axis (half energy width). This synthesis makes the WFI a very powerful survey instrument, exceeding existing facilities by up to a factor of 100 in survey power. This will allow, e.g., to observe the earliest low-luminosity AGNs in the Universe, unraveling the seeds and growth mechanism of AGN at high-redshift. In addition, the WFI will provide unprecedented high-time resolution and high count rate capabilities for the observation of bright sources with low pile-up and high efficiency. I will present the instrument concept, the status of the hardware development, and highlight the breakthrough scientific capabilities of the instrument.

Towards Practical Deep-Space Navigation using X-ray Pulsar Timing

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We describe a recently completed study, conducted by the National Physical Laboratory and the University of Leicester for the European Space Agency, on the feasibility of using X-ray timing observations of pulsars for deep space navigation, a technique commonly referred to as XNAV. We have considered all primary aspects of the system, i.e. suitable pulsars and their sky distribution, available and future instrumentation, navigation methods and algorithms, and overall performance (e.g. position accuracy). We have used simulations to identify the best combinations of navigation method and X-ray pulsars with respect to predicted performance, taking account of current and future X-ray instrumentation. The XNAV technique would allow increased spacecraft autonomy, improved position accuracies and lower mission operating costs compared to the NASA and ESA Deep Space Networks (DSN). We have also used a high-level navigation algorithm together with real data (from the RXTE mission archive) for the Crab pulsar to demonstrate key elements of XNAV. X-ray instrumentation suitable for use as a spacecraft operational subsystem must be designed to use only modest spacecraft resources. We show that instrumentation designed for the Mercury Imaging X-ray Spectrometer, in production for the ESA/JAXA BepiColombo mission to Mercury, offers a roadmap for a practical XNAV system. We identify key areas for future study.

Toward solving the mystery of the AGN soft X-ray excess with hard X-ray observatories

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The physical origin of the 'soft excess' below 1keV in many AGN spectra remains unclear. Diverse models have been suggested, including ionised reflection from the inner part of the accretion disc, ionised winds/absorbers and Comptonisation. Ionised reflection suggests a natural link between the prominence of the soft excess and the 'hard excess' or Compton reflection hump strength above 10keV, but it has not been possible to test this relationship until now, with reliable simultaneous broad-band X-ray observations from joint XMM-NuSTAR campaigns. We present extensive simulations of spectra from ionised reflection and ionised absorption using current (XMM, NuSTAR) and future (ASTRO-H) instrumental responses, to determine how these models can be distinguished using simple broad-band observables. We propose a new diagnostic to distinguish soft-excess production mechanisms using a simple simultaneous measure of their soft excess and hard excess strengths (S, R). This approach can be straightforwardly extended to other soft-excess candidate models. Our work shows how current and future state-of-the-art observatories can offer real potential for progress on this issue.

The 3XMM catalogue

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The 3XMM X-ray catalogue produced by the XMM-Newton Survey Science Centre (SSC) contains 531261 X-ray detections across 794 square degrees of sky and 372728 unique X-ray sources. This catalogue realeased on 23rd July 2013 contains almost 50% more sources than the previous version (2XMMi-DR3) and uses significant improvements to the XMM-Newton Science Analysis Software as well as incorporating developments with the calibration. Improvements include better source characterisation, a reduced number of spurious source detections, better astrometric precision, greater net sensitivity and spectra and timeseries for fainter sources, with improved signal-to-noise. The median flux is 2.4e-14 erg/cm/s and the data taken span 12 years. It is therefore the ideal resource to search for faint/distant sources as well as variable objects. We summarise the 3XMM catalogue and present some of the rare and interesting objects discovered within it, including accreting stellar mass compact objects, tidal disruption events and extreme AGN.

