XMM-Newton: The Next Decade

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ABSTRACT BOOK

Oral Communications and Posters

Edited by

Jan-Uwe Ness

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Chapter 1

Invited Speakers

Outflows, Feedback and SMBH/Galaxy Co-Evolution

Massimo Cappi[1]
[1] *INAF/IASF-Bologna*

After a brief introduction on the current state-of-the-art for studies of outflows, feedback and SMBG/Galaxy co-evolution, I will address some of the future prospects in this field.

Supernova remnants

Anne Decourchelle[1]
[1] *CEA Saclay, Gif sur Yvette cedex, France*

Supernova remnants result from the explosion of a star and keep trace, in their young ejecta-dominated phase, both of the explosion mechanism and to a lesser extent of the nature of the progenitor. They inject a large amount of energy into their surroundings, which impacts significantly the interstellar medium and to a larger extent the working of the galaxy by distributing heavy elements, heating to tens of million degrees large fractions of gas, accelerating high-energy particles, generating turbulence and amplification of the magnetic field. I will review the observational results on supernova remnants and their related scientific issues before suggesting directions for future ambitious XMM-Newton observations.

High-resolution X-ray spectroscopy: the coming-of-age

Jelle Kaastra[1]
[1] *SRON Netherlands Institute for Space Research*

Since the launch of Chandra and XMM-Newton, high-resolution X-ray spectra of cosmic sources of all kinds have become available. These spectra have resulted in major scientific breakthroughs. However, due to the techniques used, in general high-quality spectra can only be obtained for the brightest few sources of each class. Moreover, except for the most compact extended sources, like cool core clusters, grating spectra are limited to point sources. ASTRO-H makes another major step forward, in yielding for the first time high-quality spectra of extended sources, and improved spectral sensitivity in the Fe-K band. With the launch of Athena, X-ray spectroscopy will become mature. It allows us to extend the investigations from the few handful of brightest sources of each category to a large number of sources far away in space and time, or to get high time-resolution, high-spectral resolution spectra of bright time variable sources.

The origin of UV-optical variability in AGN and its relationship to X-ray variability

Ian McHardy[1]
[1] *University of Southampton*

The origin of UV-optical variability in AGN remains a major puzzle. Is it driven by some process intrinsic to the accretion disc or by reprocessing of X-rays? If driven by reprocessing, what is doing the reprocessing, a surrounding accretion disc or surrounding gas? Measurement of the lags between the various X-ray, UV and optical bands, and of their relative amplitudes of variability, for a sample of AGN of differing black hole mass and accretion rate, can provide strong constraints on the emission scenarios. For AGN with large mass black holes the lags, assuming disc reprocessing, are of order a day and require intensive monitoring for periods of 1-2 months. Swift may carry out one or 2 such programmes per year. However for lower mass AGN where the expected lags are of order an hour, XMM-Newton, using the OM as well as Epic and in combination with ground based optical observations, can obtain excellent lag measurements with only one or two orbits per AGN. I report on one such programme here. It would therefore be possible, with a large programme, for XMM-Newton to measure lags in a sample of AGN and thus greatly extend our understanding of AGN UV-optical variability.

The Role of XMM for Present and Next Generation SZ Experiments

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

A strong synergy exists between X-ray and Sunyaev-Zeldovich observations of the hot gas in clusters of galaxies. XMM-Newton has been a major asset in joint scientific analysis with data from the current generation of SZ instruments such as Planck, SPT or ACT. I will review the main X-ray/SZ results from the last few years. I will discuss the expectations and perspectives for upcoming and future measurements of the SZ signal and their combination with X-ray data, focussing on the role to be played by XMM-Newton in these studies.

Magnetars: recent discoveries and synergies with multi-band facilities

Nanda Rea[1,2]
[1] *Instituto de Ciencias del Espacio (CSIC-IEEC)*
[2] *Anton Pannekoek Institute, University of Amsterdam*

In this talk I will review the recent discoveries and theoretical advances in the field of highly magnetized neutron stars (aka magnetars). I will focus on the large impact that XMM-Newton has in our understanding of these extreme sources. Furthermore, I will shortly review on the multi-band emission of magnetars and on the potential synergies with other facilities.

Follow-up of eROSITA and Euclid Clusters

Thomas Reiprich[1]
[1] *Argelander Institute for Astronomy, Bonn University*

In the near future, eROSITA and Euclid will elevate galaxy cluster and cosmology studies to an unprecedented level. Through large area surveys, they will generate huge galaxy cluster samples. Rich science will be enabled through detailed follow-up observations of systematically selected subsamples. In particular, X-ray follow-up will be crucial and XMM-Newton could play the leading role. In this talk, examples for the science enabled and possible strategies for such XMM-Newton observations will be outlined.

