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ABSTRACT BOOK

Oral Communications and Posters

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Chapter 1

Invited Speakers

The role of X-ray astronomy in the era of the big observatories

Xavier Barcons[1]
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I will review the scientific roadmap for the future of X-ray astronomy that has been built around IXO during the last few years, in the areas of SMBH growth along cosmic time, formation of large scale structure, matter under extreme conditions and life cycles of matter and energy in the Universe. Although it is now apparent that a much reduced version of IXO might be the only way to go, the general alignment of its science goals with those listed will remain. Most of the themes put forward are quite central to mainstream contemporary astrophysics, which is a key asset to guarantee that the next large X-ray observatory serves not only a community, but the main questions of astronomy for the next one or two decades. I will also highlight synergies between IXO and planned/future large projects like ALMA, E-ELT, JWST and others like SPICA or EUCLID.

Black hole spin in X-ray binaries and AGN

Laura Brenneman[1]
[1] *Harvard-Smithsonian Center for Astrophysics, Cambridge, USA*

The last decade of science with *XMM-Newton*, *Chandra* and *Suzaku* has enabled sensitive observations of the innermost accretion flow in many black hole systems. Some of the most exciting results to come from these studies are the first robust constraints on black hole spin in both X-ray binaries (XRBs) and active galactic nuclei (AGN). I will review current work on this topic, discussing methodology and the spin measurements that have been obtained thus far for XRBs and AGN. I will also address the implications of these measurements on both stellar and galactic evolution. I will conclude by outlining the prospects for future research on black hole spin in the coming decade and beyond.

The deep sky under the X-ray limelight

Andrea Comastri[1], Piero Ranalli[2], Cristian Vignali[2], Nico Cappelluti[1], Roberto Gilli[1], Ioannis Georgantopoulos[1], Marcella Brusa[3], Xavier Barcons[4], Niel Brandt[5]
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on behalf of the XMM-CDFS Team

The presence of Super Massive Black Holes (SMBHs) in the nuclei of virtually all galaxies has opened a new cross-disciplinary field commonly refereed to as AGN-galaxy co-evolution. According to model predictions the early growth of SMBH is obscured by large amounts of gas and dust.

Deep X-ray surveys are providing a unique tool to investigate a key phase of AGN and galaxy co-evolution. The most important results obtained by the ultra-deep (3 Ms) XMM survey in the Chandra Deep Field South (CDFS) will be presented. In particular the search for and the spectral characterization of Compton thick AGN at moderate to high redshifts and the average properties (intensity and width) of the iron K emission line. Some notable examples of synergies between ultra-deep Chandra (4 Ms) and XMM observations will be reported along with a review of truly multi-wavelength studies which are possible thanks to the premiere set of available data in the CDFS.

The perspectives for future observations with present (Chandra and XMM), foreseen (eROSITA and NuSTAR) and future (IXO) missions will be outlined.

Winds and jets in X-ray binaries

Maria Diaz Trigo[1], James Miller-Jones[2], Simone Migliari[3], Arvind Parmar[4], Laurence Boirin[5]
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[2]*Curtin University, Australia*
[3]*Universidad de Barcelona, Spain*
[4]*ESA, Spain*
[5]*Observatoire de Strasbourg, France*

In the last decade we have witnessed a wealth of discoveries of hot atmospheres and winds in low mass X-ray binaries (LMXBs). The presence of highly ionised plasma in a cylindrical geometry around the compact object has been observed in all the high-inclination neutron stars and black hole LMXBs, i.e. when looking close to the disc. The plasma has been detected as an outflowing wind in black holes and in one neutron star LMXB, whilst only upper limits, $\sim$250 km/s, to the velocity of the wind could be set for the remaining neutron star sources. In black hole LMXBs outflowing winds are observed preferentially in the accretion state when the jet emission is suppressed, suggesting an anti-correlation between the existence of jets and outflowing winds.

I will review recent progress on the study of LMXB atmospheres and winds and present our program to monitor LMXBs with simultaneous X-ray and radio observations, aiming to probe the jet power as a function of the wind properties and to investigate how the radio flux density correlates with the mass-outflow rate carried by the disc wind at different accretion regimes.

Accreting Galactic black-hole systems

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

I will review the spectral and timing properties of X-ray binaries, especially the behaviour seen as the source makes a transition from the low/hard to high/soft state. The broad band spectral evolution is well modeled by a truncated disc/hot inner flow geometry, where the truncation radius moves progressively towards the last stable orbit during this transition. Here I show that this same geometry can also quantatatively match the power spectral evolution, where fluctuations propagating through the hot flow (stirred up by the MRI) make the broad band continuum power spectra, and Lense-Thirring precession of the hot flow makes the prominent low frequency QPO.

Cooling cores and AGN feedback

Andy Fabian[1]
[1] *University of Cambridge, UK*

One third of galaxy cluster cores, and most elliptical rich groups, have gas temperatures dropping into the centre where the radiative cooling time is less than a few Gyr. Heat input by a central AGN - feedback - prevents much of the gas from cooling out. XMM RGS spectra and Chandra imaging have played major roles in defining the feedback process and understanding how it operates. Cool and cold gas emitting in the optical, UV, IR and sub-mm bands is also found in the central regions of cool cores. This has an important part in the feedback cycle. The current situation will be reviewed and illustrated from an observational point of view.

Young neutron stars and the role of magnetic fields in their evolution

Eric Gotthelf[1]
[1] *Columbia University*

Recent years have seen exciting discoveries in the field of young pulsars. This review summaries the latest observational results and interpretations, with an emphasis on the key role that the magnetic field plays. Surprises are found across all classes of young NSs, including the classic rotation-powered (RP) pulsars, the strong-field magnetars, and the most recently discovered low-field anti-magnetars. For the first time, a magnetar has been found coincident with a HESS TeV source. In contrast, detection of a low B-field SGRs questions the need for a high dipole field in producing high-energy bursts. Furthermore, X-ray flares and short bursts from an energetic pulsar blurs the line between magnetars and RP pulsars. Three of the 10 central compact objects in supernova remnants are revealed as weakly magnetized pulsars, with dipole fields smaller than those of any other young NSs. They probably evolve into a large, as-yet unrecognized population of "orphan CCOs" once their SNRs dissipate. The emission properties of pulsars are telling us something about both their internal and external B-fields. How these fields are formed and what accounts for their manifestations is an important problem in current NS astrophysics

X-ray population studies of AGN

Matteo Guainazzi[1]
[1] *ESAC-ESA*

In this talk, I will present a review of "X-ray population studies of AGN". Under this coarse definition I encompass studies dealing with samples of at least 25 homogeneously selected objects with at least 25 X-ray counts each. I will show how these studies have allowed us to address fundamental questions in each of the following fields of AGN astrophysics: the nature of the accretion flow in the General Relativistic regime; the physical drivers determining the nature of the accretion flow; the AGN unification scenarios and the astrophysical driver behind the AGN multifaceted phenomenology; the nature of the AGN multiwavelength Spectral Energy Distribution; the radiative mode of the AGN feedback onto the host galaxy, and its impact on the host galaxy evolution; the mechanism powering the Narrow-Line Regions; the origin of the radio-quiet/-loud dichotomy and the origin of the radio power in the Universe; the geometrical distribution of obscuring matter in the AGN environment; and the contribution of different types of AGN to the X-ray Background.

Explosion, turn-off and recovery of accretion in novae revealed by X-rays

Margarita Hernanz[1]
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Classical and recurrent novae are explosive phenomena occurring on accret- ing white dwarfs. A variety of behaviors have been deduced from X-ray obser- vations performed with current X-ray satellites. XMM-Newton and Chandra offer excellent spectral resolution; grating ob- servations provide a lot of physical insight of the expanding ejecta. A lot of data has been gathered by Swift/XRT, yielding several detections of novae dur- ing their super soft source phase, both in the Galaxy and in M31. Statistics has considerably improved with respect to the ROSAT era, and more complete studies of the turn-off of nuclear burning of classical and recurrent novae are now possible. X-ray observations of classical novae in their post-outburst phases also reveal how accretion onto the white dwarf is resumed - with the system behaving again as a cataclysmic variable. And last but not least, prompt hard X-ray emission has also been observed in some cases (e.g., the recurrent nova RS Oph), revealing strong shocks between the ejecta and the red giant envelope of the companion. In such cases, acceleration of cosmic rays can occur in the ejecta, leading to the emission of very high energy photons, as in the case of V407 Cyg, detected by Fermi.

Studying AGN with high resolution spectroscopy

Jelle Kaastra[1,2]
[1] *SRON Netherlands Institute for Space Research*
[2] *Sterrenkundig Instituut, Utrecht University*

The high-resolution X-ray spectrometers on board of Chandra and XMM-Newton allow us to study the astrophysical processes in the various complex emission and absorption regions in AGN in great detail. Now these missions have been succesful for a decade, there is room for deep monitoring campaigns of individual AGN that allow us to exploit fully a new dimension, time-resolved spectroscopy. In this contribution I will focus on the outflows from AGN. The potential importance of outflows on their environments has been well established, however details about the physical structure, dynamics and location remain uncertain.

I will put these questions in a broader context, but illustrate them using the results of a recent long and deep multi-wavelength campaign on Markarian 509. This campaign consisted of ten regularly spaced, deep 60 ks observations with XMM-Newton, simultaneous with INTEGRAL which were followed by a simultaneous Chandra/LETGS and HST/COS observation, and interspersed with Swift and ground-based X-ray, UV and optical photometry. The time-averaged RGS spectrum allowed us to dissect the ionisation structure of the outflow, while the COS data yielded the dynamical structure. The variability as seen through EPIC in specific bands constrains the location and thereby the impact of the outflow.

The flaring X-ray sky: synergies between e.m. and gravitational wave astronomy

Stefanie Komossa[1]
[1] *MPE, Garching bei Munchen, Germany*

This talk gives an overview of current observations and future schemes to search for high-energy emission from merging compact objects.

Galaxy mergers and accretion onto their supermassive black holes represent a phase of major black hole growth and their study is therefore key to understanding galaxy - black hole scaling relations, and the formation and evolution of galaxies and massive black holes.

The combination of electromagnetic and gravitational wave signatures is a powerful future tool for studying such mergers, binaries, EMRIs, coalescing and recoiling black holes (BHs), identify host galaxies, precisely measure masses and spins of BHs, obtain new constraints on accretion physics, do cosmology, measure merger rates, and get clues on merger history and BH stalling timescales.

A wealth of electromagnetic signatures of binaries and recoiling BHs are currently being predicted, some may have already been observed, and even before the simultaneous detection with GWs, current and future X-ray missions will be efficient in searching for them.

The X-ray emission of magnetic cataclysmic variables

Koji Mukai[1]
[1] *NASA/GSFC/CRESST and UMBC*

The number of known magnetic cataclysmic variables (mCVs) has increased significantly over the last decade thanks in large part to the hard X-ray surveys by INTEGRAL and Swift missions. The quality of X-ray data on new and old mCVs has improved dramatically due to the capability of current generation of X-ray satellites, XMM-Newton, Chandra, and Suzaku. I will present selected highlights from these observation, with an emphasis on physically motivated modeling of X-ray emission and absorption in mCVs. In particular, the importance of complex absorbers in shaping the observed X-ray spectra of mCVs cannot be over-emphasized. With this in mind, I will address several topics, including the hot ($\sim$100 eV) blackbody-like soft component seen in several mCVs, and the soft to hard X-ray luminosity ratios.

Search for WHIM in X-rays

Takaya Ohashi[1]
[1] *Department of Physics, Tokyo Metropolitan University, Hachioji, Tokyo, Japan*

Warm-Hot Intergalactic Medium (WHIM) is characterized by temperatures around 10^6 K and densities only $10-100$ times the average in the universe. Recent theoretical and observational works support the view that WHIM will explain more than half of baryons which remain undetected in the present universe. Its properties will give us unique information about the history of thermalization, chemical enrichment and structure formation in the universe. I will describe some recent Suzaku results on cluster outskirts and superclusters which are related with the search for WHIM. For future high-sensitivity study of WHIM, very high spectral resolution and low intrinsic background are essential for a firm detection of WHIM and its characterization. I will discuss about expected results which will be obtained from IXO and from other dedicated X-ray missions.

Clusters of galaxies in the Planck survey

Etienne Pointecouteau[1]
[1] *IRAP, Toulouse, France*

We present the first all-sky sample of galaxy clusters detected via the Sunyaev-Zel'dovich effect from the Planck survey. This Early SZ (ESZ) sample of 189 candidates comprises high signal-to-noise clusters adn is highly reliable. For a sub-sample of 62 of these ESZ clusters (z ¡ 0.5), we have investigated the scaling relation between the Planck SZ signal and other X-ray derived quantities from XMM-Newton data. In a second approach, we have probed the relation between the SZ signal and the X-ray luminosity down to very low masses at the positions of 1600 X-ray clusters. Both analysis have underlined the concordance between the X-ray and SZ view of the ICM, and the robustness and consistency of our overall model. They also provide a robust basis for upcoming evolution studies. Finally we detail the engaged ambitious validation program with XMM-Newton, observing twenty-five new detected SZ candidates using snapshot exposures. A total of 21 are confirmed as extended X-ray sources. Most have complex and disturbed morphologies, suggesting that Planck may have started to reveal a non-negligible population of massive dynamically perturbed objects.

Magnetar candidates: new discoveries open new questions

Nanda Rea[1]
[1] *CSIC-IEEC, Spain*

I will review our current knowledge of soft gamma repeaters (SGR) and anomalous X-ray pulsars (AXP), two peculiar classes of pulsars believed to be "magnetars", i.e. neutron stars powered by a huge magnetic field. Recent studies of transient events from SGRs and AXPs allowed a large jump in our understanding of these objects, although they also prompted new unanswered questions. In particular, the recent discovery of a low magnetic field magnetar caused a re-think of some of the basic ingredients of the magnetar model.

The population of the Galactic Ridge

Mikhail Revnivtsev[1]
[1] *Space Research Institute, Moscow, Russia*

Our Galaxy hosts a large variety of types of X-ray emitting objects. The most luminous objects - accreting black holes and neutron stars - were discovered more than 40 years. Apart from these bright sources the Galaxy demonstrates a faint stripe along the Galactic plane - the Galactic Ridge X-ray emission - which origin was not clear untill recently. A set of works, aimed on complex study of population of X-ray emitting objects in the Galaxy, accurate mapping of the Galactic Ridge in broad energy range, and its ultra deep imaging resulted in solution of the long standing problem of the origin of the Galactic Ridge X-ray emission. I will demonstrate that this stripe appears as a result of cumulative emission of large number of individually faint sources of different types, mainly accreting white dwarfs and coronally active stars. I will emphasize that X-ray emission of the similar origin has a large impact on studies of outer galaxies, in which the Ridge-like emission might be virtually indistinguishable from the emission of hot interstellar plasma. I will also review the latest advances in studies of X-ray populations, which constitute the Galactic Ridge X-ray emission.

The high energy environment of extrasolar planets

Jürgen Schmitt[1]
[1] *Hamburger Sternwarte*

Almost all hitherto detected extrasolar planets revolve around late-type cool stars. Therefore the interest in the activity of cool stars in general and specifically that of extrasolar planet host stars has enormously rekindled in the last few years. I will summarize our knowledge of the X-ray properties of cool stars, and then focus on the X-ray properties of extrasolar planet host stars. I will discuss the case for star-planet interaction from the X-ray point of view. I will further discuss the possibility of X-ray eclipses during transits and finally I will present extreme (from the activity point of view) cases of host stars and the ensuing physical implications on the planetary atmospheres.

X-ray emission from stars: recent advances and future prospects

Beate Stelzer[1]
[1] *INAF - Osservatorio Astronomico di Palermo*

More than a decade of Chandra and XMM-Newton observations have yielded deep insight into the X-ray properties of stars across the HR diagram. The advent of stellar high-resolution spectroscopy has enabled detailed studies of the characteristics of stellar coronae in late-type stars and wind-driven X-rays from early-type stars. This led to many unexpected results, e.g. concerning the coronal abundances and the emission line profiles of hot stars. The significant increase in sensitivity brought into reach several classes of faint or highly extincted X-ray emitters, such as brown dwarfs, protostars and Wolf-Rayet stars. Accretion and jet shocks were established as X-ray emission mechanisms in young stars, where they compete with the traditional coronal paradigm. Moreover, the central role of stellar X-rays for the evolution of protoplanetary disks and planet atmospheres has been recognized.

The picture of X-ray emission in stars and its interaction with the circumstellar environment has revealed to be more complex and varied than anticipated. Understanding and disentangling the various processes at work is pushing present-day X-ray instrumentation to its limits. I review advances in the field and present prospects for future X-ray missions.

From abundance studies to cosmic ray physics: the impact of imaging spectroscopy

Jacco Vink[1]
[1] *Utrecht University*

I will review the impact of X-ray imaging spectroscopy on the our understanding of supernova remnants. I concentrate on two key topics: 1) How identifying and characterizing X-ray synchrotron emission has helped our understanding of cosmic ray acceleration. In this context I will also discuss the synergy with GeV (Fermi) and TeV astronomy. 2) With X-ray imaging spectroscopy we can map abundance patterns inside young supernova remnants, and what the differences are between Type Ia and core collapse SNRs.

Accreting binary populations in nearby galaxies

Andreas Zezas[1]
[1] *Harvard-Smithonian Center for Astrophysics, University of Crete*

The existing X-ray observatories give us a detailed picture of the accreting binary populations and diffuse X-ray emission in a wide range of galactic environments. I will present recent results from the analysis of Chandra data on a sample of nearby galaxies spanning the range of Hubble types. Special focus will be given on new constraints on the formation rate of accreting binaries, and the dependence of the X-ray source luminosity function on the stellar content of the sample galaxies.

Chapter 2

Solicited Speakers

The future Sino-French SVOM gamma-ray burst mission

Didier Barret[1], Jacques Paul[2], Janyan Wei[3], Shuang-Nan Zhang[4], Stéphane Basa[5], Pierre Mandrou[1], Bertrand Cordier[2], Olivier Godet[1], Stéphane Schanne[2]
[1]*IRAP*
[2]*CEA*
[3]*NAOC*
[4]*IHEP*
[5]*LAM*

The Space-based multi-band astronomical Variable Object Monitor (SVOM) is a space based mission for Gamma-Ray Burst (GRB) studies, developed in cooperation between the Chinese National Space Agency (CNSA), the Chinese Academy of Science (CAS), the French Space Agency (CNES) and French research institutes (CEA, IRAP, ...). The SVOM scientific objectives include the classification of GRBs, the study of their progenitors, the use of GRBs as fundamental physics and cosmological probes. In this paper, we will present the SVOM payload elements, the SVOM observation strategy, as well as key elements of the ground based GRB follow-up system.

LOFT - Large area Observatory For x-ray Timing

Marco Feroci[1]
[1]*INAF/IASF Rome*

LOFT is an innovative mission concept devoted to X-ray timing and spectral studies of collapsed objects, recently selected by ESA as one of the four candidate M3 missions in the Cosmic Vision programme. Thanks to its large effective area, peaking at 12 m2 (20x RossiXTE/PCA) in the energy range 2-30 keV, and its energy resolution of order of 250 eV, LOFT is proposing to study the behaviour of matter under strong gravitational fields as well as the state of matter in ultradense conditions, such as the neutron star interiors.

The main LOFT experiment, the Large Area Detector, is based on Silicon Drift Detectors, observing through a field of view of 43 arcminutes as limited by a capillary plate collimator. A coded-mask Wide Field Monitor, using the same detector technology, will complement the scientific payload, providing arcmin-images of the soft X-ray sky simultaneously over a few steradians field of view. The WFM will be able to trigger observations with the LAD, as well as to monitor the long-term behaviour of sources.

In this paper I will present an overview of the mission concept and the current status of the project.

The Nuclear Spectroscopic Telescope Array (NuSTAR)

Fiona Harrison[1]
[1] *Caltech, Pasadena, CA, USA*

The Nuclear Spectroscopic Telescope Array (NuSTAR) will be the first space-based hard X-ray (5 - 79 keV) focusing telescope. NuSTAR will provide a combination of sensitivity, spatial, and spectral resolution a factor ten to several hundred times improved over previous space missions operating in this band. During its two-year primary mission NuSTAR will undertake extragalactic and galactic surveys, and will image young (τ¡ 500 year) supernova remnants, and undertake observations of blazars simultaneously with Fermi and ground based facilities. In addition, a broad range of investigations will be possible in both the prime phase and a proposed guest investigator program. This talk will describe the mission capabilities, the baseline science program, and potential observations for an extended mission.

The Hard X-ray Modulation Telescope mission

Tipei Li[1,2], Shuangnan Zhang[1], Fangjun Lu[2]
[1] *Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
[2] *Department of Engineering Physics, Tsinghua University, Beijing, China*

The Hard X-ray Modulation Telescope (HXMT) is an X-ray astronomical satellite consisting of three slat-collimated telescopes, the High Energy X-ray Telescope (HE), the Medium Energy X-ray Telescope (ME), and the Low Energy X-ray Telescope (LE). HE is sensitive in 20-250 keV. It contains 18 individual cylindrical NaI(Tl)/CsI(Na) phoswich modules, with an area of 283.5 cm^2 each. ME contains 3 individual Si-PIN detector arrays sensitive in 5-30 keV. Its total collection area is 952 cm^2. LE uses the Swept Charge Device as the detector that is sensitive in 1-15 keV. It also contains 3 individual detector arrays, with a total detection area 384 cm^2. HXMT will perform a broad band (1-250 keV) X-ray sky survey and pointed observations of known X-ray sources to study their broadband spectroscopic and multi-wavelength temporal properties. The typical Field of View (FOV) of HXMT is 61 (FWHM), with other larger FOVs so as to measure the cosmic X-ray background. The 3σ continuum sensitivity of HXMT is about 0.5 mCrab (10^5s).

Advanced Telescope for High Energy Astrophysics (Athena) - study status

David Lumb[1]
[1] *European Space Agency*

It has been recommended that all the ESA Cosmic Visions L-class missions should be reformulated to a scale that is affordable to Europe only. The study teams have been asked to consider if revised concepts can be followed that preserve as much of the original science cases as possible. The IXO study team has been investigating a number of potential configurations to satisfy these goals, and the new baseline concept - Athena - has been subject to an internal ESTEC design activity. Following this first phase, an industry study activity is being carried out during summer 2011, with the aim of submitting the results to independent reviews: ESTEC internal technical and programmatic, and scientifically by the ESA advisory groups. We summarise the boundary conditions of this exercise, report on the baseline design concept, and highlight the expected performance parameters. Two coaligned telescopes with fixed focal planes are anticipated, with square metre class collecting area that allows a wide range of key measurements in high energy astronomy. The breadth of exciting science programme that can be achieved with the huge advance in performance (cf. Chandra, XMM-Newton and Astro-H for example) will be indicated.

eROSITA: a new X-ray all-sky survey

Peter Predehl[1]
[1] *Max-Planck-Institut für extraterrestrische Physik*

eROSITA (extended ROentgen Survey with an Imaging Telescope Array) will be the core instrument on the Russian Spektrum-Roentgen-Gamma (SRG) mission. The design driving science is the detection of 100 thousands Clusters of Galaxies up to redshifts z ¿ 1 in order to study the large scale structure in the Universe and test cosmological models including the Dark Energy. This will be accomplished by an all-sky survey lasting for four years plus a phase of pointed observations on selected objects. eROSITA consists of seven Wolter-I telescope modules, each equipped with 54 Wolter-I shells having an outer diameter of 360 mm. In the focus of each mirror module, a framestore pn-CCD provides a field of view of 1 in diameter. eROSITA is fully approved and funded by the German Space Agency DLR and Max-Planck-Society. The instrument is now in phase C/D: The flight mirror production is ongoing, the telescope structure is built and ready for the integration of subsystems. In parallel, the work in house (cameras, electronics etc.) is running, many components are already qualified.

Astrosat

Gordon Stewart[1], Astrosat Team[2]
[1]*Leicester University*
[2]*India, UK, Canada*

Astrosat is the first dedicated Indian astronomy satellite due for launch in 2012.It has a broad-band capability ranginging from the optical to approximatel 100 keV with 4 co-aligned instruments - UVIT a twin UV and optical telescope; SXT a soft X-ray imaging telescope; LAXPC a large area proportional counter and CZTI a coded mask CZT detector. The payload also contains the ASM, an All Sky Monitor. The capabilities of the instruments will be discussed and an overview of the observing programme and time allocation mechanisms given.

X-ray polarimetry with GEMS

Tod Strohmayer[1]
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The polarization properties of cosmic X-ray sources are still largely unexplored. The Gravity and Extreme Magnetism SMEX (GEMS) will carry out the first sensitive X-ray polarization survey of a wide range of sources including; accreting compact objects (black holes and neutron stars), AGN, supernova remnants, magnetars and rotation-powered pulsars. GEMS employs grazing incidence foil mirrors and novel time-projection chamber (TPC) polarimeters leveraging the photoelectric effect to achieve high polarization sensitivity in the 2 - 10 keV band. I will provide an update of the project status, illustrate the expected performance with several science examples, and provide a brief overview of the data analysis challenges.

The ASTRO-H mission

Tadayuki Takahashi[1]
[1]*ISAS/JAXA*

The joint JAXA/NASA ASTRO-H mission is the sixth in a series of highly successful X-ray missions initiated by ISAS/JAXA. ASTRO-H will investigate the physics of the high-energy universe by performing high-resolution, high-throughput spectroscopy with moderate angular resolution. ASTRO-H allows a combination of wide band X-ray spectroscopy (5-80 keV) provided by 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 an X-ray CCD camera for a soft X-ray telescope (0.4- 12 keV) and a non-focusing soft gamma-ray detector (40-600 keV). The simultaneous broad bandpass, coupled with high spectral resolution of 7 eV provided by the micro-calorimeter will enable a wide variety of important science themes to be pursued. It will resolve the fine structure of emission lines and thus macroscopic motions of the ICM down to a speed of a few 100 km/s by the doppler shift of the line center and/or the line broadening. The mission aims to understand the dynamics of the evolution of the Universe and the concentration of the energy including how the most energetic particles are produced.

Chapter 3

Stars, Star-forming Regions, Planetary and Cometary Studies

Young stars around the Horsehead nebula

Juan Facundo Albacete Colombo[1], Javier Lopez-Santiago[2], Miguel Angel Lopez-Garcia[2]
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The Horsehead nebula (Barnard 33) is the nearest bright-rimmed cloud to the Sun, where star formation is taking place at different scales. Deep mid-infrared observations reveal a large variety of objects, from class I to class III stars, including transitional disk objects . Of the 45 reddened sources inside the Horsehead nebula, 14 are bonafide young stellar objects (YSOs), being 12 of them in the surroundings of the pillar. Due to its proximity (400 pc), the Horsehead nebula is an excellent laboratory to study the physics of the X-ray emission in young stellar objects at similar evolutive stages in different environments. We present a partial X-ray view of this region and discuss the impact of a new X-ray observation centered at the Horsehead region.

A very deep X-ray look into the young stellar cluster IC348

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IC348 is the best investigated very young (3 Myr) stellar cluster at a distance ¡= 300 pc from the Sun. Numerous optical/infrared spectroscopic studies and deep Spitzer observations have provided accurate stellar and circumstellar parameters for more than 300 cluster members, including 23 spectroscopically identified young brown dwarfs with masses as low as 0.03 Msun.

Since most of these data were collected after the first Chandra X-ray observation of IC348 (in the year 2000), and since three more Chandra observations and a deep XMM-Newton observation have been obtained since then, we perform a re-analysis of these X-ray data. In the merged data of all four Chandra pointings with a total observation time of 182.86 ks, we detected 290 highly reliable X-ray sources, for 58% and 72% of which optical and infrared counterparts could be identified.

We will present the results of our correlation of these X-ray data with the known stellar and circumstellar properties of these stars. Due to the very long exposure times of the merged X-ray data, we can investigate the relations between the X-ray and stellar/circumstellar properties (luminosity, mass, ages, rotation, disks) down to very low sensitivity limits.

Rotationally modulated X-ray emission from the accretion shock in CTTS

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V2129 Oph Collaboration
V4046 Sgr Collaboration

To study the accretion shocks of classical T Tauri stars (CTTS) we obtained high-resolution X-ray spectra of two CTTS, V2129 Oph and V4046 Sgr, to look for phase-resolved X-ray signatures of shock-heated plasma.

The 200 ks Chandra/HETGS observation of V2129 Oph (a 1.35 M_sun star, rotating in 6.5 d) covered 0.5 stellar rotation. The 360 ks XMM/RGS observation of V4046 Sgr (a binary system, with two 0.9 M_sun components, synchronously rotating in 2.42 d) monitored 2.2 system rotations. The stellar photosphere, magnetic field, and accretion geometry of both stars were constrained by quasi-simultaneous optical monitoring (photometry, spectroscopy, and spectropolarimetry).

The cool plasma component of V2129 Oph varies, with high density plasma and high EM observed during the first observing segment, and lower density and lower EM observed during the second. The emission lines, produced by the high density cool plasma of V4046 Sgr, display periodic flux variations with a period of half the system rotational period.

Our results confirm that the dense cool plasma in CTTS is material heated in the accretion shock, and that the observed X-ray variability can be explained in terms different viewing angles at different rotational phases of the accretion-shock region.

X-ray emission from protostellar jet HH 154: first evidence of a diamond shock?

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In the last decade X-ray emission from about ten protostellar jets has been discovered and now it appears as a common feature of the most energetic jets. We present the X-ray observations of the protostellar jet HH 154 (observed with both XMM/Newton and Chandra) over a time base of about 10 years showing the presence of a stationary shock at the base of the jet. We interpret this result as the first evidence of a diamond shock originating from a nozzle through which the jet is launched into the unperturbed ambient medium. The origin of the nozzle could be related to the protostellar magnetic field which can be constrained by our model. Here we discuss the numerical model of the jet/nozzle system and compare the X-ray emission synthesized from our model with the X-ray observations.

Search for serendipitous TNO occultation in X-rays

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Serendipitous stellar occultation search is so far the only way to detect the existence of very small, very dim, remote objects in the Solar system. To date, however, there are only very few reported detections for trans-Neptunian objects (TNOs) in optical bands. In the X-ray band, with the RXTE/PCA data of Sco X-1 taken from 2007 June to 2009 October, we found one possible X-ray occultation event. We discuss the veracity and properties of this event, and suggest upper limits to the size distribution of TNOs at hectometre size and of main-belt asteroids at decametre size. Future observations with ASTROSAT, AXTAR, and IXO will also be discussed.

The nature and importance of the large spread in T Tauri X-ray luminosities

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Chandra Cygnus OB2 Collaboration

X-ray luminosities of T Tauri stars of a given age and mass are observed to be spread over a range of a factor of 50 or more. It is not yet known whether the large spread arises from variability on timescales of anything from weeks to many years, or from long-lived intrinsic differences in X-ray emitting power. It is also not known whether the large spread in L_X is related to the X-ray luminosities of accreting T Tauri stars being systematically lower on average than those of non-accretors by factors of order 2-3. The Chandra Cygnus OB2 Legacy Survey has recently observed about 10000 association members across a square degree of the cluster, and includes a Chandra ACIS field observed 6 years earlier in 2004. We compare the X-ray luminosities at the two epochs and discuss how the results are vital for protoplanetary disk evolution and planet formation.

Fermi detections in the vicinity of the star forming regions W43 & Westerlund 2

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on behalf of the Fermi-LAT collaboration

Particle acceleration in massive star forming regions can proceed via a large variety of possible emission scenarios, including high-energy gamma-ray production in the colliding wind zone of the massive Wolf-Rayet binary (here WR 20a and WR121a), collective wind scenarios, diffusive shock acceleration at the boundaries of wind-blown bubbles in the stellar cluster, and outbreak phenomena from hot stellar winds into the interstellar medium.

In view of the recent Fermi-LAT detection of HESS J1023-575 (in the vicinity of Westerlund 2), we examine another very high energy (VHE) gamma-ray source, HESS J1848-0145 (in the vicinity of W43), possibly associated with a massive star cluster. Considering data from other wavelengths, in particular X-rays and TeV gamma-rays, we examine the available evidence that the gamma-ray emission fromWesterlund 2 andW43 could originate in particles accelerated by the above-mentioned mechanisms in massive star clusters.

The young open cluster around 25 Ori

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We present XMM-Newton observations of the young ($\sim 7-10$ Myr) cluster recently discovered around the B1Vpe star 25 Ori. We present the results of the EPIC spatial and spectral analysis of the cluster sources, and compare them with those obtained for the younger sigma Ori and lambda Ori clusters, and for other young clusters of similar age.

Chandra/ACIS-I study of the young stellar population of the Eagle Nebula

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The Eagle Nebula (M16) is a rich star forming region at a distance of 1750pc, hosting the massive young open cluster NGC6611 (age of 1Myr). NGC6611 has a total of 54 OB stars in its center and several sites of ongoing star formation. We have analyzed the CHANDRA/ACIS-I observations centered on the cluster and on the outer regions including the well-known dusty pillar called "Column V", and on a group of embedded young stellar objects. Out of the detected 1924 X-ray sources, 1344 are candidate members of M16 and 241 of them have circumstellar disks (including two candidate Class I sources). Using photometric data of the selected cluster members, we determined the cluster disk frequency and the star formation history in the cloud. We also present the global X-ray properties of the cluster members, a comparison between the properties of Class II and Class III candidate X-ray sources, and a study of the X-ray emission from the OB members of the cluster.

Cluster members and disk fraction of Cygnus OB2

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Cygnus OB2, the massive OB association of the Cygnus-X region, hosts more than 2000 OB stars and a vast population of young pre-Main Sequence stars. It is less than 2 kpc from the Sun and a convenient laboratory for studying star formation and protoplanetary disk evolution in the presence of massive stars. The 1.08 Ms Chandra Cygnus OB2 Legacy Survey was completed in 2010 May and has unveiled a population of about 10000 X-ray sources. The X-ray catalog, together with deep infrared and optical photometry, allows a reliable multiwavelength selection of cluster members and identification of disk-bearing and disk-less stars complete down to $1\,M\odot$. I will present a study of the disks fraction of the cluster and will compare this with those of less massive clusters of similar age to probe effects of high mass stars with intense ionizing radiation fields on disk evolution. The average age of the cluster, and the age spread of the stellar population, evaluated by comparison of optical colors of X-ray sources with those predicted by evolutionary models, will be presented and discussed in the context of star formation in massive clusters.

Constraining the ages of X-ray sources in NGC 922

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We present age constraints on 13 X-ray binaries located within the drop-through ring galaxy NGC 922. Star-formation is ongoing within NGC 922 as a result of a shock-wave propagating through the galaxy, caused by a collision between NGC 922 and a neighbouring dwarf galaxy $\sim$ 330 Myrs ago. The majority of the sources are associated with the ongoing star-formation, which is occurring in both a ring close to the edge of the galaxy, and in a region close to the galactic nucleus. By estimating the ages of clusters associated with these sources, we find that those associated with star-formation are no more than 10 Myrs old. Those that are not associated with star-formation have age constraints much higher than this. The X-ray spectral characteristics of the binaries vary from one to the next. We see that both the older sources and the sources located within the star-forming ring have highly absorbed spectra, unlike the more central sources, whose spectra display low levels of absorption.

An XMM-Newton vision of the NGC 2023 cluster and its surroundings

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The southern part of the Orion B giant molecular cloud complex, L 1630, borders the large H II region, which is expanding into the molecular cloud. The interface between the molecular cloud and the H II region (IC 434) is seen as a bright ridge with the Horsehead Nebula and several smaller pillars on it. NGC 2023 is a molecular cloud situated at approximately 30 arcmin at the East of the ridge, where star formation is taking place actively. This region contains a number of molecular clumps detected in the millimetric range where stars are just forming and several class I and class II objects. We have used data from the archive of the XMM-Newton mission to look for differences in the X-ray properties of these different objects. In this poster, we present the results of our study, with special attention to the case of the source named by us MIR46, a radio source detected by the VLA and in IR by Spitzer but with no counterpart in 2MASS but detected in X-rays by XMM.

Optical follow-up of the stellar content of the XBSS

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Since the decrease in stellar X-ray emission occurs mainly during the main sequence phase after the Zero Age Main Sequence phase, flux-limited X-ray surveys detect young stars up to larger distances than old ones. As a result, main-sequence stars dominate shallow surveys while old stars are dominant in deep, high-latitude surveys due to the lower scale height of young stars. The proportion between young and old stars in those surveys has the clue to understand the star-formation history in the solar neighbourhood during the past gigayear. Comparing observations with predictions made by Galactic models one should be able to distinguish between different scenarios of star-formation. With this aim, we have conducted an optical follow-up of the stars detected in the XMM-Newton Bright Serendipitous Survey. A first work published in 2007 by us showed that there is an excess of stars in the observations with respect to predictions. The X-ray properties of the stars in excess resembled those of young stars. In this work we study spectroscopic characteristics to detect signatures of youth. The first results agree with the scenario of an excess of young stars in the observations that are not accounted for by models.

Quantifying the relation between UV and X-ray flux in nearby M stars

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We have embarked in a systematic survey for UV emission from M stars in the solar neighborhood. M dwarfs have no significant photospheric flux at UV and shorter wavelengths. Their UV emission is almost entirely due to magnetic activity in the chromosphere and transition region, while X-ray emission probes activity in the corona. Both UV and X-ray emission have the potential to photo-ionize the atmospheres of close-in planets but the relative importance of the two contributions is poorly understood. We aim at investigating the relation between X-ray and UV flux in nearby M stars. A volume-limited sample of M dwarfs within 7 pc has been extracted from the NEXXUS database which provides a compilation of X-ray luminosities from various satellites (ROSAT, Einstein, XMM-Newton). Cross-correlating the 81 stars in this sample with the GALEX archive, about half of the X-ray sources are detected in the near- and far-UV. We present our preliminary results from a comparison of the X-ray and UV emission.

X-ray emission from brown dwarf candidates in Cha I

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The physical process producing X-ray emission in brown dwarfs (BDs) is still not well understood. In young BDs, X-ray emission is though to be produced by some kind of magnetic activity and/or accretion (as in T Tauri stars), but the low frequency of detections does not permit to achieve robust conclusions. Only a small fraction of the BDs in some star-forming regions has been detected in X-rays. Investigating the characteristics of the X-ray emission of a larger sample of BDs is needed to the understanding of the process producing high-energy emission in these objects.

We have taken advantage of the high sensitivity of the EPIC on-board the XMM-Newton satellite to study the X-ray properties of brown dwarf candidates of the Chamaleon I molecular cloud selected from the literature. Our sample increases the number of BDs detected in X-rays in Cha I by a factor of two. Our aim is to investigate whether the X-ray emission coming from these objects is similar or not to that of T Tauri stars of the same region.

Revealing the young stellar population in the S254-258 region with X-rays

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In the S254-S258 region a dense cluster of very young stellar objects is sandwiched between two HII regions. This remarkable configuration has led to conjectures that the two B stars exciting the HII regions may have been ejected from the central cluster, or, alternatively, that the current star formation activity in the central cloud is triggered at the intersection of the expanding HII regions. In the second case, the two B stars should belong to a slightly older stellar generation, but no associated young low-mass stars could be identified so far around them.

In order to solve this puzzle, we have performed a deep Chandra X-ray observation of this extraordinary star forming region, and here we present the results of our X-ray analysis.

We detected 364 X-ray sources, providing, for the first time, a sample of all young stars in the region down to 0.5 Msun. The spatial distribution of the sources is characterized by a central clump (corresponding to the embedded cluster) plus a widely scattered population of young stars, strongly supporting the second formation scenario. Comparison of the X-ray luminosity function to Orion suggests a total population of about 2000 young stars in the S254-S258 complex.

A Holy Grail for stellar wind analysis: zeta Puppis seen by XMM

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zeta Puppis is one of the nearest and brightest massive stars. It was thus a natural early target for both Chandra and XMM. These first short exposures triggered a revolution in our understanding of stellar winds of massive stars. Since mid-2000, this star has been reobserved 17 times with XMM, providing more than 700ks of usable time (i.e. an order of magnitude more time than reported in literature). The result is the best X-ray spectrum of a massive star ever obtained, a clear legacy product which will only be surpassed by future facilities such as IXO. In this contribution, we present our detailed analysis of this exceptional dataset, with a special emphasis on variability and line profile analyses, as well as some ideas for future studies.