Detecting Tidal Disruption Events (TDEs) with the *Einstein Probe*

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Stars are tidally disrupted and accreted when they approach supermassive black holes (SMBHs) closely, producing a flare of electromagnetic radiation. The majority of the (approximately two dozen) tidal disruption events (TDEs) identified so far have been discovered by their luminous, transient X-ray emission. Once TDEs are detected in much larger numbers, in future dedicated transient surveys, a wealth of new applications will become possible. Including (1) TDE rate measurements in dependence of host galaxy types, (2) an assessment of the population of IMBHs, and (3) new probes of general relativity and accretion processes. Here, we present the proposed X-ray mission *Einstein Probe*, which aims at detecting TDEs in large numbers. The mission consists of a wide-field micro-pore Lobster-eye imager (60deg x 60deg, or ∼1 ster), and is designed to carry out an all-sky transient survey at energies of 0.5-4 keV. It will also carry an X-ray telescope of the same micro-pore optics for follow-ups, with a smaller field-of-view. It will be capable of issuing public transient alerts rapidly.

Chapter 12

Accretion Physics

Ultraluminous X-ray Sources with NuSTAR and Friends

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We present the results of the first large program of broadband ULX observations with XMM-Newton, Chandra, Suzaku and NuSTAR, yielding high-quality spectra and timing measurements from 0.330 keV in a sample of bright ULXs, and providing powerful information for understanding the accretion modes and nature of their central BHs. In particular, we find that all ULXs in our sample have a clear cutoff above 10 keV. This cutoff is less pronounced than expected by Comptonization from a cold, thick corona. We confirm the presence of a soft excess at low energies in the brightest ULXs, with temperatures below 0.5 keV. We make an estimates on the masses of several ULXs based on spectral variability and model fitting.

Anatomy of the AGN in NGC 5548: Evidence for an unexpected, new, heavy, variable and complex absorber

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After a very successful multi-satellite campaign on Mrk 509 in 2009, we conducted a similar campaign on the AGN NGC 5548 in 2013. The source appeared strongly absorbed in the soft X-rays during this campaign, and signatures of strong outflows were also present in the UV. A talk (PI: J. Kaastra) of an overview of this campaign is also proposed to this conference. I propose here to present the EPIC results from the campaign focusing on the analysis of the new, heavy, and variable absorber found in this otherwise archetypical type-1 source. I will put these results into context by reviewing other recent evidence for massive (either highly ionized or neutral) absorbers along the line of sight of other type-1 AGNs, and will present some of their possible interpretations under discussion in the literature: from eclipsing broad line region clouds, to clumpy dusty tori and accretion disc winds. Finally, I will argue that the combination of our new X-ray and UV data for NGC5548 places interesting and severe constraints on some of these interpretations.

A Hard X-ray Power-Law Cutoff in Cen X-4

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The LMXB Cen X-4 is the brightest and closest quiescent neutron star (NS) transient. Previous 0.5-10 keV observations in quiescence identified two spectral components: soft thermal emission from the NS atmosphere and a hard power-law tail of unknown origin. We report on a simultaneous observation of Cen X-4 with XMM-Newton (35 ks) and NuSTAR (116 ks) in 2013 January, providing the first sensitive measurement of the hard X-ray spectrum of a quiescent NS/LMXB transient. We clearly detect a cutoff the hard spectral tail above 10 keV, the first time such a feature has been detected in this source class. Comptonization is ruled out on physical grounds, while synchrotron shock emission from a pulsar wind is possible but unlikely. The spectrum is well fit by an 18 keV thermal bremsstrahlung model, which can be understood if only a small fraction of the accretion flow eventually reaches the NS. We argue that most of the flow is centrifugally inhibited by the propeller effect. The soft spectrum is consistent with NS atmosphere emission in the presence of extremely weak accretion. We discuss the implications of these results for the X-ray spectra expected from quiescent neutron stars and black holes in LMXB transients.

Unveiling recurrent jets of the ULX Holmberg II X-1: evidence for a massive stellar-mass black hole?

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We report on the discovery of an apparent triple radio structure hidden inside the radio bubble of the ultraluminous X-ray source Holmberg II X-1. The morphology is consistent with a collimated jet structure, which is observed to emit optically thin synchrotron radiation. The central component has a steep radio spectrum and is brighter than the outer components indicating a renewed radio activity. We estimate a minimum time-averaged jet power of $\sim 2 \times 10^{39}$ erg s^{-1} that is associated with a time-averaged isotropic X-ray luminosity of at least 4×10^{39} erg s^{-1}. Our results suggest that Holmberg II X-1 is powered by a black hole of $M_{\rm BH} \geq 25$ M$_\odot$, that is inferred to be accreting at a high Eddington rate with intermittent radio activity. Our results strengthen the view that physical properties of accretion and ejection are scale invariant over a possibly homogeneously populated BH mass range. Future studies may confirm a distinct formation channel of massive stellar-mass BHs, that are possibly caught for a short active time and evolve fast in environments akin to early cosmological conditions.