Exoplanets and their Host Stars

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

Among the most fundamental astrophysical discoveries are clearly the detections of many thousands of "extrasolar" planets orbiting their hosts. The majority of these new planetary systems have properties dramatically different from those in our solar system. The large distances to extrasolar planets imply that they can only be observed together with their hosts. Modern observations have shown that stars and planets are not merely accidental celestial neighbors bound by the force of gravity, rather they influence each other in a variety of ways. This also and specifically applies to the X-ray properties of exoplanet systems which I will review in my talk and give some ideas for future work in this area.

Cool star X-ray variability

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

Variability is a key characteristic of late-type stars. In analogy to the Sun, late-type stars display a range of magnetic activity phenomena. These comprise strong radiation in the X-ray band emerging from the stellar corona as a result of magnetic heating. The time-scales of the observed X-ray variability associated with magnetic activity range from hours (for flares) to years (for dynamo cycles). Next to these activity-related variability features, in Young Stellar Objects (YSO) the mass accretion from a circumstellar disk and protostellar outflows can induce X-ray emission. The YSO circumstellar environment can give rise to variability either due to intrinsic changes in mass transfer or due to geometric effects as accretion streams or structures in the disk rotate in and out of the line-of-sight. Magnetic interaction between star and disk may play a role as well.

I summarize recent developments in this research area and point out some directions for the possible contributions of XMM-Newton in the future.

Chapter 2

Solicited Speakers

Synergies with the infrared

David Alexander[1]
[1]*Durham University*

In this solicited talk I will review the synergy between XMM-Newton (and Chandra) and infrared facilities. I will focus on two key advantages from the combination of X-ray and infrared observations. First, infrared observations allow for the identification of the most heavily obscured AGNs that are weak or undetected at X-ray observations, providing a more complete census of AGN activity than from X-ray observations alone. Second, infrared observations provide constraints on the star-formation properties of the AGNs, allowing for insight into the connection between AGN activity and star formation. I will use these key advantages to discuss our progress in identifying a complete census of AGN activity and our understanding of the AGN-star formation connection. I will also review how yet greater gains can be made with future planned and proposed facilities.

Athena: ESA's X-ray observatory to study the Hot and Energetic Universe in the late 2020s

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

Athena (Advanced Telescope for High ENergy Astrophysics) is the X-ray observatory mission selected by ESA to address the Hot and Energetic Universe theme, due for launch in 2028. In this presentation, on behalf of the Athena Science Study Team (ASST), I will provide an overview of the Athena science objectives, developed thanks to the support of a large community and describe the Athena mission concept and its instruments. I will also report on a number of on-going study activities, including those aiming at placing Athena in the broad astrophysical context of the late 2020s.

The Nature of Dark Matter (including alternative interpretations)

Alexey Boyarsky[1], Oleg Ruchayskiy[2]
[1]*Leiden University*
[2]*NBi, Copenhagen*

I will review the motivation and the results of the VLP ”The Nature of Dark Matter”.

High-Redshift AGNs and the X-SERVS Survey

William Brandt[1]
[1]*Penn State University, University Park, PA 16802, USA*

In the first part of this talk, I will review how X-ray observations of high-redshift AGNs at $z = 4 - 7$ have played a critical role in understanding their basic demographics as well as their physical processes; e.g., accretion rates, jet emission, X-ray absorption by nuclear material and winds. Since 2000, XMM-Newton and Chandra have provided new X-ray detections for more than 120 such objects, and well-defined samples of $z > 4$ AGNs now allow reliable basic X-ray population studies. I will point out key remaining areas of uncertainty, highlighting where further XMM-Newton and Chandra observations can advance understanding.

I will then describe the X-SERVS project which aims to go “beyond COSMOS” via a 12 $\deg^2$ survey of three prime sky regions: W-CDF-S, XMM-LSS, and ELAIS-S1. The X-SERVS survey will allow outstanding studies of the detected AGNs and groups/clusters by powerfully leveraging multiple intensive radio-to-UV surveys: ATLAS/HerMES/SERVS/VIDEO/DES/HSC/PS1MD/VOICE/CSI/PRIMUS. We aim to dramatically advance studies of SMBH growth across the full range of cosmic environments, links between SMBH accretion and star formation, exceptional AGNs at high redshifts, protoclusters, etc. The targeted X-SERVS fields will have extraordinary legacy value as MOONS massive spectroscopy fields, prime ALMA fields, and DES/LSST deep-drilling fields.