Early magnetic B-type stars: X-ray emission and wind properties

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We present a comprehensive study of X-ray emission and wind properties of magnetic early B-type stars. We compile the complete sample of early B-type stars with detected magnetic fields to date and existing X-ray measurements, in order to study whether the X-ray emission can be used as a general proxy for stellar magnetism. For the first time we analyze the UV spectra of B stars with magnetic fields by means of non-LTE iron-blanketed stellar atmosphere model that account for the X-rays at the intensity and temperatures observed. The mass-loss rates inferred from the analysis of UV lines are significantly lower than predicted by hydrodynamically consistent models. We find that the X-ray properties of early B-type magnetic stars are diverse, and that hard and strong X-ray emission does not necessarily correlate with the presence of a magnetic field.

Star-planet interactions in X-rays - mimicked by selection effects?

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Planets can hypothetically influence their host star's magnetic activity through star-planet interactions (SPI). However, observational campaings for detecting SPI in star-planet systems have led to differing results. Especially in X-rays, samples of planet-hosting stars may exhibit strong selection effects. This is because for stars in the solar neighborhood, where one can obtain X-ray complete samples, the main planet detection method is through radial velocity shifts. The detectability of radial velocity shifts strongly depends on stellar activity, leading to correlations that can mimic trends expected from SPI. I will show which specific selection effects produce SPI-like signals in a complete X-ray sample of planet-hosting stars, and discuss how possible SPI signatures may be disentangled from these selection effects.

Detection of 14368 X-ray sources in the Carina Nebula star forming region

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The Carina Nebula harbors a large number of very high-mass stars and provides a unique target for detailed studies of violent massive star formation.

The Chandra Carina Complex Project has recently used 1.34 Megaseconds observing time to produce a 1.4 square-degree mosaic of 22 individual X-ray images. This unique data set led to the detection of 14368 individual X-ray point-sources as well as copious amounts of diffuse emission. 10714 X-ray sources can be classified as young stars, providing, for the first time, a large sample of the high- and low-mass stellar populations in the Carina Nebula.

I will first present basic results from this project, in particular the spatial distribution of the X-ray sources and the X-ray luminosity function. In the second part I will focus on multi-wavelength aspects. A deep near-infrared survey provided counterparts to 90% of the X-ray sources in the common area. This allowed us to study the ages, masses, and disk properties of the young stars and yielded important new insights into the stellar mass function in Carina, the star formation history, and the process of triggered star formation by massive star feedback.

The LETG spectrum of delta Ori

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The O-giant delta Ori was observed in the wavelength range 5-175 Å by the X-ray detector HRC-S in combination with the LETG grating on-board Chandra. We perform a multi-temperature fit and model the differential emission measure (DEM) of the spectrum, resulting in a temperature distribution, emission measures, and elemental abundances. Individual line fluxes and width have been measured.

During the observation the nearby companion of this multi star system was passing in front of the primary star. The light curve shows some increase from the start of the observation to the end. Three different time period spectra have been extracted and individual lines have been measured in the three time intervals. We search for differences in wavelengths, fluxes and widths over the duration of the observation and/or relation to the position of the companion.

Based on the intercombination and forbidden lines in He-like ions the formation of these ions relative to the stellar surface can be established. Eclipsing by the nearby companion might result in an additional confirmation of these results.

A look at the high Galactic latitude O-type star HD93521 with XMM-Newton

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The nature of the O9.5Vp star HD93521 has been subject to debate for many years. This object is a very fast rotator, located at an unusually high Galactic latitude of 62 degrees and exhibits prominent line profile variability in the optical and UV domain. It has been suggested that this star is either a rather normal Population I O-type star, that formed in isolation, far away from any known site of star formation, and displays non-radial pulsations, or a low-mass Population II object, or an O-star with a compact companion accreting matter from the O-star. To clarify this issue, we have obtained an XMM-Newton observation that we present and analyse here along with the results of high-resolution optical spectroscopy.

X-ray emission from Ap/Bp stars - bridging cool and hot stars

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X-ray emission from mid-B to mid-A stars is at all remarkable. Actually they are expected to be X-ray dark since they neither possess an outer convection zone to generate magnetic activity as in cool stars nor drive strong stellar winds as present in hot stars. Nevertheless, the magnetic A0p star IQ Aur has been detected as an X-ray source by ROSAT and its emission was explained in the framework of the magnetically confined wind shock model (MCWS). However, many other Ap/Bp stars remained undetected and some questioned this scenario in favor of unknown companions. We present new X-ray observations of the A0p stars IQ Aur, which also shows a massive flare and α^2CVn. Despite their similarity at optical wavelengths, their X-ray properties are fundamentally different. We discuss our findings in the context of X-ray generating mechanisms of magnetic, chemically peculiar, intermediate mass stars, present a comprehensive study of similar Ap/Bp stars observed by XMM-Newton and Chandra and outline a possible solution of the long standing X-ray puzzle based on stellar properties.

X-ray emission from protostellar jets

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Protostars often drive very powerful bipolar mass outflows which can remove angular momentum from the protostellar system. They are therefore essential for the star formation process. Since the X-ray discovery of the Herbig-Haro object 2 in 2001, about a dozen of these protostellar jets have been discovered in X-rays. However, the details of the X-ray emission, in particular the interplay of the X-ray emitting million degree plasma with the much cooler jet material observed in the optical, is still puzzling. As protostellar jets evolve on time scales of years, multi epoch observations are essential to understand the heating and cooling mechanisms of these objects. We present X-ray data of HH objects and discuss the general properties of X-ray emission from HH objects. We focus on similarities and differences between the X-ray properties of these objects.

Giant HII Regions in M 101: Hα-line spectra and X-ray property

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We performed a Chandra X-ray study of three giant HII regions in M101, NGC 5461, NGC 5462, and NGC 5471. The Hα spectra of NGC 5461 and NGC 5471 are also analysed. In NGC 5461, the spatial distribution of X-ray emission is in large consistent with the extent of H1105, but extends out of its south edge. In NGC 5462, the X-ray emission brightness peaks at one infrared source and does not coincide with any interior HII region. The X-rays from NGC 5471 concentrate at the B-knot. The X-ray spectra of three GHRs all contain a remarkable thermal component with a temperature ~ 0.2 keV. The Hα echelle spectra from NGC 5461 and NGC 5471 contain velocity components of normal width, while only at the B-knot of NGC 5471 the spectra contain extra broad components (FWHM $> 100\,\mathrm{km\ s^{-1}}$), which implies a violent evolution this knot has experienced. The shock velocity derived from X-ray fitting result, 340 km s^{-1}, is consistent with the expansion velocity evaluated from wings of broad component. Assuming a Sedov-Taylor evolution, derived explosion energy on order 10^{52} ergs is consistent with a hypenova origin or multiple supernova explosions. The diffuse X-ray emission at NGC 5461 seems to be of super-wind origin, while the mechanism of diffuse X-rays of NGC 5462 is still unclear.

X-ray observations of hot Jupiters

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We report on XMM-Newton observations of the planetary host star HD 189733A. The X-ray bright star has a planet orbiting at about $8R_{-}*$ which appears to affect the coronal structure. Star-planet interactions are evidenced in the strong X-ray flux from the host star, while the system's M4 binary companion, HD 189733B, went undetected in the X-ray observation and has activity levels consistent with a 7 Gyr age (Pillitteri et al. 2010, Santapaga et al. 2011). During planetary eclipse, we observed a softening of the X-ray spectrum at a $\sim 3\sigma$ level. MHD simulations show that the magnetic interaction between the planet and HD189733A changes the structure of the stellar magnetosphere and enhances the coronal density in the region between the star and planet (Cohen et al. 2011). Our X-ray observations and model predictions are globally found in broad agreement, despite the quite simple MHD model adopted.

The Chandra Cygnus OB2 Legacy Survey

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Cygnus OB2 is the most massive young stellar association within 2kpc, containing at least 65 O stars and millions of low-mass stars. Its proximity provides a unique glimpse into star formation at the largest of scales: the extreme physical conditions induced by the proximity of thousands of massive stars, and the large spatial scales under which the star formation process takes place. It represents a vital stepping stone between studies of nearby regions such as Orion and the distant super-star clusters that dominate starburst galaxies. I will present observations from the recent Chandra Legacy Survey of Cygnus OB2, which has produced a catalog of 10,000 association members across a square degree with well-defined completeness limits. Results from these and other multi-wavelength observations are helping us understand how the fundamental parameters of star formation (the initial mass function, binary star fraction, proto-planetary disk fraction and the star formation efficiency) vary in these massive regions. I will also discuss a follow-up radial velocity survey of the association that will not only reveal the current dynamical state of the association, but also probe the formation and eventual dissolution of such massive star forming regions.

The decay of stellar dynamo activity and the rotation-activity relation

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X-ray emission in late-type stars originates from a magnetically-confined plasma heated to millions of degrees by dissipation of the mechanical energy of convection and magnetic fields thought generated largely by a rotation-powered dynamo. The observed decline in X-ray luminosity of several orders of magnitude between the zero-age main-sequence and solar age is attributed to stellar rotational spin-down, though recent studies suggest grossly different or non-existent decay laws.

A large sample of 800 stars with rotation periods and X-ray luminosities is used to probe the activity-rotation relation in detail. Results suggest that coronal saturation is a product of differences in the coupling of radiative and convective interiors in faster and slower rotators, while super-saturation is induced by the poleward migration of active regions in ultra-fast rotators, as suggested by Stepien.

A model of stellar X-ray emission, combining Galactic population synthesis, stellar spin-down and the rotation-activity relationship, is compared with deep Chandra observations. The model makes allowances for binaries, biases introduced by flaring and cyclic variability, and changes in the Galactic star formation rate. Results suggest a faster decay of X-ray activity than previously thought.

Chapter 4

Interacting Binary Systems, Galactic Black Holes and Micro-quasars

The paucity of accreting millisecond X-ray pulsars

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Accretion-powered millisecond X-ray oscillations have been detected with RXTE in only 14 of about 130 accreting neutron stars in LMXBs. Three such stars produce detectable oscillations only intermittently. We show that the absence of detectable oscillations from most LMXBs, and the intermittent detection of oscillations in a few, can both be explained if the emitting regions of accreting neutron stars with millisecond spin periods typically have small inclinations relative to the spin axis and move in response to changes in the accretion flow. This nearly-aligned moving spot model is consistent with the small observed amplitudes and nearly sinusoidal waveforms of most accreting millisecond X-ray pulsars, and the large, rapid phase variations of several. These results are based on research supported by NASA grant NAG 5-12030, NSF grant AST0709015, and funds of the Fortner Endowed Chair at Illinois, and by NSF grant AST0708424 at Maryland.

XMM-Newton observations of IGRJ18410-0535: the ingestion of a massive clump

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IGRJ18410-0535 is one of the supergiant fast X-ray transients and was observed for 45 ks by XMM-Newton as part of a program aimed at studying the quiescent emission of supergiant fast X-ray transients and clarifying the origin of their peculiar X-ray variability.
IGRJ18410-0535 underwent a bright X-ray flare that started about ∼5 ks after the beginning of the observation and lasted for ∼15 ks. Thanks to the capabilities of the instruments on-board XMM-Newton, the whole event could be followed in great detail. The results of our analysis provide strong convincing evidence that the flare was due to the accretion of matter from a massive clump onto the compact object hosted in this system.
By assuming that the clump is spherical and is moving at the same velocity as the homogeneous stellar wind, we estimate a mass and radius of $Mcl \simeq 1.4 \times 10^{22}$ g and $Rcl \simeq 8 \times 10^{11}$ cm. These are in qualitative agreement with values expected from theoretical calculations. No evidence for pulsations at ∼4.7 s was found (we investigated coherent modulations in the range 3.5 ms-100 s).

Multiwavelength studies of the microquasar GX 339-4 in its 2010 outburst

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In the light of recent observations obtained with XMM-Newton, INTEGRAL, RXTE, Swift, as well as ground-based instruments operating in radio and NIR/Optical (ATCA/REM/ESO/SMARTS), we present our progress made in the understanding of GX 339-4 in distinct spectral states. We show a complete analysis of the extensive monitoring obtained as part of the 2010 Galactic Halo Scan Key Program and two ToOs we triggered with INTEGRAL simultaneously to observatories operating from radio to X-rays. GX 339-4 underwent a bright outburst starting in February 2010 and transited from the Hard to the Soft State in April 2010 (back in the Hard State in February 2011). We show the evolution of the spectral parameters and changes in the X-ray binary system components (jet, disc, hot medium). This is crucial for our understanding of the physics of the hot plasma (jet base and/or corona). We also compare the radio to X-ray broad band spectra of two emission states (hard and soft) to the results derived from other microquasars (position in HID, spectral transitions, radiative efficiency of the jet and jet-line position). Imaging, spectroscopy and timing are shown, and discussed in the context of high-energy phenomena and future perspectives of probing accretion/ejection processes around microquasars.

2011 outburst of IGR J17091-3624 as seen by INTEGRAL and Swift

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We report results from the last outburst of the BHC IGR J17091-3624 as seen by INTEGRAL and Swift. Thank to the several too observations performed by Swift simultaneously with the INTEGRAL monitoring of the galactic centre region, we collected a huge amount of broad band X-ray data all over the outburst evolution. The data analysis revealed a particular behavior of the outburst rarely observed in a transient black hole candidate. We than rediscuss the BH nature of this intriguing source.

Time lags and reflection in black hole X-ray binaries

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Timing studies of black hole X-ray binaries (BHXRBs) are becoming increasingly popular and are now a key element to help disentangle causality in these objects. It is thought that in the hard state, the soft, variable disc blackbody component leads the variability coming from the corona. This power-law component can partly intercept the disc and produce a reflection spectrum, of which the iron Kα fluorescence line is a clear signature.

It is possible to study time lags (τ) between the soft and hard bands as a function of Fourier frequency (ν). The observed dependence on frequency is $\tau \propto \nu^{-0.7}$. On time-scales longer than a second, the propagation of accretion fluctuations throughout the disc seems to explain the observed dependence. For frequencies higher than $\sim$1 Hz, the cause is still unclear.

Tying together spectral and timing methods is the only way to establish a clear link between causality and the observed spectra. For this reason, we have modelled the impact of reflection on the shape of the lags and spectra in flared accretion discs. We will show simultaneous fits using XMM-Newton EPIC-pn data that can help constrain their geometry and understand the importance of reflection in the observed lags.

Two spectral substates within low/hard States of NS-LMXBs

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A thorough analyisis of the BeppoSAX archival data showed that Low Hard State (LHS) spectra of NS-LMXBs can be divided in two main subgroups, depending on how many soft photon populations are actually detected: 2-P (two-population) and 1-P (single-population) LHS spectra. 2-P spectra characterise the brighter LHS (in excess of $\sim$ 1% Eddington) while 1-P are observed at the lowest accretion rates. The results obtained on a unbiased sample of $\sim$ 40 BeppoSAX NS-LMXBs (the half of which observed in a LHS) will be reported and discussed.

Discovery of the new gamma-ray binary 1FGL J1018.6-5856

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We present the discovery of a new gamma-ray binary system from the search for periodic modulation in the Fermi LAT light curves of all sources in the first Fermi-LAT catalog. 1FGL J1018.6-5856 was found to have a 16.6 day modulation in its gamma-ray flux that is accompanied by spectral variability. We identify counterparts in the X-ray, radio, and optical wavebands using data from the Swift XRT, ATCA, and telescopes at SAAO and LCO. The X-ray and radio counterparts are highly variable: the X-ray flux appears to be modulated on the orbital period with maximum X-ray flux coinciding with the phase of maximum gamma-ray flux. The optical counterpart has a spectral type of approximately O6V((f)) and shows little variability in a series of Swift UVOT observations. The overall properties of 1FGL J1018.6-5856 indicate that it is a member of the rare gamma-ray binary class of objects, and that it shares several properties with LS 5039. However, there are some differences from LS 5039, including the relative phasing of the gamma-ray flux and spectral modulation and the shape of the X-ray light curve. The similarities and differences will allow us to develop our understanding of the astrophysics involved in these enigmatic objects.

A new view of accretion disk corona X-ray sources

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Based on recent results from orbital period evolution and a set of new high-resolution spectroscopic studies of the accreting X-ray pulsar X1822-371 I will present a new, self-consistent, scenario of the so-called accretion-disk corona sources. X1822-371 has been long considered the classical prototype of this class of sources, having a very high inclination angle that blocks most of the X-ray radiation produced close to the accreting neutron star, it leaves only the coronal plasma as the visible emitting region. I will show evidence for this plasma to be optically thin and from spectral analysis I will show the physical characteristics of this environment, its relation with the incident hard X-ray radiation and the overall structure of this system. This scenario constitutes a completely new revisitation of the old paradigma.

Analyzing relativistic effects around black holes: XMM observations of Cygnus X-1

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We investigate the relativistic effects around black holes by spectral analysis of modified timing mode observations of Cygnus X-1 with XMM-Newton. Simultaneous RXTE observations extend the energy to 150 keV and serve to constrain the continuum, which consists of a power law with exponential cutoff and a reflection component. As the majority of the reflected photons are emitted very close to the black hole, this component is relativistically smeared. Hence, the parameters of space time are imprinted in the spectrum, which is modeled by using the relline code. We find that Cygnus X-1 is moderately spinning (a = 0.8), assuming the solution with a canonical emissivity of r-3 from a corona above the accretion disk. Using a new version of the relline code, we could show that the data is equally well described if the emission is assumed to originate from the base of a jet closer than 5 r_g above the black hole. Because of this, we use simulations to discuss how these two different models for the accretion geometry can in principle be distinguished by spectral modeling.

Observations of X-ray binaries with very-faint accretion luminosities

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In the last years a new generation of high sentitivity X-ray telescopes combined with wide-field hard X-ray telescopes have allowed the discovery of a new class of X-ray binaries: the Very Faint X-ray Transients (VFXTs).

VFXTs reach outburst peak luminosities from 1E34 up to few 1E36 erg/s (in 2-10 keV), which are almost two/three orders of magnitude fainter than the brighter systems. To date, about 30 members are known and they very likely form a non-homogeneous class of objects. A significant fraction (about 1/3) of the VFXTs exhibited type-I X-ray bursts and can thus be identified with neutron stars accreting matter from a low-mass companion. It is likely that the Beppo-SAX so-called "burst-only" sources are linked to the class of VFXTs. However, little is known about the mechanism which drives their very low accretion rate. We present and discuss latest results on sub-luminous X-ray bursters, as observed by INTEGRAL, Swift and XMM-Newton.

Possible future X-ray missions with combined large FOV, high sensitivity and sub-arcsec resolution (i.e. NHXM) would improve our knowledge of VFXT. We will show simulated observations of VFXTs with NHXM.

XSSJ1227.0-4859: a mysterious LMXB with gamma-ray association to 1FGLJ1227.9-485

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XSSJ1227-4859 is an enigmatic hard X-ray source. While it was first proposed as a magnetic Cataclysmic Variable, our recent X-ray follow-up study with XMM-Newton, RXTE and INTEGRAL reveals a peculiar highly variable flaring and dipping X-ray source with characteristics similar to type-II bursts but with an unusual low luminosity. From optical and nIR observations a 4.3hr periodicity, ascribed to the binary orbital period, indicates a LMXB nature. Surprisingly we also found to be positionally associated to the persistent high energy gamma-ray Fermi/LAT source 1FGLJ1227.9-4852 with emission up to 10GeV. If the low-energy and high energy emissions are linked, the gamma-ray emission is a significant component of the total energy budget. Further X-ray monitoring, performed early in 2011 with XMM-Newton XTE and Swift satellites investigates the peculiar nature of this source including the possibility of a twin of the MSP/LMXB PSRJ1023+0038.

XMM/HESS observations of SNR G284.3-1.8 and the binary system 1FGLJ1018.6-5857

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SNR G284.3-1.8 is an incomplete radio shell with a non-thermal spectrum which is interacting with molecular clouds and which has been associated with the Vela-like pulsar PSR J1016-5857. High energy (HE; E>100 MeV) gamma-ray emission has been reported for the AGILE and Fermi-LAT Collaborations from the direction of the SNR and the pulsar. At least part of the HE emission is variable on timescales corresponding to the pulsar period, while recently a new HE 16.4 days binary on the off-pulse emission has been identified with Fermi-LAT(ATel 3221). H.E.S.S. observations of the Carina spiral arm tangent have revealed a new very-high-energy (VHE; E>0.1 TeV) source (HESS J1018-589) positionally coincident with both the SNR and the pulsar. The H.E.S.S. discovery motivated X-ray observations with the XMM-Newton satellite centered on the SNR to investigate the origin of the HE and VHE emission. The results of the X-ray data analysis, as well as the morphological and spectral analyses of the new VHE source will be presented and discussed in the context of the multi-wavelength observations.

X-ray spectroscopy of MXB 1728-34 with XMM-Newton

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We have analysed an XMM-Newton observation of the low mass X-ray binary and atoll source MXB 1728–34. The source was in a low luminosity state during the XMM-Newton observation, corresponding to a bolometric X-ray luminosity of $5 \times 10^{36}\ d^2$ erg s^{-1}, where d is the distance in units of 5.1 kpc. The 1–11 keV X-ray spectrum of the source, obtained combining data from all the five instruments on-board XMM-Newton, is well fitted by a Comptonized continuum. Evident residuals are present at $6-7$ keV which are ascribed to the presence of a broad iron emission line. This feature can be equally well fitted by a relativistically smeared line or by a self-consistent, relativistically smeared, reflection model. Under the hypothesis that the iron line is produced by reflection from the inner accretion disk, we can infer important information on the physical parameters of the system, such as the inner disk radius, $R\_\mathrm{in} = 25 - 100$ km, and the inclination of the system, $44^\circ < i < 60^\circ$.

Evidence for intermediate mass black holes: the case of ESO 243-49 HLX-1

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The debate about the existence of intermediate mass black holes with masses between ∼100 – 100,000 Solar masses has raged for some time now, with no convincing evidence confirming their existence provided until recently. The current front-runner is the brightest ultra-luminous X-ray source HLX-1 in the galaxy ESO 243-49 with a record breaking maximum luminosity of $\sim 10^{42}$ erg s^{-1}. HLX-1 is ∼400 times the Eddington limit of a 20 Solar mass black hole, and ∼10 times brighter than the second brightest ultra-luminous X-ray source. I will present here a review of the current state of knowledge on this intriguing source and will outline the results of multi-wavelength studies from radio to gamma ray wavelengths. I will also present recent results obtained in near-IR to UV wavelengths with the Hubble space telescope, and radio observations taken with the Australia Telescope Compact Array. These results continue to suggest that HLX-1 contains a black hole with a mass between ∼3,000 – 100,000 Solar masses, and we investigate the possibility that HLX-1 is the remnant of a dwarf galaxy that was accreted by ESO 243-49.

XMM-Newton's view of the multiple fluorescence lines of GX 301−2

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We present an in-depth study of the HMXB GX 301−2 during its pre-periastron flare using data from *XMM-Newton*. The overall spectrum is well fitted with a powerlaw continuum modulated by a partial covering model at low energies. The absorption column is strongly variable from 120–240×10^{22} atoms/cm^2 on time scales of a few 100 sec. Different fluorescent lines are found in the spectrum, the most prominent being the iron K-alpha line, which is responsible for 12% of the 2–10 keV flux. Besides this line, iron K-beta, and the K-alpha lines of sulfur, argon, calcium, and nickel are evident. In addition strong indications exist that also a chromium K-alpha and a nickel K-beta line is detected. Using these strong lines we draw conclusions on the line producing region and the relative abundances of these elements in GX 301−2. The system shows a strong pulse period of 685 sec in its lightcurve. We find a short interval in our observation during which the pulsations cease almost completely, without any indication of an increasing absorption column. A similar dip was found earlier in *RXTE* data, and we compare our findings to these results as well as to similar states in Vela X-1 and interpret them.

4U 0115+63: phase lags and cyclotron resonant scattering

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High mass X–ray binaries are among the brightest objects of our Galaxy in the high energy domain (0.1-100 keV). In this contribution, we present our study of the energy dependent pulse profiles of the high mass X-ray binary pulsar 4U 0115+63 to investigate how they are affected by cyclotron resonant scattering.

We analyze archival BeppoSAX, RXTE, and INTEGRAL observations performed during a giant outbursts of the source. We exploit a cross correlation technique to compare the pulse profiles in different energy ranges and develop a relativistic ray-tracing model to understand our findings. We also study the phase dependency of the cyclotron absorption features by performing phase resolved spectroscopy.

We show for the first time that the pulse profiles of 4U 0115+63 display clear "phase-lags" at energies close to those of the cyclotron absorption features, which characterize the X-ray emission of the source. We reproduce qualitatively this phenomenon by assuming an energy dependent beaming of the emission from the column surface and verify that our model is also compatible with the results of phase resolved spectral analysis.

Multiwavelength rapid timing & broad-band spectroscopy of X-ray binaries

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The advent of precise timing instruments at optical and near-infrared (ONIR) telescopes in recent years has given us the capability of going beyond X-ray timing. Observations of several sources have revealed ONIR variations on a wide range of timescales from 10 ms up, and intriguing flux correlations with X-ray fluctuations - all of which give us unique and quantitative insight on the interplay between various physical components (jet, disc and corona) in the accreting binary systems. I will discuss our simultaneous ONIR and X-ray observations on several black hole and neutron star binaries, and examine the most informative statistics that can be extracted from the data including power spectra and frequency resolved time lags. I will also review ONIR fast time observations by other groups and will discuss important new observations that probe strong infrared variability at wavelengths of 10 microns and longer. Finally, I will show how simultaneous optical-to-near-infrared broad-band spectroscopy is proving crucial for disentangling the observed SEDs into the contributions from various physical components, and for localising the spectral break expected from jet synchrotron emission in the infrared.

Resolving the nature of the dipping/flaring branch in Cygnus X-2

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The fundamental nature of the brightest group of low mass X-ray binaries: the super-Eddington Z-track sources remains an unanswered question critical to the understanding of LMXB in general, and to the mechanism of relativistic jet formation in these sources. Part of the problem in resolving the physics in these sources has been the confused nature of the so-called "dipping-flaring" state. We present results of a study of this state combining fifteen years of RXTE All Sky Monitor data with analysis of pointed observations to identify dipping. The ASM data show remarkable variations of dip and flare occurrence with major longterm variations in the observed luminosity of Cygnus X-2. We show that the distribution of dip events with orbital phase peaks at phase ~ 0.7 indicating absorption in the bulge in the outer disk. The nature of dipping/flaring as absorption events is confirmed by results of a one-day campaign using XMM, Chandra and the European VLBI network, in which the spectral evolution in dipping shows that the absorption consists of progressive covering of an ADC that must be extended, by absorber in the outer disk, clearly resolving the confusion between dipping and real flaring occasionally seen in Cygnus X-2.

Optical counterparts to ultraluminous X-ray sources

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Ultraluminous X-ray sources (ULXs) are extragalactic non-nuclear sources with X-ray luminosities of $> 10^{39}$ erg s^{-1}, the Eddington limit for a stellar mass black hole ($M \sim 10 M solar$). One explanation is that we are observing accretion onto intermediate mass black holes ($10^2 - 10^4 M solar$). The alternative is that we are observing the most extreme stellar mass accretors in our universe. The debate over the black hole mass in these binary systems has been ongoing for more than 30 years. Here we present a new catalogue of the possible optical counterparts to ULXs that reside within 5 Mpc. Such counterparts can be used to delve deeper into the nature of these systems. We find that, of 45 ULXs, 13 have unique counterparts, with a further 10 hosting 24 potential candidates. We discuss SED fitting of these sources to gain more information on both the resident black hole and its companion star, and projects developing from this study.

Cyg X-1: shedding light on the spectral variability of black holes

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We present an analysis of extensive recent monitoring observations of the black hole HMXB Cygnus X-1 obtained as part of the 2007 to 2011 Key Programme observations of the INTEGRAL mission. Cyg X-1 is one of only three persistent black hole binaries in our galaxy that spend most of their time in the hard spectral state. After spending 3 years in the hardest regime of its parameter space, the source displayed a softening and flaring episode in mid 2009 and entered an on-going soft state in early 2010 June. While the hard X-ray spectrum of Cyg X-1 is one of the best studied examples of its kind, e.g. through our monitoring campaign with RXTE, the INTEGRAL monitoring allows us to study the spectral evolution from about half an hour over a few days to weeks, timescales that have been only sparsely sampled so far. The parameter ranges for the hard and soft states are constrained and discussed with a special focus on the comparison with previous observations of Cyg X-1 and transient sources, where such measurements, which are important for understanding the physics of the hot plasma of the jet base and/or the corona, are typically difficult to obtain.

XMM-Newton observations of the shortest orbital period black-hole candidate MAXI J1659-152

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We present the analysis of the XMM-Newton observation of the black-hole candidate MAXI J1659-152 taken during the early phase of its outburst in September 2010. We discovered the presence of period absorption dips, which point to the orbital period of this binary. Furthermore, a detailed spectral analysis is given for both instruments, during dips and no-dips states.

GRO J1008−57: high precision timing and spectral evolution

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The transient high mass X-ray binary GRO J1008−57 underwent an outburst in December 2007, which was recorded by *RXTE*, *Suzaku* and *Swift*. With ∼180 mCrab this outburst was the most luminous since the start of the *RXTE* ASM monitoring in 1996. The system is only visible in X-rays during outbursts, which repeat mostly on the 249 day orbital period of the system.

Due to the relatively short outburst durations of around 15 days, the orbital coverage is quite low. Hence determining the orbit is challenging. By analysing pulse arrival times of the 2007 lightcurves together with data from an outburst in 2005 recorded by *RXTE*, we were able to improve the existing orbital parameters.

Since the discovery of GRO J1008−57 in 1993 a cyclotron absorption feature at 88 keV is claimed, which could not be securely confirmed yet. Focusing on the spectral evolution we also found evidence for this possible cyclotron line. Additionally we discovered an absorption like feature at around 22 keV, which is, however, only seen at high luminosities. *RXTE* will observe the outburst of GRO J1008−57 in April 2011 to clarify its existence.

High mass accretion rate spectra of GX 339-4: black hole spin from reflection?

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Black hole spins are currently very controversial, with the results from the relativistically broadened iron line typically giving higher values of spin than those found from fitting disc continuum models. GX 339-4 is the archetypal source for this, with multiple claims of very high spin from the iron line profile. I re-analyse all the XMM-Newton burst mode spectra of this source and show that the iron line shape inferred from these fits is highly dependent on the chosen continuum model. These data are all in bright states, where the disc continuum is important at 6 keV. The disc emission seen in the disc dominated spectra is clearly broader than the simple diskbb model, so fitting such models to the continuum forces a broad residual into the data. Broader disc continuum models give a much narrower derived line profile, consistent with the lower spin value from disc spectral fitting.

Pulse profile variations in GX 1+4

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The symbiotic accreting X-ray pulsar GX 1+4 shows significant changes in its pulse profile together with strong, irregular luminosity variations typical for this source class. We present results of a comparative study of profiles obtained over several years with INTEGRAL.

Long-term spectral changes in GX 1+4

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GX 1+4 is the best known member of the small class of symbiotic accreting X-ray pulsars. It shows strong, irregular luminosity variations typical for this source class. Long-term monitoring indicates significant spectral changes on timescales of months to years. We discuss these changes and their relation to the accretion mechanism in this kind of source.

Observation of blackbody excess in persistent Be/NS binary pulsars

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Many X–ray accreting pulsars have a soft excess below 10 keV. This feature has been detected also in faint sources and at low luminosity levels, suggesting that it is an ubiquitous phenomenon. In the case of the high luminosity pulsars ($L > 10^{36}$ erg s^{-1}), the fit of this component with thermal emission models usually provides low temperatures (kT < 0.5 keV) and large emission regions (R $\geq$ a few hundred km); for this reason, it is referred to as a 'soft' excess. On the other hand, thanks to the observations perfomed by XMM–Newton at an unprecedented sensitivity level, we detected a different feature in persistent, low–luminosity ($L \sim 10^{34}$ erg s^{-1}) and long–period (P > 100 s) Be accreting pulsars: in their case the observed excess can be modeled with a rather hot (kT $>$ 1 keV) blackbody component of small area (R ≤ 0.5 km), which can be interpreted as emission from the NS polar caps. Here we present the results of recent XMM–Newton observations of RX J1037.5-5647 and RX J0440.9+4431, which were previously poorly studied member of this class of sources, and discuss if the description of the other persistent pulsars is applicable also in this case.

Chandra and theoretical insight into the evolution of accreting binary populations

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I will present a union of observational and theoretical studies of the formation and evolution of populations of compact objects found within galaxies through X-ray studies of accreting binary populations (X-ray binaries). I will present new Chandra-based empirical calibrations for how the X-ray binary emission from normal galaxies scales with star-formation rate (SFR) and stellar mass (M*) for galaxies with SFRs over the wide range of 0.01-400 Msol/yr. Using the Chandra Deep Field surveys, I will show how the X-ray power output from accreting binary systems in the star-forming galaxy population as a whole evolves out to z 1.5 in response to large changes in the star-formation activity of the Universe. Finally, I will discuss efforts to incorporate advanced X-ray binary population synthesis models (implemented over the Millenium Simulation) describing the evolution of the X-ray binary activity in the star-forming galaxy population, and present initial physical insight provided by these models when matched to our empirical Chandra measurements.

On the cooling tails of thermonuclear X-ray bursts: news from Terzan 5

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To date, thermonuclear bursts from neutron stars had a distinctive signature: cooling along the burst decay. We have found a set of bursts from IGR J17480-2446 (a recently discovered source in the globular cluster Terzan 5) that do not show such cooling signature, yet we are able to identify them as thermonuclear bursts from an accreting neutron star. We conclude that the detection of cooling along the decay is a sufficient, but not a necessary condition to identify an X-ray burst as thermonuclear. We also find that the peak burst to persistent luminosity ratio determines whether or not cooling is present in the bursts from IGR J17480-2446, and argue that the apparent lack of cooling is due to the "non-cooling" bursts having both a lower peak temperature and a higher non-burst (persistent) emission. Finally, we compare these findings with X-ray bursts from other rapidly accreting neutron stars.

Constraining the black hole mass for an ultraluminous X-ray source NGC1313 X-2

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Dynamical mass measurements using HST, Gemini and VLT have been attempted for only one ultraluminous X-ray source NGC1313 X-2. It is found that the existing measurements clearly disfavors models with black hole mass above 40 solar masses, but allow two models with quite different formation and evolution history: a 16 solar mass black hole model with a 4 Myr old, initially 55 solar mass, currently 20 solar mass secondary, and a 3 solar mass black hole model with a 44 Myr old, 7.6 solar mass secondary.

Simultaneous X-ray timing and spectroscopy observations of the UCXB 4U 0614+091

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The ultra-compact X-ray binary (UCXB) 4U 0614+091 consists of a neutron star orbiting around a carbon-oxygen or oxygen-neon-magnesium white dwarf with an orbital period of ≈ 50 min. We recently discovered an emission feature at ≈ 0.7 keV in this source. We interpreted this feature as a relativistically broadened reflection line of O VIII Lyα, caused by X-rays reflected off the accretion disc in the strong gravitational field close to the neutron star. This is the first time that a broad fluorescent O VIII Lyα line is seen in the X-ray binary. This source also shows strong kHz quasi-periodic oscillations (QPOs). By modeling the relativistically broadened oxygen line and simultaneously measuring kHz QPOs we can obtain two independent measurements of the inner radius of the accretion disc as a function of the neutron star mass. Additionally we are using high resolution optical spectra of this source in order to constrain the neutron star mass. Constraints on the mass and radius of the neutron star obtained by three independent methods can give us a handle on the neutron star equation of state and are a good test of the theoretical models for the relativistically broadened lines and kHz QPOs.

An X-ray ionized nebula around the eclipsing black hole binary M33 X-7

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The nearby galaxy M33 harbours one the most massive stellar-mass black holes, circling a 90 solar-mass O star companion in a close, highly inclined orbit. The evolutionary history of the system is still a matter of debate. Here we report that the X-ray binary system is embedded in a relatively dense and symmetric optical HII region where it excites high-ionization HeII 4686 line emission in the nebula. Thus, M33 X-7 appears to be the textbook example of an X-ray ionized nebula allowing independent estimates of the luminosity of (ultra-) luminous X-ray sources. Using CLOUDY simulations we confront the observed X-ray spectra and the spectro-photometrically derived structure of the nebula with various models of stellar and of X-ray source ionizing continua. We derive improved estimates for the stellar luminosity and temperature, and we present independent constraints on the otherwise unobservable soft X-ray (0.054 - 0.3 keV) luminosity of an accreting black hole.

On the variability of the Si complex in the enigmatic Cygnus X-3

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Cygnus X-3 is one of the most enigmatic X-ray sources in the sky. The nature of the high-energy source (Black Hole or Neutron Star) is still not firmly settled. There is also uncertainty about the mass and type of the companion star. Existing models describe the system either as a high or a low-mass system, but all of these models give Cyg X-3 a prominent place in our understanding of stellar evolution.

In this work, we present a study of the Si complex at 6.185A using XMM- Newton/RGS data. The source was observed three times using the RGS detector, and each observation coves nearly 2 cycles of the orbital period of the system. We have performed orbital phase resolved spectroscopy of the Si XIV Ly alpha line in order to study the photo-ionization process in the stellar wind of the companion. We discuss these properties in the framework of the several types of proposed donors.

4U 0115+63: a bonanza of cyclotron resonance scattering features

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We report on an X-ray outburst of the transient Be/X-ray pulsar 4U 0115+63 in 2008, which reached an X-ray brightness of about 250 mCrab. Using pulse arrival time analysis, the available *RXTE*- and *INTEGRAL* lightcurves allow us to upgrade the orbital parameters of the binary. Furthermore we measured the pulse period ephemeris of the neutron star. We also studied the time- and energy dependence of the neutron stars pulse profile. A time- and phase resolved quantitative spectral analysis confirmed the presence of multiple cyclotron resonance scattering features. In agreement with previous observations we find an anti-correlation of the fundamental cyclotron energy at about 11 keV and the X-ray luminosity.

Characterising the timing and spectral properties of ULXs

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Ultra luminous X-ray sources (ULXs) are a contentious class of bright X-ray sources in external galaxies with ongoing debate as to the true nature of the compact objects they undoubtedly harbour. Whilst fits to spectroscopic data are somewhat degenerate, combining this approach with current timing methods can help decipher the nature of these enigmatic sources. Whilst a small number of ULXs have characteristic variability that includes quasi-periodic oscillations (QPOs, e.g. NGC 5408 X-1, M82 X-1) and constrained power-density, several have been shown to have suppressed variability on observation timescales. I will present a model for ULXs which can simultaneously describe both the X-ray spectrum and timing characteristics and supports the identification of these objects with stellar mass black holes accreting at extreme rates. I will present recent evidence in its favour including the energy dependent variability of NGC 5408 X-1 and the luminosity dependent spectral behavior of M33 X-8.

Spectroscopy of the stellar wind in the Cyg X-1 system

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The accretion onto the black hole in the HMXB Cygnus X-1 is powered by the strong line-driven wind of its companion HDE226868. As the star almost fills its Roche lobe, the wind density and mass loss rate are enhanced along the binary axis, such that the wind is focused in this direction. As large density and temperature inhomogeneities are present in the wind, it consists of clumps of lower ionization stages and temperatures, embedded in a highly photoionized material.

We present results of the detailed analysis of the stellar wind of Cygnus X-1 from high-resolution Chandra-HETGS observations. Absorption dips are present in the light curve and are believed to be caused by clumps in the wind. The comparison of the spectral properties between dip spectra and persistent flux (non-dip spectra) leads to closer investigation of clumps in the wind: while the H-like and He-like absorption lines reveal the highly photoionized wind, the lines of lower ionization stages visible only in the dip spectra constrain properties of the clumps. By studying the observations at different orbital phases of the system, we can compare different parts of the wind and thus study structure and dynamics of the wind directly.

The low mass X-ray binary system 4U 1735-44

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Low mass X-ray binaries are interacting binary systems composed of a compact object, here a neutron star, and a companion star with a typical mass of one solar mass.