Swift/X-ray telescope monitoring of the supergiant fast X-ray transient IGR J17354-3255

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We report on the first monitoring of the supergiant fast X-ray transient IGR J17354-3255 with the soft X-ray instrument Swift/XRT. The Swift observations span 1.2 orbital periods (P=8.4474 d) for a total exposure of about 24 ks. The study of the flux variability of the sources in the XRT field of view allowed us to unambiguously identify the soft X-ray counterpart of IGR J17354-3255. The 0.3-10 keV XRT light curve shows a moderate orbital modulation and a dip. We compared the observed X-ray light curve with those calculated with a model based on the Bondi-Hoyle accretion theory, for different wind parameters, eccentricities and spectral type of the donor star. We found that the X-ray orbital modulation produced by a neutron star in an eccentric orbit cannot explain the presence of the dip. We showed that an eclipse or the onset of a gated mechanism are the most likely explanations for the dip.

A close re-examination of the XMM-Newton observations of GX 339-4.

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The inner disc radii of XRBs are currently believed to truncate from the ISCO when transitioning from the high/soft to the low/hard state. Disc truncation has been used to explain the observed deviations in the ($F \propto T^4$) relation and also qualitatively explain jet formation via an inner ADAF. However the mechanism for truncation and the assumption of a constant colour correction factor remain unclear. If the colour correction factor were in fact flux dependent, disc truncation would no longer need to be invoked.

We re-assess a decade of XMM-Newton data of the BH binary GX339-4, taken with the EPIC pn-camera. Previous work by several groups using this same data, reached contradictory conclusions. Here we track variations in the spectrum within the hard state observation using flux-sliced spectra. We use the high-resolution RGS data to fix the interstellar absorption, eliminating one source of uncertainty in the modeling. Unlike previous work, we use the very latest relativistic reflection models, and attempt to enforce physical consistency of the parameters for disc (thermal), coronal (power law) and reflected (disc reprocessed) emission. The result is a new, and arguably more robust, conclusion on the requirement for disc truncation in the hard states of XRBs.

Studying the inner accretion disk of GX 339-4 with NuSTAR and Swift

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The latest outburst of the famous transient black-hole binary GX 339-4 at the end of 2013 was intensely monitored by NuSTAR and Swift. Here we present the spectral analysis of four NuSTAR and Swift observations following the rise of the outburst and a final observation at the end of the outburst. During the outburst GX339-4 never left the low-hard state. The NuSTAR data provide excellent data quality to study the reflection component in this state. The iron line shows a significant broadening which is best described by relativistic effects close to the black-hole. If we assume a standard disk with an emissivity index of q=3, the accretion disk seems to be truncated before reaching the ISCO, as expected in the low-hard state. However, if we use a lamp-post geometry for the X-ray corona and self consistently describe the emissivity, the data can be explained by either a truncated accretion disk or a corona located several tens of r_g above the black-hole. Both scenarios show a weak dependence on flux, with the strongest relativistic effects measured at the highest flux phases. We discuss the physical implications of both models.

MINBAR: A comprehensive study of 6000+ thermonuclear shell flashes from neutron stars

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Thermonuclear (type-I) X-ray bursts have been observed from accreting neutron stars since the early 1970s. These events serve as a valuable diagnostic tool to constrain the source distance; accretion rate; accreted fuel composition, and hence evolutionary status of the donor; and even the neutron star mass and radius. Additionally, large samples of bursts can serve to test models describing ignition and burning, and hence constrain the nuclear processes taking place. The Multi-INstrument Burst ARchive (MINBAR) is an effort to combine large samples of burst observations from *BeppoSAX*/WFC, *RXTE*/PCA, and *INTEGRAL*/JEM-X. We have searched observations of the approximately 100- known X-ray burst sources, and have accumulated more than 6000 events from 83 sources over the past 20 years. We describe the assembly of the catalogue, the analysis procedures, and the science outcomes and prospects. Notable results so far include a systematic analysis of short recurrence time bursts; evidence for accretion rate variation during bursts; studies of the burst behaviour of new transients; and long-duration bursts including super bursts.