X-ray studies of solar system objects: now and the next decade

Graziella Branduardi-Raymont[1]
[1] *MSSL - University College London, UK*

XMM-Newton and Chandra have revealed the multiplicity of X-ray emissions from planets, comets and minor bodies in our solar system. This presentation will review the main findings so far and will look forward to the unique contributions that XMM-Newton can continue to provide in solar system exploration.

As a prime example, Jupiter's polar regions show bright soft X-ray aurorae with a line-rich spectrum arising from charge exchange interactions of atmospheric neutrals with local and/or solar wind high charge-state heavy ions. At energies above $\sim$3 keV the auroral X-ray spectrum is featureless, pointing to an origin from electron bremsstrahlung. Jupiter's atmosphere scatters solar X-rays, so that the planet's disk displays an X-ray spectrum that closely resembles that of solar flares. The arrival of Juno at Jupiter this July will enable in situ measurements simultaneous with XMM-Newton observations, offering unique opportunities to validate models developed to describe the planet's behaviour. Unlike Jupiter, Mars and Venus lack a strong magnetic field, yet they show X-ray emissions from their disks and exospheres, via solar X-ray scattering and charge exchange.

Future XMM-Newton observations of solar system targets, under different solar activity conditions, will provide ever deeper insights into their close relationships with their parent star.

The Hot Gaseous Halos of Spiral Galaxies

Joel Bregman[1]
[1] *University of Michigan, Ann Arbor, Michigan, USA*

In the Milky Way, absorption and emission line measurements of O VII and O VIII show that the halo environment is dominated by a nearly spherical halo of temperature 2×10^6 K, metallicity of 0.3-0.5 solar, and with a density decreasing as $r^{-3/2}$. The mass of the hot gas, estimated through extrapolation to the virial radius, is comparable to the stellar mass, but does not account for the missing mass. The Milky Way hot halo appears to be rotating at about 180 km/s, which is consistent with model expectations, depending on the time of infall. Around massive spiral galaxies, hot halos are seen in emission out to about 70 kpc in the best cases. These show similar gas density laws and metallicities in the range 0.1-0.5 solar. The gas mass is comparable to the stellar mass, but does not account for the missing baryons within the virial radius. If the density law can be extrapolated to about three virial radii, the missing baryons would be accounted for.

What X-ray images and CCD energy resolution can tell us about the physics of ICM

Eugene Churazov[1]
[1] *MPA*

X-ray images and moderate-resolution energy spectra provide us with a wealth of data on the global properties of galaxy clusters. Additional information is recored in small scale surface brightness and spectral perturbations. We argue that statistical analysis of many small fluctuations in different X-ray energy bands offers a convenient way of characterizing the nature of perturbations and reveals important clues on the ICM physics and on the AGN feedback process.

Deep X-ray surveys

Andrea Comastri[1]
[1] *INAF-Osservatorio Astronomico di Bologna, Italy*

I will summarize the most relevant achievements of the ultra deep XMM survey in the Chandra Deep Field South and the lessons learned for the planning of future X-ray surveys.

Cluster outskirts and the missing baryons

Dominique Eckert[1]
[1] *Geneva University*

Galaxy clusters are located at the crossroads of intergalactic filaments and are still forming through the continuous merging and accretion of smaller structures from the surrounding cosmic web. Deep, wide-field X-ray studies of the outskirts of the most massive clusters bring us valuable insight into the processes leading to the growth of cosmic structures. In addition, cluster outskirts are privileged sites to search for the missing baryons, which are thought to reside within the filaments of the cosmic web. I will present the XMM cluster outskirts project, a VLP that aims at mapping the outskirts of 13 nearby clusters. Based on the results obtained with this program, I will then explore ideas to exploit the capabilities of XMM during the next decade.

What have we learned from the XMM-Newton surveys of Local Group Galaxies?

Frank Haberl[1]
[1] *Max Planck Institute for extraterrestrial physics*

The study of X-ray source populations and diffuse X-ray emission in nearby galaxies is of major importance in understanding the X-ray output of more distant galaxies as well as learning about processes that occur on interstellar scales within our own Galaxy. Depending on the star formation history of the galaxies different types of X-ray sources dominate the total X-ray emission. With modern observatories like XMM-Newton the various classes of X-ray sources (high and low mass X-ray binaries, supernova remnants, super-soft sources) can be studied to the faintest end of their luminosity distribution in Local Group galaxies. XMM-Newton successfully surveyed the large spiral galaxies M31 and M33 and the star forming, irregular Magellanic Clouds. I'll summarise the most important results we have obtained from older populations like low mass X-ray binaries and classical novae in M31 to the younger populations of high mass X-ray binaries and supernova remnants in the Magellanic Clouds. I'll discuss still open questions in this field of research which can be addressed using the high sensitivity of the XMM-Newton instruments.