The neutron star accretes matter from the companion star and an accretion disc is formed. In such discs features like the iron Kalpha fluorescence line, possibly relativistically broadened, and high frequency Quasi-Periodic Oscillations (kHz QPO) can be seen.

The study of these features can lead to a proof for relativistic effects and gives evidence of the nature of the compact object. A distinction between a neutron star or a black hole is possible and the mass and radius of the compact object can be constrained.

The results of the analysis of X-ray data from the neutron star low mass X-ray binary 4U 1735-44 are presented in the poster. The observations reported here were performed with the satellites BeppoSAX, XMM-Newton and RXTE. The obtained data allow a detailed study of both the spectral and timing features of the source.

Especially for the XMM-Newton observation pile-up effects have to be taken into account. These effects on the observation of 4U 1735-44 are studied in detail.

RXTE monitoring of GRS1758-258

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GRS 1758-258 is the least well studied of the three persistent black hole X-ray binaries in our Galaxy. It is also one of only two known black hole candidates, including all black hole transients, which shows a decrease of its 3-10keV flux when entering the thermally dominated soft state, rather than an increase.

We present the spectral evolution of GRS 1758-258 from RXTE-PCA observations spanning a time of about 10 years from 1997 to 2007. The results of this analysis are compared to that of the INTEGRAL monitoring of the source. We will also compare the long term behaviour of the source to that of the bright persistent black hole X-ray binary Cygnus X-1 and discuss the observed state transitions in the light of physical scenarios for black hole transitions.

Unveiling the nature of IGRJ17177-3656 with X-ray, NIR and radio observations

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We report on the first broad-band (1-200 keV) simultaneous Chandra - INTEGRAL observation of the recently discovered hard X-ray transient IGR J17177-3656.The observation took place about two weeks after the source discovery on March 22, 2011, at a flux level of about 15 mCrab in the 1-200 keV range. We extracted the most precise X-ray position of IGRJ17177-3656, RA(J2000)=17h 17m 42.62s, DEC(J2000)= -36deg 56m 04.5s (90% uncertainty of 0.6"). We also report Swift as well as near infra-red and radio follow-up observations. With the multi-wavelength information at hand, we discuss the possible nature of the source.

ULX NGC 5408 X-1: a deep search for correlated timing & spectral behavior

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We present X-ray timing and spectral results of the Ultraluminous X-ray source NGC 5408 X-1, one of the few ULXs known to show quasi-periodic behavior, and a strong candidate for an intermediate mass black hole. For this study, we use a cumulative exposure of 750 ksecs derived from XMM-Newton observations, including $\sim$ 400 ksecs from recent pointings. We again detect QPOs from the source, and our timing analysis reveals QPO frequencies in the range from about 5-50 mHz. The qualitative nature of the variability of the source is consistent with stellar mass black holes in the Steep Power-law (SPL) state; where the power spectral density rises below a certain frequency, then flattens and often shows a QPO on the rising portion. Spectral analysis was carried out using the EPIC-pn camera. The energy spectra were fit with multi-colored disk blackbody (to account for soft excess), a power-law and a hot plasma emission model (apec in XSPEC). This model gives acceptable fits in all cases. Combining this multi-epoch data, we search for the signatures of correlated timing and spectral behavior similar to those seen in stellar mass black holes. We discuss the implications of these results for mass estimates of X-1.

X-ray spectral variability in ultraluminous X-ray sources

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We present a systematic analysis of the X-ray spectral variability of a number of Ultraluminous X-ray Sources (ULXs) using XMM-Newton observations. We find that a Comptonization model plus a disc component describe well the spectral behaviour of ULXs. We checked the consistency of this spectral model on the basis of the variability patterns of its spectral parameters. Even if the parameters change between observations, the corona usually remains optically thick and cool. A soft excess is often observed. Some sources appear to show two rather well defined spectral states, typically not correlated with the total X-ray luminosity. We also attempted to determine the chemical abundances in the local environment of ULXs using both EPIC and stacked RGS spectra.

The most luminous ULXs: evidence for IMBHs?

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Although ultraluminous X-ray sources (ULXs) have long been touted as candidates to host intermediate-mass black holes (IMBHs), recent observational evidence has strongly suggested that the majority of them are smaller black holes accreting at extreme (super-Eddington) rates. However, a handful of the very brightest ULXs are so luminous that they defy explanation as stellar-mass black holes, even if at very super-Eddington accretion rates, indicating they must be considered as IMBH candidates. We will present results from the analysis of *XMM-Newton* and *Chandra* data for a new sample of 10 candidate very luminous ULXs, all within 100 Mpc and with $L(\mathrm{x}) > 5 \times 10^{40}$ erg s^{-1}, including 4 candidate hyperluminous X-ray sources (HLXs). Our analyses indicate that the most luminous ULXs are both spectrally harder and display more short-timescale variability than typical ULXs, suggesting they might be in a different accretion mode. Optical follow-up is now also revealing possible counterparts to some objects consistent with stellar clusters, a predicted host for IMBHs. We conclude these ULXs remain good IMBH candidates, and thus offer the best chance of finally proving the existence of such objects.

Resolving iron emission lines in 4U 1538−52 with XMM-Newton

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We present the results of a *XMM-Newton* observation of the high-mass X-ray binary 4U 1538−52 at orbital phases between 0.75–1.00 (in the eclipse-ingress phase). Here we concentrate on the study of discrete features in the energy range from 5.9 keV to 7.8 keV, i.e. on the iron Kα line region, using the *EPIC/PN* instrument on board *XMM-Newton* observatory. We clearly see a Kα neutral iron line at ∼6.4 keV and were able to distinguish two hot lines from highly photoionized Fe XXV and Fe XXVI. We discuss the implications of the simultaneous presence of iron with both low and high ionization levels.

The enigma of Supergiant Fast X-ray Transients: Swift broad-band results

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We present an overview of our Supergiant Fast X–ray Transients (SFXT) project by highlighting the unique observational contribution Swift is giving to this new field. In 2007 we demonstrated that while the brightest phase of the outburst only lasts a few hours, further activity is observed at lower fluxes for a remarkably longer time, up to weeks. Since then, Swift has been detecting outbursts from these fast transients with the BAT and following them intensely for days with the XRT. We now have a firm estimate of the time SFXTs spend in each phase. The 4 SFXTs we monitored for 1–2 years spend between 3 and 5 % of the time in bright outbursts. The most probable flux level at which a random observation will find these sources, when detected, is $F \sim 1$–2×10^{-11} erg cm^{-2} s^{-1} (2–10 keV, unabsorbed), corresponding to luminosities of a few 10^{33} to a few 10^{34} erg s^{-1}. The duty-cycle of inactivity ranges between 19 and 55 %.

Spectral analysis of LMXB Aql X-1 in soft and hard states with Suzaku

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Low-Mass X-ray binaries (LMXBs) are known to have soft and hard states, like Black Hole Binaries (BHBs). Since LMXBs are similar to BHBs in many respects, comparison between them will help us to understand their accretion mechanisms.

Studies of LMXBs in the hard state were so far hampered by their low luminosities. This difficulty is being overcome with the help of RXTE, Integral, and Suzaku.

In the present research, we analyzed archival Suzaku data of the LMXB Aql X-1, which is a recurrent transient with large luminosity changes. The data were obtained on 7 occasions during an outburst, covering both the soft and hard states. The soft-state data gave consistent results with previous studies (Mitsuda+1984, Makishima+1986). In the hard state, the source was detected with the XIS and HXD over a 0.8-100 keV range. The obtained wide-band spectrum is well fitted with a multi-color disk emission plus thermal Comptonization model. Seed photons of the Comptonization were confirmed to be provided by blackbody radiation from the neutron star surface. The accreting matter is considered to consist of an outer flat disk, and an approximately spherical hot inner flow.

Kilohertz QPOs and broad iron emission lines as a probe of strong-field gravity

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Kilohertz quasi-periodic oscillations (kHz QPOs) and broad iron emission lines are thought to be produced at the inner edge of an accretion disk around neutron stars in low X-ray binary systems (LMXBs).

The frequency of kHz QPOs and the width of iron lines strongly suggest that these phenomena take place just few kilometres above the surface of the neutron star and hence they should probe the strong gravitational field around these stars.

Both QPO variability and iron lines hold the promise of searching for signatures of strong-field general relativity, e.g. the innermost stable circular orbit (ISCO) or Lense-Thirring precession.

Here I present new results of the kHz QPOs and broad iron lines in the persistent neutron star LMXB 4U 1636-53. In this source we find that there is a complex relation between kHz QPOs and properties of the iron line, which is difficult to explain if both phenomena reflect properties of the same region in the accretion disk.

Suzaku studies of SFXTs

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An SFXT (Super-giant Fast X-ray Transient) is a subclass of High Mass X-ray Binaries, composed of a supergiant star and a highly magnetized neutron star. Although SFXTs are usually X-ray dim, they often show fast and violent X-ray flares with 2-3 orders of magnitude flux increases.

Trying to understand the flare mechanism of SFXTs, we re-analyzed archival Suzaku data of one such object, IGR J16195-4945, obtained on 2006 September 20. In the gross observation time of 70 ks,an intense flare with a duration of about 10 ks was detected.During the flare, the XIS (1-10 keV) and HXD (12-40 keV) count rates increased by a factor of five or more,but the absorbing column density remained the same within 10 %. Moreover, the flare was accompanied by a decrease .in the equivalent width of the fluorescent Fe-K line,and possible line broadening.

These results argue against a popular scenario which invokes clumpy stellar winds to explain the SFXT flares. Instead, the data prefer an alternative scenario of magnetic gating,which assumes intermittent gas accretion onto a neutron star with a rather strong magnetic field of $sim10^{13}$ G.

Magnetospheric accretion shocks in the X-ray spectrum of 4U 1626-67

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4U 1626-67 is an ultra-compact binary pulsar with a pulse period of 7.7 sec and an orbital period of 40 min. Its X-ray spectrum exhibits strong Doppler line pairs from highly ionized Ne and O. In 2008 the pulsar underwent another episode of torque reversal since the one in the early 1990. We observed the X-ray source one year after the event with the HETG spectrometer onboard *Chandra*. While the light curve before torque reversal is featureless, it now shows enhanced flaring similar to observations before the first reversal episode. The X-ray continuum now also exhibits significantly larger blackbody temperatures and smaller emission radii. The spectrum for the first time shows a narrow Fe K fluorescence line. We show while a photo-ionized plasma cannot fit the Ne and O Doppler line emissions, a collisionally ionized plasma provides a better description of the data. Based on this new interpretation of the Doppler line emissions, we propose that magnetospheric accretion shocks and shocked matter moving towards the magnetospheric poles provide a more consistent description than the ionized disk paradigm.

The spectral state transitions of ESO 243-49 HLX-1

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The hyper luminous X-ray source ESO 243-49 HLX-1, which reaches a luminosity of 10^{42} erg/s (0.2-10 keV), currently provides the strongest evidence for the existence of intermediate mass black holes. We present an X-ray study of the source based on XMM-Newton, Chandra and Swift XRT data which covers more than 2 years. We found that HLX-1 showed two fast increases in the count rate of a factor ∼40, separated by ∼380 days. The unabsorbed luminosities ranged from 2.5×10^{40} to 1.3×10^{42} erg/s. The source was observed in two main, well defined states that are consistent with the high/soft or thermal state, and low/hard state, reminiscent of Galactic stellar-mass black hole binaries. In this picture, the luminosity of the source in the low/hard state should be few percent of the Eddington luminosity at most, giving an additional lower limit on the mass of the black hole of ∼7000 M⊙. The relatively low disk temperature (0.2 keV) in the high/soft state also suggests the presence of an intermediate mass black hole.

Long term spectral variation in the neutron star X-ray binary, 4U 1636-536

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We present here an undergoing X-ray spectroscopic research of the long term variation in the neutron star X-ray binary system, 4U 1636-536. The source has been exhibiting a transient-like behaviour since 2002. Recent X-ray/optical photometric studies suggest that the ∼30-40 d variation seen in wide range of wavelengths could be due to the instability of accretion process within the system. Because of its short variation timescale and abundant archive data from various X-ray observatories, 4U 1636-536 indeed represents an ideal laboratory to study the physics of accretion near compact object like neutron star and black hole. To do this, we have been conducting a spectroscopic analysis at different epochs of variation by utilising X-ray data mainly from Suzaku satellite as well as other X-ray instruments covering different energy bands.

The XMM-Newton view of SFXTs: the case of IGRJ16418-4532

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We will report on a XMM-Newton ToO observation of the poorly studied, candidate Supergiant Fast X-ray Transient (SFXT) IGRJ16418-4532, performed during its latest outburst in February 2011. For the first time, the EPIC pointing, with its uninterrupted exposure lasting 40ks, allowed us to continuously follow the previously unknown richness of the source X-ray flaring behavior, which showed a high dynamic range of more than two orders of magnitude, never observed in IGRJ16418-4532. The observation caught several, rapid and bright X-ray flares, both at the beginning and at the end of the exposure. In the middle, a much lower, although variable, intensity state was observed. We will report on the temporal and spectral analysis of this observation, discussing our results in the context of the XMM-Newton view of these new transient supergiant High Mass X-ray Binaries, where the mechanism which produces the short flaring X-ray emission is still unclear.

Spectral properties of the transition between soft and hard state in GX 339-4

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Black hole X-ray binaries (BHBs) are known to evolve through different states during an outburst. Although there is general agreement that an outburst begins and ends in the low/hard state (LHS) – where X-ray emission is dominated by hard (comptonised) photons – and that there is in between a transition to the high/soft state (HSS) – where a thermal component is present – the exact properties and mechanism of the transitions are still under debate.

In the 2010 outburst of GX 339-4 the transitions between LHS and HSS were densely covered by observations obtained with RXTE. We define a sample of observations located in the region of state transition by selecting all observations within a certain hardness ratio range. This range was selected based on temporal variability properties. All observations with type-B QPOs have been included in the sample. We performed spectral analysis on PCA as well as on combined PCA / HEXTE data. During the soft intermediate state (SIMS) in the LHS-HSS transition the mean photon index is $\sim$2.5, while it reduces to $\sim 1.9-2$ in the SIMS of the HSS-LHS transition. As we cover the same hardness ratio range in both transitions, this finding implies that the high energy part of the spectrum is harder in the SIMS of the LHS-HSS than in the SIMS of the HSS-LHS transition.

Implications on our understanding and on models of state transitions will be discussed.

A detailed X-ray characterisation of ULXs

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We present the initial highlights of work aimed at providing a holistic view of the X-ray properties of ultraluminous X-ray sources (ULXs), based on *XMM-Newton* data. This combines the diagnostic power of three analyses for each set of data, namely energy spectra, power spectral densities (PSDs) and RMS spectra, to provide the clearest view of the behaviour of these extraordinary objects. We will show the initial highlights of this work, and discuss how these results limit physical models for the X-ray emission of ULXs, and the nature of their compact accretor.

Revealing the stellar wind and the accretion flow of Vela X-1 using XMM-Newton

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We present an analysis of a 124 ks orbital phase resolved observation of the prototypical wind accretor Vela X-1 with XMM-Newton. The observation covers the eclipse egress from phase 0.13 to phase 0.26. During the observation, a huge flare took place thereby allowing us to study the spectral properties both outside and during the flare. We have been able to model separately the several contributions to the observed spectrum: a direct component from the neutron star, a scattered component from the wind and a soft component. We analyse separately the variations in the density column of these three components as well as the variations in the Fe K fluorescence lines and provide an interpretation within the current stellar wind theory of massive stars. We also give clues to the possible origin of the soft component, also present in the spectra of many wind accretors, and whose origin is currently unknown.

Suzaku Observations of GX 339-4 in the Low/Hard State

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We present the results from X-ray and near-infrared observations of the Galactic black hole binary GX 339–4 in the low/hard state with Suzaku and IRSF in 2009 March. The spectrum in the 0.5–300 keV band is dominated by thermal Comptonization of multicolor disk photons, with a small contribution from a direct disk component, indicating that the inner disk is almost fully covered by hot corona with an electron temperature of ≈175 keV. The Comptonizing corona has at least two optical depths, $\tau \approx 1$ and ≈0.4. Analysis of the iron-K line profile yields an inner disk radius of 13.3 (7.3–19.7 at 90 percent confidence level) times the gravitational radius, with the best-fit inclination angle of ≈50°. This radius is consistent with that estimated from the continuum fit by assuming the conservation of photon numbers in Comptonization. Our results suggest that the standard disk of GX 339–4 is likely truncated before reaching the innermost stable circular orbit (for a non rotating black hole) in the low/hard state at ∼1 percent of the Eddington luminosity. The one-day averaged near-infrared light curves are found to be correlated with hard X-ray flux with a power law slope of 0.45.

Decoding the time-lags in accreting black holes with XMM-Newton

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All accreting black holes show X-ray variability at some level. The combination of variability and spectral information using powerful Fourier-based techniques allows us to measure the causal relationship between different X-ray spectral components, by studying the correlations and time-lags between them. Previous work in this area focussed on studies of hard X-ray bands with proportional counter detectors, with results that were hard to interpret physically. XMM-Newton has enabled a revolution in this area by simultaneously opening up the soft X-ray band for variability study and providing CCD energy-resolution, making it much easier to pick out the signals from the accretion disc and look for reverberation signatures which allow us to measure the light-travel time between the power-law continuum source and the disc. I will describe the results of our XMM-Newton program to study hard state black hole X-ray binaries with these techniques, revealing for the first time that variability is generated by the standard accretion disc itself (not a hot flow or corona), and showing the first detected signature of X-ray reverberation from the inner accretion disc around a stellar-mass black hole.

A ULX in a young massive stellar cluster

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We have discovered a new ULX in a young supercluster. Only one previous ULX has been found to be coincident with such a massive stellar cluster, and it is not clear if that source is actually inside the cluster. The new source is visible at ULX luminosities in two Chandra and one XMM observation, spanning 8 years, with the highest observed luminosity being a few times 10^{40} erg/s. The colours of the stellar cluster hosting the source indicates a young stellar population between 10 and 100 Myr old, and the total mass of the cluster is 10^6 solar masses. It resides in a slightly sub-solar metallicity environment. According to our current understanding of stellar evolution, such a massive BH can not be formed from a single star with the metallicity of the host cluster. Our observations therefore indicate that the BH was formed through stellar collisions in the centre of the super-cluster.

The broad iron emission line profile of XTE J1650-500

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The question of whether relativistic iron emission lines, a prediction of the disc reflection model, are present in the spectra of both X-ray binaries (XRBs) and active galactic nuclei (AGN) remains an ongoing debate. The AGN debate primarily centres around whether the ∼6 keV curvature is due to a broad emission line or complex absorption. For XRBs it is more generally accepted that a broad emission feature is present, but there are still questions over whether the observed line profiles are artificially broadened by instrumental effects, and whether they can be explained by some other physical process.

Here we present a detailed analysis of the XMM observation of the binary XTE J1650-500 during its 2001 outburst, focusing on the profile of the iron emission. Given the width of this feature, we present strong arguments against non-relativistic interpretations. In addition, we make use of the contemporaneous observation with the gas-based Beppo-SAX detectors to demonstrate that the line profile is not significantly modified by instrumental effects, and must have an astrophysical origin. We therefore conclude that a relativistically broadened iron line is the most plausible scenario, and discuss the relevance of this result to the separate debate on relativistic emission lines in AGN.

A jet ejection event from the intermediate mass black hole HLX-1 in ESO 243-49

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Observations have established two varieties of black hole: stellar mass (∼3-20 M⊙) and supermassive ($\sim 10^{6-9}$ M⊙) black holes. The stellar variety are formed from the collapse of massive stars, but how the supermassive ones form is unclear. It maybe from mergers of intermediate mass black holes ($\sim 10^{2-5}$ M⊙), but observational evidence for these objects has been weak. HLX-1 in ESO 243-49 has a minimum mass of 500 M⊙, derived from its maximum X-ray luminosity of 1.1×10^{42} ergs s^{-1} (0.2-10.0 keV) and the conservative assumption that this value exceeds the Eddington limit by at most a factor of 10. It is therefore a very strong intermediate mass black hole candidate. Here we present transient radio emission associated with flaring from a jet ejection event from HLX-1, never seen previously from such an Ultra Luminous X-ray source. The radio emission, in conjunction with Swift X-ray data and employing the black hole fundamental plane suggest a conservative black hole mass upper limit of $\sim 1 \times 10^5$ M⊙. The mass range obtained for HLX-1 is well within the mass domain of intermediate mass black holes, thus confirming the nature of HLX-1 and testifying that such objects exist.

Suzaku wide-band spectral analysis on short/long time scales of Cygnus X-1

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We analyzed 0.5–300 keV data of Cyg X-1 with Suzaku, acquired on 25 occasions from 2005 to 2009, with a net exposure of 450 ks. We have studied intensity-related spectral changes in Low/Hard state on three time scales using different methods: day-to-month changes via direct comparison among the 25 spectra; 1-second changes studied with "intensity-sorted spectroscopy" (Makishima+2008); and 0.1-second changes, utilizing "shot analysis" originally developed by Negoro+1997 with Ginga. We found that the emission in ¡ 10 keV is decomposed, in a model-independent manner, into two different components; a relatively harder one (¡10 keV) varying on ¡ 1 sec, and a softer one (¡2keV) varying on ¿ days. These can be identified respectively with the disk emission and the soft Comptonizaiton, as employed by Makishima+2008. We also successfully extended previous shot analysis by Negoro+1995 into much lower (0.5 keV) and higher (300 keV) energies, and found that the y-parameter and the temperature of the Compton cloud both decrease gradually through the rising phase of the shot, but suddenly return to their time-averaged values immediately (¡ 0.1 sec) past the shot peak; in contrast, the disk emission (¡2 keV) is much less variable. Considering them, we discuss conceivable physical condition.

Challenging ultraluminous X-ray sources

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The nature of ultraluminous X-ray sources (ULXs) continues to provide us with a strong theoretical challenge. While the mass of the black hole (BH) hosted in them has yet to be determined, recently different investigations found evidence of a possible correlation between ULXs and low metallicity environments. Based on these findings, we suggested that a fraction of ULXs are extremely heavy (30-80 solar masses) stellar BHs accreting from a massive donor via Roche-lobe overflow. Their accretion mode is likely to be quite unusual.

Here I will show further evidence in support of the correlation between ULXs and low metallicity environments. I will also analyze the complex X-ray spectral variability patterns of some ULXs, suggesting that they are accreting near or slightly above the Eddington limit, as expected for moderately massive (few tens of solar masses) stellar BHs. Finally, I will present new results from simulations of various realizations of young star clusters hosting massive BH binaries with massive donors, showing that their typical offset with respect to the parent cluster is consistent with observations.

Analysis of high energy data from LS I +61 303 based on its 4.6 yr periodicity

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The most peculiar radio characteristics of the TeV emitting high-mass X-ray binary LS I +61 303 are two periodicities: A large periodic outburst which exhibits the same period as the orbit (phase Φ) and a second periodicity of 1667 days (phase Θ), which modulates the orbital phase and amplitude of the large outburst. Recent analysis of the radio spectral index provides strong evidence for the presence of the critical transition from optically thick emission (related to a steady jet) to an optically thin outburst (related to a transient jet) as in other microquasars. In parallel to this transition, a transition from a low/hard X-ray state to a transitional state would be expected. We show how the critical transition from optically thick emission to an optically thin outburst is modulated by Θ. Folding over large Θ intervals mixes up different states and can yield a false picture of the emission behaviour of the source along the orbit. We therefore analyse the implications of the connection between radio and X-ray behaviour for hard X-ray/high energy data from LS I +61 303 obtained, e.g., with INTEGRAL, taking into account this long-term periodicity.

Chapter 5

Cataclysmic Variables and Novae

An observational study of accretion flow in the inner disk of dwarf novae

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We present UV and X-ray data of Dwarf Novae (DN) from the XMM-Newton and RXTE observatory. We perform timing analysis of high time resolution UV and X-ray light curves deriving power spectra to study the flux variability in the framework of model of propagating fluctuations of Keplerian disks. We show for three DN systems, SS Cyg, VW Hyi and RU Peg, that the UV and X-ray power spectra are similar in quiescence and show similar break frequencies. We derive inner disk radii for these systems in a range (1.5-0.8)e10 cm. The RXTE outburst data of SS Cyg will be discussed separately in comparison with the timing analysis of the quiescence data. We calculate the correlation between the simultaneous UV and X-ray data using XMM-Newton obtained in quiescence and find time lag consistent with delays in the X-rays of 90-200 sec in the three DN. This can be explained by the travel time of matter from a truncated inner disk to the white dwarf surface. Overall, we suggest that DN may have large scale truncated accretion disks in quiescence which may also explain the UV delays in the outburst stage and the accretion may occur through a rotating accretion disk coronae.

Classical novae as supersoft X-ray sources in the Andromeda galaxy M31

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Classical novae (CNe) represent the major class of supersoft X-ray sources (SSSs) in the central region of our neighbouring galaxy M31. Since 2006, we carry out an on-going dedicated monitoring of the M31 central region with XMM-Newton and Chandra, specifically designed to detect and characterise SSS states of CNe. Here we present results from the first three monitoring campaigns (2006 - 2009). In total, we found 21 X-ray counterparts of CNe, only four of which were known previously. Additional to the investigation of several interesting individual sources, this sample, combined with our earlier findings based on archival data, allowed us to compile a catalogue of 60 CNe with X-ray counterpart in M31. This is by far the highest number of these sources known in any galaxy. We present results from a statistical study of this catalogue including several correlations between optical and X-ray parameters of CNe (e.g. SSS turn-on and turn-off time or spectroscopic expansion velocity). In a simulation we addressed the question if all CNe show SSS states. Furthermore, we found a first hint for differences in the X-ray properties of novae in the bulge and disk of M31.

XMM-Newton observations of the unique binary system HD49798/RXJ0648-4418

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We present X-ray and optical observations of HD49798/RXJ0648-4418, the only X-ray binary consisting of a hot sub-dwarf and a white dwarf. This system is particularly interesting because its fast-spinning white dwarf (P=13 s) was found, with XMM-Newton timing measurements, to have a mass of 1.3 solar masses.

Its X-ray emission consists of a highly pulsed, soft, thermal component, well fit with a blackbody with kT=40 eV, accounting for most of the luminosity, and a harder component, consistent with a power-law or with a thermal bremsstrahlung with kT=8 keV. A luminosity of 10e32 erg/s is produced by accretion onto the white dwarf of the helium-rich matter from the wind of the companion, but the X-ray properties are similar to those of white dwarfs accreting from Roche-lobe overflow.

At the end of the current He-burning phase, the sub-dwarf mass donor will expand and reach the Roche-lobe, causing a higher accretion rate onto the white dwarf which can reach the Chandrasekhar limit. This could lead to the formation of a millisecond pulsar through accretion induced collapse. Alternatively, this system could be a Type Ia supernova progenitor, with the appealing characteristic of a short time delay, being the descendent of relatively massive stars.

From X-ray dips to eclipse: witnessing disk reformation in the RN U Sco

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The recurrent eclipsing nova U Sco was observed simultaneously in X-rays, ultraviolet (UV), and optical with XMM-Newton on days 22.9 and 34.9 after outburst. The first 2/3 of the first X-ray light curve contains four deep dips while the UV and optical light contains smooth eclipses. The dips disappeared by day 34.9, yielding clean X-ray and UV eclipses. We interpret the change from X-ray dips to eclipse as part of the formation process of an accretion disk while the nova was still active. The X-ray dips on day 22.9 can be caused by clumpy absorbing material intersecting the line of sight while moving along highly elliptical trajectories. When expelled from the companion, the material is in a low state of ionisation and poses significant absorption only to X-rays ($\lambda < 911$ Å), which explains the absence of dips in UV and optical.
The X-ray spectra contain photospheric continuum emission from the white dwarf plus unusually strong emission lines. The X-ray continuum does not fully disappear during dips or eclipse, and must at least partially be Thompson scattered in surrounding material that is not eclipsed. Both, continuum and emission lines in the X-ray spectra give clear whitness of a gradual temperature increase.

The spectral evolution of Nova LMC 2009

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Nova LMC 2009 is a rare example of a nova that was monitored with grating X-ray spectra over several months, before maximum, at maximum and immediately afterwards. It is also the "most often observed" nova with XMM during outburst, and only case of an extragalactic nova monitored in this way. LMC 2009 is thought to be a recurrent nova, but we find that the RGS grating spectra show dramatic differences with Galactic recurrent novae like RS Ophiuchi and U Scorpii. In addition to other interesting features, we will discuss what the X-ray spectra teach us about the dependence on metallicity of the nova outburst.

Swift X-ray observations of classical novae: the super-soft source sample

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Swift is an excellent facility for studying Classical and Recurrent Novae. I will present the sample properties of 64 Galactic and Magellanic Cloud novae, mostly observed by Swift, of which 25 have been detected as super-soft X-ray sources. The sample is biased towards fast novae, and thus towards higher mass white dwarfs. I examine new and previously claimed correlations within the super-soft novae, and show that clues exist in the optical properties of novae to the presence of super-soft X-ray emission. A high degree of variability is a common characteristic of nova super-soft emission; I examine both the periodic and non-periodic behaviour and their discuss possible origins.

Orbital-phase resolved spectroscopy of FO Aqr (IP) using XMM-Newton data

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We re-analyze the XMM-Newton EPIC pn data of the intermediate polar FO Aqr. The total spectrum can be represented by a composite model consisting of two plasma emission models (MEKAL) and two Gaussian emission lines at 6.4 keV and 6.7 keV together with a neutral absorption and partial covering absorption model. We examine the change of the X-ray spectrum of the source over the orbital period of the system (4.85 hr.) by fitting the orbital phase-resolved spectra of the source to the composite model. We find that the neutral absorption increases by a factor of 4 towards the orbital minima. We detect change in the flux of the 6.4 keV an 6.7 keV lines over the orbital period. We also focus on the changes in the spin pulses of the white dwarf over the orbital period. We investigate the amplitudes of the spin pulses (20.9 min.) at orbital phase bins of 0.1. The spin amplitudes change inphase with the orbital variations, reaching up to 0.8 c/s around the orbital maxima and dropping down to 0.15 c/s around the minima. Therefore, we show that the absorption component also influences the spin pulse of the system which otherwise would be unaffected.

Variable supersoft X-rays from nova M31N 2007-12b: an intermediate polar?

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The He N nova M31N 2007-12b was covered by our XMM-Newton/Chandra M 31 monitoring program with 10 d spacing between observations. In four XMM-Newton observations we detected bright supersoft X-ray emission from the nova (starting 21 d to 30 d and ending 60 d to 120 d after optical outburst) which makes M31N 2007-12b one of the novae with the shortest X-ray phase known. The X-ray spectrum can be fitted with a white dwarf (WD) atmosphere model with solar abundances (temperature ~ 70 eV to ~ 80 eV, radius of emission region $\sim 6 \times 10^8$ cm) assuming Galactic foreground absorption. The luminosity during maximum was at the Eddington limit of a massive WD and dropped by ~ 30 percent in the observation 60 d after outburst. We detected a stable 1110 s pulsation (interpreted as the WD rotation period). Dips in three observations might indicate a 4.9 h or 9.8 h binary period of the system. Nova envelope models with < 50 percent mixing between solar-like accreted material and the O Ne degenerate core can describe the data. We derive a WD mass, an ejected and burned mass of 1.2 M$\odot$, 2.0×10^{-6} M$\odot$ and 0.2×10^{-6} M$\odot$, respectively. The observed periodicities indicate that the nova erupted in an intermediate polar system which seems also to be supported by the large photospheric radius of the WD.

Synthetic spectra for super-soft sources

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XMM-Newton provides high-resolution and high-S/N spectra of extremely hot white dwarfs, e.g. burst spectra of novae. Their analysis requires state-of-the-art NLTE model atmospheres.

The Tübingen Non-LTE Model-Atmosphere Package (*TMAP*) calculates such model atmospheres and spectral energy distributions at a high level of sophistication.

We present our model atmospheres and show examples of their application.

On the origin of the Fe lines in AM Herculis

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The origin of the plasma emission lines of highly ionized Fe in the prototypical system AM Herculis is rather controversial. Quite opposite locations are discussed, either at the bottom or the top of the accretion column. We present the results of phase-resolved EPIC pn spectrophotometry, which combined with high-resolution Chandra HETG spectroscopy and line-profile synthesis locate the lines at intermediate height in a stratified accretion column. The feasibility of line spectroscopy with IXO is discussed briefly.

Dwarf novae in globular clusters

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Globular clusters (GCs) are old, dense stellar systems which harbor an excess of X-ray sources. These are mainly close binaries and part of them can be produced through dynamical encounters in the dense cores of GCs. Cataclysmic variables (CVs) in GCs and in the field possibly show different properties (magnetic nature, mass of the white dwarf) due to different formation mechanisms. A striking observational difference is the possible lack of outbursts from dwarf nova (DN) CVs in GCs compared to the field.

I will present the discovery of a new DN in the GC M13, the 13th detected in a GC, and the spectroscopic observations of two DNe in the GC M22, which bring further insights on the nature of CVs in GCs. The detection of one DN in M13 when more could have been expected likely indicates that our knowledge of the Galactic population of CVs is too limited: DNe may have a much smaller mean duty cycle (1%), as suggested by some population synthesis models and recent observations in the field. The case of CV1 in M22 is intriguing as our observations indicate a likely short orbital period of 1.2 h, in conflict with its optical luminosity.

Phase-dependent effects on X-ray spectra of magnetic cataclysmic variables

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The X-ray emission in the post-shock region of magnetic cataclysmic variables (mCVs) is mainly due to an optically thin bremsstrahlung. However, the observed flux of some systems shows variations along the orbital motion, which can be explained by phase-dependent absorption and/or occultation of the emitting regions. An appropriate modeling of such effects demands a 3D representation of the system. In this work, we explore the phase-dependent effects on the emission of mCVs. We use CYCLOPS-X, a 3D code that reproduces the bremsstrahlung emission from post-shock regions. In our code, the post-shock and pre-shock regions are extended and defined by the dipolar magnetic field lines. The code may include one or two emitting regions. All the effects that depend on the orbital phase are consistently calculated in a 3D geometry. Hence, the viewing angle and the location of the accretion columns completely define whether the absorption or occultation are total, partial, or absent. We present illustrative light-curves and spectra. The increase of the sensitivity of X-ray observatories makes possible to obtain mCVs data with enough time resolution to allow a detailed study of their magnetic accretion region as provided by CYCLOPS-X.

RS Cae - a soft X-ray dominated polar

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In AM Her-type cataclysmic variables, a strong magnetic field of the white-dwarf primary governs the accretion processes, and the accretion stream is funnelled along the field lines towards the poles of the white dwarf. Their X-ray emission consists of two main components: the harder emission from the cooling accretion column above and the softer emission from the heated accretion region on the white-dwarf surface. On the basis of XMM-Newton and optical observations, we investigate the properties and flux contributions of these components.

RS Cae has been selected for this campaign due to its high soft X-ray flux that was measured in the ROSAT All-Sky Survey. Our XMM-Newton data cover about five orbital cycles of the binary and are clearly dominated by soft X-ray emission. Spectral fits with single- and multi-temperature models indicate a high bolometric soft-to-hard flux ratio of above 100. RS Cae, thus, counts to the sub-group of X-ray soft AM Her-type systems, which are believed to show inhomogeneous accretion processes.

Chapter 6

Magnetars, Isolated Neutron Stars and Pulsars

A new magnetar candidate located outside the Galactic plane

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Magnetars are believed to be neutron stars with surface magnetic field strengths $> 10^{13}$ G. There are currently only 16 confirmed members of this class, with an additional 5 candidates. While two magnetars are located in the Magellanic Clouds, the remaining objects are all within the Galactic plane. The association of a number of magnetars with supernova remnants has led to the conclusion that they are all young objects ($<$ 10,000 years old) with low spatial velocities ($<$ 500 km s^{-1}), consistent with the low Galactic latitudes. We have recently discovered a new transient magnetar candidate in archival XMM-Newton data that is located $\sim$20 deg off the plane. The transient behaviour, X-ray spectrum, and lack of an optical counterpart lead us to conclude that it is most likely a new member of the magnetar class. A run away progenitor star that wandered outside the plane prior to going supernova can possibly explain the high Galactic latitude.

Monitoring PSR B1509-58 with RXTE: spectral analysis 1996-2010

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We present an analysis of the X-ray spectra of the young, Crab-like pulsar PSR B1509-58 (pulse period P 151ms) observed by RXTE during 14 years since the beginning of the mission in 1996. The uniform dataset is especially well suited for studying the stability of the spectral parameters over time as well as for determining pulse phase resolved spectral parameters with high significance. The phase averaged spectra as well as the phase resolved spectra can be well described by an absorbed power law.

SGRs and AXPs: white dwarf pulsars versus magnetars

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The recent observations of SGR 0418+5729 offer an authentic Rosetta Stone for deciphering the energy source of Soft Gamma Ray Repeaters (SGRs) and Anomalous X-ray Pulsars (AXPs). It is shown how a consistent model for SGRs and AXPs can be expressed in terms of canonical physics and astrophysics within massive, fast rotating, and highly magnetized white dwarfs. Within this model, we obtain the theoretical prediction for the lower limit of the first time derivative of the rotational period of SGR 0418+5729, $\dot{P} \geq L\_X P^3/(4\pi^2 I) = 1.18 \times 10^{-16}$ s/s being L_X and P the observed X-ray luminosity and rotational period of the source, and I the moment of inertia of the white dwarf. Besides the case of SGR 0418+5729, we also show that the energetics of all SGRs and AXPs, including their outburst activities can be well explained through the change of rotational energy of the white dwarf, associated to the observed sudden changes of the rotational period. For all sources, we find a surface dipole magnetic field $7.5 \times 10^8 \mathrm{G} \lesssim B \lesssim 2.1 \times 10^{11} \mathrm{G}$, well below the critical field $B\_c = m^2\_ec^3/(e\hbar) = 4.42 \times 10^{13}$ G.

Magnetic fields in neutron stars: from interiors to surrounding accretion discs

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I consider two cases of interest involving magnetic fields and neutron stars (NSs): (1) is a unified model for magnetic properties of isolated NSs possible? (2) How does accretion around NSs deform the magnetic field configuration?

For topic (1), I describe how a dynamo mechanism could be the keystone to create a grand unification scenario for explaining the different flavours of isolated NSs. During the proto-NS phase the star interior is subject to the neutron-finger instability, this can activate a mean field dynamo and generate a large scale magnetic field, whose properties will depend on how the star was initially rotating.

As regards topic (2), magnetic fields play a fundamental role in accretion discs, nevertheless highly idealised models from the 80's are still being used. I will discuss a possible way of improving the old analytic models with a semi-analytic approach. The results suggest a magnetic field profile quite different from the currently used one, with even an inversion of the toroidal component in some cases. This draws a new picture about which parts of the disc spin the star up or down and can have drastic consequences on the NS spin history.

X-ray and optical observations to constrain equation-of-state of neutron stars

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We try to constrain the nuclear Equation-of-State (EoS) by observations of neutron stars in our galactic neighbourhood. There are seven thermally emitting neutron stars known from X-ray and optical observations, the so-called Magnificent Seven (M7), which are young (few Myrs), nearby (one to few hundred pc), and radio-quiet with blackbody-like X-ray spectra, so that we can observe their surfaces. As bright X-ray sources, we can determine their rotational (pulse) periods and their period derivatives from X-ray timing. From XMM and/or Chandra X-ray blackbody spectra, we can determine their temperatures. With precise astrometric observations using the Hubble Space Telescope, we can determine their parallax (i.e. distance) and optical flux (done for RXJ1856 and RXJ0720). From flux, distance, and temperature, one can in principle derive the radius using just the Stefan-Boltzmann law. Then, from identifying atomic absorption lines in X-ray spectra, if originated from the thin neutron star atmosphere, and also from rotational phase-resolved spectroscopy, we can determine the compactness (mass/radius) and/or gravitational redshift. The latter is currently applied for one case (RBS1223). If also applied to RXJ1856, radius (from luminosity and temperature) and compactness (from X-ray data) will yield the mass and radius - for the first time for an isolated single neutron star. We will present the status of our project.