The impact of an X-ray superburst from the neutron star in 4U 1636-536 on the accretion disk

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Superbursts are rare hours-long X-ray flashes observed from accreting neutron stars. A thousand times more energetic than the regular short Type I bursts, superbursts are thought to be powered by thermonuclear fusion of carbon deep below the neutron star surface. Because of their long duration, these bursts are well suited to study how the accretion disk changes as it is illuminated by the powerful superburst emission. We analyze one of only two detailed superburst observations, and find spectral features that suggest the burst flux is reflected from the accretion disk. An enhanced hard tail in the spectrum may indicate that the accretion rate temporarily increases. Using detailed models of reflection spectra we constrain changes in the ionization state and the geometry of the accretion disk throughout the superburst.

A Unified View of the Spectral States of ULXs Using the Te/Tin Ratio

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Ultra-Luminous X-ray sources (ULXs) are unusually bright X-ray objects in external galaxies. Though still controversial, they are good candidates for intermediate mass black holes (Makishima+2000). They are found either in the Disk-like state wherein the spectra have round shapes, or in the Power-Law (PL) state with power-law shaped spectra. Although the former spectra are often fitted with a Slim disk model while the latter ones with a Comptonized disk model (Cdm), the former are also reproduced with the Cdm, leading to more reasonable interpretation (Miyawaki+2009).

Aiming at a unified description of the two states, we applied the Cdm to the spectra of several ULXs observed by *Suzaku*. Regardless of the spectral states, the model was successful on every data set, yielding relatively cool disk with a sub-keV temperature $T_{\rm in}$, and a corona with an electron temperature of $T_{\rm e} \sim$ a few keV. To quantify the fitting results, we introduced a new parameter $Q = T_{\rm e}/T_{\rm in}$, which represents the balance between coronal cooling by photons and heating by ions. We found that Q successfully distinguish the two states of ULXs, with $Q \sim 3$ for the Disk-like state and $Q \sim 10$ for the PL state.

X-ray emission from hot accretion flows

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We developed a model for a precise study of spectral formation in hot accretion flows (ADAFs). We compare predictions of the model with X-ray observations of accreting black holes and we find a good agreement with black hole binaries observed below 1 per cent of the Eddington luminosity. On the other hand, we note large discrepancies between the standard ADAF model and AGNs observed at such luminosities. We find that the model can be reconciled with the observational data for AGNs if relevant hadronic processes (in particular, production of relativistic electrons through charged pions decay) are taken into account.

The Quiescent Neutron Star and Hierarchical Triple, 4U2129+47

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4U 2129+47 is a quiescent, eclipsing neutron star that 30 years ago showed "Accretion Disk Corona" behavior. Now faded, 4U 2129+47 provides tests of neutron star quiescent emission. It has shown low temperature thermal emission (neutron star surface), a power law tail (unknown origin), and sinusoidally modulated absorption (disk) as well as periodic eclipses. Subsequent XMM observations indicated that the tail and sinusoidal modulation disappeared, as if the accretion stream and disk vanished, although recent (2012) Chandra observations may indicate a mild-resurgance of the tail. With the loss of the tail, the soft X-ray flux also decreased by 40%. This could indicate further cooling of the neutron star surface. It also has been speculated that 4U 2129+47 is part of a hierarchical triple, with the third body in a much longer orbit. The XMM and recent Chandra observations exhibit significant residuals for the eclipse ephemeris. We discuss the possibility of a third body, and we also consider the alternative that the residuals are akin to those in EXO 0748-676, which are attributed to changes in the magnetic structure of the secondary. Changes in the secondary, and hence the accretion stream, could be related to the loss of the hard tail.