Synergies with CTA and VHE Astrophysics

Werner Hofmann[1]
[1] *Max Planck Institute for Nuclear Physics, Heidelberg*

The Cherenkov Telescope Array (CTA) is a next-generation observatory for very high energy (VHE) gamma-ray astronomy. With one array of imaging atmospheric Cherenkov telescopes each in the northern and southern hemispheres, CTA will provide full-sky coverage, enhance flux sensitivity by one order of magnitude compared to current instruments, cover gamma-ray energies from 20 GeV to 300 TeV, and provide angular resolution of a few arc-minutes across a multi-degree field of view.

In the context of its Key Science Projects (KSPs), CTA will conduct a census of particle acceleration in the universe, with quarter-sky extragalactic, full-plane Galactic and Large Magellanic Cloud surveys planned. Additional KSPs are focused on transients, acceleration up to PeV energies in our own galaxy, active galaxies, star-forming systems on a wide range of scales, and the Perseus cluster of galaxies. A major element of the programme is the search for dark matter, in particular the annihilation signature of WIMPs. Like for current-generation VHE instruments, CTA science will strongly rely upon multiwavelength observations of sources, with the X-ray domain playing a particularly crucial role.

The presentation will briefly introduce CTA, summarize its science perspectives, and address the synergies with instruments in other wavebands.

Tidal disruption of stars by SMBHs

Stefanie Komossa[1]
[1] *Max-Planck-Institut fuer Radioastronomie*

The tidal disruption and subsequent accretion of stars by supermassive black holes produces spectacular flares in the X-ray sky. First found with ROSAT, ongoing and upcoming sky surveys will find these events in the 1000s. In X-rays, tidal disruption events (TDEs) provide us with powerful new probes of accretion physics under extreme conditions, of the formation of disk winds, of relativistic effects near the SMBH, and of the presence of supermassive binary black holes. This talk reviews the status of observations, and discusses future prospects. XMM-Newton will continue to play an important role in identifying new events and carry out spectroscopic follow-ups.

Gaia: status, upcoming data releases and the mission archive

Xavier Luri[1]
[1] *Departament de Fisica Quantica i Astrofisica / Institut de Ciències del Cosmos, Universitat de Barcelona (ICCUB-IEEC)*

The Gaia mission, launched in December 2013, is now nearing two years of scientific operations. This talk will review the status of the mission, from the satellite operations to its updated scientific performances, with a focus on the expected contents of the successive mission data releases. Specifically the first Gaia Data Release, scheduled for end of summer 2016, will be discussed in detail along with the features of the Gaia archive from which the data will be served. The overall goal of the talk will be to provide the XMM community a clear picture of the astrometric, photometric and spectroscopic data that Gaia will produce in the next five years in view of identifying possible synergies with XMM.

Perspectives for High-Energy Astrophysics at ESO

Vincenzo Mainieri[1]
[1] *ESO, Garching bei Muenchen, Germany*

Synergies between XMM-Newton and Optical-NIR facilities at ESO are proven by the large number of publications using data from the two observatories. I will review the the current synergies and highlight the future prospects along the evolution of the instrumentation plan at ESO.

Binaries across the spectrum - the case for simultaneous multi-wavelength studies

Matthew Middleton[1]
[1] *University of Cambridge (IoA), Cambridge, UK*

Accreting binary systems harbouring a compact-object radiate across many orders of magnitude in frequency due to their various physical structures and processes (jet/outflow, inward accretion flow + secondary star). Typical observations of their broad-band SEDs provides valuable insights into the time-averaged energetics, however, *time-resolved* studies are potentially even more powerful as binary systems vary on relatively short timescales and we are provided a means by which to study how the physical structures interact. I will review some of the progress made in studying such systems using time-resolved analyses and discuss the future requirements for simultaneous multi-wavelength observations.

Synergy with new radio facilities: from LOFAR to SKA

Raffaella Morganti[1,2]
[1] *ASTRON, the Netherlands Institute for Radio Astronomy, Postbus 2, 7990 AA, Dwingeloo, The Netherlands*
[2] *Kapteyn Astronomical Institute, University of Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands*

A number of new radio telescopes are coming on-line paving the way to the Square Kilometre Array. Their new capabilities, e.g. large field of view, broad instantaneous band and fast response, offer new possibilities for the science. I will briefly give an overview of the facilities that are becoming available. Many of them have open time and some are planning large surveys that will be made available to the entire astronomical community, providing an important legacy.