First dedicated observations of the isolated neutron star in the Carina Nebula

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2XMM J104608.7-594306 is a newly discovered isolated neutron star (INS) sharing most of the properties of the intriguing "Magnificent Seven" (M7). In spite of many efforts to discover new M7-like objects, this is the first example of a thermally emitting INS to be detected beyond the Gould Belt. It displays a purely thermal soft X-ray emission, stable flux, has no counterparts at other wavelengths and is likely located in the Carina Nebula, at a distance of 2kpc. 2XMM J104608.7-594306 is unique since it has an intermediate temperature between the M7 and the only RRAT thus far detected in X-rays. Current estimates on the birthrates of thermal INSs and RRATs show that they may outnumber active radio pulsars. In this case, the rate of Galactic core-collapse supernovae cannot account for all different INSs without invoking relations between the several subgroups. The investigation of this INS is therefore of particular importance since it may well be a missing link between the M7, magnetars and RRATs. We report here the results of a dedicated observational campaign with XMM-Newton and the VLT on 2XMM J104608.7-594306, which are used to constrain its evolutionary status and to shed light on its relation to other INSs.

Understanding neutron stars through multi-wavelength observations of pulsars

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Fermi LAT collaboration

Neutron stars are most easily detected as pulsars. Until recently, most pulsars known were detected initially in the radio domain. X-ray observations have shown that a small proportion of these pulsars also emit at higher energies. Since the launch of the Fermi satellite in 2008, many new energetic pulsars have been detected in the local galaxy in the gamma-ray domain and large populations of millisecond pulsars have been identified in Galactic globular clusters. Our follow-up XMM-Newton observations have revealed X-ray counterparts for these high energy emitting pulsars. We present modelling of the lightcurves and spectra that is beginning to give us an insight into how the high energy emission is created as well as helping us to constrain the as yet unknown neutron star equation of state. Further, we show that the large population of globular cluster millisecond pulsars inferred from our observations could explain the longevity of globular clusters.

Chapter 7

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

At the rescue of forgotten SNRs with XMM-Newton and Chandra

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We present the first results of a far-reaching Spaniard-Argentinian research program aimed at disclosing X-ray supernova remnants (SNRs). Here we report results on five remnants. Three of them belong to the mixed-morphology class. We have discovered a candidate for CCO in one of them. The other two objects are a PWN, and a very unusual source formed by a partial shell, internal x-ray emission and a possible compact object centered at the radio structure.

X-ray light curves of gamma-ray bursts without flares

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In the present work we focus on a specific question concerning the X-ray light curves of Gamma-Ray Bursts (GRB): does the X-ray continuum of GRBs without flares show any difference with respect to that of GRBs with flares? We address this question by analysing a sample of 64 long X-ray light curves observed by Swift/XRT with redshift and without flaring activity. We compare the results obtained with the equivalent properties of the continuum underlying the light curves with flares considered in Margutti et al. (2011). We find that the initial steep decay occurring in different types of light curves has likely the same origin but is significantly different between light curves with and without flares. The energy output of the X-ray light curves and of the prompt emission is similar for the light curves with and without flares, pointing to a similar progenitor but with different physical conditions that determine the appearance of flares. We then investigate different scenarios that can account for the observed properties.

Thermal X-rays from ejecta and shocked ISM in SN1006 as observed by XMM-Newton

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The remnant of SN1006 is well known to be the archetypical cosmic-ray accelerating supernova remnant, with two bright limbs dominated by non-thermal emission. In the soft X-ray band the emission is dominated by a thermal component which was traditionally associated to the shocked stellar ejecta fragments. One of the longstanding issue is the lack of apparent X-ray emission from the shocked ISM, which may provide evidence for proton acceleration through the observation of CR back-reaction effects. We present a comprehensive study of the X-ray thermal emission of SN1006, reporting the detection of ISM in the SE and the spatial distribution of the ejecta metal abundances. We briefly discuss a few MHD simulations aimed to reproduce the morphology of ejecta emission.

Synchrotron X-ray structures in SNR shells: particle acceleration probe

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Some of SNRs (SN 1006, RX J1713 and others) have nonthermal X-ray emission features that are well interpreted as synchrotron emission of energetic electrons accelerated at SNR shock waves. The particle acceleration process should be accompanied by effective generation and amplification of turbulent magnetic field. Amplitudes of these magnetic field fluctuations could be much greater than an average magnetic field. The turbulent magnetic field will affect the formation of SNR X-ray emission especially at energies near the synchrotron spectrum cut off. We present results of modeling of X-ray images and spectra for SNRs with efficient particle acceleration and strong magnetic field fluctuations. X-ray images of synchrotron radiation are shown to be intermittent. The important prediction of the model is an appearance of small scale structures with highly polarized X-ray emission with high (up to 50%) degree of polarization. These structures depend sensitively on the spectrum of magnetic field fluctuations. This dependence could be used to study the spectral properties of turbulent magnetic field and their connections to the highest energy particles accelerated at SNR shocks. We discuss the perspective of X-ray polarization observations in SNRs with the next generation of X-ray observatories.

An extended X-ray PWN counterpart to the VHE gamma-ray source HESS J1303−631

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The very high energy (VHE) Gamma-ray source HESS J1303−631 was discovered by the H.E.S.S. collaboration in 2004. At the time, no obvious counterparts were known in other wavelengths and a follow-up observation by Chandra revealed no obvious counterpart to the Gamma-ray source, placing it in the category of "dark" VHE Gamma-ray sources. A 30 ksec observation by XMM, however, reveals an extended X-ray pulsar wind nebula associated to the pulsar PSR J1301−6305 and provides evidence for the association of the H.E.S.S. source with the pulsar. This, combined with the detection of significant energy dependent morphology in the VHE source and a stationary leptonic model of the spectral energy distribution, allow the identification of this source as a "synchrotron under luminous" pulsar wind nebula.

Particle acceleration in SN 1006

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SN 1006 is a type Ia supernova remnant evolving at high latitude in a relatively uniform interstellar medium. Its X-ray emission exhibits both thermal emission from the shocked ejecta and nonthermal synchrotron emission from the electrons accelerated at the forward shock. Its 30 arcmin extent allows to perform detailed study of the shock structure.

I propose to present the results obtained with a large program on SN 1006 carried out with XMM-Newton. The characterization of the synchrotron emission, at small spatial scale, reveals the properties of the acceleration along the forward shock. This provides new insights into the acceleration process and notably regarding its dependence to the obliquity of the ambient magnetic field.

XMM-Newton and Suzaku observations of Vela supernova remnant ejecta fragments

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The Vela Supernova Remnant (SNR) is one of the nearest SNRs, subtending more than 8 degrees on the sky. Its environment is complex: the remnant is bright, soft, and sharply defined to the east and north, but much fainter and less well ordered in the west and south. Age estimates for the associated pulsar range from $\sim$ 11400 years to as much as 18000 years, making the the SNR a moderately old remnant. The discovery of protrusions beyond the projected rim suggested that these protrusions could be ejecta fragments (Aschenbach et al. 1995, Nature 373, 587), and subsequent X-ray observations by a number of workers confirmed enhanced abundances in a number of these fragments. We will present analyses of several ejecta fragments based on XMM-Newton and Suzaku X-ray observations. This will include an examination of the composition, morphology, structure of Vela Fragment "D", the largest and brightest of the fragments, and explore the possibility that the fragment consists of several components.

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X-ray and radio observations of a new SNR in the Large Magellanic Cloud

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Because of their energy and hot gas inputs into the Interstellar Medium (ISM), the study of Supernova Remnants (SNRs) is crucial for a complete understanding of the chemical composition and evolution of the ISM in a galaxy. Located at a distance of 50 kpc, the Large Magellanic Cloud (LMC) offers the ideal laboratory for the study of a large sample of SNRs in great detail. Since its first detection in X-rays, it has been extensively observed, but the major step forward came from the ROSAT survey of the LMC, which revealed 758 sources, among which 46 sources are SNRs and candidate.

The source [HP99] 456 is one of the best SNR candidates classified in the ROSAT catalog on morphological and spectral criteria. We have performed data analysis of recent observations of this source with XMM-Newton and confirm a structure like a SNR shell. In addition, a narrower and harder region can be observed, that may be a Pulsar Wind Nebula candidate. Follow-up observations have been performed to search for radio counterparts. In this presentation, we will present results of radio and X-ray data analysis of this new composite Supernova Remnant in the LMC.

Chandra and XMM-Newton observations of the extraordinary GRB 060729

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We will report on the results of the Swift-discovered Gamma Ray Burst 060729. The X-ray afterglow of this burst has been extraordinary. It has been so bright that it could be followed by Chandra almost 2 years after the burst. The late-time Chandra observations show a break at about a year after the burst suggesting a jet half opening angle of about 14°. GRB 060729 was also observed by XMM-Newton about a day after the burst for 62 ks which is one of the longest XMM observations ever of a GRB. The X-ray spectra allow a detailed analysis of the intrinsic absorber properties of this burst.

Hard X-ray emission from central stars of planetary nebulae

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The central stars of planetary nebulae (CSPNe) are hot stars whose photospheric emission can extend into the X-ray domain, with spectra peaking at 0.1-0.2 keV and diminishing above 0.4 keV. Unexpected, intriguing hard X-ray emission peaking above 0.5 keV has been reported for several CSPNe and for a number of white-dwarfs (WDs), the immediate descendants of CSPNe. Different mechanisms may be responsible for the hard X-ray emission from CSPNe: coronal emission from a late-type companion, shocks in fast winds as in OB stars, leakage from underneath the CSPN's photosphere, coronal activity of the CSPN itself, or accretion of material from a disk or a companion star. Binary companions and magnetic fields are thought to play an important role in the formation and shaping of PNe, whereas clumping in the stellar wind may have notable effects in the PN formation and evolution by modifying the stellar mechanical energy output. Therefore, the hard X-ray emission associated with CSPNe may have significant implications for our understanding of the formation of PNe. Here we present the observational results on the search for hard X-ray emission from CSPNe and discuss the different production mechanisms.

X-ray analysis and modeling of the PWN in G0.9+0.1

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The composite SNR G0.9+0.1 has been observed in different energy ranges. We performed a spatially resolved spectral study of the PWN in G0.9+0.1 using two observations with the XMM-Newton telescope. It shows that the spectral index within four annuli, covering the inner part of the PWN and centered on the assumed pulsar position, increases with growing distance to the pulsar. The surface brightness drops accordingly. A radially symmetric leptonic model was applied in order to reproduce the observed X-ray emission. With the adopted model we were able to reproduce the general characteristics of the spectra. Using the optimized parameter values, we compared the modeled inverse Compton radiation with the published H.E.S.S. very high energy γ-ray data.

XMM-Newton observations and multi-wavelength studies of the TeV gamma-ray source

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The TeV gamma-ray source HESS J1427-608 was discovered during the H.E.S.S. Galactic Plane Survey. At the time, there was no evidence for a counterpart at other wavelengths, and it was therefore considered a dark, or unidentified, source. In this contribution, we will present a new multi-wavelength view of this enigmatic source.

Furthermore, additional H.E.S.S. observations have nearly doubled the exposure in the TeV domain, confirming earlier results. In order to investigate the keV X-ray environment in the direction of the TeV gamma-ray emission, dedicated observations were carried out with XMM-Newton. The results of a search for both point-like and diffuse X-ray emission will be shown. Archival radio data at 843 MHz from the Molonglo Galactic Plane Survey and ^{12}CO line emission were also analysed to complement the high-energy view of this source and to search for any evidence of a coincident molecular cloud. We describe the spectral energy distribution with models for leptonic and hadronic emission. Different scenarios for the nature of this source, in particular a hypothetical pulsar wind nebula, will be discussed.

Early report on the spectral survey of mixed-morphology SNRs with Suzaku

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We will report of early results of the Spectral Survey of Mixed-Morphology SNRs (MM-SNRs) using the Suzaku satellite. Out of the dozen MM-SNRs observed with Suzaku, about half are found to exhibit over-ionized plasma states. Most of them are associated with GeV/TeV gamma-ray emissions and molecular cloud interactions. The other half exhibit no clear indication of over-ionized plasma. However some of them show peculiar features which are not found in the shell-like SNRs. Based on these observational facts, we will discuss possible implications of MM-SNRs in comparison with the shell-like SNRs.

Circumstellar interaction in Type Ia supernova 2003lx

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An X-ray source that was discovered at the position of the Type Ia supernova (SN) 2003lx through two serendipitous *Swift* observations in 2008 January. The corresponding merged image revealed a 7σ detection at 2.1 arcsec from the supernova optical position. The positional coincidence and the absence of an earlier X-ray source in the *ROSAT* data strongly suggested that the discovered source was indeed a X-ray SN Ia. It could be fit with a thermal spectrum with best-fit temperature $kT \sim 4$ keV, implying an X-ray luminosity of $L = (3.8 \pm 1.5) \times 10^{41}$ ergs s^{-1} of 0.3 – 2.0 keV (at redshift $z = 0.0377$), while a power-law model with $\Gamma = 1.8 \pm 0.4$ also provided satisfactory fits. The fitted temperature was consistent with typical temperatures observed in young supernova remnants. If the X-ray source were indeed from a SN Ia, then the observed luminosity inferred a progenitor companion having a mass-loss rate of $\dot{M} \sim 10^{-4} M\odot$ yr^{-1} (wind velocity $v = 10$ km s^{-1}) in a white dwarf binary system. An AO-10 XMM-*Newton* observation had been accepted to identify the nature of the X-ray source detected, and to study it evolution. If confirmed, it will be the first concrete X-ray SN Ia detected.

The XMM-Newton survey of the SMC: SMP SMC 22 and other planetary nebulae

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We present the results of a sensitive search for X-ray emission from the known planetary nebulae in the Small Magellanic Cloud carried out with XMM-Newton.

Significant emission was detected from SMP SMC25 and SMP SMC22, with soft X-ray luminosity of $(0.2–6)\times10^{35}$ erg s^{-1} and $\sim 10^{37}$ erg s^{-1}, respectively.

The exceptionally high X-ray luminosity of the Super Soft Source SMP SMC 22 is probably due to the high mass of its central star, which is rapidly evolving toward the white dwarf's cooling branch, and to a small amount of intrinsic absorption in the nebula itself. Its very soft spectrum is reproduced well with a non-local thermodynamical equilibrium model atmosphere composed of H, He, C, N, and O, with abundances equal to those inferred from studies of its nebular lines. The derived effective temperature of 1.5×10^5 K is in close agreement with that found from the optical/UV data.

IKT 16: a composite SNR in the SMC

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SMC XMM-Newton Large Project Collaboration

We present results from an X-ray and multiwavelength study of the supernova remnant IKT 16 in the Small Magellanic Cloud, conducted as part of the XMM-Newton SMC Large Project. This is an X-ray and radio faint SNR, which in previous studies was found to contain a region of harder X-ray emission near its centre. Using all available XMM-Newton data, alongside multi-frequency radio-continuum surveys and optical observations, we have tightly constrained the spatial and spectral properties of this system. We find this to be the largest SNR in the SMC, with a radius of 37 pc, shock temperature of 1 keV and age of 14700 yrs. The derived properties of this SNR indicate that it is in the Sedov-adiabatic phase of evolution and is expanding into a low-density environment near the centre of the SMC. We find the hard source near the centre of the remnant to be the PWN associated with the SNR, making this system the first confirmed composite SNR in the SMC and the most distant object in this class discovered to date.

XMM-Newton observations of the Dark Accelerator MGRO J1908+06

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MGRO J1908+06 is one of the brightest TeV gamma-ray sources in the Galactic disk. It was originally discovered with Milagro and later confirmed with H.E.S.S. and VERITAS as an extended TeV source. A nearby GeV gamma-ray pulsar, PSR J1907+06, was recently discovered with the Fermi LAT suggesting that MGRO J1908+06 is an asymmetric pulsar wind nebula. While counterparts to the pulsar have been found at X-ray and radio wavelengths, no emission other than TeV gamma rays has so far been detected from MGRO J1908+06. The pulsar wind nebula appears to have an extremely low X-ray to TeV gamma-ray flux ratio. We have obtained XMM-Newton data for the region near MGRO J1908+06 and present the results of our search for extended X-ray emission from the pulsar wind nebula.

XMM observation of IGR J11014-6103: a new peculiar "double-head" bow-shock PWN

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Searching for a soft X-ray counterpart of the INTEGRAL unidentified source IGR J11014-6103, we discovered in archival X-ray observations an extended, cometary-like emission composed by an elongated tail extending for 4arcmin and terminating with a much brighter double-spot on its head.

We analyzed the source and the surrounding region in gamma-rays, X-rays, optical, NIR and radio wavelengths, finding possible counterparts for one of the two bright point-like spots.

We discuss possible interpretations of the source on the frame of bow-shock pulsar wind nebulae and acceleration regions, based on the analysis of the properties of the detected emission as well as on its morphology.

The supernova remnant population in M33 as seen by XMM-Newton

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We are conducting a legacy survey of the nearby, face-on spiral galaxy M33 with XMM-Newton. This survey will cover the entire D25 isophote with a minimum exposure of 100 ks and some regions with twice that exposure. A key objective of this project is the study of the supernova remnant (SNR) population in M33. Our XMM survey will provide high quality spectra from the brightest SNRs and will cover twice the area of our Chandra survey of M33. We present a preliminary analysis of these high-quality spectra to identify ejecta-dominated SNRs and to determine if the derived abundances are consistent with a Type Ia or Type II progenitor. Our Chandra survey identified two SNRs that are most likely the result of a core-collapse explosion. We will also use these spectra to characterize the emission from what may be the first pulsar-wind nebula detected in M33. The expanded coverage and increased sensitivity of the XMM survey will allow us to search for previously unknown SNRs or SNRs that have not been detected in X-rays. Of the 82 known X-ray SNRs, 14 are expected to have sufficient statistics ($>$ 500 counts) to carry out a detailed spectral analysis.

XMM-Newton observations of the supernova remnant G8.7-0.1

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Many TeV sources detected over the past few years in the Galactic plane are still not identified. It is suspected that some of the sources are the relics of supernova remnants, only visible through the TeV emission from hadronic high energy particles that have not yet merged with the continuous sea of cosmic rays. To support such a scenario, middle-aged supernova remnants that show evidence for TeV emission should provide important clues, as the objects in this evolutionary stage still provide a wealth of observational data. We report on XMM-Newton observations of the 15,000-28,000 year-old supernova remnant G8.7-0.1, which is located in positional coincidence to one of the brightest unidentified TeV sources, HESS J1804-216. The Northern part of the remnant emits strong thermal emission as detected with XMM-Newton, whereas the Western part of the remnant is devoid of thermal emission but apparently a strong TeV gamma-ray emitter. We also report the discovery of a new X-ray pulsar wind nebula candidate, which appears presumably just by chance in positional coincidence with the supernova remnant.

Some critters play Frisbee: observations of various pulsars and their nebulae

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We present X-ray imaging observations of several pulsars and their wind nebulae, comparing them to radio images where appropriate. While most pulsar wind nebulae have either a torus+jet morphology or a bow shock/tail morphology, in some cases it appears there is a hybrid morphology where on large scales there is a bow shape from their motion, and on smaller scales a torus+jet morphology which is tilted and offset with respect to the symmetry axis of the apparent bow shock. We present a simple model of the effects of an equatorially enhanced wind on a ram-pressure confined nebula. We discuss implications of this picture for birth sites and potentially related TeV sources.

X-ray study of the supernova remnant G296.8-0.3

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In this work we report X-ray observations of the southern SNR G298.6-0.3 performed with the XMM-Newton telescope, and complementary radio/infrared data. In order to explore possible evolutionary scenarios to understand its unusual morphology observed at radio frequencies, we investigate the correlation between the spatial and spectral properties of the X-ray emission detected from the object. The results show that there is internal X-ray emission and a partial shell-like structure on the northwest side of the remnant that correlates well with the radio emission. A thermal model plus a non-thermal component provides a good fit of the overall X-ray spectrum. In addition, we find a weak compact X-ray source located close to the geometrical center of the radio structure. Its properties are consistent with the so-called compact central objects (CCO). A detailed spectral analysis showed that its X-ray emission is well-fitted either by a single power-law or two blackbody component model. Finally, we discuss the correlation between the global emission detected at the SNR and its possible association with the central source.

Supernova remnants and candidates detected in the XMM-Newton M 31 Large Survey

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In the XMM-Newton Survey of M31 carried out as a Large Program 25 supernova remnants (SNRs) and about 30 SNR candidates have been detected in M31. We have studied the X-ray spectra of the nine brightest sources. In addition, we analyzed the optical emission line fluxes of the SNRs and candidates using the Hα, [S II], and [O III] data of the Local Group Galaxy Survey. We calculated the [S II]/Hα flux ratio, which is a diagnostic tool to distinguish the shock-ionized diffuse emission of SNRs from those of H II regions or planetary nebulae. Using the combination of the X-ray hardness ratios, the optical fluxes, and the [S II]/H alpha ratio as selection criteria we confirm several new SNRs in M31. By increasing the number of known SNRs in M31 we are able to study the SNR population in a spiral galaxy similar to our Milky Way and reveal their global distribution, which will provide insight into their impact on the chemical and dynamical evolution of the galaxy and on the cosmic ray production.

X-ray study of the southern extension of the SNR Puppis A

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Puppis A is an extended SNR which shows clear signs of interaction with an inhomogeneous interstellar medium, and has an associated neutron star. The SNR has been intensively studied in the radio continuum regime by Castelletti et al. (2006,A&A 459, 535) and in X-rays (Katsuda et al. 2010,ApJ 714,1725, and references therein), while its environment was investigated in molecular and atomic lines by Dubner et al. (i.e.: 1988A&AS 75, 363). The X-ray studies, performed using ROSAT, Chandra and XMM-Newton data, were up to now concentrated in the central and northern parts of the SNR. However, our investigation of data from the XMM-Newton Slew Survey shows that there is significant X-ray emission towards the as yet under-explored southern extent of the remnant, where the radio data suggest an interaction of the local shock front with a molecular cloud. The correlation X-ray/radio emission is being investigated.

The widest study of GRB X-ray afterglows: energetics, time-scales and luminosity

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Gamma Ray Bursts (GRB) are intense flashes of gamma-ray radiation able to outshine the gamma-ray sky during their short lives. In spite of many theoretical and observational progresses, the nature of their central engine is still clouded in mystery. We present here the widest analysis of GRB X-ray afterglows, ever: during its ∼6 year life-time, Swift has provided X-ray afterglow data for more than 600 bursts. Using this catalog we can address the study of GRB afterglows from a statistical point of view; moreover, for the first time, we can study the properties of these events in the source rest frame, constraining the luminosity and amount of energy released during the different phases of the X-ray afterglow evolution. Finally, this study will provide the first complete characterization of the X-ray afterglow of short GRBs: when compared to long GRBs, this study will help clarifying the nature of short GRB systems, sources which are currently listed among the most promising candidates for gravitational wave emission.

An XMM X-ray and millimeter-line study of supernova remnant Kes78

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We have performed an XMM-Newton X-ray spectroscopic study for the northeastern edge of the supernova remnant Kes 78. The X-rays from the radio brightness peak, which a long molecular strip appears to connect, suffer a heavier absorption than those from other part along this XMM-observed section of the shell. The X-rays are emitted by underionized hot (1.5 keV), low-density (0.1 cm^{-3}) plasma with solar abundance, and the plasma may be of intercloud origin. The thermal pressures of the X-ray emitting gas and the optically emitting structures along the shell is lower than the magnetic pressure in the OH maser region by up to two order of magnitudes. Using the CO observations from PMOD, KOSMA, and FCRAO, we also found SNR Kes 78 is interacting with a long molecular strip in the northeast and a large cloud in the east, a result that explains the peak in radio brightness and the OH maser. The age of the remnant is inferred to be some 6 kyr and the distance to the remnant is revised as 4.8kpc.

Chapter 8

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

X-ray properties of local Lyman break galaxy analogs

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Recent work on local galaxies has found that X-ray luminosity correlates strongly with star formation rate. Our knowledge of star formation in the distant (z¿1) Universe is confined to studies in the rest-frame ultraviolet. X-ray properties of the best-studied high redshift, UV-selected galaxies (Lyman break galaxies, LBGs) have been deduced using stacking analyses of large samples of galaxies for long (¿30 Ms) effective Chandra exposures. A new opportunity provides us with another way to study these star-forming galaxies: GALEX has recently selected a low-z (z 0.1) LBG population, the Lyman break analogs (LBAs). We present our study of the X-ray properties of these LBAs, as compared to other local star-forming galaxies and to (stacked results of) z 3 LBGs. With this study, we constrain the intermediate SFR range (SFR=3-20 M_$\odot$ yr^{-1}) of the local X-ray/SFR correlation and put the higher-z studies on much firmer footing.

Clustering between high-mass X-ray binaries and OB associations in the Milky Way

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We present the first direct measurement of the spatial cross-correlation function of high-mass X-ray binaries (HMXBs) and active OB star-forming complexes in the Milky Way. This result relied on a sample containing 78 hard X-ray selected HMXBs and 458 OB associations. Clustering between the two populations is detected with a significance above 7σ for distances $\leq$1 kpc. Thus, HMXBs closely trace the underlying distribution of the massive star-forming regions that are expected to produce the progenitor stars of HMXBs. The average offset of a few hundred parsecs between HMXBs and OB associations indicates migration velocities of the order of 100 km s^{-1} which are consistent with natal kicks, rather than being caused exclusively by Galactic rotation. The characteristic scale of the correlation function suggests an average kinematical age (since the supernova phase) of $\sim$4 Myr for the HMXB population. Despite being derived from a global view of our Galaxy, these signatures of HMXB evolution are consistent with observations of individual objects.

Unresolved X-ray emission: late-type vs early-type galaxies

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We analyzed comprehensively the unresolved X-ray emission in a broad sample of late-type and early-type galaxies. After removing the luminosity arising from bright X-ray binaries, we studied the contribution of different X-ray emitting components to the unresolved X-ray emission.

In late-type galaxies the following three major components contribute to the unresolved X-ray luminosity. First, the population of faint unresolved active binaries (ABs) and cataclysmic variables (CVs), whose contribution approximately scale with the stellar mass. Second, unresolved young stars and young stellar objects. Their collective emission roughly correlates with the star-formation rate of the host galaxy. Finally, diffuse ISM with temperature of kT 0.2-0.4 keV.

In low-mass early-type galaxies the unresolved X-ray emission is dominated by ABs and CVs. Massive ellipticals also host moderate or large amount of diffuse ISM (kT 0.3-0.8 keV), which may determine the X-ray appearance of these galaxies at energies ¡2 keV. Interestingly, five massive ellipticals in Virgo cluster exhibit exceptionally high X-ray luminosities in the 2-8 keV band, indicating the presence of an additional X-ray emitting component. The nature of this component is uncertain, hence we investigated its possible origin in full particulars.

The complex diffuse emission in Centaurus A

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and the Cen A VLP Team

Centaurus A, the nearby radio galaxy and late-stage merger provides a unique opportunity to observe the complex emission that arises from an active galaxy and study the dynamics of the merger process. This system has been subject to a series of deep *Chandra* observations to probe the constituents of this galaxy including the particle acceleration processes of the jet, the nature of the low-mass binary population and the thermodynamic parameters of the hot ISM.

Here I will present the properties of the central diffuse gas of the system, where this complex emission can be related to the dust lanes present in the galaxy. With these high quality data I have analysed spectral regions based on the X-ray morphology of the central region, determining the variations of temperature and abundance. In addition to this I will discuss the correlation of the hydrogen column density to Spitzer data, which are used to provide maps of the dust that is present in the system.

Fe Kα line emission in the Galactic Centre: a role for Sgr A*?

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The X-ray reflection nebulae (XRN) in the Galactic Centre (GC) region have been proposed to be the smoking gun of a past AGN activity of Sgr A*. This activity must have left a trace in the ionization of molecular clouds (MCs) in the central molecular zone (CMZ), seen through the Fe fluorescent line at 6.4 keV and the Thomson scattering of hard X-rays into the line of sight. I will show that the XRN/Sgr A* scenario alone has strong difficulties in accounting for the observed fluorescence; indeed, a strong component induced by cosmic rays interaction with the MCs is needed in order to account for all the spectral/temporal properties of the MCs. I will show the results of my studies on the Fe Kα emission from the MCs in the Arches cluster region, which state that Sgr A* cannot be the source of ionization for every 6.4 keV bright cloud; these MCs are likely to be the site of particle bombardment induced Fe Kα line emission. I will also present the discovery of the MC showing the fastest variability in the 6.4 keV line flux, clearly related to an X-ray transient other than Sgr A*.

Study of the X-ray source populations in the starbust galaxy M83 with XMM-Newton

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We present an analysis of three XMM-Newton observations of the starbust galaxy M83 with the aim of providing X-ray luminosity functions in order to characterize the populations of X-ray binaries in this galaxy. We detected 218 X-ray sources in the energy range of 0.2-12 keV, down to a luminosity limit less than $\sim 8 \times 10^{36}$ erg/s in the direction of M83 (63 sources within the D25 ellipse of M83). We observed 153 new sources (25 new sources within the D25 ellipse of M83), while the remaining sources were already detected in previous observations of M83. Hardness ratios, together with X-ray variability and, when available, identification with sources in other wavelengths, allowed us to classify the observed sources as X-ray binaries, supernova remnants, and super-soft sources in the galaxy, and active galactic nuclei and foreground stars in the direction of M83.

Characterization of the Diffuse X-ray Background

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Our current interpretation of the diffuse X-ray emission below 1 keV includes a combination of five components: Solar Wind Charge eXchange (SWCX), Local Bubble (LB), Galactic Halo (GH),Warm-Hot Intergalactic Medium (WHIM), and unresolved point sources. Resolving the different components is made particularly difficult due to the similar spectra of the components, primarily X-ray lines from heavily ionized metals. In the past several years our group has focused on a comprehensive approach to study and disentangle these components using XMM-Newton, Suzaku, and Chandra. In this paper we will present our results and future plans, focusing on the galactic emission (our work on the WHIM will be presented in a separate paper). In particular, (a) we used shadow experiments with XMM-Newton and Suzaku to separate foreground and background emission and characterize the emission from LB, GH, and SWCX; (b) we are performing a monitoring campaign with XMM-Newton to characterize the SWCX variability over a 2-year period; and (c) we are building a sounding rocket experiment (called DXL) with 1000 cm2 proportional counters to study the spatial distribution of the X-ray emission due to SWCX.

The XMM-Newton survey of the Small Magellanic Cloud

Frank Haberl[1]
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Using the XMM-Newton observatory, we performed an X-ray survey of the Small Magellanic Cloud (SMC), our neighbouring dwarf irregular galaxy. The XMM-Newton large project comprises of 30 ks observations of 30 fields, which together with archival data cover about 5.5 square degrees. The total exposure is distributed inhomogeneously over this area with about two thirds covered by 10−30 ks, while in some areas 400-600 ks are reached. First investigations of our point-source catalogue show that it is complete down to a limiting flux of about 10^{-14} erg/s/cm^2 which corresponds to 4x10^{33} erg/s at the distance of the SMC. The XMM-Newton survey provides a unique data set to investigate the X-ray source populations of the SMC, in particular its remarkable population of Be/X-ray binaries, super-soft X-ray sources and supernova remnants. On behalf of the XMM-Newton SMC-survey collaboration I'll present in this talk an overview of the SMC survey with some highlights while first results from more specific projects are presented in other contributions to this conference.

X-ray point source population of the region southeast of 30 Doradus in the LMC

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We present the initial results of an X-ray point source population survey of a ~ 7 deg^2 region southeast of 30 Doradus in the Large Magellanic Cloud (LMC) using archival *XMM-Newton* data. We have retrieved and reduced relevant data from the XSA to characterize the X-ray emission from each of the detected point sources. We will determine candidate counterparts to the X-ray sources using primarily optical, UV and IR catalogues. In addition we will assess and remove the contribution of contaminating extragalactic Active Galactic Nuclei to the detected population, as well as likely foreground Galactic sources, to obtain a purely LMC sample. Our ultimate goal is to construct an X-ray Luminosity Function for the X-ray binaries (XRBs) in this region of the LMC to compare to the results of a galaxy scale XRB population simulation code which, along with the known stellar population from optical studies, will allow us to determine the likely evolutionary history of this region of the LMC and compare it to other regions of this galaxy.

Compact radio emission in ultraluminous X-ray sources

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Ultraluminous X-ray sources (ULXs) are extragalactic, off-nuclear X-ray sources with luminosities exceeding 10^{39} erg/s, much higher than the typical luminosities of X-ray binaries in our Galaxy but lower than X-ray emitting active galaxies. The physical nature of all ULXs is still unknown. The diverse scenarios proposed include intermediate mass black holes (IMBHs), supernova remnants, secondary nuclear black holes in post-merger galaxies, microquasars, or stellar mass black holes radiating at super-Eddington luminosities. I will present milliarcsecond-scale radio observations of some ULXs located within optically bright galaxies, resolving their compact radio emission, and measuring its brightness temperature and spectral properties. Among the results, we confirm an earlier identification of a ULX with a supernova remnant, obtaining the most accurate estimates of its size and age, and detect compact radio emission from two ULXs being possible candidates for IMBHs.

Calibration of SFR tracers for short & extended bursts: FIR & X-ray luminosities

Hector Oti-Floranes[1], Jose Miguel Mas-Hesse[1]
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To derive the history of star formation in the Universe a set of calibrated star formation rate (SFR) tracers is required. Using evolutionary synthesis models, we have computed the predicted evolution of different estimators of the SFR assuming nearly-instantaneous (IB) and continuous star formation (EB) regimes, and the effect of interstellar extinction and metallicity.

A self-consistent calibration of a complete set of SFR tracers in the whole electromagnetic range has been obtained, focusing here on the far infrared and X-ray luminosities (FIR & Lx). We will discuss the validity of the different tracers in different scenarios and compare our predictions with previous calibrations of general use. Also, we will show how the estimators predictions can reproduce the FIR and Lx values of a sample of star-forming galaxies assuming usual ages of starburst regions, and using typical values for the parameters considered: extinction, and efficiency in the conversion from mechanical energy injected into the medium to X-rays emission.

Finally, we stress that in order to measure the intensity of star formation episodes we should distinguish between IB regimes, for which star formation strength (Mo) should be used, and EB regimes, for which the more common SFR (Mo yr-1) should be used.

X-ray and Ly alpha emission of Haro 2 = Mrk 33

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Haro 2 is one of the few galaxies of the local universe which shows a prominent Lyman alpha emission.

We have performed X-ray and UV spectral analysis on Haro 2 with spatial resolution, using Chandra and HST data. Results show that the two starbursts present in the central region of the galaxy are in different evolutionary states, with ages of 4 Myr and ¿ 5 Myr given by the analysis of CIV and SiIV line profiles using evolutionary synthesis models. Also, we have confirmed that while both bursts emit diffuse soft X-rays, only in the younger burst a prominent non-resolved hard source is detected.

We have identified a compact Ly alpha component associated to the stellar clusters, and an extended, diffuse emission which is not correlated with Halpha. Spatial correlation bewtween the soft X-ray radiation and diffuse Ly alpha emission is observed when comparing Chandra image with HST UV spectra of both knots. We will discuss the possibility that both emissions are related, e.g. by boosting Ly alpha by collisional excitation on the edge of the expanding shells.

Similarities and differences with other local Ly alpha and X-ray emitters will be presented.

The origin of the X-ray emission in Local Luminous Infrared Galaxies

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Deep infrared cosmological surveys show that Luminous and Ultraluminous Infrared Galaxies (LIRGs, L_IR =10^{11} to 10^{12} Lsun, and ULIRGs, L_IR=10^{12} to 10^{13} Lsun) are major contributors to the star formation rate density at z∼1-2. However, unlike local ULIRG where most of the activity is taking place in very compact (<<1kpc) nuclear regions, in z∼2 infrared bright galaxies the star formation appears to be distributed over spatial scales of a few kpc as in local LIRGs. These results highlight the importance of studying the population of local LIRGs. We are carrying out detailed study of the X-ray properties of a sample of local (d< 70 Mpc) LIRGs using XMM-Newton. The main goal is to study the extreme processes of star formation and/or AGN taking place in this cosmologically important class of galaxies.

X-raying the high-latitude ISM

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The interstellar medium (ISM) triggers the course of Galactic evolution. Stars enrich the ISM with metals, and this serves as a reservoir for new stars. Low-metallicity gas stripped from companion galaxies, often visible as high-velocity clouds (HVCs), also feeds the ISM and affects star formation. We present a thorough analysis of the ISM along the line of sight towards the AGN Mrk 509 based on a stacked 600 ks XMM-Newton/RGS spectrum and a 16 ks HST/COS spectrum. These extremely high quality spectra allow us to constrain the velocity, chemical and ionization structures of the seven detected ISM components in unprecedented detail. Their location within the Galaxy is estimated. Three HVCs are detected. They consist of warm clouds photo-ionized by the UV / X-ray extragalactic background. The O VI-VII excess we observe suggests additional collisional ionization, perhaps due to an impact with the Galactic halo. The gas at rest is warmer than the typical disk gas as most of the carbon is ionized. We also find a significant amount of dust consisting of pyroxene silicates and hematite oxides.

The XMM-Newton survey of the SMC: the point source catalogue

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The analysis of the large program XMM-Newton survey of the Small Magellanic Cloud (SMC), in combination with archival data, resulted in ∼5000 detections of ∼3000 X-ray sources. This is the first complete coverage of the X-ray point sources population of this nearby dwarf irregular galaxy to a limiting luminosity of $\sim 4 \times 10^{33}$ erg s^{-1} in the (0.2−10.0) keV band. Our catalogue allows to study complete samples of source classes like high mass X-ray binaries and super soft X-ray sources of an entire galaxy at low metallicity. In this poster I'll present, on behalf of the XMM-Newton SMC-survey collaboration, the point source catalogue, together with statistical studies from cross-correlation with other catalogues and multi-wavelength source classifications.

The XMM-Newton survey of the SMC: the Be/X-ray binary population

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The Small Magellanic Cloud (SMC), a nearby dwarf irregular galaxy, hosts an extraordinary large population of ∼90 known Be/X-ray binaries, compared to the $50 - 100$ times more massive Milky Way, where around 100 high mass X-ray binaries are known. X-ray pulsations which indicate the spin period of the neutron star were observed in ∼55 SMC systems. Using the XMM-Newton observatory, we performed a complete X-ray survey of the SMC. This allows us to investigate the statistical properties of the Be/X-ray binary population of the entire galaxy and also to find interesting individual cases. Additionally to ∼30 detections of previously known Be/X-ray binaries we found several further candidates. We discovered the two new X-ray pulsars SXP 11.87 and SXP 214 and a likely Be/white dwarf system, similar to XMMU J052016.0-692505 in the LMC. On behalf of the XMM-Newton SMC-survey collaboration I'll present in this talk first results of our research of the SMC Be/X-ray binary population.

Seyfert's Sextet: one step further in the evolution of compact groups

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In the context of cosmological evolution, groups of galaxies should be more prominent in the X-ray band as they grow older. Many examples of bright common envelopes are now observed in systems where galaxies are of early types and share a common potential. While Seyfert's Sextet (HCG79) might not have reached the later stages of these more classical groups, it should still represent a relatively evolved phase of coalescence. Radio continuum data, which show evidence for weak extended emission in its central regions, and the optical halo detected lead us to expect extended X-ray emission. And yet the gaseous content of the group is extremely low, as shown by our new Chandra observation of this system.

Interstellar dust as a probe to study GRBs and magnetars, and vice versa

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An expanding ring can be observed when a burst of X-rays is scattered by a thin layer of interstellar dust. This phenomenon was detected for the first time during the XMM-Newton follow-up observation of GRB 031203, one of the few gamma-ray bursts (GRBs) firmly associated with a nearby supernova; its analysis led to important constraints on the early X-ray emission of this GRB and to an accurate distance determination for the dust concentrations in our Galaxy along this line of sight.

Only fainter time-variable rings were subsequently detected around a few other GRBs until 2009, when three extremely bright X-ray rings appeared during an outburst of the magnetar 1E 1547.0-5408 and could be studied in detail for two weeks by Swift and XMM-Newton. From the analysis of this high quality dataset, we could reconstruct the properties of the brightest burst, constrain the magnetar distance and test the existing dust models.

The study of these rare events constitutes a unique tool to measure the distance of Galactic sources of explosive high energy emission and to investigate the properties and spatial distribution of cold Galactic dust.