Monte Carlo modelling of Comptonised X-ray radiation from accretion flows onto neutron stars and black holes

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Accretion flows onto Galactic compact objects such as neutron stars and black holes have been best studied in the X-ray band. Recent progress in observational instruments allows us to investigate detailed temporal and spectral behaviour of the flows which should contain important information on accretion physics. However, precise comparison between the high-quality data and theoretical models requires careful treatment of X-ray generation in the accreted plasma which can have complicated structure. For this purpose, we have developed a general-purpose calculation framework of radiative transfer based on Monte Carlo methods, and applied it to Comptonisation. Multiple Compton scatterings, which play a key role in the radiative processes, are accurately traced by the simulation in complicated geometry. Using this framework, we build a radiation model of a columnar flow onto a magnetised neutron star where thermal and bulk Comptonisation are responsible for generating the X-ray spectrum, and extract physical properties of the accretion column by analysing broadband data of Vela X-1 obtained with Suzaku (Odaka et al. 2013, 2014). The same framework is applied to the low/hard state of black hole binaries, and we discuss features of quasi-periodic oscillation and X-ray polarisation.

Relativistic jets without large-scale magnetic fields

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The canonical model of relativistic jets from black holes requires a large-scale ordered magnetic field to provide a significant magnetic flux through the ergosphere—in the Blandford-Znajek process, the jet power scales with the square of the magnetic flux. In many jet systems the presence of the required flux in the environment of the central engine is questionable. I will describe an alternative scenario, in which jets are produced by the continuous sequential accretion of small magnetic loops. The magnetic energy stored in these coronal flux systems is amplified by the differential rotation of the accretion disc and by the rotating spacetime of the black hole, leading to runaway field line inflation, magnetic reconnection in thin current layers, and the ejection of discrete bubbles of Poynting-flux-dominated plasma. For illustration I will show the results of general-relativistic force-free electrodynamic simulations of rotating black hole coronae, performed using a new resistivity model. The dissipation of magnetic energy by coronal reconnection events, as demonstrated in these simulations, is a potential source of the observed high-energy emission from accreting compact objects.

X-ray observations of supersoft binaries: Status and perspectives

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Luminous supersoft X-ray binaries form a distinct class of objects characterized by their very soft X-ray spectra with temperatures on the order of 30 eV and near Eddington rate luminosities. We review observations of representative class members obtained with XMM-Newton and Chandra over the past decade. Implications for physical models of supersoft X-ray binaries will be discussed along with perspectives for future observations with ongoing and planned X-ray missions.

The ultraluminous state refined: spectral and temporal characteristics of super-Eddington accretion

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Recent evidence - in particular the hard X-ray spectra obtained by NuSTAR - reveals that ultraluminous X-ray source (ULX) behaviour is inconsistent with known sub-Eddington accretion modes, as would be expected for an intermediate-mass black hole. Instead, it appears that the majority of ULXs are powered by super-Eddington accretion onto stellar-mass black holes. The key question for ULXs then becomes: how does this super-Eddington accretion work? Here we present new results from ULX spectral and timing studies that delve deeper into their underlying physical mechanisms. We firstly show that the spectral and temporal characteristics of ULXs appear intrinsically interwoven, with high levels of variability apparent when the spectra are dominated by a soft component. It has been suggested that this component represents the emission from an optically-thick wind driven radiatively from the ULX; we examine evidence that may corroborate this model. Finally, we present a revised picture of super-Eddington processes in which we also consider how both mass accretion rate variability propagating through a super-Eddington disc, and scattering within the wind, might affect the X-ray characteristics as a function of accretion rate and of viewing angle. We show that its predictions are qualitatively similar to the observed behaviour of ULXs.

An optical version of the Fundamental Plane of Black Hole activity

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Black Hole accretion and jet formation have long been thought to be scale invariant. One empirical relation suggesting scale invariance is the Fundamental Plane of Black Hole activity, which is a plane in the space given by black hole mass and the radio/X-ray luminosities. We search for an alternate version of this plane using optical emission instead of X-ray luminosity. We use a complete sample of 39 supermassive black holes selected from the Palomar Spectroscopic Survey with available radio and optical measurements and information on black hole mass. The stellar mass X-ray binary GX339-4 has also been included to examine if physical processes behind accretion is universal across the entire range of black hole mass. We present results of multivariate regression analysis performed on the AGN sample and show that the sample stretches out as a plane in the 3D logarithmic space created by bolometric luminosity, radio luminosity and black hole mass. We examine the positioning of GX339-4 in the new-found plane to reflect on the complete mass scaling of the relation. We also explore implications for X-ray to Bolometric correction factor for AGN and finally discuss the radio loudness of Seyferts and Liners in light of the new-found correlation.

The potential of X-ray polarimetry

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Up-scattering of low-energy photons by Inverse Compton processes in a hot gas of electrons (i.e. Comptonization) is a common astrophysical mechanism particularly important in accreting systems like X-ray binaries (XRBs) and Active Galactic Nuclei (AGN). Polarization signals produced by scattering strongly depend on the optical thickness and geometry of the scattering medium as well as on the observer's viewing angle. The polarization degree and angle can be used to constrain, for example, the still unknown parameters which characterize the hot corona responsible for the production of X-ray radiation in AGN or the dominant mechanism responsible for the broadening of the Iron K-alpha emission line whose origin is still a matter of debate in the case of low mass X-ray binaries with a neutron star. Conducting accurate Monte Carlo simulations we show the potential of X-ray polarimetry, a new perspective of X-ray astronomy. The spectroscopic part of our results can already be exploited today in the light of XMM-Newton and Chandra data and is even more appealing in the perspective of data from NuStar and future X-ray missions.

Sub-Eddington Model Atmospheres, specta, and color corrections for X-ray Bursting Neutron Stars

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The interiors of neutron stars are denser than an atomic nucleus; because of this, measurements of their masses and radii can be used to constrain the equation of state in the ultra high density regime, a regime that is poorly understood both theoretically and experimentally. Observations of thermal emission from neutron stars allows for simultaneous measurements of mass and radius, assuming accurate atmosphere models and if the distances to these objects are known. The hydrogen and helium accreted by X-ray bursting neutron stars is periodically consumed in runaway thermonuclear reactions that cause the entire surface to glow brightly in X-rays for a few seconds. During these bursts, both the mass and radius of the neutron star can be measured. By simultaneously probing neutron star masses and radii, X-ray bursts are one of the strongest diagnostics of the nature of matter at extremely high densities. Accurate determinations of these parameters are difficult, however, due to the highly non-ideal nature of the atmospheres where X-ray bursts occur. Observations from X-ray telescopes such as RXTE and NuStar can potentially place strong constraints on nuclear matter, once uncertainties in atmosphere models have been reduced.

The accreting intermediate mass black hole candidate ESO 243-49 HLX-1

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The X-ray source HLX-1 in the galaxy ESO 243-49 has a maximum X-ray luminosity of 1.3e42 erg/s (0.2-10.0 keV). From the conservative assumption that this value exceeds the Eddington limit by at most a factor of 10, the minimum mass is then 500 solar masses and hence an excellent intermediate mass black hole candidate. The maximum mass estimated from radio observations is 9e4 solar masses. The X-ray luminosity varies by a factor of 50 with an apparent recurrence timescale of approximately one year. This X-ray variability is associated with spectral state transitions similar to those seen in black hole X-ray binaries. Transient radio emission consistent with discrete jet ejections during the transition from the low/hard to the high/soft state is also observed. However, the fast X-ray and optical rise are difficult to understand in the framework of the standard disc instability model. We discuss the various mechanisms for accretion onto the black hole as well as the processes that could be at work for the delayed outburst observed in 2013.

Type I bursts and irradiated discs

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Thermonuclear (Type I) X-ray bursts on accreting neutron stars have long been recognized as powerful diagnostic tools to constrain conditions at the stellar surface. These events can also be expected to have a significant effect on the accretion environment. We present a study of 1,700 Type I bursts in which we allow the accretion rate to increase by varying the intensity of the pre-burst persistent emission, showing that the spectral fits are significantly improved. This is true even for bursts that reach the Eddington limit of the star. We interpret this result to enhanced accretion induced by radiation torque on the disc, and discuss why unrelated confounding spectral effects are implausible. Finally we discuss how three-dimensional computer simulations can help us gain a better understanding of the physics of accretion through an irradiated disc.