Hot gas in groups: the intriguing case of NGC 4756

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The environment appears to have a strong influence on fundamental properties of galaxies, such as star formation and morphology, and their evolution. Similarly, galaxies play a role in determining the properties of the hot intergalactic medium in groups, heating and enriching it through a variety of mechanisms. In this context, we have studied the case of NGC 4756, a bright, unperturbed elliptical galaxy at the center of a loose group. The central part of the group contains a significant fraction of early-type galaxies. At the periphery, a compact clump of galaxies with signatures of interactions can be identified. This could depict the NGC4756 structure as an "evolving group". We present the results from a careful analysis of the XMM-Newton observation of this system, which is, unfortunately, projected onto the background cluster Abell 1631.

Classification of X-ray sources in the direction of M31

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XMM-Newton M31 Large Program Collaboration

M31 is our nearest spiral galaxy, at a distance of 780 kpc. Identification of X-ray sources in nearby galaxies is important for interpreting the properties of more distant ones, mainly because we can classify nearby sources using both X-ray and optical data, while more distant ones via X-rays alone.

The XMM-Newton Large Project for M31 has produced an abundant sample of about 1900 X-ray sources in the direction of M31. Most of them remain elusive, giving us little signs of their origin. Our goal is to classify these sources using criteria based on properties of already identified ones. In particular we construct candidate lists of high mass X-ray binaries, low mass X-ray binaries, X-ray binaries correlated with globular clusters and Active Galactic Nuclei based on their X-ray emission and the properties of their optical counterparts, if any. Our main methodology consists of identifying particular loci of X-ray sources on X-ray hardness ratio diagrams and the color magnitude diagrams of their optical counterparts. In addition we check for variability both in X-rays and in the optical band.

Studies of the hot interstellar medium in the Large Magellanic Cloud

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The supergiant shell (SGS) LMC 2 in the Large Magellanic Cloud (LMC) is a large structure in the cold interstellar medium (ISM) with a size of about 1 kpc. Diffuse X-ray emission that shows correlation with this supergiant shell has been found with ROSAT and indicates that it is filled with hot gas with temperatures around 1 million Kelvin.

In order to study the properties and the distribution of this hot phase of the ISM, we have analysed archived XMM-Newton EPIC data of the SGS LMC 2 region. We have created mosaic images for three different energy bands which clearly show the distribution of the hot ISM as well as a structure near the northern rim of LMC 2 which might be a superbubble. The mosaic images also show spectral variation within the SGS. We will present spatially resolved spectra of this region, which are created after the removal of point sources.

Thermal and non-thermal X-ray emission in the Galactic Centre

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We use XMM-Newton observations to probe the distribution of thermal and non-thermal X-ray emission within the central 50 parsec of the Milky Way. The thermal emission at kT 1 keV, which is traced by He-like Sulphur (2.4 keV) and Argon (3.1 keV) lines, is strongly concentrated to the east of the Galactic Centre in a region characterised by a high density of Giant Molecular Clouds. This same region exhibits bright 6.4-keV iron-line emission arising from the fluorescence of the molecular material. The 1-keV plasma most likely originates in multiple supernova explosions, although it is difficult to identify individual remnants within the region of enhanced surface brightness. The He-like iron line at 6.7 keV traces the distribution of hotter (kT 5-8 keV) thermal emission. This component is much more symmetrically distributed around the Galactic Centre and exhibits a radial fall-off in surface brightness consistent with an origin in the integrated emission of relatively low-luminosity point sources. When the thermal contribution is removed, the 4.5-6 keV and 7.2-9 keV continuum bands reveal an underlying non-thermal component, the properties of which will be discussed.

Virgo Cluster spiral galaxies and their Mach cones

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The detailed comparison between observations and simulations of ram-pressure stripped Virgo Cluster spiral galaxies allowed a construction of a 3D view of their orbits within the hot intracluster medium. The 3D velocities and Mach numbers derived from simulations provide simple Mach cone geometries for studied galaxies. We search for hot gas within Mach cones in observations of selected Virgo Cluster spiral galaxies - NGC 4569, NGC 4388, and NGC 4501. Low-resolution maps show extraplanar diffuse extended X-ray emission. In NGC 4569 the hot gas from a galactic superwind fills the entire Mach cone forming a halo at a temperature of 0.5 keV. Hot gas tails at a temperatures of 0.7-0.9 keV in NGC 4388 and NGC 4501 within their Mach cones are most likely due to the mixing of the stripped interstellar medium into the hot intracluster medium of the Virgo Cluster.

Hot gas in groups: NGC 5328

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The X-ray content of early-type galaxies is expected to be tightly connected with the galaxy mass, via the ejecta of the stellar evolution, although no clear correlation with mass proxy emerges from observations. We know also from optical studies that the environment, to some extent, drives the evolution in early-type galaxies. It is therefore essential to independently study the contribution to the X-ray emission coming from the galaxy and that from the surrounding environment. This is easier in small structures like galaxy groups. We present here the X-ray view of NGC 3528, a small group apparently virialized, at least in the core, as we see from the deep optical data we collected. The group might represent a filament falling into the Abell 3754 cluster, and therefore offers a clean view of early-type galaxy processing at the border of a rich environment.

Spectroscopic decomposition of the Galactic Ridge X-ray emission with Suzaku

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The origin of the Galactic Ridge X-ray Emission (GRXE) has been a long-standing mystery, and only recently the deep Chandra imaging revealed that the most GRXE flux is from faint X-ray point sources (Revnivtsev+09).

Especially in the hard X-ray band, magnetic cataclysmic variables (MCVs) are thought to be the only candidates of low-luminosity hard-X-ray-emitting sources. To spectroscopically study the GRXE, we first constructed a spectral model of MCVs, and confirmed that the model accurately reproduces spectra of 17 nearby MCVs observed by Suzaku (Yuasa+10).

Then, we applied the model to broad-band GRXE spectra up to 50 keV which were obtained by stacking 1-Ms Suzaku Galactic bulge observations in $\sim 2^\circ$ around $(l, b) = (-1^\circ, 0^\circ)$. The model successfully reproduced hard-X-ray part of the spectra with a representative WD mass parameter of $0.66(0.59 - 0.75)\ M\odot$. Its extrapolation to lower energies resulted a residual which can be accounted by a optically-thin thermal emission whose temperature is consistent with a typical value of hot coronal sources (~ 1.5 keV).

In total, the GRXE spectra were beautifully explained by the two representative components which have clear physical counterparts. The present spectroscopic result is complementary to imaging, and also supports the point-source origin of the GRXE.

Chapter 9

Active Galactic Nuclei

Redshift evolution of X-ray selected AGN bias in the COSMOS field

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We present a study of the redshift evolution of the projected correlation function of 593 X-ray selected AGN with spectroscopic redshifts $z < 4$, extracted from the 0.5-2 keV X-ray mosaic of the $2.13 deg^2$ XMM-COSMOS survey. We find evidence of a redshift evolution of the bias factor for XMM-COSMOS AGN with an average mass of the hosting DM halos $logM\_0[h^{-1}M\_\odot] \sim 13.12 \pm 0.12$ that remains constant at all $z < 2$. Splitting our sample into broad optical lines AGN (BL), AGN without broad optical lines (NL) and X-ray unobscured and obscured AGN, we observe an increase of the bias with redshift in the range $\overline{z} = 0.7 - 2.25$ and $\overline{z} = 0.6 - 1.5$ which corresponds to a constant halo mass $logM\_0[h^{-1}M\_\odot] \sim 13.28 \pm 0.07$ and $logM\_0[h^{-1}M\_\odot] \sim 13.00 \pm 0.06$ for BL /X-ray unobscured AGN and NL/X-ray obscured AGN, respectively. The theoretical models which assume a quasar phase triggered by major mergers can not reproduce the high bias factors and DM halo masses found for X-ray selected BL AGN with $L\_BOL \sim 10^{45} erg$ s^{-1}, suggesting that secular processes such as tidal disruptions or disk instabilities outnumber the contribution from major mergers up to $z \sim 2.2$.

Spectral energy distribution of heavily obscured AGN beyond the local Universe

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We present a multi-wavelength study of a sample of heavily obscured AGN in the CDFS selected via X-ray spectral analysis. We select a sample of 14 heavily obscured AGN through X-ray spectral analysis using the recent ultra-deep X-ray observations of the CDFS. The X-ray spectra of the 14 highly obscured AGN of our sample are very flat and well-fit by either a transmission model with high absorbing column density or by a reflection-dominated model. In addition, a strong Fe emission line is detected at 6.4keV in the spectra of 5 objects, clearly indicating strong obscuration of the primary radiation from the nucleus. Exploiting all the publicly available photometry in the CDFS/ECDFS, we investigate the properties of the SED of our sample of heavily obscured AGN and study their evolution with redshift, luminosity, SFR and stellar mass of the host galaxy. We fit the SED using libraries of empirical and synthetical templates. The results of our SED fitting show that X-ray selected, heavily obscured AGN exhibit rather heterogeneous properties with SED shapes which vary as a function of redshift and AGN luminosity, as well as with the mass and SFR of the host galaxy.

Exploring X-ray and radio emission of type 1 AGN up to $z \sim 2.3$

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The origin of radio emission from AGN, except in sources with strong jets, is still poorly understood. Similarly, the origin of the local bi-modal distribution in radio-loudness is a debated issue. To address these topics, we analysed a large sample of ~ 800 type 1 AGN X-ray selected, covering a redshift range $0.3 < z < 2.3$, where the bulk of this population resides. Here we present our results on the interplay between radio and X-ray emission in AGN, that allow us to further extend our knowledge on the origin of radio emission, and its relation to accretion. Complementary control radio-selected samples assure that our conclusions are not an effect of the X-ray selection, but are likely a property of the dominant QSO population.

The dominant emission process of the X-ray spectrum of Cen A

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The radio galaxy Cen A emits up to the TeV energy range. But is the dominant emission mechanism in the high-energy domain thermal or non-thermal?

The hard X-ray spectrum of Cen A as measured by INTEGRAL shows a significant cut-off at energies $Ec = 434$ keV with a photon index of $\Gamma = 1.73 \pm 0.02$. A thermal Comptonisation model gives $kT = 206 \pm 62$ keV within the optically thin corona. The reflection component is significant at 1.9σ only with $R = 0.12 \pm 0.10$, and a reflection strength $R > 0.3$ can be excluded at the 3σ level. Time resolved spectral studies show that the flux, absorption, and spectral slope varied in the range $f(3 - 30\,\mathrm{keV}) = (1 - 9) \times 10^{-10}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$, $NH = (7 - 16) \times 10^{22}\,\mathrm{cm^{-2}}$, and photon index $\Gamma = 1.75 - 1.87$. Extending the cut-off power law or the Comptonisation model to the gamma-ray range shows that they cannot account for the high-energy emission. But also a broken or curved power law model can represent the data, therefore a non-thermal origin of the X-ray to GeV emission cannot be ruled out.

While gamma-rays are caused by non-thermal processes, the main process in the hard X-ray emission can still not be unambiguously determined, being either dominated by thermal inverse Compton, or by non-thermal emission from the base of the jet.

AGN without BLR: new clues for a new scenario

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In standard Unification Models, all radio quiet Active Galactic Nuclei (AGN) should possess a Broad Line Region (BLR), and only the presence of a dusty absorber along the line of sight to the object can prevent us from observing it. However, there is now mounting evidence that this scenario is not tenable, due to the presence of X-ray unobscured sources without optical broad lines, and type 2 objects with no broad lines in polarized light. I will review new results on X-ray and optical selected samples, putting them in the context of a new scenario, where the detection of the BLR is not only a matter of orientation, but can be regulated by physical parameters of the AGN.

The UV deprived quasar Ton34 at z=2 has now become a BALQSO!

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Among the sample of quasars observed in the far UV with HST and studied by Telfer etal., Ton34 stands as the most deprived UV quasar known, revealing a sharp drop shortward of 1200Ang. A powerlaw fit to the continuum reveals an index as steep as -5 shortward of Lyman limit. It is not clear whether a flux recovery might be taking place in the extreme UV. The origin of the ionizing flux drop is unknown, yet the emission line spectrum is not radically different from that of other powerful quasars. In a recent ApJ Letter, we reported the emergence of a high-velocity, broad absorption line outflow in Ton34, which shows up as a CIV broad absorption line in a SLOAN spectrum. No absorption trough was present in two different spectra acquired in 1981 at Las Campanas and Palomar observatories, indicating the emergence of the outflow in less than 8yr (rest-frame). We infer a balnicity index of 600, but the absorption trough is likely saturated, with the absorbing gas covering 25% of the emitting region. We conclude that Ton34 has undergone a BALQSO phase, the third case so far among AGN (yet the first case among bright quasars).

Explaining the global X-ray Baldwin effect with XMM-Newton

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We have analyzed the first XMM-Newton, Swift and archival ROSAT PSPC observations of the quasar LBQS 0102-2713. The first XMM-Newton and Swift observations have revealed an extreme huge soft X-ray photon index, which ranges between 3.35 and 4.41, the UV brightness of the source and the absence of significant absorption by neutral hydrogen. The new data allowed a combined spectral fitting to the Swift UVOT and the XMM-Newton/ROSAT data which results in a huge luminosity of $5.98 \times 10^{47}\ erg\ s^{-1}$ and alpha_ox values ranging between (-1.87±0.11) and (-2.11±0.12). The nature of the soft X-ray emission can be explained as local Comptonized emission of the UV disc photons in the pseudo-Newtonian potential. The Eddington ratio is extremely high with L/L_edd with ranges between 6.0 and 49.2. For the dimensionless electron temperature of the plasma cloud θ we derive an upper limit of about 10 keV. The huge UV luminosity density, the extremely low alpha_ox values and the absence of X-ray emission above 2 keV strongly support the prediction of the global X-ray Baldwin effect, that the X-ray emission is decreasing with increasing UV luminosity, which is now for the first time explained based on XMM-Newton.

Host galaxies of AGN in the COSMOS field: black hole growth and star formation

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Super massive black holes (SMBHs) seem to be the galaxies' beating heart. Intense studies in the local Universe have allowed to put solid observational constraints on the coupling between the BH and its host galaxy. However many aspects of this picture and its evolution are still unclear. Using the XMM-COSMOS sample and taking advantage of the wide multi-wavelength COSMOS dataset and the zCOSMOS/VIMOS optical spectra, we were able to characterize the host galaxy properties i.e. stellar masses and star-formation rates for a large and almost complete sample of both obscured and un-obscured AGN hosts. Here I present the general properties of the AGN host galaxies and their relation with the AGN activity.

The combined Swift/BAT and INTEGRAL-ISGRI hard X-ray (SIX) survey

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Swift/BAT and INTEGRAL-ISGRI are detecting hundreds of AGN at energies ¿15 keV. However, the low-redshift and low-luminosity AGN are sparsely sampled due to the lack in sensitivity of the current flying hard X-ray instruments. The most absorbed AGN are therefore escaping the detection and the AGN population in the local Universe is so far poorly understood.
The SIX survey allows to overcome these limits. This survey is obtained merging the sky observed by Swift/BAT and by INTEGRAL-ISGRI for selected extragalactic sky areas . By sampling fluxes of the order of 10^{-12} erg cm^{-2} s^{-1} the SIX survey is able to detect the weak radiation piercing through the absorbing matter surrounding the AGN. In the SIX survey we detect 130 sources over a limited sky area. We compare our updated sample of Seyferts and blazars to predictions of population synthesis models, discussing their evolution and their circum-nuclear environment. The impact of the SIX survey to current flying and future missions is discussed as well.

Three-year Swift/BAT survey of AGN: reconciling theory and observations?

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We derived and analyzed the absorption distribution using a complete sample of AGN detected by SwiftBAT in the first three years of the survey. The fraction of Compton-thick AGN represents only 4.6% of the total AGN population detected by SwiftBAT. However, we show that once corrected for the bias against the detection of very absorbed sources the real intrinsic fraction of Compton-thick AGN is 20(+96)%. We proved for the first time (also in the BAT band) that the anti-correlation of the fraction of absorbed AGN and luminosity it tightly connected to the different behavior of the luminosity functions (XLFs) of absorbed and unabsorbed AGN. This points towards a difference between the two subsamples of objects with absorbed AGN being, on average, intrinsically less luminous than unobscured ones. Moreover the XLFs show that the fraction of obscured AGN might also decrease at very low luminosity. This can be successfully interpreted in the framework of a disk cloud outflow scenario as the disappearance of the obscuring region below a critical luminosity. Our results are discussed in the framework of population synthesis models and the origin of the Cosmic X-ray Background.

Hard X-ray spectral variability of the brightest Seyfert AGNs with Swift/BAT

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We present the results of spectral variability in the 20–100 keV energy band from 58 months of continuous observations with the Swift/Burst Alert Telescope (BAT) of the 6 brightest AGNs in the hard X-ray band (NGC 4151, NGC 2110, NGC 4388, IC 4329, Circinus galaxy and NGC 4945). We studied the variability of the (50–100 keV)/(20-50 keV) hardness ratio derived from the light curves in 3 energy bands. The light curves are very well correlated, with a the hardest (50–100 keV) light curve variations slightly preceding the softer (20–50 keV) variations on time-scales of $\leq$1 d. NGC 4388, IC 4329 and NGC 4945 show spectral transitions in the form of a softening of the spectra with increasing flux. The spectral state transitions found are well reproduced by a constant reflection component and variable flux of the Comptonization component. A pure change in the spectral slope photon index is needed to reproduce the spectral softening with increasing flux observed. The spectral state transitions are not reproduced by a change in the temperature of the electrons from the Comptonizing corona. The results might indicate that the spectral state transitions observed are driven by changes of the optical depth of the corona.

Winds and massive outflows in nearby and distant AGNs: an X-ray (re)view

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Among the most exciting findings from a decade of XMM-Newton and Chandra observations of AGNs have been the discovery of strong, blueshifted, and variable FeK absorption lines indicating the presence of massive and high-velocity outflows in nearby AGNs and distant QSOs (see abstracts for contributed talks on comprehensive studies from Tombesi et al. and Giustini et al.). These outflows are of great astrophysical interest because they likely offer direct probes of the launching regions of winds and relativistic jets in AGNs/QSOs. They are also of cosmological interest because they may be transporting most of the mechanical energy emerging from black holes, thereby providing a significant AGN-host galaxy feedback mechanism. After more than a decade of XMM-Newton and Chandra operations, it is maybe timely to set the stage for a) reviewing what have been the major achievements in these studies (as based on comprehensive studies on sample of AGNs/QSOs, and very deep observations on single interesting targets), b) address their impact on the AGN-hosts "relations", but also their current limitations, and c) present their potentialities in the light of future high energy missions.

Exploring extremely obscured accretion

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A high X-ray-to-optical flux ratio (high FX/FOpt) is believed to be a good indication of obscured accreting sources (QSO2) at $z \geq 1$. The study of these sources is currently one of the hottest topics in extragalactic astronomy, given the now clear strong connection between AGN and galaxy evolution.

We present a programme on-going at the recently-commissioned GTC to identify sources with FX/FOpt>20 extracted from 4 different samples based on 2XMM and SDSS (XBS, BUXS...) at medium-to-high X-ray fluxes. At the moment we have 19 identifications (15 with GTC) between $z = 0.5$ and 2.9 (median $z \sim 1.1$) including one "normal" absorption line galaxy, one BL Lac object, and both Narrow and (surprisingly) Broad Emission Line AGNs.

Preliminary analyses show that all these sources have QSO-level 2-10keV luminosities ($> 10^{44}$ erg/s) and all of them (except for one of the BLAGN) have indications of X-ray absorption in their spectra by column densities in excess of 10^{22} cm^{-2}, so they would all but one be "X-ray QSO2s".

We will discuss the good quality X-ray spectra (median 1200 cts) and optical spectra obtained so far, and what they teach us about obscured accretion at high redshift.

Unveiling highly obscured AGN in water maser host galaxies

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The majority (95%) of water maser sources associated with AGN shows high column densities or are even Compton-thick (60%). The percentage of Compton-thick AGN rises up to 76% when only water masers associated with edge-on accretion disks are considered. If confirmed, this suggests that radio surveys to find water maser sources can be an alternative way to identify potential highly obscured AGN with respect to pointed X-ray observations. Indeed, synthesis models of the cosmic X-ray background predict a significant contribution from obscured AGN. However, these objects have been, so far, very difficult to find. Here we report the results of XMM-Newton observations of three well-known water maser galaxies. The XMM spectra at energies > 2 keV are best represented by a deeply absorbed power law (NH 3 x 10^{23} cm^{-2}) plus a strong Gaussian component at 6.4 keV. The discovery of an Fe K alpha line with an equivalent width > 1 keV in the spectra of the two disk-maser sources suggests the presence of Compton-thick absorbers along the line of sight and confirms the effectiveness of H2O maser surveys to identify potential highly obscured AGN in the local Universe.

Imaging the X-ray, UV and optical emission regions of quasars

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Direct imaging of the accretion disks of black holes requires angular resolution of the order of tens of nano-arcseconds at redshifts of about 1. We show that by employing nature's own telescopes, we can indirectly image AGN accretion disks by multi-wavelength monitoring of microlensing events in AGN. We also present results from the first attempts to measure the X-ray energy dependence of microlensing in order to determine the size of the X-ray emitting regions as a function of energy. In particular we focus on the systems RXJ 1131-1231 and PG 1115+080. These are an interesting pair for both physical and observational reasons. Physically, they have very different black hole masses, log M_BH/M_solar = 7.8 and 9.1 based on their emission line widths. Observationally they are both microlensing active because they both have some images lying in regions of dense caustic networks.

Rest-frame stacking of 2XMM catalog sources: Fe K line properties

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The aim of this work is to characterize the average Fe K emission properties of active galactic nuclei (AGNs) in the source rest-frame. We selected a sample of 248 AGNs from the 2XMM catalog, covering a wide redshift range 0 ¡ z ¡ 5 and with the EPIC-PN net 2-10 keV rest-frame counts ¿= 200 and power law photon indices in the range 1.5-2.2. We employed two fully independent rest-frame stacking procedures to compute the mean Fe K profile. The counting statistics for the integrated spectrum is comparable to the one available for the best studied local Seyferts. To assess the significance of the observed Fe K emission line features and the artifacts possibly introduced by the stacking procedures, we have carried out simulations. We report that average Fe K line profile in our sample is best represented by a combination of a narrow and a broad line. The equivalent widths of the narrow and broad (parametrized with a diskline) components are 33 eV and 100 eV, respectively. We also discuss the implications of the adopted continuum modeling on the broad line parameters and its significance.

Multi-wavelength variability of the Seyfert galaxy NGC 3516

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Active galactic nuclei (AGN) show flux variability over a wide range of energies. The origin of variability as well as correlations between various energy bands are not well understood. It is believed that the optical emission originates in the accretion disk surrounding the super massive black hole (SMBH) and the X-ray emission comes from the hot corona close to the SMBH. Two main theories argue for a possible connection between optical and X-ray emission in AGN, namely reprocessing of X-rays to optical emission and Compton up scattering of optical photons to X-ray energies. To have a clear understanding of the relation between optical and X-ray emission, one needs to have simultaneous optical and X-ray observations. XMM-Newton provides a way to carry out simultaneous optical and X-ray observations. We exploit this capability of XMM-Newton and have examined four data sets of simultaneous X-ray and optical observations of the Seyfert 1.5 AGN NGC 3516 observed using the EPIC and OM instruments on board XMM-Newton. We found that in all cases (i) X-ray variability exceeded that of the optical and (ii) No significant correlation was noticed between the X-ray and the optical bands. Further results of this study will be presented.

The high-redshift AGN COSMOS Universe

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Multiwavelength identification campaigns from medium deep and deep X-ray surveys with XMM and Chandra have opened a new perspective in the study of the high-redshift (z> 3) AGN population. However, samples sizes have been quite limited because large area surveys have been too shallow, and the deep survey areas are too small. For the first time, were able to provide sizable samples of AGN with luminosities above logLx=43.5. We present the properties of the largest sample (72 sources) of X-ray selected z> 3 AGNs, from the Chandra COSMOS survey. This sample defines the space density and evolution of the z> 3 X-ray selected AGN population. With 9 sources, we well sample the z> 4 population, and the z> 5 population is beginning to emerge with a 2 source sample plus a candidate at z=6.8. The results are compared with predictions from XRB synthesis models and semianalythic models of galaxy formation.

NGC 7314: X-ray properties of a candidate type II NLSy1

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We present preliminary results from the study of the type II Seyfert galaxy NGC 7314. Archival data by ASCA, BeppoSAX, Suzaku and XMM-Newton were used.

We mainly focused on the long term properties of the high energy emission of the source and on its timing characteristics on short time scales. Our results add further clues to the picture in which NGC 7314 is an absorbed counterpart of NLSy1.

Hard X-ray continuum vs iron line in a flux-limited sample of AGN

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X-ray observations of radio-quiet AGN show evidence that the primary X-ray continuum is reflected from cold material surrounding the central nucleus, leading to the production of an iron Kα line and a reflection component. In this scenario, the Fe line flux should follow the intrinsic variability of the source in the timescale which corresponds to the distance of the circumnuclear material responsible for its production. In order to test this hypothesis, we analyzed a flux-limited sample of AGN from the Swift/BAT survey. Our method exploits X-ray observations below 10 keV (Chandra, XMM-Newton, Suzaku and Swift) to measure the flux of the narrow core of the iron line, and the Swift/BAT lightcurves ($15 - 150$ keV) for the variability of the intrinsic continuum.

PG 1211+143: a "timing" approach

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Time lags between X-ray energy bands have been measured in a number of active galactic nuclei (AGN). Soft-to-hard lags are usually detected at relatively low frequencies, their magnitudes increasing with the energy separation between the bands. Interestingly, the same behaviour is observed in many black hole X-ray binaries (BHXRB), supporting the idea that AGN are the scaled-up counter parts of smaller size black hole systems. The recent detection of a negative (i.e. hard-to-soft) high frequency time lag in the X-ray data of 1H 0707-495 has revealed the presence of a distinct component, possibly a reverberation feature. We present the timing analysis of the archived XMM-Newton observations of the bright quasar PG1211+143. We revealed the presence of a negative (hard-to-soft) lag at the frequencies where positive lags are usually detected. Being the source about one order of magnitude more massive than 1H 0707-495 the detected lag, once rescaled for the mass, might be due to the same underlying physical mechanism.

Absorption/reflection properties of type 2 AGN observed with XMM and INTEGRAL

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We present the results of a systematic broadband study of a sample of type 2 AGN observed with XMM and INTEGRAL. The sample is composed by 34 sources, among them 15 are firstly hard X-ray selected by INTEGRAL. We reproduced the 0.3-100 keV spectra with an heavily absorbed primary component plus a reflected continuum and iron line(s). The unabsorbed component emerging below 2 keV is well reproduced throughout a scattered power-law. The column density distribution of the absorbing gas is peaked around 1e23 cm-2, with 6 Compton thick sources, several objects "almost" Compton thick (NH about 1e24 cm-2) and 3 unabsorbed (NH less than 1e22 cm-2). The measured values of the equivalent width of the Fe line and the reflection fraction, in our sample, make difficult to associate the reflecting medium with the absorbing gas. Although degeneracy in the fitting procedure may exist, we do not find evidence of a new population of obscured AGN characterized by low scattered component ant high reflection continuum, as claimed by Suzaku and Swift observations of newly discovered hard-X ray detected AGN. The most recent scenarios for absorption/reflection in AGN, the "standard" molecular torus and clumpy torus, are discussed in view of our results.

Identifying close supermassive binary black holes in Active Galactic Nuclei

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The galaxy formation and evolution by mergers imply existence of massive binary black holes at the centers of many galaxies. While observations have revealed widely separated supermassive binary black holes, evidence for compact binary systems of supermassive black holes is lacking. We will present a new technique to identify unresolved, close binary systems of super-massive black holes in active galactic nuclei based on their broadband X-ray emission. If one of the sources is highly absorbed, the system will have unique X-ray spectrum and variability signatures, which can be distinguished from other possible scenarios. We apply this technique to the Suzaku & XMM-Newton observations of radio-quiet Active Galactic Nuclei, and identify candidates for sub-parsec binary supermassive black holes. This new technique increases the prospects of finding close binary system of massive black holes particularly with sensitive Hard X-ray observations such as those expected from the international X-ray observatory (IXO) and will have an important impact on our understanding of black hole growth, nuclear activity and galaxy evolution.

Relativistic Fe line in the lamp-post scheme of the black-hole accretion disc

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One of the interpretations of the broad feature in the spectra of several AGNs and black hole binaries in the energy range 2-10keV is a relativistically smeared iron line. This line can arise when the accretion disc is illuminated by a hot corona above. We revisit the lamp-post setup in which the corona is positioned on the axis above the rotating black hole and show the importance of the local reprocessing for the expected shape of the broad iron line in the observed spectra. We will compare our results with the `laor` profile, where the broken-power law for radial emissivity and the limb darkening law for the emission directionality is assumed.

The non-thermal core of 3C 111

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With the Large Area Telescope (LAT) aboard the Fermi satellite a large number of new sources in the gamma-ray regime was discovered, among which many radio galaxies.

However, the exact underlying physical processes which create the high energy radiation in radio galaxies are still unclear. To uncover these processes we study the spectral energy distribution (SED) of 3C 111, an X-ray bright radio galaxy, using data from the Suzaku satellite combined with Fermi/LAT, INTEGRAL and Swift/XRT data.

The Suzaku data can be represented by a simple power law (photon index = 1.6 +/- 0.07) with a Gaussian feature to account for the iron line at 6.4 keV. The combined data do not require a high-energy cut-off at energies below 150 keV and no Compton reflection component is detectable. The Suzaku spectrum shows aspects of both Seyfert type radiation (the iron line) and blazar type components (the non-cut off power law, absence of Compton reflection). Preliminary results show a good fit with a simple synchotron-self compton model.

By studying the processes that create the high energy emission in 3C 111, we hope to understand more about radio galaxies in general.

Multiwavelength campaign on Mrk 509: simultaneous LETGS and COS observations

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We present here the results of a 180 ks Chandra-LETGS observation simultaneously taken with HST-COS, as part of a major multi-wavelength campaign on Mrk 509. We detect several absorption features originating in the ionised absorber of the source along with broad emission lines and radiative recombination continua in the X-ray spectrum. The absorption features belong to ions with, at least, three distinct ionisation degrees, and are relatively shallow (column densities of the order of a few 10^{20} cm^{-2}). The less ionised component is slightly redshifted ($\Delta v \sim 70$ km s^{-1}) and is not in pressure equilibrium with the others, so it possibly belongs to the interestellar medium of the host galaxy. The other components are outflowing at velocities of -200 and -460 km s^{-1}, respectively. The HST-COS observation found seven or more UV kinematic components of which, at least, three of them can be associated with the observed X-ray components based on their kinematic properties. Using these results in combination with a previous FUSE observation, we find evidence that the UV absorbing gas might be co-located with the X-ray absorbing gas and belong to the same structure.

The Chandra Survey of Outflows in AGN with Resolved Spectroscopy (SOARS)

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AGN outflows are widely invoked as the key mediators between the co-evolution of black holes and their host galaxies. Yet, the key question remains: do the outflows actually deliver enough power to their environments to alter evolution in a meaningful way? To address this, we present results from the Chandra SOARS (Survey Outflows in AGN with Resolved Spectroscopy) program, a 1.4 Ms Chandra GO/GTO campaign to perform spatially resolved HETG spectroscopy of outflows in some of our nearest AGN.

We use the sensitive line diagnostics offered by HETG to (1) measure the mass and energy imparted by the AGN outflow into its kpc-scale environment; and (2) create a full kinematic map of the galaxy in conjunction with SINFONI IFU observations, thereby directly constraining the extent of the outflow. Our results have key implications for the role of galactic-scale outflows in AGN as moderators of galaxy evolution, and may suggest that outflows have radically different properties in early- and late-type AGN.

Stacking of the X-ray spectra of deep surveys

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The study of X-ray spectra of the AGNs is a powerful instrument to understand the physics in extreme gravitational fields. In particular, the presence and equivalent width of the Iron line at 6.4 keV gives important information about their innermost regions.

Stacking of good quality spectra allows to improve SNR in hard X-rays, increasing the probability to detect the line. We present our results of stacking of the deepest Chandra fields: CDFN, CDFS, AEGIS. Our sample spans a broad range of redshift, up to z=3.5, and is characterized by lower luminosities at the same redshifts of the sources of LH (Streblyanska et al 2005) and XMS+XWAS (Corral et al 2008), formerly analysed with stacking methods.

We found a significant narrow Iron line in the low luminosity sample, and at redshift 1.01.3; a strong narrow Iron line was also found in the absorbed sample. We will discuss the dependence of the line significance and properties on redshift and luminosity.

We are applying our analysis method to the deepest XMM-Newton survey, XMM-CDFS, in order to check the trend of the Iron line with luminosity and redshift, and to understand the evolution of the accretion over cosmic time scales.

The ultra hard X-ray luminosity function of AGN

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Active Galactic Nuclei (AGN) are considered to be among the highest energetic sources in the Universe. The mechanism of the energy production is thought to be linked to gas accretion on a supermassive black hole. Furthermore, the presence of the AGN seems to be important in regulating the formation of the whole galaxy.

In this work, we study the luminosity function of AGN, considering the ultra hard X-ray band (5-10keV), as the radiation is affected the least by absorption, compared to the soft (0.5-2keV) and hard (2-5keV) X-ray bands. Moreover, this selection includes also Compton thick objects. Our dataset is a compilation of shallow and deep X-ray observations, such as: the XMM Hard Bright Source Sample (HBSS) and the XMM Medium Sensitivity Survey (XMS), XMM-COSMOS, AEGIS and the Chandra Deep Fields (North and South). We also use, for the first time, the very deep observations of XMM in the Lockman Hole ($F(\lim, 5-10\text{keV}) = 1.8 \cdot 10^{-15}\text{ergs}^{-1}\text{cm}^{-2}$).

We deploy parametric and non-parametric methods to investigate the evolution of the luminosity function with redshift and compare our results with previous works both in harder and softer X-ray bands.

Resolved mid-IR emission as an isotropic probe in AGN at high & low powers

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We extend our previous work showing that resolved mid-infrared imaging of active galactic nuclei (AGN) is an isotropic probe of their intrinsic luminosities. New observations of 25 AGN at low luminosities with 8m telescopes (VLT, Gemini) agree with a mid-IR vs. intrinsic-X-ray power correlation previously determined for typical Seyfert galaxies. The correlation is highly significant in both flux:flux and luminosity:lumonisity planes, and shows a very narrow scatter. Furthermore, the MIR to X-ray flux ratio is found to be independent of the Eddington fraction over 6 orders of magnitude, down to $\lambda \sim 10^{-5}$. High spatial resolution spectroscopy and comparison with Spitzer observations shows that most star formation activity on scales of tens of pc has been resolved out and that we are able to isolate emission from the nuclear region effectively. Our low luminosity heterogeneous sample includes LINERs, Compton-thick AGN and even jet-dominated sources like M87, so the narrow scatter is giving us fundamental information about emission processes connecting the infrared and X-ray regimes unbiased by sample selection. We also describe preliminary inferences from all-sky AGN sample observations, and discuss limitations of a number of commonly used Bolometric luminosity indicators including optical and infrared forbidden lines, and low frequency radio observations.

On the difference in average spectral index in Seyfert 1 and Seyfert 2 galaxies

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Using the known properties of the Active Galactic Nuclei (AGN) population in the X-rays like Nh distribution, mass function, luminosity function, etc., we simulate flux-limited AGN surveys in the medium (<10 keV) and hard (>10 keV) X-rays. We furthermore make the assumption, supported by observational evidence, that the spectral index is related to the accretion rate. We show that this leads naturally to an observational bias that would induce a difference in average spectral index in Seyfert 1 and Seyfert 2 galaxies, which has been observed several times. We quantify this bias and compare it with the published average spectral indices found in several surveys.

An X-ray view of accretion disk winds in AGN

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I will present the state of the art X-ray observations of the inner regions of AGN, focusing on the formation of high velocity winds by the accretion disk. Both archival and GO XMM-Newton observations have been used to unveil the X-ray properties of BAL, mini-BAL, and NAL QSOs, known to host high velocity winds associated to their nuclear regions. Several samples of sources have been studied:

(a) substantial samples of distant $\langle z \rangle \sim 2$ sources have been analyzed through spectral, photometric, and statistical techniques, to gain insights into their mean properties as a population;

(b) a sample of $\langle z \rangle \sim 0.5$ bright sources has been studied through detailed X-ray spectral analysis, also from a time-resolved point of view;

(c) the best nearby ($z \sim 0.1$) candidate, PG 1126-041, has been studied using the most sophisticated spectral analysis techniques applied to a large dataset with a high S/N ratio, including the longest X-ray exposure of a mini-BAL QSO so far.

The time-resolved X-ray spectral analysis field has been finally opened for BAL, mini-BAL, and NAL QSOs, allowing to put strong constraints on the physics of their accretion/ejection flow. Results will be discussed in the context of accretion disk winds scenarios, and cosmic feedback contribution by such phenomena.

Study of the PSD shape of 87 AGN with XMM-Newton

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The AGN behavior is thought to be a scale up version of the Galactic black holes (BH). An example of this correspondence is recently found in the X-ray variability power spectral density (PSD) shape, with characteristic timescales scaling with the BH mass. However, these results are based on few sources (e.g. MRK335).

We have performed the first extensive study of the AGN's PSD. It comprises 87 AGN observed with XMM-Newton satellite (140 observations). We have fitted the PSDs to two models: 1. a single power law and 2. a broken power-law. This study has been done in three energy bands (soft, hard, and total). We have also looked for quasi-periodic oscillations (QPOs) by including a Gaussian profile to the fit.

Around 70% of the sample shows AGN variability. LLAGN shows a lack of variability patterns. The broken power-law model is preferred only in 15/87 sources. No QPO is detected (apart from KUG1031+398). We will present the variability properties of the sample and the confrontation of them with other AGN characteristics, as their luminosities, AGN types, or BH masses. We will discuss how these results can be understood under the unification of Galactic with supermassive BHs.

Spotting the misaligned outflows in NGC 1068 using X-ray polarimetry

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We model the X-ray polarization expected to emerge from the complex structure of the active nucleus in the Seyfert-2 galaxy NGC 1068. Using the radiative transfer code STOKES, we presume that the X-ray polarization of NGC 1068 is dominated by scattering or reprocessing in the polar outflows, in the inner and outer accretion disk as well as in the dusty torus. Radiative transfer effects between the different reprocessing regions are coherently taken into account. We show that X-ray polarimetry will allow us to unambiguously measure the polarization angle induced by scattering inside the polar outflows, which constrains their projected orientation on the sky. A possible misalignment between the torus and the polar outflows in NGC 1068 has been suggested and can be tested with X-ray polarimetry. It is nowadays possible to efficiently conduct X-ray polarimetry between 2 keV and 35 keV; if a broad band polarimeter is part of a future X-ray telescope, we can, for most modeling scenarios, even measure the angular difference between the axes of the torus and of the polar outflows. Such results are an important input for any dynamical modeling of the inner structure of the accretion and ejection flows in Seyfert galaxies.

The hot and cold phases of the X-ray warm absorber in NGC 3783

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We investigate the presence of thermal instabilities in the X-ray warm absorber of the bright, well-studied Seyfert galaxy NGC 3783. We assume the absorbing medium to be in total pressure equilibrium (total pressure = gas pressure + radiation pressure). By comparing the observed ionic column densities to a set of theoretical modeling results, we constrain the ionization parameter of the incident radiation and the total column density of the warm absorber. The X-ray data is taken from the 900 ksec Chandra observation of NGC 3783 and the radiative transfer modeling is carried out with the TITAN code. We also obtain theoretical temperature profiles of the medium that are compared to a data analysis based on the absorption measure distribution (AMD). It turns out that both, the observational AMD and the theoretical modeling are in agreement with a forbidden temperature zone that may be attributed to the occurrence of thermal instabilities. The absorbing, constant pressure plasma is probably a clumpy, two-phase medium where cold, dense clumps are embedded in a hotter, diffuse gas. We explore the temperature solutions for the net cooling of these two gas phases.

Swift and XMM-Newton observations of Mkn 335 and WPVS 007

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We will report on the results from our most recent XMM and Swift observations of the Narrow Line Seyfert 1 galaxies WPVS 007 and Mkn 335. The X-ray transient AGN WPVS 007 was an X-ray bright source during the ROSAT All-Sky Survey, but basically disappeared from the X-ray sky for almost two decades. FUSE observations in 2003 revealed the nature of this disappearance: strong absorption. FUSE spectra showed deep absorption line troughs in the UV spectrum of WPVS 007. These findings make this AGN a direct link between NLS1s and Broad Absorption Line QSOs. In some ways similar is the NLS1 Mkn 335 which has been observed in X-ray in a bright state over decades, but was found by Swift in an extremely low state in May 2007. Our XMM observation from June 2009 show the presence of a strong ionized partial covering absorber in the X-ray data.

Chandra's view of local optically "dull" X-ray bright galaxies

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Why do some luminous X-ray sources (Lx $> 10^{42}$ erg/s, rest-frame 2-8 keV) lack any detectable optical emission lines? Such high X-ray luminosities typically suggest power from accretion onto supermassive black holes, which produce copious UV photons to photoionize the line-emitting circumnuclear gas, or a large amount of dark matter, which can bind more hot gas for a given optical luminosity. Competing explanations for these high X-ray luminosity, line-less sources include: (1) optical dilution by the host galaxy starlight, (2) obscuration, (3) radiatively inefficient accretion flows, (4) X-ray variability, or (5) extended hot gas. Resolving this puzzle is crucial for understanding the AGN phenomenon and its cosmic evolution, and the completeness of optically-selected samples. We present new—and perhaps surprising—*Chandra* observations of eight candidate Optically Dull X-ray Bright Galaxies at low redshift (z$\sim$0.3), identified with ROSAT and SDSS.

First results from the Chandra Environments of Radio-loud AGN (ERA) Survey

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We present the first results of the ERA (Environments of Radio-loud AGN) Survey, a Chandra Large Project addressing the epoch and environmental dependence of radio-loud AGN feedback. The radio-loud AGN population is known to evolve between z $\sim$2 and z $\sim$0, and there is also evidence for environmental evolution of FRII galaxies, which are found in different environments at low and medium redshifts. Additionally, local FRI sources inhabit different environments from FRII sources, suggesting a complex interdependence between an AGN and its environment. We are seeking to extend current knowledge from recent studies of radio-galaxy feedback at low redshift, by carrying out a deep X-ray survey of a sample of 25 radio galaxies at z $\sim$0.5 and with radio powers from low power FRI to powerful FRII sources. We have measured X-ray luminosities and temperatures and generated X-ray surface brightness profiles for each galaxy cluster/group. We relate these to the properties of the radio lobes/jets to investigate the dependence of radio luminosity and other AGN properties on environment. In the future, we intend to investigate environmental epoch dependence, links to black hole and host galaxy properties, and carry out comparisons with samples of clusters without radio-loud AGN.

Extreme X-ray luminosity star-forming galaxies: extraordinary starbursts or AGN?

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Surveys have revealed a class of object displaying both high X-ray luminosities (L_X $> 10^{42}$ erg s^{-1}), and a lack of a discernable active galactic nucleus (AGN) in the optical band. If these sources are powered by star formation activity alone, they would be the most extreme X-ray luminosity star-forming galaxies known. We have investigated the mechanism driving the X-ray luminosities of such galaxies by studying the X-ray emission of three mid redshift ($z \sim 0.1$) examples of this class, selected from a cross-correlation of the SDSS DR5 and 2XMMp DR0 catalogues. X-ray spatial and long-term variability diagnostics of these sources suggest that they are compact X-ray emitters. This result is supported by the detection of rapid short term variability in an observation of one of the sources. The spectra of all three sources are best fitted with a simple absorbed power-law model,thus betraying no significant signs of star formation. These results indicate that the X-ray emission is powered by AGN activity. But why do these sources not display optical AGN signatures? We show that the most likely explanation is that the optical AGN emission lines are being diluted by star formation signatures from within their host galaxies.

Extended X-ray jet and TeV emission in a low frequency peaked BL Lac object

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BL Lac objects are known to have very energetic jets pointing under small viewing angle towards the observer. Many of these show high luminosity over the whole energy range up to TeV, mostly classified as high-energy peaked BL Lac objects. Recently, TeV gamma-ray emission was detected from a low-energy peaked BL Lac object. Interestingly, this source has also a clear detection of an X-ray jet. We present a detailed study of this X-ray jet and its connection to the radio jet as well as a study of the underlying physical processes in the energetic jet, producing emission from the radio to the TeV range.

The synchrotron emission of the extreme blazar 1ES 0229+200

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Blazars provide a direct view on the high energetic jet produced in the center of the active galactic nucleus. Especially the high energy peaked BL Lac objects offer the possibility to identify the emission processes and the particle acceleration in the jet because of their broad emission range up to TeV energies. We present new simultaneous observations of 1ES 0229+200 in optical, UV and X-rays with high quality spectra that allow detailed studies of the synchrotron emission which extends up to $\sim$ 100keV. A key issue to understand the intrinsic jet emission is the correct consideration of the dominant host galaxy of this source and the absorption, e.g. the XMM-Newton spectra show a clear additional absorption that could be source intrinsic. 1ES 0229+200 is a high-frequency peaked BL Lac object with a known hard TeV spectrum. It was detected up to 10TeV and is beside 1ES 1426+428 the only TeV blazar with z>0.1 that has been measured up to this high energy. The new results about the synchrotron emission will also be discussed in the context of extreme blazars.

Multiwavelength observation campaign of Mrk 509: UV spectra of the X-ray Outflow

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and the Mrk 509 Consortium

We present HST/COS ultraviolet spectra of Mrk 509 obtained simultaneously with a Chandra/LETGS spectrum as part of a multiwavelength campaign in 2009 that included observations with XMM-Newton, SWIFT, and Integral. Our high S/N spectrum detects additional complexity in the absorption troughs from a variety of sources in Mrk 509, including the outflow from the active nucleus, the ISM and halo of the host galaxy, and infalling clouds or stripped gas from a merger that are illuminated by the AGN. The UV absorption only partially covers the emission from the AGN nucleus with covering fractions lower than those previously seen with STIS, and are comparable to those seen with FUSE. Given the larger apertures of COS and FUSE compared to STIS, we favor scattered light from an extended region near the AGN as the explanation for the partial covering. As observed in prior X-ray and UV spectra, the UV absorption has velocities comparable to the X-ray absorption, but the bulk of the ultraviolet absorption is in a lower ionization state with lower total column density than the gas responsible for the X-ray absorption. We conclude that the outflow from the active nucleus is a multiphase wind.

Long-Term monitoring of X-ray selected and TeV BL Lacertae sources

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To study optical variability of extragalactic objects the long-term campaign was conducted on mount Kanobili in Abastumani Observatory since 1997, which allowed to collect about 250000 CCD frames for 70 blazars during 2600 nights. The list of target objects includes 15 sources selected from the ESSS (Perlman et al., ApJS v.104 p.251, 1996. At the starting date of the project only two TeV sources were known Mrk 421 (Punch et al., Nature 358, 477 (1992)) and Mrk 501 (Quinn et al., ApJL 456 L83 (1996)). Later on, eleven sources included in our list of X-ray selected BL Lacertae has been detected as sources of strong Te-V emission by VERITAS, HESS and MAGIC.

Here we present the preliminary light curves of four X-ray selected BL Lacertae and eleven sources already detected at TeV. Most frequently monitored source among later once is 1ES 1959+650 (740 nights), which shows maximum amplitude of variation 1.22 magnitude in R band. Highest amplitude of variation was detected in the case of 1ES 0647+250 equals to 1.5 magnitudes. Lowest observed amplitudes of optical variation are detected for 1ES 0229+200 and 1ES 2344+514, which are equal to 0.15 magnitudes.

A search for obscured sources in the 2nd Palermo BAT catalogue

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We are studying the spectral properties of the AGN sample in the 2nd Palermo BAT catalogue, focussing on the obscuration properties of the sample. Using their position on a hardness/nH plot (as developed by Malizia et al 2007), we identify some Compton thick candidates, and we study their broad-band properties combining the Swift XRT (0.2-10 keV) and Swift-BAT (15-150 keV) spectra.

Radio loud AGN in the 2XMMi catalogue - multiwavelength view

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We are carrying out a search for all radio loud Active Galactic Nuclei observed with XMM-Newton, including targeted and field sources to perform a multi-wavelength study of these objects. We have cross-correlated the Vern-Cetty & Vern (2010) catalogue with the XMM-Newton Serendipitous Source Catalogue (2XMMi) and found around 4000 sources. A literature search provided radio, optical, and X-ray data for 403 sources. This talk summarizes the first results of our study.

XMMU J144854+085357, another example of an X-ray "Compton ghost"

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We present the discovery of an extended X-ray source from the 2XMM catalogue, which we regard as an example for a so-called "inverse-Compton ghost". Deep optical imaging failed to detect a cluster of galaxies at the position of the X-ray source. However, we find a faint radio source at 1.4 Ghz, which is morphologically similar to the X-ray source, but far too faint to explain the X-ray emission by inverse Compton emission from the lobe of an active radio galaxy. We therefore conclude that we see remnant inverse-Compton X-ray emission from jets that have been switched off. Since the energetic electrons needed for synchrotron radio emission ($\gamma > 10^4$) cool faster than the electrons relevant for inverse Compton scattering of the CMB ($\gamma \sim 1000$), the extended X-ray source can last longer than the GHz radio source.

X-ray spectrum of a new QSO at z=4.21

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We present the discovery of an X-ray selected QSO at z=4.21 in a deep XMM EPIC observation. We have been able to extract the X-ray spectrum, which can be modeled by a canonical power law with photon index $\Gamma = 1.8$, detectable up to 25 keV in the QSO rest frame. The 2-10 keV luminosity of the object is 10^{45} erg/sec, we find no evidence for intrinsic photo-electric absorption or an iron fluorescence line.

Relativistic outflow or huge Fe absorption edge in the z=2.73 QSO HS 1700+6416?

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We present the detection of a broad absorption feature in the X-ray spectrum of the quasar HS 1700+6416, indicating either the presence of high velocity out-flowing gas or a huge absorption edge from FeXXV. HS 1700+6416 is a high-z (z=2.735), high luminosity quasar, classified as a Narrow Absorption Line (NAL) QSO, on the basis of the SDSS spectrum. One broad absorption feature is clearly visible in a 50ks Chandra observation taken in 2000. The 30ks XMM-Newton spectrum taken in 2003 shows an hint of the same feature and possibly the presence of thermal emission in the soft X-rays, while two similar features, at different energies, are visible when the 8 close Chandra observations, carried out in 2007, are merged together.

Discovery of a new tidal disruption event candidate from the 2XMM Catalog

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Stars approaching a supermassive black hole (SMBH) can be tidally disrupted and subsequently accreted, providing a unique way to find and study inactive SMBHs. We report on our discovery of a new tidal disruption event candidate, 2XMMi J184725.1-631724, with unprecedented X-ray spectra near the flare peak. It lies toward the center of an inactive galaxy IC 4765-f01-1504 ($z = 0.0862$). It was detected serendipitously in two XMM-Newton observations separated by 211 days, with the flux increasing by a factor of $\sim$9. The source was not detected in X-rays by ROSAT in 1992, indicating a long-term variability factor of $>$64; neither by Swift in 2011, implying a flux decay factor of $>$12 since the last XMM-Newton observation. The XMM-Newton X-ray spectra are dominated by a strong cool thermal disk ($>$80%, tens of eV) with the luminosity appearing to follow the $L \propto T^4$ relation, often seen in the thermal state of the BH X-ray binaries. The spectral fits imply a black hole mass of $\sim 10^6$ solar mass.

Systematic errors on black hole spin

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Determining black hole spin from broad iron lines is potentially the best approach in active galactic nuclei. However this measurement is rather subtle and although a number of spin values have been published in recent years, the affect of systematic errors remains largely unquantified. We explore systematic effects on the measured spin parameter. These effects are illustrated using all available Suzaku and XMM-Newton data on the Seyfert 1 galaxy Fairall 9. We explore effects resulting from imperfect instrument calibration, different data analysis techniques, and imperfect spectral models.

We find that systematic errors dominate over statistical errors. Moreover, we identify a particularly important degeneracy that exists between narrow emission features in the iron K band and the blue wing of the broad line – CCD spectra do not have sufficient spectral resolution to separate these two features and the spin parameter is very sensitive to proper modeling of this region of the spectrum. We investigate the extent to which time-variability of the spectrum (i.e. multi-epoch fitting) can be used to break this degeneracy.

The bolometric output of AGN in the XMM-COSMOS survey

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The rapid development of new observational capabilities provides the opportunity to detect both the obscured and the unobscured flavours of active galaxies, the Type 2 and Type 1 Active Galactic Nuclei (AGN), respectively. In particular, the combination of sensitive X-ray and mid-IR observations allows us to unveil the emission of Type 2 AGN that would be otherwise precluded to our investigation. The combined AGN/host-galaxy information that lays in the broad-band spectral energy distribution (SED) is fundamental to constrain the physical evolution of AGN and understand their role in the framework of galaxy evolution. I will present a study on the multi-wavelength properties of an X-ray selected sample of both obscured and unobscured AGN drawn from the XMM-Newton wide-field survey in the COSMOS field. Their SEDs, the morphology of the host galaxies, and the stellar masses indicate that there is a preference for these obscured AGN to be hosted in bulge-dominated galaxies, while the tight correlation between mid-IR and hard X-rays is used as a reliable proxy for the intrinsic AGN emission.

X-ray absorption variability In NGC 4507

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We present a complete spectral analysis of an XMM-Newton and Chandra campaign of the obscured AGN in NGC 4507, consisting of six observations spanning a period of six months. We detect strong absorption variability on time scales between 1.5 and 4 months, suggesting that the obscuring material consists of gas clouds at parsec-scale distance. The lack of variability on shorter time scales rules out the possibility of absorption by broad line region clouds, which was instead found in other studies of similar sources. This shows that a single, universal structure of the absorber (either BLR clouds, or the parsec-scale torus) is not enough to reproduce the observed complexity of the X-ray absorption features of AGNs.

Testing disk-jet connections in blazars via GeV and multi-wavelength variability

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We present GeV-band power spectra density (PSD) functions for a small sample of blazars monitored with the Fermi Gamma-Ray Observatory. We find the first-ever evidence for characteristic time scales (breaks) in the GeV PSDs of three objects. We also compare the GeV PSDs to optical- and radio- band PSDs for three blazars. Our aims are to quantify the variability properties of the GeV-emitting region in the jet and to test links between the disk and the jet. We will also place our results in context with respect to the relation between X-ray PSD breaks, black hole mass, and accretion rate quantified via the X-ray PSDs of Seyferts.

The Chandra 3C snapshot survey of radio galaxies with z≤0.3

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We report the preliminary results of our Chandra snapshot survey of 3CR radio galaxies at z≤0.3. We compare these observations with VLA radio maps and HST data to search for extended emission corresponding to jets and hotsposts. Here we give the basic data: the X-ray intensity of the nuclei and any features associated with radio structures such as hotspots and knots in jets. We briefly present the X-ray spectral and photometric analysis of their nuclear emission and of their extended structures. The work at SAO is supported by NASA grant GO1-12125A.

Large scale extragalactic jets in the Chandra era

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We report initial results from a systematic investigation of the properties of large-scale AGN jets detected in X-rays. We have uniformly analyzed archival Chandra data for more than 90 such sources and measure fluxes in three X-ray bands to estimate spectra. We discuss the sample, the reduction methods, and present first results for the ratio of X-ray to radio flux and the spectral analysis for jet knots and hotspots. Utilizing archival VLA and MERLIN data, we examine the X-ray and radio properties for the jet knots and hotspots in the sample which includes quasars and low- and high-power (FR1 and FR2) radio galaxies. As two different processes have been proposed for the X-ray emission mechanism – synchrotron and inverse Compton – we discuss on a possible new classification scheme for extragalactic jets based on our data. From our comparison of their radio-to-X-ray properties, several aspects on their nature became unexpectedly unclear, as different emission processes seems to provide no differences in the observable quantities.

Multiwavelength campaign on Mrk 509: the nature of the soft X-ray excess

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We present a study of the broadband continuum of the Seyfert-1/QSO Mrk 509, using XMM-Newton and Swift observations, part of an unprecedented multiwavelength campaign on this AGN. The XMM-Newton data are from a series of 10 observations of 60 ks each, taken in Oct-Nov 2009. Mrk 509 was also monitored with Swift for a period of 100 days. With these data we have established the broadband continuum and investigated its variability on the timescale of our campaign. We have found that in addition to the X-ray power-law, the spectrum displays soft X-ray excess emission, which interestingly varies in association with the thermal optical-UV emission from the accretion disk. Our results suggest that the soft X-ray excess in Mrk 509 is the tail of the disk spectrum, which has been stretched to higher energies by Comptonisation in a warm (0.2 keV) optically thick ($\tau \approx 15$) corona surrounding the inner regions of the disk. This makes Mrk 509, with a black hole mass of about 1–3 $\times 10^8$ solar masses, the highest mass known system to display such rarely observed behaviour in AGN: this is a unique result, only made possible by our long multiwavelength campaign.

Reverberation and accretion disk outflows in AGN

Lance Miller[1]
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Many type I AGN are highly variable at X-ray energies, and often show time lags between hard and soft energy bands. Time lags can be in the range 10s to 1000s of seconds. Although these have been known for several years, we have recently recognised that their energy-dependence and variability-frequency-dependence may be understood as "smoking gun" signatures of reverberation from circumnuclear material. We show how changes in sign of time lags at high frequencies arise naturally in reverberation models. The reverberation signatures are consistent with spectral analyses that indicate high covering factors of absorbing and scattering material. We present results from new radiative transfer modelling and discuss the significance of these results for our understanding of winds and outflows from AGN accretion disks.

The Circinus Galaxy: shedding X-ray light on the energetics of AGN outflows

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We present striking new results on the Circinus galaxy, the second nearest (4 Mpc) AGN and the closest type 2 Seyfert. This spiral galaxy is also peculiar in that it is radio-loud, with a pair of lobes spanning 7 kpc, and has a starburst ring and an ionization cone.

Our new deep (200ks) Chandra data show, in a detail never achieved before for this kind of object, shells of shocked gas outside the radio lobes, with a temperature kT=0.74±0.11 keV. Thanks to the exceptional spatial resolution achievable for Circinus, we have discovered that, unlike what has been observed in Centaurus A, the radio and X-ray emission in Circinus are spatially coincident, and notably edge-brightened, implying that we may be seeing the shock in radio (synchrotron) as well as in X-rays. This morphology is closely related to what is seen in supernova remnants, but it has never been observed before in AGN outflows. This may lead to a reinterpretation of results on more distant systems, where this resolution is not achievable.

Circinus may prove crucial to understand AGN feedback and its dependence on power and galaxy morphology.

Optical study of blazars 1FGL J2001.1+4351 and B2 2308+34

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After discovery of J2001.1+4351 (MAGIC, M. Mariotti et al., ATel 2753, 22 July 2010) and B2 2308+34 (FERMI/LAT, F.DAmando et al., ATel 2783, 9 Aug 2010) at VHE we started systematic monitoring in Abastumani Observatory using 70-cm meniscus (f/3) and Apogee Ap6E CCD camera. Here we present the results of very frequent observations conducted in the 2nd half of 2010. Thanks to good weather condition we collected about 800 (J2001.1+4351) and 480 (B2 2308+34) frames during 94 and 67 nights, respectively. Constructed light-curves show that maximum observed amplitudes of variation was detected in the case of B2 2308+34 (1.31 mag., rms=0.04). The variability amplitude of J2001.1+4351 is 0.82 magnitudes (rms=0.02) in R band.

Suzaku discovery of a new variable component in MCG–6-30-15

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We re-analyzed the Suzaku XIS and HXD data of the Seyfert I galaxy MCG–6-30-15 obtained in January 2006, focusing on hard X-ray variability. Through intensity-sorted spectroscopy, we discovered a very hard spectral component, varying independently of the dominant power-law emission. This new component, dominant in the 15–45 keV range, can be modeled in several different ways; e.g., a thermal Comptonization emission with a relatively high optical depth, or a partially-absorbed power-law with a photon index of 2.

When this component is included in the fitting model, the time-averaged 2.5–55 keV spectrum of MCG–6-30-15 can be reproduced successfully by invoking a moderate reflection coming approximately from a flat plane. At the same time, the best-fit iron-line broadening reduces to a level where the emission region is located at > 8 times the gravitational radii from the central black hole. Therefore, a super massive black hole in this AGN is not required to be in the extreme Kerr condition, in contrast to the conclusion by Miniutti et al. (2007) who analyzed the same data set (Noda et al. 2011).

Search for relativistic signals in the XMM long light curves of AGN

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Broad iron lines have been detected in the X-ray spectra of AGN for almost 15 years now. Their flux appears to be roughly constant on short time scales. Despite this observational fact, if the line emission is emitted by material orbiting the central black hole at very small radii, and if the disc at these distances is highly inhomogeneous, then, due to strong relativistic effects, we may expect to detect quasi-periodic signals in the line (or in general, in the reflection dominated parts of the X-ray spectrum) emission. I will present results from a detailed analysis of the longest AGN X-ray lightcurves in the XMM archive, regarding the possible presence of such signals in them.

The nature of X-ray absorbed QSOs

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A significant population of broad-line z=2 QSOs have heavily absorbed X-ray spectra. Submm observations show that these QSOs are embedded in ultraluminous starburst galaxies, unlike most unabsorbed QSOs at the same redshifts and luminosities. The radically different star formation properties between the absorbed and unabsorbed QSOs implies that the X-ray absorption is unrelated to the torus invoked in AGN unification schemes. Instead, these objects represent a transitional phase in an evolutionary sequence relating massive black holes and the formation of galaxies. Prior to this phase, the galaxy is rapidly forming its stars, and the growth of the black hole is obscured. After the X-ray absorbed phase, the naked QSO shines brightly, and its host elliptical galaxy is essentially fully formed. The most puzzling question about these objects has always been the nature of the X-ray absorber. I will present a study of the X-ray absorbers based on deep (50-100ks) XMM-Newton spectroscopy, and show that the absorption is due to a dense, ionised wind driven by the QSO, with a kinetic luminosity compatible with the theoretical requirements for producing the M-sigma relation.

The INTEGRAL Narrow Line Seyfert 1 galaxies

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Narrow Line Seyfert 1 galaxies are among the most interesting class of active nuclei. Their observational properties suggest that they are high accretion rate systems probably associated with relatively small back hole masses with compared to classical Seyfert 1 galaxies. However, the number of known NLSy1 detected above 10 keV is small notwithstanding the importance of the high energy data to discriminate between the major compelling models. Here we present a detailed study of a sample of 14 NLSy1 detected above 10 keV by INTEGRAL/IBIS, through an accurate broad-band analysis using INTEGRAL data combined with XMM-Newton, Suzaku and Swift. Their high energy spectral properties have been related to their accretion parameters in order to unveil the nature of these extreme AGN. We have estimated the fraction of NLSy1 in the hard X-ray sky to be nearly 15%, in agreement with the estimate derived from optically selected NLSy1 samples.

Multiwavelength campaign on Mrk 509: testing realistic comptonization models

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The 1-month monitoring (10 observations, 1 every 4 days) of the Seyfert 1 galaxy Mkn 509 simultaneously with XMM and INTEGRAL provides a unique opportunity to test thermal comptonisation models. Thermal comptonisation of soft UV photons, from the accretion disc, by hot (100 keV) electrons is indeed commonly believed to be at the origin of the high energy emission in this class of objects. Our main purpose here is to adopt and fit directly to the different observations of Mkn 509 a detailed model of Comptonization for the primary continuum. This allows to fit simultaneously the data from the UV to the hard X-ray band, including the soft X-ray excess and the reflection components. We will present our results focusing on the direct constraints we obtain on the physical parameters (like the temperature and optical depth) of the different emitting regions.

Multiwavelength campaign on Mrk 509: Fe K reverberation in Mrk509

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We present a study of the iron K band of the Seyfert-1/QSO Mrk 509, during an extensive XMM-Newton monitoring, consisting of 10 pointing ($\sim$ 60 ks each, part of an unprecedented multi-wavelength campaign) as well as a reanalysis of previous XMM-Newton, Chandra and Suzaku observations. We measure the variability-reverberation of the resolved FeKa component ($\sigma \sim 0.12$ keV) that is variable on a time-scale of weeks, tracing the hard X-ray continuum without any measurable lag. No excess of variability is observed on time-scales shorter than a day, indicating an origin in the inner broad line region or the outer part of the accretion disc. The narrow core is constant on several years time-scale, consistent with being produced at 0.2-0.4 pc, probably the inner wall of a molecular torus. An indication for enhanced variability at 6.7 keV (on time-scales between 6-60 ks, corresponding to an orbiting time at r$<$ 6rg) suggests an association with the red wing of an ionised broad line, or an ionised absorber.

CAIXA III: a catalogue of AGN in the XMM-Newton archive III. Timing analysis

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We present the variability (excess variance) properties of the CAIXAvar (a Catalogue of AGN in the XMM-Newton Archive) sample. It consists of all the radio-quiet unobscured (NH$< 2 \times 10^{22}$ cm^{-2}) AGN observed by XMM-Newton in targeted observations (with exposures longer than 10 ks) whose data are public as of June 2010. With its 161 objects, this is the largest catalogue of high signal-to-noise X-ray data for which the excess variance has been computed. We observe that the source variability is correlated with BH mass at more than 99.999% probability, indicating a universal scaling of the PSD with BH mass. The dependence on the BH mass is also the driver of the correlations between variability vs. bolometric luminosity and vs. FWHM Hbeta. Moreover, the study of the variability vs. accretion rate relations and its comparison with models assuming a scaling of the PSD break frequency with both accretion rate and BH mass, will be presented. Finally the correlation between variability and 2-10 keV spectral index will be discussed.

Broadband long-term variability of very high energy blazars

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In recent years, more and more focus has been placed in broadband studies of blazars as a way to understand the mechanisms responsible for the acceleration of ultra-relativistic particles in these objects. We present in this work preliminary results of the study of the long-term lightcurve and Spectral Energy Distributions (SED) of the TeV blazar Mrk421. For this purpose, we have gathered data spanning the last 20 years in 4 different wavelength bands from: UMRAO, RXTE, Fermi and the combined very high energy (VHE) lightcurve available from the literature from past and current ground-based Cherenkov Telescopes (HEGRA, H.E.S.S., Whipple, VERITAS and MAGIC). The data and the results reported here have been mostly gathered using public archives and Virtual Observatory (VO) tools.

This work aims to be the seed for a systematic study of the long-term lightcurve and SED of blazars observed in the VHE regime. Hence, it is expected that the knowledge gained from this work will set the foundations for the publication in the VO of data from the future Cherenkov Telescope Array , a European effort to build the first open VHE ground-based observatory, expected to become operational around 2015.

Kinematics from spectral lines for AGN outflows based on radiation-driven wind

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We build a velocity-dependent photoionization model of the warm absorber of the Seyfert 1 galaxy NGC 3783. We compute the ionization, temperature, line Doppler shifts, and line profiles for all lines in the spectrum of the outflow by adopting a functional form for the velocity of the flow and a density profile appropriate for radiation driven winds. The model reproduces the observed relationship between the gas ionization and the velocity shift of the line centroids as well as the asymmetry of the absorption lines in the X-ray spectrum of NGC 3783. It is found that the distribution of asymmetry seen in this spectrum requires the presence of two outflows: a higher ionization component responsible for the blue wings of the high ionization lines and the red wings of the low ionization oxygen lines, and a lower ionization flow that makes up for the blue wings of the oxygen lines.

An hard X-ray view of AGN: reflection, the Unified Model and the CXB

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We present the deepest (∼100Ms) study of the average hard X-ray spectra of radio-quiet AGN ever performed. Our sample consists of all the ∼ 200 Seyferts detected by INTEGRAL. Using all the available IBIS/ISGRI public data, we produced the average stacked spectra of different classes of Seyferts in the $17 - 250\,\mathrm{keV}$ band. We found that, in agreement with the unified model of AGN, the average spectra of Seyfert 1s and Seyfert 1.5s are consistent. The spectrum of Compton-thin Seyfert 2s shows instead a much greater curvature. When compared to those of Seyfert 1s and Seyfert 1.5s, it presents a strong excess in the 20–60 keV band, due to a stronger reflection component. We found that most of this excess is due to the contribution of mildly obscured (Nh in the $(1-7)\times10^{23}\,\mathrm{cm}^{-2}$ range) Seyfert 2s. The unabsorbed reflector in these objects has an average value of $R > 1$, which might imply the existence of partially covering Compton thick clumps in the line of sight. We will discuss the impact of our results on the Cosmic X-ray Background synthesis models, and on the unified model of AGN.

The structure of AGNs from X-ray eclipses

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Eclipses of the X-ray source in Active Galactic Nuclei are rather common. We discovered the first example of these events a few years ago in the Seyfert Galaxy NGC 1365, and we now have a sample of about 10 sources with clear evidence of rapid X-ray occultations due to clouds crossing the line of sight. I will show several examples of these eclipses, in both type 1 and type 2 AGNs, and I will discuss the physical and geometrical structure of the central region of AGNs as inferred from these observations. Finally, I will show how X-ray eclipses may provide a strong test of general relativistic effects in AGNs, through the analysis of the changes of the iron line profile during the occultations. Such experiment may be possible even today with present observatories (XMM and Suzaku) under particularly favorable conditions, and will be relatively straightforward with future large-area X-ray observatories.

Star formation properties of obscured AGN

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We use a sample of X-ray selected AGN in the CDFS from the 3Ms XMM observations with enough photons to derive measurements of the AGN obscuration, and investigate the properties of their hosts. Using moderate luminosity radio emission (excluding radio-loud sources), far-infrared properties, and SED decomposition, we assess the link of X-ray obscuration with star-formation in the host. This helps us identify the source of X-ray obscuration in non-local redshifts and study any evolutionary link between the AGN and the host galaxy.

The X-ray properties of typical high-redshift radio-loud quasars

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We report spectral, imaging, and variability results from four new XMM-Newton observations and two new Chandra observations of high-redshift ($z \geq 4$) radio-loud quasars (RLQs). Our targets span lower, and more representative, values of radio loudness than those of past samples of high-redshift RLQs studied in the X-ray regime. Our spectral analyses show power-law X-ray continua with a mean photon index that is consistent with measurements of lower redshift RLQs. These continua are likely dominated by jet-linked X-ray emission, and they follow the expected anti-correlation between photon index and radio loudness. Our data also constrain intrinsic X-ray absorption in these RLQs. We find evidence for significant absorption in one RLQ of our sample; the incidence of X-ray absorption in our sample appears plausibly consistent with that for high-redshift RLQs that have higher values of radio loudness. In the Chandra observation of PMN J2219−2719 we detect apparent extended (~ 14 kpc) X-ray emission that is most likely due to a jet; the X-ray luminosity of this putative jet is ≈ 0.02 times that of the core.

Dissecting photometric redshifts for AGN using XMM- and Chandra- COSMOS samples

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Accurate photometric redshifts for X-ray selected AGN are usually difficult to be achieved. First of all, powerful AGN are characterized by a power-law Spectra Energy Distribution (SED). Such shape create a color-redshift degeneracy that only a complete and deep multi-wavelength coverage can break. Secondly, AGN are hosted in galaxies which in most of the cases contribute to the global SED. The number of possible type of galaxies and relative host/AGN contribution is so high that SED fitting-redshift degeneracy is unavoidable. Finally, flux variability is an intrinsic property of AGN and many multi-wavelength surveys are not taking this into account while planning the observations, making hard a good SED fitting. Thanks to a)the strategy adopted to gather photometry in the COSMOS fields and b) to spectroscopy of very faint targets we finally understood how to take into account the physical properties of AGN when computing reliable photometry redsihft. Here we present our robust results (accuracy of 0.016 with only 7% outliers) for the XMM- and Chandra- COSMOS surveys.

Catching a tidal disruption event at the peak

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The XMM-Newton slew survey, in conjunction with the ROSAT All-Sky Survey (RASS), has sufficient sensitivity to detect the peak soft X-ray emission from galaxies undergoing a tidal disruption event out to $z \sim 0.1$. We report on the first success from a program designed to identify and monitor these events. In June 2010, a large soft X-ray flare, with Lx=10^{44} ergs/s, was seen from a faint SDSS galaxy. A subsequent Calar-Alto optical spectrum showed the galaxy to be inactive with no evidence for emission lines. We initiated a monitoring program with the SWIFT and XMM-Newton satellites, to follow the evolution of the source flux and spectra, and found it to be wildly variable on weekly timescales. Here, we weigh the evidence and assess whether this behaviour fits with any of the current tidal disruption models.

The sudden death of the nearest quasar

Kevin Schawinski[1]
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Galaxy formation is significantly modulated by energy output from supermassive black holes at the centers of galaxies which grow in highly efficient luminous quasar phases. The timescale on which black holes transition into and out of such phases is, however, unknown. I present the first measurement of the shutdown timescale for an individual quasar using XMM-Newton and Suzaku observations of the nearby galaxy IC 2497, which hosted a luminous quasar no more than 70,000 years ago that is still seen as a light echo in "Hanny's Voorwerp," but whose present-day radiative output is lower by at least two, and more likely by over four, orders of magnitude. This extremely rapid shutdown provides new insight into the physics of accretion in supermassive black holes and may signal a transition of the accretion disk to a radiatively inefficient state. I will also show preliminary evidence that similar behavior may be common on nearby Seyfert AGN.

High-excitation & low-excitation radio galaxies: an X-ray comparison

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It is known that FR II narrow-line radio galaxies (NLRG) can be divided into two optical sub-classes: high-excitation galaxies (HEGs) and low-excitation galaxies (LEGs). The latter category comprises objects with [OIII] EW < 10 Å, or [OII]/[OIII] ratio > 1, or both. Although LEGs share the same radio properties as HEGs, they are less bright in the [OIII] line by a factor of 10 at the same total radio luminosity (Buttiglione et al. 2010). The cause of this difference is not well established. Indeed it could be due either to very strong obscuration or to different accretion modes. X-rays can play a fundamental role in discriminating between these two scenarios. In order to address this point, we studied 14 objects (6 LEGs and 8 HEGs) observed with *Chandra*. These sources belong to the 3CR sample and are characterized by $z < 0.1$. For each sub-class, we define the average nuclear X-ray properties.

The X-ray spectra of a large sample of type 1 AGN

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We present the X-ray spectral properties of 761 Type 1 AGN, selected from a cross-correlation of the SDSS DR5 Quasar catalogue and 2XMMi. The spectra are fit with simple power law models to which additional absorption or soft excess features are added if required by the F-test at a 99% significance level.

The resulting distribution of best-fitting photon indices is considered, and relationships between the photon index and the X-ray luminosity, redshift and Eddington ratio are discussed.

4% of the sample require intrinsic absorption at levels higher than expected for type 1 objects. The fraction of absorbed sources and the N_H values are not seen to vary with luminosity or redshift.

8% of objects require a soft excess component, modeled with a blackbody component of temperature kT. This temperature correlates with the 2-10 keV X-ray luminosity, but not the blackbody luminosity or the black hole mass. A strong correlation is found between luminosities in the blackbody and power law components.

Exploratory X-ray monitoring of high redshift radio-quiet quasars

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I will present initial results from an exploratory X-ray monitoring of luminous, high redshift radio-quiet quasars (RQQs). This project consists of two groups of RQQs: 1) four sources at $z \simeq 4.2$ monitored by *Chandra*, and 2) three sources at $z \simeq 2$ monitored by *Swift*. The two groups have matched luminosities to disentangle the strong $z - L$ dependence. The prime goal of this project is to test claims that quasars were more X-ray variable in the early universe with implications for evolution scenarios of the central engine in active galactic nuclei. The X-ray monitoring is also supported by near-simultaneous optical monitoring from the ground in order to search for potential correlated optical-X-ray variations. The data will provide basic assessments of variability amplitudes and timescales that will allow planning of more ambitious and systematic X-ray monitoring of such distant RQQs in the future, perhaps with *IXO*.

Resolving the radial dependence of relativistic spectral line emissivity

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We discuss the approach towards resolving the radial dependence of relativistic spectral line emissivity near a black hole by the help of the future X-ray spetroscopy. The strong gravitational field of the black hole has indispensable effects on the observed profile of the spectral line from an accretion disc near the black hole. The observed profile of a spectral line is broadened and skewed by fast orbital motion and redshifted by gravitational field. These effects can help us to constrain parameters of the system with a black hole, both in active galactic nuclei and stellar-mass black hole. Here we explore the fact that the accretion disc emission can be mathematically imagined as a superposition of radiating accretion rings that extend from the inner edge to the outer rim of the disc, with some radially varying emissivity. In our work we show that the characteristic double-horn profile of several radially confined (relatively narrow) accretion rings or belts could be recognised by the planned instruments onboard future satelites (such as the ESA proposed Large Observatory for X-ray Timing).

Radio and X-ray emission in radio-quiet quasars

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The origin of the radio emission coming from the nuclear region in radio-quiet quasars, i.e. those quasars without bright radio jets and lobes, is still poorly understood. In 2007 Blundell & Kuncic proposed that the nuclear radio emission in radio-quiet quasars is thermal free-free emission from the base of an outflow, similar to the outflows observed in about 50% of all Seyfert 1 galaxies. This theory predicts a specific free-free X-ray luminosity for the observed radio luminosity. To test this theory we use a sample of 22 radio-quiet PG quasars which have measured X-ray and radio luminosities, as well as an EPIC or high-resolution X-ray spectrum to determine the Galactic and intrinsic absorption. We find that the theory overpredicts the X-ray luminosity by 1 to 3 orders of magnitude and that only in 2 of the 22 quasars the difference between predicted and measured X-ray luminosity can be explained by absorption. We therefore conclude that the nuclear radio emission is not related to an AGN wind with properties similar to those outflows observed in Seyfert 1 galaxies. I will discuss the importance of understanding the origin of the nuclear radio emission and discuss the alternative explanations.

Relative abundances of the warm absorber in Mrk 509

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The abundances in the immediate surroundings of super-massive black holes are important as they tell us how enriched the gas is that disappears into the black hole, and thus learn us about the enrichment processes in the host galaxy. Until recently broad emission lines were used, however this method has to make some, likely incorrect, assumptions, see for instance Wang et al. 2010. Here we present the relative abundances determined from the narrow absorption lines of the warm absorber, situated likely about 0.3 pc from the black hole, in the Seyfert 1 galaxy Mrk 509. Using the stacked 600 ks RGS spectrum recently obtained, we derive relative abundances similar to those in the proto-solar nebula, but with a sub-solar iron to oxygen ratio of 0.80 +-0.03. Due to the excellent statistics and the improvement in atomic data, this is the first time that accurate and reliable abundances have been determined for the warm absorber, the ionized outflow observed in about 50% of all Seyfert 1 galaxies. I will compare the relative abundances to the metalicity relationship measured in starforming galaxies and the relative abundances measured in clusters of galaxies.

An 85-ks Suzaku observation of the low-excitation radio galaxy NGC 6251

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We present an 85-ks Suzaku observation of NGC 6251, the brightest example of a low-excitation radio galaxy (LERG). We have previously suggested that LERGs violate conventional AGN unification schemes: they may lack an obscuring torus and are likely to accrete in a radiatively inefficient manner, with almost all of the energy released by the accretion process being channeled into powerful jets. Our observations confirm that there are no signatures of accretion-related X-ray emission in NGC 6251, and we provide strong upper limits to the presence of (1) the 6.4 keV Fe Kα line, (2) heavily absorbed X-ray emission, and (3) the Compton reflection hump. We discuss our results in the context of the interplay between inflow and outflow in radio-loud AGN.

A Monte Carlo code for accreting sources

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The X-ray emission of radio-quiet AGN is believed to be produced by Comptonization of the soft UV photons of the accretion disk by a thermal corona of hot electron-positron pairs. In the simplest scenario, the resulting continuum is well reproduced by a power law distribution, with a spectral index function of the electrons' temperature and the optical depth of the corona. Moreover, the emerging radiation should be linearly polarized, with a degree mainly dependent on the geometry of the corona and the inclination angle with respect to the line of sight.