Chapter 13

General Relativity: Compact Objects & Reverberation

Timing properties and X-ray lags of an ultraluminous X-ray source

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I will present results obtained from a comprehensive X-ray variability and spectral-timing analysis of the ultraluminous X-ray source (ULX) NGC 5408 X-1. We find that the source's variability properties closely resemble those of black hole binary systems (BHB) during canonical hard-intermediate states. The detection of a highly significant soft X-ray lag, which is one of the main results, will be presented and discussed. In particular, I will point out the analogies with reverberation X-ray lags observed in different BH-accreting systems (from active galactic nuclei to BHB), which suggest the same triggering mechanism is at work in sources of widely different sizes.

The disc-jet-spin connection: 3C273

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Black hole spin is difficult to measure as it leaves an imprint only close to the horizon, but it may be required to produce most dramatic relativistic jets. For stellar mass black holes there are two established methods to measure spin, from the disc continuum peak temperature in disc dominated states, and from the iron line profile in states with more hard X-ray flux. However, these two methods do not always agree! In AGN the higher black hole mass means a lower disc temperature, so the peak is in the unobservable EUV region, and only the iron line method can be used, but in very high mass AGN, the disc temperature is so low that the peak starts to be visible in the far UV. We use archival data from 3C273 where the observed far UV emission clearly requires a disc around a high spin black hole. The accretion flow dissipates all the available accretion energy, yet the jet in this system is known to be as powerful as the observed accretion flow. Since there is no accretion power left, the jet must be powered by another source of energy - and the only one remaining is black hole spin.

Reverberation mapping in the lamp-post geometry of the compact corona illuminating a black-hole accretion disc in AGN.

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The X-ray reverberation mapping of the inner parts of the accretion disc might be used to distinguish between different geometries of the corona, compact or extended, or to measure the properties of the central super-massive black hole, especially its spin. In this contribution I will summarize the basic properties of the reverberation mapping in the lamp-post geometry of the compact corona where the ionisation of the disc due to its illumination is taken into account. The theoretical lag vs. frequency and energy dependences will be shown for different model parameters such as the height of the corona and mass and spin of the black hole. The influence of these parameters on the measured time lags will be discussed and simulations for the future X-ray observatory Athena shown.

Time Lags Reveal the Soft X-ray Excess is not from Reflection in the NLS1 PG1244+026

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The switch between soft leading the hard band on long timescales, to the opposite behaviour on short timescales, is interpreted as the combination of intrinsic fluctuations propagating down through the accretion flow giving the soft lead together with reflection of the hard X-rays giving the soft lag. While most work has focused on the short timescale soft lags, we show that the longer timescale soft leads also give important constraints. We build a full model of the spectral and time variability including both propagation and reflection, and compare our model with the observed power spectra, coherence, lag-frequency and lag-energy spectra. We find that spectra where the soft excess is dominated by reflection cannot reproduce the soft lead at low frequency since reflection will always lag. Conversely, we find that the separate soft excess models have difficulty reproducing the soft lag at high frequency, as although they have some reflected flux at soft energies, this does not contribute enough signal to overwhelm the soft lead. However, reflection should also be accompanied by reprocessing of the non-reflected emission, and this should add to the soft excess at low energies. It is this, rather than reflection, which dominates the soft lag behaviour.

Iron K reverberation in Active Galactic Nuclei

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XMM-Newton, with its long exposure times and large effective area, has revealed a new perspective through which to study the innermost regions of supermassive black holes. Reverberation lags measure the light travel time between the direct X-ray continuum emission produced in the corona, and the reflected emission off the nearby accretion disc. In this talk, I will present our most recent developments in Iron K reverberation, where there is clear evidence of the red wing of the Fe K line responding before the line centroid. In total, Fe K lags have been discovered in eight Seyfert galaxies, and we can now discern a linear scaling relationship between the amplitude of the Fe K lag and the black hole mass. We find remarkably similar Fe K lags profiles in sources with maximally spinning black holes, while in one AGN with a lower spin, the corresponding Fe K lag is narrower. Finally, I will present the results from the joint XMM and NuSTAR campaign, where we probe the lag above 10 keV. X-ray time lag studies offer an orthogonal approach to spectral analyses, and together they are revealing a self-consistent model for the X-ray emission mechanisms near the central black hole.