We have developed a Monte Carlo code to study the spectrum and the degree of polarization of the radiation produced by such processes. Varying the disk and corona parameters, the code can be applied to many astrophysical situations and, combined with a ray-tracing code, can offer a fully relativistic description of the phenomenon.

Rare AGN populations found in the XMM-Newton serendipitous source sample

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A large number of serendipitous sources have been detected in XMM-Newton observations, and detection of rare objects can be expected from such a large sample. We utilize the XMM-Serendipitous source catalogue to search for and to study properties of rare AGN populations; (1) buried AGNs and (2) AGNs with relatively low mass central black holes (BHs). Buried AGNs are selected by using two approaches. First, hardness ratios are used to selected highly absorbed objects showing little scattered emission, which suggests the nucleus is buried by geometrically thick obscuring matter, and a new sample of buried AGNs is made. Second, we cross-match the XMM catalogue and infrared sources detected in the AKARI all sky survey, and develop a simple way to find candidates for obscured AGNs. We also construct a new sample of AGNs with relatively low mass BHs by using large amplitude X-ray variability. A significant fraction of this sample has a relatively large Eddington ratio implying they are in the growing phase of BHs. We will present the ways to selected these AGN populations and summarize their observational properties.

The X-ray view of accretion disk winds in AGNs

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X-ray evidence for massive, highly ionized, ultra-fast outflows has been recently reported in a number of local Seyfert galaxies through the detection of blue-shifted Fe K absorption lines. We present the results of a comprehensive spectral analysis on a large sample of 42 Seyferts and 5 broad-line radio galaxies observed with XMM-Newton and Suzaku. We assessed the global detection significance of the Fe K absorption lines, solving any claimed publication bias, and performed a detailed photo-ionization modeling. The associated outflows are present in >40% of the sources and have mildly relativistic velocities, in the range 10,000-100,000km/s. Their location on sub-pc scales favors a direct interpretation as accretion disk winds/ejecta. Moreover, their estimated high mass outflow rate and significant mechanical power suggest they may provide a new additional source of cosmological feedback besides radio-jets.

Jets and outflows in radio galaxies: implications for AGN feedback

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One of the main debated astrophysical issues is the role of AGN feedback in galaxy formation. If it is known that massive black holes have a profound effect on the formation and evolution of galaxies, how black holes and galaxies communicate is still an unsolved problem. For radio galaxies most studies of feedback have primarily focused on jet/cavity systems in the most massive and X-ray luminous galaxy clusters. The recent high-resolution detection of warm absorbers in some Broad Line Radio Galaxies (BLRG) allows us to investigate the interplay between the nuclear engine and the surrounding medium from a different perspective. I will briefly present the XMM-Newton/RGS detection of a warm absorber in two out of three BLRG. These absorbers are slow and probably related to the torus. Their kinetic luminosities always account for less than one percent the bolometric luminosity and the jet kinetic power. Despite the small number of BLRG, a first comparison between RL and RQ properties will be presented. Finally, I will discuss the correlation found between the mass outflow rate/kinetic luminosity and the radio loudness.

The nature of sub-mm emission from X-ray bright AGN

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HerMES, team

Combination of X-ray with sub-mm observations provides the most robust constraints on the star-formation of AGN to test competing models for the interplay between galaxy formation and black hole growth. The Herschel Multi-tiered Extragalactic Survey (HerMES), the largest project that will ever be performed with Herschel, is ideally suited to studying star formation over the z=1-3 epoch. Here we will present the X-ray/sub-mm properties of the HerMES sources detected by Chandra in CDFN (2Ms) and Lockman (70ks). Less than 25% of the X-ray sources have a 250m counterpart. The majority of the latter (>50%) are AGN dominated in X-rays. One of our key findings is that the hardness ratio distributions of the 250m detected and undetected sources imply a strong connection between X-ray absorption and rapid star-formation in AGN. Although the obscuration of AGN is a consequence simply of the geometry of the surrounding material and our line of sight to the nucleus, the prevalence of X-ray absorption in star-forming AGN implies an alternative source of absorbing material, perhaps related to the gas which is fuelling the star formation or to outowing material from the early stages of AGN feedback.

X-ray signatures of circumnuclear gas in AGN

Tracey Jane Turner[1]
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X-ray spectra of AGN are complex. X-ray absorption and emission features trace gas covering a wide range of column densities and ionization states. The absorbing complex shapes the form of the X-ray spectrum, while variations in the line-of-sight gas naturally explain the spectral variability observed. High resolution spectra show the absorbing gas to be outflowing, perhaps in the form of an accretion disk wind. I discuss recent progress, highlighting some new results and reviewing the implications that can be drawn from the data.

Revelations from the best X-ray detection of a two-sided jetted AGN

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Over the past decade X-ray measurements of the jets and environments of radio-loud AGN have demonstrated that mechanical power provides significant heat and momentum input to the surrounding medium. Mechanical powers have been estimated using the holes bored by slowly-expanding old lobes in cluster gas, or through inferring highly relativistic bulk speeds for quasar jets out to vast distances. In the former case, the jets themselves are not normally X-ray detected, and the latter case is plagued by uncertain geometry and beaming parameters. Unique insights can be gained from sources in the plane of the sky, and so largely free from differential relativistic effects, if both jet and counter-jet X-ray emission are detected. Such detections are naturally limited to low redshift. The best current example is NGC 4261. We will discuss the lobe cavity power and complexities in the gas structure caused by the twin jets. We will further present an argument, based on the appearance today of the X-ray jet and counterjet, that the jet flow from the central engine has not been steady over time.

Evidence for black hole accretion disc in the AGN RXJ1633+4718 in X-ray

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We report the discovery of a luminous ultra-soft X-ray excess in a radio-loud narrow-line Seyfert 1 galaxy, RX J1633+4718, from archival ROSAT observations. The thermal temperature of this emission, when fitted with a blackbody, is as low as 32 eV. This is in remarkable contrast to the canonical temperatures of ∼0.1–0.2 keV found hitherto for the soft X-ray excess in active galactic nuclei (AGN), and is interestingly close to the maximum temperature predicted for a postulated accretion disc in this object. In fact, this ultra-steep X-ray emission can be well fitted as the (Compton scattered) Wien tail of the multi-temperature blackbody emission from an optically thick accretion disc, whose parameters inferred (black hole mass and accretion rate) are in good agreement with independent estimates using optical emission line spectrum. We thus consider this feature as a signature of the long-sought X-ray radiation directly from a disc around a super-massive black hole, presenting observational evidence for a black hole accretion disc in AGN.

Chandra and XMM-Newton observations of AGN with low mass black holes

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Active galactic nuclei (AGN) with black hole masses around or below $\sim 10^6\,M_{\odot}$ are of special interest in understanding the growth of massive black holes and black hole demography in the universe. We present results of our X-ray observations using Chandra and XMM-Newton on a small sample of such AGN. Firstly, we focus on such AGN with low accretion rates, which complements the study by Greene & Ho (2007) by extending the Eddington ratio into a previously unexplored region in the parameter space. Our Chandra observations indicate that there exist AGN with low mass black hole accreting at relatively low mass rates (L/L_Edd <0.1), implying that there may be a large population of black holes in this mass range which are missed in surveys due to their dimness. Secondly, we present analysis of an XMM-Newton spectrum for one AGN with low black hole mass, and large-amplitude X-ray variability discovered in another.

Formation of dusty tori and narrow line regions in AGNs by radiative feedback

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We have rececntly proposed a model in which the dusty tori of AGNs are formed by the anisotropic radiative pressure of their accretion disks (Liu and Zhang, 2011, ApJL, 728, L44). The model can explain successfully the observed distribution of column density of AGNs and the fraction of type 2 AGNs as functions of X-ray luminosity. This model predicts the existence of a type of bright AGNs with dusty tori, but with very weak broad lines, in agreement with recent observations of weak line quasars. In this paper, we propose that the narrow line regions of AGNs are also formed as a consequence of the anisotropic radiative pressure of the accretion disks in AGNs. This model can explain the observed correlation between the sizes of their narrow line regions and luminosity.

Chapter 10

Clusters of Galaxies

Quantifying X-ray substructures in clusters of galaxies

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We present a new method to quantify substructures in clusters of galaxies, based on the analysis of the intensity of structures detected in a residual image, which is the result of the subtraction of a surface brightness model, obtained by fitting a two-dimensional analytical model (β-model or Sérsic profile) with elliptical symmetry, from the X-ray image.

Our method was applied to 36 clusters observed by the *Chandra* Space Telescope that are in the redshift range $z \in [0.02, 0.2]$ and present a signal to noise ratio greater than 100.

We present the calibration of the method and preliminary results on the scaling between the substructure quantification and the intracluster plasma physical quantities, such as the metallicity, X-ray luminosity, and temperature. We also search for correlations between the cluster morphology with its total mass and redshift.

Our method is instrument independent and could also be applied on XMM-Newton and future X-ray space missions data such as IXO.

Cluster X-ray luminosity-temperature relation at mean z = 1.8

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The evolution of the properties of the hot gas that fills the potential well of galaxy clusters is poorly known, since models are unable to give robust predictions, and observations lack a sufficient redshift leverage and are affected by selection effects. Here, with just two high-redshift, ¡z¿ 1.8, clusters avoiding selection biases, we obtain a significant extension of the redshift range and we begin to constrain the possible evolution of the Lx-T relation. The two clusters, JKCS041 at z=2.2 and ISCSJ1438+3414 at z=1.41, are, respectively, the most distant and the second most distant clusters, overall, that can be used for studying scaling relations. Their location in the X-ray luminosity versus temperature plane, with an X-ray luminosity five times lower than expected, suggests at the 95 per cent confidence level that the evolution of the intracluster medium has not been self-similar in the last three-quarters of the age of the Universe. Our conclusion is reinforced by data on a third, X-ray-selected, high-redshift cluster, too faint for its temperature when compared to a sample of similarly selected objects. Precise knowledge of evolution is central for using galaxy clusters as cosmological probes in planned X-ray surveys, such as WFXT or JDEM.

Metal abundance evolution in distant galaxy clusters observed by XMM-Newton

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Taking advantage of EPIC XMM-Newton high throughput and effective area, we selected a sample of 40 high redshift galaxy clusters ($0.4 < z < 1.4$) to perform a spatially resolved spectral analysis. In this work, we are aiming to study the evolution of metal abundance through cosmic time in different regions of the clusters (inside and outside the core), in order to determine whether a variation in abundance with redshift could be entirely the result of physical processes associated with the production and release of Fe into the ICM or partially connected with a redistribution of metals strictly related to the evolution of the cool cores. Our analysis is revealing hints of a negative evolution of the metal abundance with redshift not limited to the cluster cores but involving also regions well outside the cores ($R > 0.4R500$), extending to the external regions of the clusters the results obtained by Maughan et al. (2008) and Balestra et al. (2007).

On the redshift evolution of galaxy cluster scaling relations and implications

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An understanding of the relations of galaxy cluster properties including X-ray observables and physical parameters is important for the study of the evolution of the intracluster medium (ICM) as well as for the application of galaxy clusters to constrain cosmological models. The combination of a literature review and new reults from XMM-Newton observations of very distant clusters provide new observational constraints on scaling relations and the evolution of the ICM. The new results are explored in the light of the theoretical framework and by a comparison with new cosmological simulations which for the physics of the ICM clearly favour a scenario of preheating of the ICM by a very early feedback energy input. We also discuss implications on the heavy element budget and the expectations for deep X-ray surveys.

Cluster cosmology with eROSITA

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The eROSITA mission, which aims for four year all-sky survey in X-rays, will improve the results of the ROSAT survey by approximately a factor of 30, and provide a better spectral coverage of the sources from 0.2 to 10 keV.

One of two main goals is to detect 50-100 thousand clusters of galaxies up to z $\sim$ 1 in the main survey, and up to z $\sim$ 1.5 in the deeper ecliptic pole regions. Studying the cluster X-ray luminosity function and the clustering of galaxy clusters in the survey will allow us to trace the growth of structure of the Universe. This will provide the basis for the test of cosmological models and to constrain major cosmological parameters such as σ_8, Ω_M, Ω_Λ and the equation of state parameter of Dark Energy. Cluster and large scale structure evolution also provide a good test of the large variety of proposed non-standard cosmology models.

We present a forecast of the mission yields and prospects, and discuss the feasibility of cosmological model constraints.

A self-similar study of SZ cluster number counts from X-ray properties

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Thanks to the development of the missions of observation, our knowledge on the inner properties of galaxy clusters has greatly progressed. On one hand,the first missions and surveys in X-ray, allowed us to detect the dominant baryonic component and deep gravitational potential with, for the first time, an extremely good precision. On the other hand, it was showed the Sunyaev-Zel'dovich effect cluster surveys are revelant for cosmological application because the signal depend on an integral over the intracluster gas, independently of its spatial distribution. In a near future, surveys (using SZ effect) from Planck-Surveyor, South Pole Telescope, Atacam Telescope...will be crucial for placing constraints on the cosmological parameters.

I will present a self-consistent modeling of clusters using their X-ray and SZ properties. First,I will present my results from the X-ray study on the scaling relation between the mass and the X-ray temperature. I'll developp, in a second time the method used to constrain the scaling parameters using a combinaison of cosmological probes (CMB,BAO,SN Ia) and the X-ray temperature function. Finally, I will present the predicted SZ number counts and their redshift distribution considering both cosmological constraints as well as data on the X-ray clusters temperature function in a consistent way.

Pairs of clusters observed with XMM-Newton

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We have analysed the properties of two pairs of intermediate redshift clusters Abell 222/223 and Abell 1758 North/South, based on XMM-Newton data, deep multi-wavelength optical imaging with CFHT/Kegacam, and, for the second pair, numerical simulations. Temperature and metallicity maps of the X-ray gas show striking features, particularly in one of the members of each pair, implying ongoing mergers at least in Abell 223 and in Abell 1758 North. For the latter cluster, the comparison of the metallicity map with the results of numerical simulations suggests that in the metal rich regions, winds have been more efficient in transporting metal enriched gas to the outskirts than ram pressure stripping. Optical galaxy luminosity functions (GLFs) tend to show dips and wiggles, as well as an excess of bright galaxies over a Schechter function fit , confirming the merging structure of each of these four clusters, both at optical and X-ray wavelengths.

Clusters of galaxies in a deep XMM-Newton observation

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Within the XMM-Newton Distant Cluster Project (XDCP), we highlight a deep (250 ks) archival XMM-Newton observation, targeting the AGN LBQS J2212-1759. We find 9 extended sources, of which 6 are confirmed to be the emission from galaxy clusters, either from previous publications or through our own spectroscopic campaign. We identify 3 distant clusters at $z \geq 1$ in the field, of which 2 are new discoveries. 3 extended sources could not be identified. We present (1) X-Ray analyses of the extended sources, (2) results from optical spectroscopic follow-up, (3) galaxy overdensity maps derived from deep CFTH-LS data, and (4) implications for cosmology based on this single $\sim 0.3\,\mathrm{deg}^2$ field.

X-ray observations of PKS 0745-191 at the virial radius: are we there yet?

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Recent works using Suzaku data reported the detection of several galaxy clusters out to the virial radius. In particular, in the case of PKS 0745-191 (z=0.1028) a detection out to ∼1.5 r200 was reported, which showed a flattening (and in one case even an inversion) of the entropy profile in the outskirts of the cluster. We present an analysis of archival ROSAT/PSPC data of the cluster, which reveals that the gas density in the outskirts of PKS 0745-191 is significantly below the Suzaku measurements. Combining this result with the temperature profiles from several other satellites, we find a discrepancy of 25% in the value of r200 and of a factor of 2 in the virial mass compared to the Suzaku results. We show that the discrepancy in surface brightness is most likely explained by the existence of additional sky components at the low Galactic latitude of the source which were not taken into account in the Suzaku background modeling. Our results illustrate the difficulty of measuring the properties of the ICM in cluster outskirts with narrow-field instruments, and highlight the importance of the background modeling in regions with complicated soft emission.

Testing the low-mass end of X-ray scaling relations with Chandra galaxy groups

Helen Eckmiller[1], Daniel Hudson[1], Thomas Reiprich[1]
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Well-determined scaling relations between X-ray observables and cluster mass are essential for using large cluster samples to constrain fundamental cosmological parameters, such as the luminosity-temperature, mass-temperature, luminosity-mass relations. These have been investigated extensively for clusters, but less so for groups, and some evidence supports a systematic "break". We want to test scaling relations for the low-mass range to resolve the issue whether there is a systematic difference between clusters and groups, and to provide a reliable mass determination for future samples. We performed a detailed analysis of a sample of 26 X-ray galaxy groups observed with Chandra, compiled from statistically complete parent samples and selected by luminosity and redshift, determined the main physical quantities like temperature and mass, and various X-ray scaling relations. We then compared the group properties to several other group and cluster samples. We have found evidence for a similarity break between groups and clusters, for example the L-T relation steepens for low temperatures, which could indicate a larger impact of heating on cooler systems. We also detect a decrease in the gas mass fraction below 1 keV. Also scatter for groups is larger, which could be due to complex baryonic physics in the group cores.

XMM-Newton's view of the highest redshift X-ray luminous galaxy clusters

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XDCP Collaboration

XMM-Newton has been the unrivaled workhorse for X-ray selecting new high redshift galaxy clusters in the first half of cosmic time, in particular based on serendipitous archival searches. The most successful survey in this field has been the XMM-Newton Distant Cluster Project (XDCP), which has compiled a spectroscopically confirmed X-ray cluster sample of 30 systems at $z>0.8$ (18 at $z\geq1$) with a homogeneous redshift coverage all the way out to $z\sim1.6$. This talk will shortly review the XDCP survey strategy and will then focus on the properties of the most distant massive X-ray luminous galaxy clusters at $1.3<z\leq1.6$.

Metallicity across sloshing cold fronts

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After the discovery of cold fronts, several clusters hosting these features have been found (Ghizzardi et al. 2010). Cold fronts in cool core clusters are thought to be induced by minor mergers and to develop through a sloshing mechanism. Among the properties characterizing cold fronts, metal abundance behavior across the discontinuity is still an important missing piece of the puzzle. Within a sloshing picture, we expect that the central cool, metal rich gas is displaced outwards into lower abundance regions, thus generating a metal discontinuity across the front. On the contrary, when the gas starts flowing back towards the center, the cold front continues to propagate and no metal dicontinuity is expected to be created. Abundance discontinuities across cold fronts have been observed in some cool core clusters (Sanders et al 2005, Fabian et al 2005) although Dupke & White (2007) did not find them in A496. We analyze the XMM-Newton data of a small sample of bright, nearby clusters hosting one or more sloshing cold fronts searching for metal discontinuities. We also build abundance maps to study the correlation between surface brightness and metal distribution anisotropies. We present here the results for the Centaurus cluster.

ICM in cluster outskirts affected by large scale structure discovered in A1689

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Anisotropic gas temperature and entropy distributions in cluster outskirts of A1689 are discovered using Suzaku. The high temperature and entropy region in the northeastern outskirts is connected to an overdense filamentary structure, while the outskirt regions in contact with low density void environments have low gas temperatures and entropies, deviating from hydrostatic equilibrium. These results indicate that the evolution of the ICM is closely related to the large-scale structure environments, as predicted by hierarchical structure formation. Intensive joint X-ray and lensing analyses show that the hydrostatic mass is $\sim 60-90\%$ of spherical lensing one but comparable to a triaxial halo mass within errors in $0.6r2500 < r < 0.8r500$ and that it is significantly biased as low as $< 60\%$ within $0.4r2500$, irrespective of mass models. The thermal gas pressure within $r500$ is, at most, $\sim 50-60\%$ of the total pressure to balance fully the gravity of the spherical lensing mass, and $\sim 30-40\%$ around the virial radius. Although these constitute lower limits taking possibility of halo triaxiality into account, these small thermal fractions suggest nonthermal pressure, such as bulk and/or turbulent motions. Future prospects for ASTRO-H and IXO missions are also presented.

Deep Chandra and XMM-Newton observations of NGC 4472

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We present preliminary results from our deep (300 ks) Chandra/ACIS-S and archival (100 ks) XMM-Newton observations of the nearby early-type galaxy NGC 4472. This galaxy is the dominant member of a group that is falling into the Virgo cluster, and is the nearest/brightest example of a group/cluster merger. Our goal is to study the gas dynamics of the merger process at or as close as possible to the spatial resolution of Chandra. Our observation shows a complex array of filamentary structures and surface brightness discontinuities in the gas on scales of hundreds of pc to tens of kpcs that were not visible in the short AO-1 observations. It is clear that the visible features are the result of both multiple epochs of nuclear activity and subsonic gas motions induced by the ongoing merger with the Virgo cluster. We will present multi-band images, temperature, elemental abundance, and entropy maps, and temperature/density/pressure profile across surface brightness discontinuities in the gas.

HIFLUGCS-SDSS: star formation efficiency and the matter density parameter

Tatiana Laganá[1]
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It is believed that the baryon content of galaxy clusters are representative of the matter distribution of the universe, and can be used to reliably determine the matter density parameter. This assumption is challenged by recent evidence from optical and X-ray observations that the total baryon mass fraction increases towards rich clusters. Thus, we investigate the dependence of stellar, gas and total baryon mass fractions as a function of total mass. We extracted twenty clusters from the HIFLUGCS sample that have available DR7 SDSS data. From the optical analysis we derived the stellar masses. Using XMM-Newton and ROSAT we derived the gas masses. Then, adopting a scaling relation we estimate the total masses. Our findings for the stellar mass fraction agree with previous studies, where we observe a clear decrease with increasing mass. The gas mass fraction shows an increasing trend with increasing total mass, but not in the same proportion. This suggests that the efficiency of star formation varies on cluster scale. As a consequence, the mass-to-light ratio shows a dependence on total mass from lower to higher mass systems. We also discuss the consequences of these results in the context of determining the matter density parameter.

Abell 2390 revisited: hints of ripples, bubbles and sloshing

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Abell 2390 is a well-studied, massive, rich cluster with hot intracluster gas, ranging from ~ 7 to 12 keV. It has a central galaxy with a strong radio activity, being a proto-typical 'Perseus cluster' at 10 times higher z. Previous work has focused mainly on the overall intracluster medium (ICM) physical properties and showed the presence of bubbles in the intracluster gas.

We have reprocessed both XMM-Newton and Chandra data in order to investigate not only the existence of faint features in the ICM, but also their connection with the cluster central galaxy and cluster dynamics (based on the gas temperature map). We show here that this cluster presents substructure in the gas temperature map, showing evidence of recent dynamical activity, perhaps in the form of sloshing. We also detect with the deep Chandra image signs of bubbles and ripples due to acoustic waves. However, about 10 times more exposure is needed to confirm the presence of acoustic waves in the ICM, such as the one observed in the Perseus Cluster.

Scaling relations with a complete sample of galaxy groups

Lorenzo Lovisari[1], Thomas Reiprich[1], Yuying Zhang[1], Helen Eckmiller[1]
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Well-determined scaling relations between X-ray observables and cluster mass are essential to constrain fundamental cosmological parameters. Scaling relations have been investigated extensively for galaxy clusters, however the question of whether these relations hold true also for galaxy groups remains unsettled. We are in the process of improving the accuracy of scaling relations using a complete sample of 23 groups to study if there is a systematic difference between clusters and groups and the influence of non-gravitational physics on low-mass systems.

Swift observations of galaxy clusters

Alberto Moretti[1]
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Cluster observations are currently limited by the high level of instrumental background (Chandra and XMM-Newton) or by the poor imaging capabilities (Suzaku). Here I present a new and unexploited data-set coming from the observations of the X-ray Telescope (XRT) on board the Swift satellite, which combines a low and stable background with a good and uniform PSF (HEW = 18 arcsec) across the whole field of view (20 arcmin diameter). In particular, I present the outer region (0.5-0.8 r_{200}) temperature profiles of 2 nearby clusters (Abell 2141 and Abell 1413, z $\sim$ 0.15). By means of realistic simulations I argue that XRT deep observations would provide us with the most accurate temperature profile measurement so far performed around the virial radius. Moreover I present a catalog extracted from a serendipitous survey obtained from deep follow-up GRB observations, spanning 30 degrees of high latitude sky at the level of $\sim$ 1E-14 cgs flux limit.

AGN feedback in galaxy groups: a combined X-ray/low-frequency radio view

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It is now widely accepted that the powerful radio sources hosted by the central dominant ellipticals of galaxy clusters are the main source of feedback regulating cooling in the hot intra-cluster medium. However, most galaxies in the local Universe are found in galaxy groups, whose lower masses mean that AGN feedback may have a greater effect. We present results from a combined X-ray/low-radio-frequency study of 18 galaxy groups, selected to show signs of interaction between the AGN and the intra-group medium, but with a wide range of morphologies and AGN power. X-ray observations from XMM-Newton and Chandra allow us to determine gas properties, identify disturbed features, and study temperature and abundance structure. Low-frequency (235-610 MHz) radio observations from the Giant Metrewave Radio Telescope allow us to track the history of AGN outbursts, in some cases over multiple activity cycles. We use these data to study the relationship between the radio and mechanical power of AGN jets across 7 decades of radio luminosity, and discuss the implications for models of AGN feedback across cosmological time. Finally, we describe a new project based on the first statistically complete sample of galaxy groups studied in the X-ray, radio and optical bands.

Cluster physics and cosmology with Chandra, XMM-Newton, Suzaku, eROSITA, and IXO

Thomas Reiprich[1]
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Recent results on scaling relations of nearby and distant massive galaxy clusters are given based on Chandra, XMM-Newton, and weak gravitational lensing data. The extension of relations into the galaxy group regime is discussed based on an X-ray selected group sample. A brief update on temperature profiles in the very cluster outskirts as determined with Suzaku is provided. Some prospects are shown for constraining primordial non-Gaussianity with eROSITA. Last not least, we show that IXO will likely discover serendipitously the first galaxy group in the Universe (at $z \sim 3.5$) in the standard structure formation scenario, given a large enough field-of-view of the WFI.

A multi-wavelength approach to the CC-NCC dichotomy

Mariachiara Rossetti[1], Silvano Molendi[1]
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The origin of the dichotomy between "cool core" (CC) and "non-cool core" (NCC) clusters has been subject of debate in recent years, between "evolutionary" models (where clusters can evolve from CC to NCC, mainly through mergers) and "primordial" models (where the state of the cluster is fixed "ab initio" by early mergers or pre-heating). I will report some results supporting evolutionary models, obtained with a multi-wavelength approach to galaxy clusters. I will show that the majority of NCC objects in a representative sample observed with XMM-Newton hosts regions that are reminiscent of a CC, suggesting that they have undergone a cool core phase during their life (Rossetti & Molendi 2010). To strengthen this result, I am currently investigating the correlation between metal abundance and different thermodynamical properties of the ICM (temperature, entropy). I will also show that, analyzing a complete sample of clusters observed both in X-rays (Chandra and XMM) and in the radio band, none of the clusters which host a radio halo can be classified as a CC. This suggests that the main mechanisms which can start a large scale synchrotron emission are the same that can destroy CC (Rossetti et al. 2011).

Chandra's view of high-redshift cool-core clusters

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Cool-core (CC) clusters dominate the local cluster population. Numerous X-ray studies have provided a detailed knowledge of the properties of the Intra cluster medium (ICM) in these systems, and multi-wavelength data have shown that the CC phenomenon is regulated by complex physics involving interactions of the ICM with the brightest cluster galaxy.

In this talk we present recent results on the evolution of CCs out to redshift z=1.3. Using high-resolution Chandra data, we obtained a robust measure of the surface brightness concentration parameter, C_SB, which is an excellent proxy of the cooling time. Relying on three representative cluster samples spanning different redshifts we assess quantitatively the change in the CC strength distribution. At variance with previous results, we find a moderate evolution of the cool-core population with redshift, while confirming the lack of strong CC at z>0.5.

In addition, we present the deepest Chandra observation (370 ksec) of a distant cluster, WARPSJ1415 at z=1.03, that shows a significant temperature drop towards the cluster core, and probably the highest metallicity peak ever observed in galaxy clusters. This data unambiguously demonstrates that at z=1, a cool core cluster has ICM properties similar to the ones of local cool-cores.

Baryons at the edge of the X-ray brightest galaxy cluster

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Studies of the diffuse X-ray emitting gas in galaxy clusters have provided powerful constraints on cosmological parameters and insights into plasma astrophysics. However, measurements of the faint cluster outskirts have become possible only recently. Using data from the Suzaku X-ray telescope, we determined an accurate, spatially resolved census of the gas, metals, and dark matter out to the edge of the Perseus Cluster. Contrary to previous results, our measurements of the cluster baryon fraction are consistent with the expected universal value at half of the virial radius. The apparent baryon fraction exceeds the cosmic mean at larger radii, suggesting a clumpy distribution of the gas, which is important for understanding the ongoing growth of clusters from the surrounding cosmic web.

The XMM-BCS galaxy cluster survey

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The XMM-BCS project is a coordinated X-ray, optical and mid-infrared galaxy cluster survey in a field covered by the SPT and ACT Sunyaev-Zel'dovich effect experiments. The aims of the project are to study the cluster population in the 14 deg^2 test field, for the first time comprehensively compare the selection function of the different cluster finding approaches and perform a cross-calibration of mass scaling relations.

We present a catalog of 46 X-ray selected clusters from the initial 6 deg^2 survey region. The survey gives us a comprehensive outlook on the cluster and group population out to redshift ~ 1. We provide physical properties for our sample including photometric redshift estimates derived from the Blanco Cosmology Survey imaging data and spectroscopic redshift measurements for a low redshift subset of clusters. An initial cross-comparison with the optically selected cluster catalog is also carried out.

As first example of science derived from mosaic-mode XMM-Newton observations, we report on the discovery of two galaxy clusters, SPT-CL J2332-5358 and SPT-CL J2342-5411, in X-rays. These clusters were also independently detected through their Sunyaev-Zel'dovich effect by the SPT. They are thus the first clusters detected under survey conditions by all major cluster search approaches.

XMM-Newton/SDSS Cluster Survey (XSCS) I. The first cluster sample

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We present a first release of the XMM-Newton/SDSS Cluster Survey (XSCS). The XSCS is a search for galaxy clusters detected serendipitously in pointed observations with XMM-Newton with coverage by the Sloan Digital Sky Survey (SDSS). The main aims of the survey are the identification of new X-ray galaxy clusters, to investigate their X-ray scaling relations, to study the correlation of X-ray and optical properties, to identify distant cluster candidates beyond the SDSS limit, and to prepare for the eROSITA cluster surveys.

In this presentation we describe our basic strategy to identify our cluster sample which currently comprises almost 1200 objects. A cross-match of the X-ray selected cluster candidates with 4 recent optical cluster catalogs from SDSS data revealed a photometric redshift for 275 objects. among them 182 with spectroscopic confirmation. We developed an automated method to reprocess the X-ray observations, extract the X-ray spectra and to derive the temperature, luminosity and X-ray redshift for the optically confirmed clusters. Here we present the first cluster sample with measurements of X-ray temperature and luminosity, covering the redshift range from 0.08 to 0.61.

Dusty and distant galaxies inside and out an X-ray luminous cluster

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The X-ray luminous cluster Cl 1257+47 at z = 0.9 was observed with XMM, Chandra and Spitzer. The link between Spitzer and the X-ray data has not been fully exploited until now. By reprocessing the Spitzer data we can derive new improved star formation rates to the unusually high number of MIPS detections within the X-ray bright core. The IRAC reprocessed data will allow us to better identify high redshift sources, some which will be identified as X-ray sources. By applying improved photo-zs we will discuss how these results can be use to put bounds on the existence of AGNs at high z.

A deep study of X-ray cavities in the cooling flow cluster A1991

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We present results based on the detailed analysis of deep XMM-Newton and Chandra archival observations of Cluster Abell1991, with an objective of examining properties of X-ray cavities in it. This study has enabled us to detect a pair of cavities. Feedback from the AGN is believed to be the most promising mechanism for the formation and evolution of such cavities. We employed the contour binning, unsharp masking as well as 2D smooth model generation techniques for the investigation of such cavities and other hidden features in the selected target. Both these cavities are roughly of elliptical shape and show a decrement in the surface brightness. Spectroscopic analysis of X-ray emission extracted from different regions enabled us to examine the variations in derived parameters like electron density, entropy, metal abundance, temperature, and enthalpy, etc. Our results imply that these cavities are originated due to the AGN outflows associated with cluster cooling flow. We also derive various cavity properties like power, size and pressure which in turn enabled us to understand the mechanism of such cavity formation.

Statistical properties of galaxy cluster morphology estimators

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X-ray observations of galaxy clusters reveal a large range of morphologies. The determination of cluster masses from X-ray data rely on the assumption of hydrostatic equilibrium and spherical shape, which are not satisfied in clusters showing substructure. Deviations from a virialized state influence global cluster properties and X-ray scaling relations. It is therefore important for the understanding of cluster properties and cosmological applications to mark clusters which show substructure. The most promising and popular method to characterize substructure in clusters are power ratios and center shifts which trace asymmetries of the gravitational potential. Measurements, however, can be heavily biased by Poisson noise. We therefore performed an extensive analysis of the effect of Poisson noise and background on substructure measurements using a large sample of simulated X-ray observations. We quantify the bias and error in detail and give ranges where morphological analysis is feasible. This will enable us to study the evolution of substructure over a large redshift range where photon statistics vary substantially and investigate its impact on cluster scaling relations. In addition, we present the currently largest sample of clusters (> 80) with substructure measurements based on a compilation of several catalogs (REXCESS, LoCuSS etc.).

X-ray spectroscopy of the Virgo Cluster out to the virial radius

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We will present results from the analysis of a mosaic of thirteen XMM-Newton pointings covering the Virgo Cluster from its center northwards out to a radius $r \sim 1.2$ Mpc (~ 4.5 degrees), reaching the virial radius and beyond. This is the first time that the properties of a modestly sized $M_{vir} \sim 1.4e14 M_{sun}$, $kT \sim 2.3$ keV, dynamically young cluster have been studied out to the virial radius. The density profile of the cluster can be described by a surprisingly shallow power-law with index 1.21 ± 0.12. In the radial range of $0.3 r_{vir} < r < r_{vir}$, the best fit temperature drops by roughly 60 per cent. Within a radius $r < 450$ kpc, the entropy profile has an approximate power-law form with index 1.1, as expected for gravitationally collapsed gas in hydrostatic equilibrium. Beyond $r \sim 450$ kpc, however, the temperature and metallicity drop abruptly, and the entropy profile becomes flatter, staying consistently below the expected value by a factor of 2-2.5. The most likely explanation for the unusually shallow density profile and the flattening of entropy at large radius is clumping in the ICM. Our data provide direct observational evidence that the ICM is enriched by metals all the way to r_{200} to at least Z=0.1 Solar.

Toward understanding mass proxies of galaxy clusters for modern cosmology

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We selected a representative, volume-limited sample of 52 X-ray luminous clusters and 20 X-ray less-luminous clusters within the Local Cluster Substructure Survey (LoCuSS; $0.15 < z < 0.3$). We have been following up this volume-limited sample homogeneously with XMM-Newton, Subaru as well as MMT/Hectospec, and developing a method combining three techniques, i.e., X-ray, weak lensing, and velocity dispersion, toward understanding cluster mass proxies for high precision cluster cosmological tests from near future dark energy experiments, e.g., eROSITA. In parallel, we have been analyzing mock samples taken from the Millennium simulations and comparing the results from observations and simulations. With the enlarged sample compared to that in Okabe et al. (2010) and Zhang et al. (2010), we are able to study the mass dependence in our calibration. We will report our most recent results calibrating cluster mass proxies using multi-wavelength data together with a line of efforts toward understanding underlying physics, e.g., star formation efficiency, metal enrichment history, and feedback, which account for biases and scatter in the mass proxies.

Chapter 11

Extragalactic Surveys and Population Studies, the Cosmic X-ray Background, WHIM and Cosmology

AGN activity and the stellar masses and colors of their host galaxies

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We determine the fraction of galaxies that host AGN at $z = 0.2 - 1$ as a function of the galaxy's stellar mass and color, and the X-ray luminosity of the AGN. We use X-ray data from three extragalactic surveys (XMM-LSS, COSMOS and ELAIS-S1) to identify AGN within PRIMUS (a low-resolution spectroscopic survey of $> 120,000$ galaxies). We find that the fraction of AGN rises with increasing stellar mass, but falls with increasing X-ray luminosity. However, the AGN fraction as a function of stellar mass follows a power-law distribution that is independent of X-ray luminosity; equivalently the distribution of X-ray luminosities is independent of the stellar mass. Furthermore, we show that the probability of a galaxy hosting an AGN may be primarily driven by Eddington ratio, and does not depend on stellar mass, indicating that the same physical processes may be responsible for triggering and regulating AGN activity in galaxies of all stellar masses. We also investigate the dependence of the AGN fraction on the color of the host galaxy, fully accounting for selection effects that depend on stellar mass and X-ray luminosity. We find a very weak enhancement (factor ~ 2) of the AGN fraction in the green valley.

Young X-ray binary populations in low metallicity star-forming galaxies

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We present an investigation of the connection between spatially resolved star-formation and the young (<100 Myr) X-ray Binary (XRB) populations in the Small and the Large Magellanic Clouds, our two nearest star-forming galaxies, using X-ray and optical photometric and spectroscopic data. For the Small Magellanic Cloud we find that the High-Mass XRBs are observed in regions with star-formation rate bursts ∼25-60 Myr ago, while for the Large Magellanic Cloud we find that these populations are concentrated in regions as young as ∼13-50 Myr. The similarity of this age with the age of maximum occurrence of the Be phenomenon (∼40 Myr) indicates that the presence of a circumstellar decretion disk plays a significant role in the number of observed XRBs in the 10-100 Myr age range. We discuss the effect of age and metallicity in the relative number of Be-XRBs in the two galaxies in comparison with the Milky Way, and with predictions of population synthesis models for sub-solar metallicity galaxies.

X-ray absorption of high-z GRBs and quasars as a probe of the missing baryons

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Evidence will be presented that the missing baryons can be probed via soft X-ray absorption of high-redshift sources. Observations with the Swift satellite of X-ray afterglows of more than a hundred gamma ray bursts (GRBs) with known redshift reveal ubiquitous soft X-ray absorption. The directly measured optical depth at a given observed energy is found to be constant on average at $z > 2$. Such an asymptotic optical depth is expected if the foreground diffuse intergalactic medium (IGM) dominates the absorption effect, and if the metallicity of the diffuse IGM reaches 0.2 - 0.4 solar at z = 0. We also analyzed the 12 highest S/N $z > 2$ quasar spectra observed with XMM-Newton, and their optical depths are found to be consistent with the mean GRB value. The four lowest-z quasars ($2 < z < 2.5$), however, do not show significant absorption. The best X-ray spectra of radio-quiet quasars (RQQs) at $z > 2$ provide only upper limits to the optical depth, which are still consistent with the RLQs, albeit with much lower S/N. Lack of quasar absorption poses a challenge to the smooth IGM interpretation, and could allude to the opacity being rather due to the jets in RLQs and GRBs.

The search for obscured AGN in the COSMOS and CDFS survey

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The search for, and the characterization of the evolutive and physical properties of AGN in their "obscured growth" phase is a key topic of present research in the field of observational cosmology. Significant advances have been obtained in the last ten years thanks to the sizable number of XMM-Newton and Chandra surveys, complemented by multiwavelength follow-up programs. I will present some of the recent results from the COSMOS and CDFS surveys and the ongoing efforts aimed at obtaining a complete census of accreting Black Holes at z=1-3.

Study of the anisotropies of the unresolved X-ray background

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Chandra deep and wide surveys have been used to study the angular clustering of the unresolved X-ray background. We will present recent results obtained with Chandra and XMM-Newton in the Chandra Deep Field North, South and in COSMOS survey. Surprisingly deep pencil beam Chandra surveys do not show any signature of clustering both in the soft and in the hard energy bands. This contradicts previous results obtained in the same fields. Thanks to the 3D density fields obtained with multiwavelength data, the COSMOS survey allowed us to select narrow energy bands where filamentary large scale structures are likely to show signature of highly ionized O, Ne and Fe clustered emission form the elusive WHIM. We have detected a clustering signal at energies corresponding to the feature of the OVII triplet at z=0.22. Such a feature is typical of the WHIM at $10^6 - 10^7$ K. With these results we provide the first measurement/upper-limit of Omega_WHIM with clustering studies.