A New Route to Phase-Resolved Spectroscopy of Pulsations and QPOs in X-ray Binaries

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The accretion disks in neutron star and stellar-mass black hole X-ray binaries provide an opportunity to study matter in strong gravitational fields. In particular, using spectral-timing measurements of X-ray emission, we can analyze the inner parts of the accretion disk and corona. Here we present the application of a new spectral-timing technique to carry out phase-resolved spectroscopy of rapid periodic and quasi-periodic signals from X-ray binaries. This technique measures relative phase and does not require ephemerides or exactly periodic signals, so it is applicable to a wide range of data, from X-ray millisecond pulsations to kHz and low-frequency QPOs. The method gives new insight into the physical mechanisms underlying these signals as well as the geometry of the emitting regions.

Accretion tomography with X-ray reverberation: Localizing the X-ray emission in AGN

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Relativistic X-ray reverberation has emerged as a powerful probe of the inner accretion systems. It relies on the simple principle of a primary X-ray source reflected by a Compton-thick partially ionized material. By measuring the delay as a function of energy in the iron K band at different variability time-scales, emission from different region sizes is separated. Here, I will review some of the recent reverberation results, and present our latest work from a long joint campaign to study the highly variable AGN MCG-5-23-16 with XMM-Newton, Suzaku and NuSTAR.

Chapter 14

Extrasolar Planets and their Hosts

X-ray irradiation of hot Jupiters with atmospheres amenable to comprehensive follow-up

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Intense stellar X-ray and extreme ultraviolet irradiation on planetary atmospheres is thought to cause atmospheric heating and expansion, which eventually results in mass-loss. To put models of irradiated atmospheres to a test, measurements of both the X-ray and EUV emission are required for a large sample of planets, covering a wide parameter range. A sample of six planets with atmospheres that have the potential to be studied using time-resolved transit spectroscopy at UV and optical wavelengths have been observed with the Chandra X-ray observatory. With the measurements we characterize the activity of the host stars and derive an estimate for the planetary mass-loss rate. For future transit campaigns, we derive the Lyman alpha luminosity from the measurements.

Chapter 15

Galactic Centre

Chapter 16

Transients of the Multi-Band Sky

Chapter 17

The Sky at High Energies

Very high energy gamma ray observations of M 31 with VERITAS

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VERITAS, an array of 12 m imaging atmospheric Cherenkov telescopes in southern Arizona, is one of the world's most sensitive detectors of astrophysical very-high-energy (VHE, > 100 GeV) gamma rays. We present the current status of the VERITAS observations of M 31 (Andromeda Galaxy) including an upper limit on the VHE flux and a comparison with theoretical predictions. The dominant mechanism for the formation of diffuse gamma rays is expected to be through the inelastic collision of high-energy cosmic rays with the interstellar medium (ISM). M 31 provides an opportunity to probe this mechanism due to its proximity and spatial extent, with the VERITAS point-spread function sufficient to resolve the ISM dense star-forming ring and the galaxy core with its multiple supernova remnants.

Unveiling long-term variability in XMM-Newton surveys: the EXTraS project

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The 3XMM-DR4 catalogue, the XMM-Newton Slew Survey (XSS) and the associated XMM-Newton EPIC data, are extensive resources for exploring high energy, time-domain astrophysics. Amongst these data are potential, hitherto unidentified variable sources, ranging from short duration (seconds) transients through to objects varying on timescales of years. Variability signatures can be key to understanding the energetics and physical processes in a diverse range of astrophysical settings. The EU/FP7-Cooperation Space framework project, 'Exploring the X-ray transient and variable sky' (EXTraS), aims to exploit these XMM-Newton resources to explore, as fully as possible, the range of X-ray variability present and provide the results to the community through a public database. Here we outline one of the project's core aims, i.e. identifying and characterising long-term (days to years) variability. The 3XMM-DR4 catalogue contains $\sim$67000 sources with multiple detections. 3XMM, in conjunction with the XSS, which has now covered almost 70% of the sky, often with multiple slews, offers excellent scope for identifying new variable objects by tracking their flux between XMM-Newton observations. We discuss the plans for the EXTraS long-term variability catalogue and highlight some examples of the detection of long-term variability in 3XMM-DR4/XSS data.

Name Index