66 months of sky survey with Swift-BAT: the 3rd Palermo BAT catalogue

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The Burst Alert Telescope (BAT: 14-150 keV) on board of Swift is providing the opportunity for a substantial gain of our knowledge of the Galactic and extragalactic sky in the hard X-ray domain, thanks to its continuous monitoring of the sky (50%-80% per day). Here we present the third Palermo Swift-BAT hard X-ray catalogue obtained from the analysis of the data relative to the first 66 months of the Swift mission and including about 1600 high-energy sources. With a program of soft X-ray follow-up observations and by using archival data we were able to associate a counterpart to most of these high energy emitters: 59% are extragalactic objects, 20% are Galactic objects and 9% are known soft X-ray emitters whose nature has not been determined yet. We compare our catalogue with those obtained from the INTEGRAL-ISGRI data and with the gamma-ray sky as seen by Fermi.

On the missing heavily obscured AGN population

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Deep X-ray surveys are very efficient in detecting obscured and unobscured AGN out to high redshifts. These surveys have been extremely important for constructing the most complete census of AGN activity to date and measuring the evolution of AGN across cosmic time. However, there is now clear evidence that the majority of the most obscured objects (such as Compton-thick AGN) remain unidentified in even the deepest X-ray surveys.

Through extensive SED analysis of 322 sources in the GOODS fields using the deepest X-ray, *Herschel* infrared data, and VLA radio data available to date, we have robustly identified a large population (25%) of AGN with excess radio core emission over that expected from star-formation processes. Half of these radio-excess AGN also have a dominant AGN component in the mid-IR band, as compared to only 16% of the "radio-normal" AGN. We have found that the radio core luminosity of the X-ray detected AGN correlates with the X-ray and mid-IR luminosity. However, more than half of these radio-excess AGN are not detected in X-rays and are likely to be the missing population of distant Compton-thick AGN.

Probing the missing baryons in X-ray

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Two problems of the "missing baryons" exist at very different scales, and have a fundamental impact on our understanding of cosmic structure evolution. On the large scale, it refers to the problem that the observed baryonic matter in the local universe accounts for less than 50% of the total baryons. On the small scale, it refers to the fact that the cold baryon fraction (cold gas + stars) in Milky-Way size galaxies is well-below the cosmic baryon fraction, and a large amount of these missing galactic baryons are likely associated with extended, hot gaseous halos. While the link between the two problems is under debate, they are both expected to be in a temperature region where the majority can only be probed in X-ray. I will discuss some recent progress on both fronts, and the possible connection between the two types of the "missing baryons".

XMM-Newton surveys of X-ray galaxy groups

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I will present a review our understanding of X-ray galaxy groups, based on the recent success of legacy XMM surveys, CDFS, COSMOS, DEEP2, CFHTLS. With a wealth of systems discovered, I will show how the formation of Universe and its galaxies is traced in galaxy groups from nearby groups to a redshift of 2. I will explore the galaxy groups lensing and clustering properties, which enabled a consistent measurement of the groups' total mass. Finally, the evolution of galaxies in groups and AGN feedback effects, revealed by these surveys will be described.

X-ray binary evolution across cosmic time

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High redshift galaxies are unique laboratories for studying the formation and evolution of X-ray binary (XRB) populations on cosmological timescales, as they probe metallicities and star-formation rates not present in the local universe. I will discuss results from a large population synthesis study that models the XRB populations from the first galaxies of the universe until today. We use as input in our modeling the Millennium II Cosmological Simulation and the updated semi-analytic galaxy catalog by Guo et al. (2011), in order to properly account for the star formation history and metallicity evolution of the universe. Our modeling, which is compared to the most recent Chandra surveys of distant galaxies, gives prediction about the integrated specific X-ray luminosity as a function of redshift and the evolution of the galaxy X-ray luminosity function of normal galaxies in different redshift bins.

X-ray emission from the Warm-Hot Intergalactic Medium (WHIM)

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A large fraction of the low redshift baryons is believed to reside in a warm-hot filamentary gas in the intergalactic medium (WHIM). In the past we have successfully used XMM-Newton data to identify and characterize the WHIM angular signature using the autocorrelation function (AcF). We have recently also characterized the same signal using data from Chandra. Using the output of large scale hydrodynamic simulations we have also investigated the correlation between low energy X-ray emission and SZ effect from WHIM filaments. Although the bulk of the total luminosity in the SZ effect is associated with collapsed structures, our work indicates that a significant fraction comes from unbound objects, mostly from overdense regions, like the WHIM. Due to the unique emission mechanism, the X-ray and SZ correlation provides additional constraints on the structure of the intergalactic gas. In this paper we will discuss the results of our investigation on the expected correlation between X-ray emission and SZ signals and the implications for current X-ray and SZ observatories. We will also present our preliminary results using actual data from Chandra and XMM-Newton, and the Atacama Cosmology Telescope (ACT).

Searching for Compton-thick AGN in the CDFS

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We analyse the 3Ms XMM and 4Ms Chandra data in the Chandra Deep Field South in order to search for Compton-thick AGN candidates. This provides so far the most sensitive - in terms of photon statistics - search for Compton-thick AGN in the high redshift Universe $z \sim 1$ where the bulk of the X-ray background is produced. We are employing two methods. We are looking for AGN which present direct evidence for a hidden Compton-thick nucleus in their X-ray spectra ie either a direct absorption turn-over or a reflection dominated spectrum or a high-equivalent-width FeKa line. Moreover, we compare the above results with X-ray to mid-IR techniques which identify Compton-thick AGN on the basis of a low L(2-10 keV)/L6micron ratio.

[Ne V]-selected heavily obscured AGN at the epoch of the X-ray background

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We will discuss a novel method to select heavily obscured, candidate Compton-thick AGN at $z \sim 1$; these objects are thought to account for most of the "missing" X-ray background emission at 30 keV. The ratio between the X-ray flux and the [Ne V]3427 emission line flux is used to diagnose the level of nuclear absorption, under the assumption that [Ne V] is a good proxy of the intrinsic accretion power. This method has been calibrated on local AGN and has been shown to work for SDSS QSOs observed by both XMM and Chandra. We applied the same diagnostic ratio on [Ne V]-selected AGN in the XMM/Chandra COSMOS field finding a significant fraction of heavily obscured, possibly Compton-thick objects at $z \sim 1$. Our results will be reviewed and compared with those obtained by different selection criteria over a broad redshift range.

AGN clustering in deep X-ray surveys

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We present the clustering properties of 1537 X-ray selected sources with spectroscopic redshifts in the CDF-N,CDF-S ,ECDF-S,C-COSMOS, AEGIS in the full band (0.5-10keV) in the redshift interval 0¡z¡3. This analysis presents the most detailed direct measurement to date of the X-ray clustering at faint X-ray fluxes and high (z 1) redshifts. We perform a spatial correlation function analysis for each field and for the whole sample finding a clustering length of ro 6 Mpc. Furthermore, we investigate whether there is X-ray luminosity dependence on the clustering length in the redshift range z=0.7-1.4. We provide the most robust evidence yet for such dependence in the sense that the clustering length increases at higher luminosities.

First results from Chandra/AKARI NEP survey: search for Compton-thick accretion

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AKARI-NEP Deep Survey Team

We present the first results of the search for Compton-thick (CT) AGNs in a 250 ksec Chandra observation in the Deep AKARI North Ecliptic Pole (NEP) Field. The search for CT AGNs across cosmic time and the quantification of their contribution to the total accretion onto super-massive black holes are still fundamental questions. The IR Camera on the Japanese-led satellite mission AKARI has already provided Near-IR to Mid-IR measurements with its unique and continuous wavelength coverage over 2–25 μm in 9 filters, which fill the 9–20 μm gap between wavelengths covered by IRAC and MIPS of Spitzer. With these filters, AKARI allow us to efficiently distinguish non-AGN starburst populations from hidden AGN activity at $0.5 \lesssim z \lesssim 1.5$.
The recently obtained Chandra observation and AKARI data will enable us to classify a few hundred IR-selected AGN candidates into unabsorbed, Compton-thin absorbed, and CT AGN candidates (non-detections with Chandra). We will verify the CT nature by testing for the expected Fe reflection feature in the rest-frame stacking analysis. Our extensive photometric and spectroscopic follow-up programs in the AKARI field will enable us to derive the host galaxy and AGN properties and comparing them to unabsorbed and Compton-thin absorbed AGNs.

Obscured quasars: powerful black holes and their host galaxies

Vincenzo Mainieri[1]
[1] *ESO*

We explore the connection between black hole growth at the center of X-ray selected obscured quasars and the physical properties of their host galaxies in a bolometric regime where several theoretical models invoke major galaxy mergers as the main fueling channel for black hole accretion.

We use the superb multi-wavelength coverage in the COSMOS field to obtain reliable estimates of the total stellar masses and star formation rates of the hosts, as well as a morphological analysis of the ACS/HST images, optical spectroscopy and X-ray spectral analysis.

Obscured quasars mainly reside in massive galaxies ($M\star > 10^{10}$ M$\odot$) and the fraction of galaxies hosting such quasars monotonically increases with the stellar mass. The fraction of Type-2 QSO hosted in star-forming galaxies increases with redshift: $\sim$ 50% at z$\sim$ 1 and $\sim$ 70% at z$\sim$ 2. The specific star-formation rate of these hosts is comparable to what measured for normal star-forming galaxies (e.g Noeske et al. 2007; Pannella et al. 2009). The morphological analysis has indicated that the majority of the host galaxies are bulge dominated, there being a few cases of disk galaxies or mergers. We will discuss the implication of these findings on the importance of major mergers as triggers for the accretion activity in obscured quasars.

Clustering and halo occupation distribution of ROSAT all-sky survey AGNs

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Clustering of AGNs is a measure of the mass of the hosting dark matter halos (DMHs) and its measurement in various AGN luminosities, types, and redshifts is important in understanding the environment in which super massive black hole accretion takes place.

We report the results of our investigation on clustering of AGNs in the ROSAT All-Sky Survey (RASS) using the cross-correlation function (CCF) with the Sloan Digital Sky Survey (SDSS) galaxies, allowing more accurate measurements than AGN auto-correlation function. Our CCF analysis between the RASS AGNs and SDSS Luminous Red Galaxies (LRGs) in 0.16<z<0.36, found, for the first time, an X-ray luminosity dependence of the clustering. We have applied the Halo Occupation Distribution (HOD) modeling to the CCF and determined constraints of the distribution of AGNs among DMHs as a function of their mass. At z≈ 0.3, AGNs with log Lx [erg s^{-1}] ≈ 44 reside, on average, in DMHs with 10^{13} h^{-1} $M\odot$ and AGN fraction among galaxies decrease with the DMH mass. We do not see, however, such a decrease for log Lx [erg s^{-1}] ≈ 43 AGNs at z≈ 0.1. We expect significant improvements on clustering and HOD analysis AGNs with the upcoming eROSITA.

The X-ray content of the XMM-Newton SSC survey of the Galactic plane

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The Survey Science Center of the XMM-Newton satellite has carried out optical follow-up observing campaigns with the aim to investigate the nature of the X-ray sources discovered in the Galactic plane. A group of 27 fields covering a total area of 7 deg^2 at low galactic latitudes ($|b| < 20$) has been studied. Spectroscopic observations helped by cross-correlations with large optical and infrared catalogues has allowed us to positively identify around 30% of the X-ray sources. We find that the majority are F, G, K, M stars, where coronal activity is responsible for the soft X-ray emission. We identified some other interesting objects: 1 CV, 2 T-Tauri and 3 Be stars, tentatively classified as gamma-Cas like. At mid galactic latitudes ($|b| < 3-16$ deg) 7% of the X-ray sources are spectroscopically classified as AGNs. X-ray stellar population models account well for the observed logN-logS curves for identified active coronae. At very low latitudes ($b \sim 0$), active coronae can explain the observed number of sources in the soft band (0.5-2.0 keV), while in the hard band (2.0-12 keV) we find a clear excess of sources above the expected extragalactic contribution.

Investing Chandra and XMM time to detect the missing baryons

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About 50% of the Universe's baryons are missing. They are thought to be hiding in an intergalactic network of extremely tenuous million degree plasma: the Warm-Hot Intergalactic Medium (WHIM). The only way to detect the missing baryons and start studying their continuous interplay and feedback with Large Scale Structures with current instrumentation, is to expose the Chandra and XMM gratings for several Ms, against the best WHIM sightline possible. Deeper and systematic studies must await for larger throuput, higher spectral resolution strumentation.

Two years ago, we identified and selected the best WHIM sightline in the Universe, against the FUV and X-Ray bright blazer 1ES 1553+113, and last year we were awarded the first half Ms observation of this target. The observation will be performed between April and may 2011. Here we present preliminary results from this first part of the awarded Chandra Large Program, and will dedicate the second part of the talk to a future possible WHIM-dedicated mission, WHIM-Ex, that will enable the study of hundreds of WHIM filaments, along tens of possible sightlines.

Highly-absorbed X-ray binaries in the Small Magellanic Cloud

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Many of the high mass X–ray binaries (HMXRBs) discovered in recent years in our Galaxy are characterized by a high-absorption, most likely intrinsic to the system, which hampers their detection at the softest X-ray energies. We have undertaken a search for highly-absorbed X-ray sources in the Small Magellanic Cloud (SMC) with a systematic analysis of the all the XMM-Newton SMC observations. We obtained a sample of 29 sources showing evidence for an equivalent hydrogen column density larger than $3{\times}10^{23}$ cm^{-2}. Five of these sources are clearly identified as HMXRBs: four were already known (including three X-ray pulsars) and one, XMM J005605.8–720012, reported here for the first time. For the latter, we present optical spectroscopy confirming the association with a Be star in the SMC. The other sources in our sample have optical counterparts fainter than magnitude 16 in the V band, and many of them have possible NIR counterparts consistent with highly reddened early type stars in the SMC. While their number is broadly consistent with the expected population of background highly-absorbed active galactic nuclei, a few of them could be HMXRBs in which an early type companion is severely reddened by local material.

X-ray binaries in dwarf spheroidal galaxies of the local neighburhood

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Dwarf spheroidal galaxies allow to observe "pristine", primitive X-ray binary, that cannot be the product of dynamics like in globular clusters. For this reason, they are particularly interesting to understand close binary evolution. We observed the dwarf spheroidal galaxy Leo I for 80,000 seconds with XMM-Newton and detected 105 non Galactic X-ray sources (XRS) in its field. We also studied an archival XMM-Newton observation of the Fornax dwarf spheroidal galaxy, and compare it with Leo I. 104 non Galactic XRS were detected in the Fornax field; one of them coincides with a blue object at the outskirt of the Fornax 4 globular cluster. In both observations about a third of the XRS are identified with extragalactic objects observed in optical and radio. We discuss the similarities between the two XRS groups and the differences, which may be due to the a small number of intrinsic LMXB in the two galaxies. Using proprietary and archival ground based and HST observation, we attempt an identification of X-ray binary candidates in these galaxy.

XXL - an overview of the ultimate XMM extragalactic survey

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In December 2010, the XXL survey, an XMM Very Large Programme, has been granted time to map two extragalactic regions of 25 deg^2, at a depth of $\sim$ 5 10^{-15} erg/s/cm^2 (i.e. using 10 ks XMM observations).

The main goal of the project is to constrain the Dark Energy equation of state using clusters of galaxies. This survey will also have lasting legacy value for cluster scaling laws and studies of AGNs and XRB.

We present the layout of the some 450 XMM observations. We discuss the most relevant science topics along with the associated multi-λ surveys. We give an overview of the working organisation of the project as well as plans for the catalogue releases.

The X-ray background in the 5-10 keV band from the XMM-CDFS survey

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XMM-CDFS Team

The XMM-Newton pointings of the Chandra Deep Field South constitute the deepest observation ever performed with XMM-Newton. Thanks to the high troughput of the telescope at high energies, this is also the most sensitive survey in the 5-10 keV band, so that it is extremely well suited to the determination of the hard X-ray LogN-LogS and to estimate the cosmic background level in that band. In this talk, we show the complexity of the instrumental background in terms of energy and spatial dependence, and present the best possible estimate based on the current knowledge of the EPIC instrument. We review the source detection process, and assess its reliability and completeness thanks to extensive simulations of mock surveys. We present the 5-10 keV LogN-LogS, and an estimate of the unresolved background fraction.

Search and characterization of star-forming galaxies in X-ray surveys

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We are searching for X-ray emission from two samples of candidate star-forming galaxies in the COSMOS and Chandra Deep Field South surveys, selected on the basis of their multi-wavelength properties. We review the X-ray properties of the candidates and the outcome of different X-ray based selection criteria, in order to propose a selection method, mainly based on X-ray parameters and with known reliability. A comparison with more advanced selection procedures based on statistical classification tools is also made. The luminosity function of star forming galaxies at moderate and large redshifts is presented and compared to theoretical predictions. The possible evolution of the LF is also discussed.

The XMM-Newton Slew Survey - the whole X-ray sky and the rarest X-ray events

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XMM-Newton is the most sensitive X-ray observatory ever flown. This is impressively evident during slew exposures which yield on average only seven seconds of on-source exposure time. XMM-Newton slew data now cover over half of the whole sky, and movies showing the history and construction of this new X-ray view of the cosmos are presented here. Many new sources and familiar features are visible, including the largest extended structures and the brightest sources in the sky.

With the recent release of our fifth update to the Slew Survey Catalogue, we are able to present significant new developments and highlights; The soft-band slew sensitivity limit is close to that of the RASS, and a large-area RASS-Slew comparison now provides the best opportunity for discovering extremely rare high-variability objects, and a number of examples of these, including black hole tidal disruption events and newly-discovered novae, are presented here. The hard-band slew survey goes significantly deeper than all other previous large area surveys, and many new hard X-ray sources have been discovered. The hard-band survey is now able to fill the gap in luminosity functions which currently exists between shallow all-sky surveys (e.g. HEAO-1 A2) and medium deep surveys (e.g. 2XMM).

AGN variability at hard X-rays

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The global variability properties of AGN in the highest energy X-rays have been poorly studied up to now. Swift/BAT offers the unique opportunity to observe a large number of AGN on different time scales in the hard X-ray band above 20 keV. An early study using the first 9 months of Swift observations has indicated that the more absorbed type 2 AGN seem to be more variable than the less absorbed ones. We selected a sub-sample of 100 bright AGN from the 58-month BAT survey and studied their variability properties as a function of AGN class, on different timescales and in several energy bands. We confirm larger variability on shorter timescales and at lower hard X-ray energies for the Seyfert galaxies. On average, the type 2 AGN are more variable than type I objects. We do not find any significant correlation between the amplitude of the variations and the basic AGN parameters, such as the hard X-ray luminosity, the black hole mass and the Eddington ratio. We present our results in comparison with observations at energies below 10 keV for Seyfert galaxies, and with the gamma-ray variability findings of Fermi/LAT for beamed sources.

The X-ray/infrared correlation for star-forming galaxies at z∼1

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I will present results from our recent study of the X-ray/infrared (IR) correlation, carried out as part of the Herschel Multi-tiered Extragalactic Survey (HerMES) guaranteed-time key programme, with data from the field of GOODS-North. Combining X-ray data from the 2Ms Chandra survey and infrared data from Herschel's sub-millimeter bolometer array, SPIRE, we are able to investigate the X-ray/infrared correlation in the high star formation rate, starburst-mode regime for galaxies at cosmologically significant redshifts. Once obvious AGN are excluded, the X-ray/IR properties of our sample of luminous and ultraluminous infrared galaxies (LIRGs and ULIRGs) at <z>∼1, are compared to those of local (z<0.1) and intermediate redshift (z∼0.6) samples of equivalently infrared-luminous sources. We conclude that there is no evidence for evolution in the X-ray/IR correlation with redshift, however, we note that in contrast to normal star-forming galaxies, LIRGs and ULIRGs are X-ray deficient relative to their infrared output. This suggests fundamental differences in the origin of X-ray emission in systems undergoing starburst episodes and has implications on the use of the X-ray/infrared correlation, both as a star-formation tracer and as a means of separating AGN from star-forming galaxies in extragalactic surveys.

The many facets of the AGN population in the CDFS: the XMM-Newton perspective

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We present preliminary X-ray spectroscopic results obtained with XMM-Newton in the Chandra Deep Field South (CDFS) in the context of the 3Ms XMM-CDFS survey. The main focus is on the obscured AGN population at redshifts z∼1-2 selected by means of hardness ratio, optical properties, and infrared-to-optical colors. The X-ray source overdensity previously found at z∼0.7 is also investigated, and average properties derived using stacked spectra.

Luminosity functions of LMXBs in different stellar environments

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Based on archival data of Chandra observations of nearby galaxies, we produced accurate luminosity distributions of LMXBs in different environments – dynamically formed systems in globular clusters and in the nucleus of M31, and field sources of presumably primordial origin. For the first time we reached a detection sensitivity of 10^{35} erg s^{-1}. We found that the luminosity distribution of GC and field LMXBs differ throughout entire luminosity range, the fraction of faint (Lx $< 10^{37}$ erg s^{-1}) sources among the former being ~ 4 times smaller than in the field population. This presents a challenge for the models suggesting that the entire field LMXBs were formed in GCs. The XLF of sources in the nucleus of M31 is similar to GC-LMXBs at the faint end but differs at the bright end in the $\sim$ 2.5-3 σ range. The difference is likely caused by the factor of 10-20 difference in stellar velocities in globular clusters and galactic nuclei, which leads to different roles of various dynamical formation channels.

Chapter 12

X-ray Astronomy Missions, Optics, Instrumentation, Data Analysis and Archiving

The MIRAX X-ray astronomy mission on the LATTES satellite

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MIRAX is a hard X-ray astronomy experiment that will be part of the Brazilian Lattes satellite, to be launched in 2015 for a 4-year mission in a near equatorial (15°) circular LEO. MIRAX instruments were recently reviewed and reconfigured due to mission constraints and new collaboration opportunities. MIRAX will perform a hard X-ray (5–200 keV) survey of more than half of the sky with high localization power ($\sim$ 1') and high sensitivity (26 mCrab for one orbit and 0.3 mCrab for one year). This will be achieved by a set of 4 identical coded-mask imagers that will operate in scanning mode, with pointing direction offset 25° to the south of the zenith in order to maximize the coverage of the central Galactic plane. The instruments are based on position-sensitive (0.6mm pitch) 5mm-thick CdZnTe detectors with 189 cm^2 effective area at 10 keV each and 2–3 keV energy resolution. The main objective of MIRAX is to study, with unprecedented depth and time coverage (milliseconds to years), a large sample of transient and variable phenomena on accreting neutron stars and black holes. In this work we describe the new configuration of MIRAX and discuss results of background and imaging simulations.

AXIOM: Advanced X-ray Imaging Of the Magnetosphere

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and the AXIOM collaboration

AXIOM is a concept mission which aims to explain how the Earth's magnetosphere responds to the changing impact of the solar wind in a global way never attempted before, by performing wide-field soft X-ray imaging and spectroscopy of the magnetosheath, magnetopause and bow shock, at high spatial and temporal resolution.

The use of remote X-ray imaging techniques is a very novel approach, made possible by the relatively recent discovery of solar wind charge-exchange X-ray emission, found by XMM-Newton to occur in the vicinity of the Earth's magnetosphere, and to peak in the sub-solar magnetosheath, a region where both solar wind and neutral exospheric densities are high.

We describe how an appropriately designed and located X-ray telescope, supported by simultaneous in situ measurements of the solar wind, can be used to image the dayside magnetosphere, magnetosheath and bow shock, with a temporal and spatial resolution sufficient to address several key outstanding questions concerning how the solar wind interacts with planetary magnetospheres on a global level. The relatively small, low-resource AXIOM model payload incorporates a wide-field soft X-ray telescope, analysers designed to measure the bulk properties of the solar wind, and a magnetometer for accurate measurements of the solar wind magnetic field.

eROSITA data reduction, source characterization, and X-ray catalogue creation

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eROSITA (extended ROentgen Survey with an Imaging Telescope Array) is the main instrument on the Russian Spektrum-Roentgen-Gamma (SRG) mission scheduled for launch in late 2012. Its 4 year all-sky survey in the 0.3-10 keV energy band will result in the detection of up to 100,000 Clusters of Galaxies and on the order of 3 million AGN with important implications for both cosmology and AGN evolution. The all-sky survey will be followed by several years of dedicated pointed observations. Max-Planck-Institut für extraterrestrische Physik, Astrophysikalisches Institut Potsdam, and Remeis-Sternwarte Bamberg are currently setting up a data processing pipeline which will create a set of calibrated eROSITA data products as well as an all-sky X-ray source catalogue. Several source detection and characterization algorithms, including Maximum Likelihood point spread function fitting and a Bayesian background-source separation algorithm (see poster by Guglielmetti et al.) are currently adapted for use in the eROSITA processing pipeline. Detailed simulations of the eROSITA sky, including cosmological large-scale structure simulations, an extragalactic point source population, as well as particle and instrumental background, are under way to test and characterize these algorithms. We will describe the current state of the work and give an outlook on future activities.

The Chandra LETGS spectrum of the standard candle white dwarf GD 153

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White dwarf spectra are ideally suited for calibrating the low energy end of the effective area of instruments aboard X-ray observatories. The available model spectra, that are used to fit the X-ray data include detailed white dwarf atmosphere physics for given abundances, with the surface gravity, temperature, and radius as free parameters. Once these parameters are determined we have precise standard candles for calibration.

As part of an ongoing effort of the IACHEC white dwarf working group, guaranteed time observations of GD153 have been obtained using the Chandra LETGS to complement the existing LETGS spectra of the white dwarfs HZ 43 and Sirius B. The results from this analysis allows to precisely determine not only the physical parameters of these 3 white dwarfs but also improve the in flight calibration at low X-ray energies for the Chandra LETGS.

Exospheric solar wind charge exchange X-ray emission as observed by XMM-Newton

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One potential source of background for astronomers concerned with studies of diffuse Galactic and extra-galactic X-ray emission is locally produced X-rays from Solar Wind Charge Exchange (SWCX) interactions with neutral atoms in the Earth's exosphere. We present a study of 3012 XMM-Newton observations and show that around 3.5% of these unambiguously contain a strongly variable SWCX signal; this signal can be the strongest diffuse soft X-ray component within an observation. Many more observations will be affected by SWCX but are not immediately detectable through time variability; they are only detected by comparison of multiple pointings of a target field. The characterisation, understanding and awareness of the SWCX component is important for proper consideration of its contribution to diffuse-emission studies.

Whilst SWCX is a source of background for many, it also provides a diagnostic of the charge-state distribution of the solar wind and the mass transport around the Earth's magnetosheath. We discuss the compositional and temporal information that can be gathered and describe predictive modelling efforts of SWCX emission. We concentrate on the signatures of a passing Coronal Mass Ejection. We show that XMM-Newton preferentially detects SWCX on the sunward side of the Earth's magnetosheath.

The precision of the Chandra X-ray Observatory for astrophysical inference

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The precision with which Chandra can infer astrophysically useful quantities depends both on the signal-to-noise ratio of observations and on the accuracy of its calibration. Calibration uncertainties are generally correlated in complicated ways, rendering traditional methods of assessing uncertainties and of error analysis inappropriate. Here we apply a Monte Carlo method in which current knowledge of the response of Chandra instruments is represented by random sampling of plausible perturbations to a nominal response function. These are employed in parameter estimation exercises to assess the effects of the instrument uncertainties on derived parameter values. We use this method to assess the limiting accuracy of Chandra for understanding typical X-ray source model parameters. The code we have developed to solve this problem can be applied to general model fitting of Chandra observations and is publicly available through the Chandra Users website.

X-ray loading, gainshift and (modified) timing mode of XMM-Newton's EPIC-pn

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Knowing the instrument's behaviour is highly important when analyzing the collected observational data. Here we investigate the issue of the energy gainshift associated with the EPIC-pn instrument on-board XMM-Newton, when it is operated in Timing mode.

The gainshift arises as a result of CTI effects or X-ray loading. This depends on the source brightness and the effectiveness of the noise correction. X-ray loading has clearly been detected in Imaging mode, while the importance of its impact on the Timing mode observations is still under investigation. The consequences of X-ray loading in general are pattern migration from higher to lower pattern types and a shift to lower energies for all events associated with the affected CCD column.

Current results show a clear correlation between X-ray loading and X-ray flux of the source, but other correlations may also reveal ways to understand and correct for the energy gainshift in the data.

A pequliar case of Timing mode is the Modified Timing mode, and here we also explain its properties and its potential impact on the scientific results dealing with bright X-ray sources.

eROSITA mirror module development

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MPE will provide the X-ray Survey Telescope eROSITA for the Russian Spektrum-Roentgen-Gamma Mission to be launched in 2012. It consists of a compact bundle of 7 co-aligned mirror modules with a focal length of 1600 mm and 54 nested mirror shells each. The 61 arcmin field-of-view will yield a high grasp of about 1000 cm^2deg^2 around 1 keV and 10 cm^2deg^2 at 10 keV. An angular resolution of 15 arcsec HEW on-axis (resulting in an average angular resolution of $\approx$26 arcsec HEW over the field-of-view and $\approx$30 arcsec including all optical and spacecraft error contributions) will allow to distinguish between point sources and extended emission of clusters from galaxies which are relevant for cosmological studies. Stray-light is suppressed by X-ray baffles consisting of concentric cylinders mounted on top of each mirror module. After an extended test program with several single mirror shells, test modules and a qualification model the integration of flight mirror modules has been started. A résumé is given on the development and test program including first results on the X-ray performance of partially integrated mirror modules.

CIAO 4.3: pushing the Chandra spatial resolution to its limit

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The CIAO (Chandra Interactive Analysis of Observations) software package was first released in 1999 following the launch of the Chandra X-ray Observatory and is used by astronomers across the world to analyze Chandra data as well as data from other telescopes. The latest version of the software - CIAO 4.3 released in December 2010 - includes several enhancements with respect to previous CIAO versions and one of the most important allow to significantly improve the already unprecedented spatial resolution of Chandra X-ray imaging with the Advanced CCD Imaging Spectrometer (ACIS) through subpixel event repositioning techniques. We describe how it is possible to reprocess older Chandra data to apply a subpixel algorithm and show examples of images with optimized resolution. We also describe other improvements in CIAO including the new instrument response tools, updates to the Sherpa modeling and fitting Python application in CIAO, and the new set of CIAO contributed scripts written with the aim to automate repetitive tasks and extend the functionality of the CIAO software package.

Applying the Background–Source Separation algorithm to eROSITA simulated data

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Galaxy clusters and groups are one of the science drivers of the eROSITA mission. The BSS algorithm is planned to be applied to eROSITA simulated datasets for recovering galaxy clusters, groups and their parameters (see poster by Brunner et al.). The BSS algorithm was tested on CDFS data.

The BSS algorithm is a powerful tool in X-ray image analysis for the detection and characterization of both point-like and extended astronomical objects. The technique has several benefits: joint estimate of background and sources, Poisson statistics preserved through the whole algorithm, proper quantification of uncertainties for background and sources, proper handling of background as well as effects like vignetting, variations of detector quantum efficiency and strong gradients in the exposure time. Sources are detected independent of their morphology in a probabilistic multi-resolution analysis. All detected sources are automatically parameterized with a maximum-a-posteriori technique to produce a list of source positions, fluxes and morphological parameters.

The simulated eROSITA images include the expected particle and instrumental background and a population of AGN and galaxy clusters. The cluster component is modeled employing cosmological hydrodynamical simulations.

The current status of the feasibility study for applying the BSS algorithm to eROSITA data is reported.

The development of a bent Si crystal for X-ray imaging polarimetry

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We report the development of a bent Si crystal for use of X-ray polarimeter. DLC (Diamond-Like Carbon) is deposited on the back side of reflection surface of a Si(400) crystal sheet. The Si crystal is bent by the residual stress between DLC and Si. We can control the curvature with DLC thickness. The surface is very smoothed. An angular reflectivity was measured at 8 keV. With the bending of the crystal, the angular width of the peak is broadened. The modulation factor was measured to be about 0.7 for 8 keV. If the energy of the X-ray emission is at Fe-K lines, which are very important for X-ray astronomy, the Bragg angle becomes more close to 45 degree. It means that higher sensitivity for the polarization would be expected for these lines. The sensitivity in wide energy band with the high modulation factor indicates that the bent crystal can be a new tool for the X-ray polarimeter. A preliminary design of the polarimetric optics composed by the Si(400) crystal and a small-size detector is proposed. Any kind of crystals can be bent with our method, and then a combination of different crystals will further improve the performance of polarimetric optics.

Non-equilibrium ionization codes based on AtomDB v2.0

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The new version of the AtomDB atomic database (v2.0) contains ionization and recombination rates enabling modeling of non-equilibrium ionization (NEI) plasmas as well as those in collisional ionization equilibrium (CIE). Here we present a non-equilibrium ionization codes based on AtomDB2.0. Through a comparison between NEI and CIE calculations, between the new and old (v1.3) versions of AtomDB, we demonstrate the importance of NEI calculations, the atomic data/processes involved in some typical NEI scenarios of astrophysical interests by various line-ratio diagnostics as well as other measurements such as equivalent widths, cooling curves, and spectra.

XMM-Newton mission operations - how long may it live?

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The XMM-Newton X-ray space observatory is now operated in its second decade. Spacecraft and payload are operating without major degradation and scientific demand is still very high. Therefore new possibilities of mission extensions and ways of operations may be required. This puts challenges on both the spacecraft with its payload and the ground system.

We will describe the health status of the mission in combination with estimates on the possible lifetime of important spacecraft sub components. New ideas to extend the operational lifetime significantly further are presented. This concerns technical spacecraft issues like the power and fuel management as well as the maintenance of the ground segment with migration to up to date operating systems and control architecture.

EGSE updating of the EPIC on-ground Flight Spare cameras

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Two *flight spare* (*FS*) cameras of the *EPIC* instrument are still available on–ground. The possible extension of the *XMM–Newton* mission even further than 2014 could require substantial changes in the SW and/or TC & TM database, in order to deal with the expected ageing and/or failures of the on–board instrument. It will be very useful to check on–ground these changes, before their on–board uploading, therefore the two *FS* cameras must be kept ready to this aim. Currently they can be operated through the original *Electrical Ground Support Equipment* (*EGSE*), which was developed about 15 years ago in order to support all the test campaigns up to the launch: it is not suitable to test SW changes, therefore *ESA* and the *EPIC* Consortium has agreed to replace it with a new equipment running SCOS 2000, in order to fully reproduce on-ground the on-board status and to operate the *FS* cameras with the same tools used by *ESA*. Here we describe the proposed architecture and the development status.

The Cherenkov Telescope Array: an advanced gamma-ray observatory

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The next-generation observatories in high-energy astrophysics will give unprecedented insight into the non-thermal universe. The discovery of emission at energies above 50 GeV from a variety of astrophysical objects with current gamma-ray instruments unveiled a large variety of cosmic particle accelerators; contemporaneous gamma-ray and X-ray observations of objects like supernova remnants or active galactic nuclei demonstrated the power of multiwavelength observations. The Cherenkov Telescope Array (CTA) is an international effort to build the next-generation gamma-ray observatory, with a factor of 10 improvement in sensitivity in the 100 GeV to 10 TeV range, an extension to energies well below 50 GeV and above 100 TeV and an improved angular resolution of the order of a few arcmin. CTA is currently in the preparatory phase, construction is planned to start in 2014. I will present the key physics goals and the major design concepts of CTA.

(Presentation on behalf of the CTA Consortium)

Absolute timing accuracy of the EPIC-pn CCD camera on XMM-Newton

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A reliable timing calibration is essential for the comparison of XMM-Newton lightcurves with those from other observatories and the physics derived from those. The timing calibration is based on pulsar analysis, but due to pulsar timing noise and glitches, it is essential to monitor these calibration sources regularly. To this end, the XMM-Newton observatory performs observations twice a year of the Crab pulsar to monitor the absolute timing accuracy of the EPIC-pn camera in the fast Timing and Burst modes. We analysed the 38 XMM-Newton observations (0.2-12.0 keV) of the Crab (PSR B0531+21) taken over ten years. Using these data, we determined the absolute timing accuracy by studying the time shift between the main X-ray and radio peaks in the phase folded lightcurves. A time shift of 303 +/- 9 microsec was measured, in agreement with other high energy observatories like Chandra, INTEGRAL and RXTE. We also find that the X-ray pulse precedes the radio pulse, in the same way as observed by the aforementioned observatories. The derived absolute timing accuracy from the analysis is +/- 53 microsec.

Calculation framework of X-ray radiation based on Monte Carlo simulations

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We have developed a new calculation framework of X-ray radiation which is reprocessed in astrophysical objects in order to interpret high-quality observational data obtained with modern X-ray observatories. The calculation is based on Monte Carlo simulations which deal with transport and reprocessing of photons in matter with realistic geometry. Our framework provides simulation methods for three important physical situations in high energy astrophysics: neutral matter illuminated by X-rays, photoionized plasma driven by strong X-rays, and hot Comptonizing plasma. For proper interpretation of high-resolution spectra and hard X-ray observations, which are affected by multiple interactions in complicated geometry, we implement detailed treatment of the physical processes.

To demonstrate our framework, we have studied accreting neutron star Vela X-1. Time variability of the wide-band spectrum up to 50 keV over a short time scale of 2 ks obtained with *Suzaku* reflects physical conditions of the accreted plasma. We discuss physical mechanism of X-ray radiation from the neutron star based on the observation and the simulation. We also investigate X-ray reflection from giant molecular cloud Sgr B2, and discuss morphology of hard X-rays above 20 keV as well as iron fluorescence.

A phenomenological approach to calibrating the EPIC-MOS detector response

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Several years after the launch of XMM-Newton it was noticed that the redistribution function (RMF) of both EPIC-MOS cameras were evolving in an unexpected way. The EPIC-MOS detector plane is constructed from EEV type 22 CCDs. These front-illuminated devices have complex redistribution properties. At low energies (less than 1 keV) the shape of the RMF has a strong secondary shoulder below the main photopeak due to incomplete charge collection at the surface of the CCD. Sources close to the telescope boresight showed evidence for a gradual increase in the relative strength and shape of this shoulder with respect to the main photopeak. No evolution is observed for sources significantly away from the optical axis. The extent of the RMF "patch", as it is known, appears correlated with the total photon dosage suggesting that the physical properties of the surface of the CCDs are being modified as a result of the absorption of X-rays.

Here we describe a method of calibrating the RMF using an iterative scheme to derive the RMF parameters for a given epoch and chip region by finding the best simultaneous fit to MOS data using spectral models of astrophysical sources and the onboard Fe-55 calibration source.

Atomic data needs for X-ray analysis and AtomDB v2.0

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Although the analysis of even CCD-resolution X-ray spectra benefits from good-quality atomic data, the high-resolution X-ray data available from existing X-ray satellites have shown the absolute need for atomic data of all stripes: wavelengths, absorption cross sections, and collisional and radiative rates. This process will continue with upcoming telescopes such as Astro-H and IXO. I will describe the successes of both theoretical calculations and laboratory measurements as well as the many remaining needs and the science that hinges upon them. These include, amongst other issues, accurate wavelength measurements in the soft X-ray band, calibrated line ratios of selected strong lines, and high-resolution absorption cross sections for common atoms. I will also describe the release of v2.0 of the AtomDB, a unified collection of atomic data suitable for analysis of astrophysical X-ray spectra and how it can help with these needs.

Study of the background rejection efficiency for the NHXM-HED anti-coincidence

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The NHXM (New Hard X-ray Mission) observatory is a medium size mission designed to observe X-ray emission in the 0.5 - 80 keV range with high spatial and spectral resolution, together with a sensitive X-ray imaging polarimetric capability. The mission, submitted to the 2010 ESA Cosmic Vision call, has as main scientific objective the study of the physics of accretion in black holes and of the particle acceleration mechanism at work in different sources. The spectral-imaging camera includes a High Energy Detector (HED) sensitive in the 7-120 keV band surrounded by an Anti-Coincidence system (AC) conceived to reduce the particles and gamma rays induced background. In this poster we present a set of simulation results on the AC, performed with GEANT4, with the aims of investigating the rejection efficiency, at different energy thresholds, for different inorganic scintillators crystals.

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