I will then focus on some of the results obtained with the Low Frequency Array (LOFAR) on topics where a strong synergy with XMM is (or should be) present. In particular, I will focus on pulsars (e.g. fast switching mode pulsars) and accreting systems among the galactic objects. For the extragalactic objects, the combination radio/X-ray is key for understanding the energetics and, therefore, the impact that radio AGN have on their surroundings. I will in particular focus on results from observations of radio galaxies and clusters. Fast response to transient objects in the radio sky is also receiving a lot of attention with LOFAR (and other radio telescopes).

A Decade of WHIM search: Where do We Stand and Where do We Go

Fabrizio Nicastro[1]
[1] *INAF - OAR, Via Frascati 33, 00040 Monte Porzio Catone (RM), Italy*

All hydrodynamical simulation in the framework of our Standard Cosmological Model (SCM) agree in predicting that half of the baryons in the Universe at $z<0.5$ should lie in a tenuous web of hot intergalactic matter (the so called WHIM), connecting already virialized structures. The search for this important baryonic component of the Universe started now more than a decade ago with the first claim of detection of 2 OVII WHIM filaments along the line of sight to the blazar Mkn 421. Since then several other detections were proposed. I will review all these claims of detection and show that the WHIM has not been found yet. The ultimate hope with current instrumentation, relies on the VLP that we were granted in the current XMM cycle, to observe the brightest blazar in the $z>0.4$ X-ray sky. Half of this program has already been performed and the remaining will be performed in early 2017, when the target is predicted to undergo a maximum of activity. I will present the preliminary results from this observing campaign, including possible new WHIM candidates and current limits on the OVII-WHIM baryonic mass. Finally, I will discuss future potentials with the Athena-XIFU.

Report of Hitomi (ASTRO-H)

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

Hitomi (ASTRO-H) was successfully launched on February 17, 2016, and initial check-out and start-up operations are being carried out. The satellite has been built by a major international collaboration, and carries microcalorimeters, wide-field CCDs, hard X-ray imagers, and soft gamma-ray detectors. We will report on the status of Hitomi along with some initial results.

The XXL survey: first results and future

Marguerite Pierre[1], XXL consortium[2]
[1] *CEA Saclay*
[2] *http://irfu.cea.fr/xxl/members*

We review the first results from the XXL survey (14 articles - December 2015). In the light of our recent results, we discuss the cosmological interpretation of very large X-ray cluster surveys and present a new approach to the question. We draw a roadmap for the coming decade.

eROSITA on SRG

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

eROSITA is the primary telescope on the Russian-German X-ray mission Spectrum-Roentgen-Gamma. The instrument is near its completion: All parts are in place, all seven cameras and seven mirrors plus spares are calibrated, the integration is almost done. All subsystems behave as planned, the performance is as expected. Now we are in the process of doing the final tests before eROSITA will be shipped to Russia for integration into the spacecraft. The launch is now planned for end of September 2017. In parallel to the instrument development, the preparation of the mission is also on its way: The data analysis software is operating, and we are working together with our Russian partners on details of the mission planning. More than 100 German scientists organised in 12 working groups contribute to the mission with simulations, analyses and scientific proposals.

Perspectives for hot stars in the next decade

Gregor Rauw[1]
[1] *University of Liege, Belgium*

XMM-Newton has deeply changed our picture of X-ray emission of hot, massive stars. High-resolution X-ray spectroscopy as well as monitoring of these objects revealed a number of previously unexpected features that challenge our understanding of the dynamics of the stellar winds of massive stars. In this contribution, I will briefly summarize the results obtained over the past 15 years and highlight the perspectives for the next decade. It is anticipated that coordinated (X-ray and optical or UV) monitoring and time-critical observations of either single or binary massive stars will become the most important topics in this field over the coming years. Synergies with existing or forthcoming X-ray observatories (NuStar, Astro-H, eROSITA) will also play a major role and will further enhance the importance of XMM-Newton in our quest for understanding the physics of hot, massive stars.

Cosmology with AGN: can we use quasars as standard candles?

Guido Risaliti[1,2]
[1] *University of Florence*
[2] *INAF - Arcetri Observatory*

The non-linear relation between X-ray and UV luminosity in quasars can be used to estimate their distance. Recently, we have shown that despite the large dispersion of the relation, a Hubble Diagram made of large samples of quasars can provide unique constraints on cosmology at high redshift. Furthermore, the dispersion of the relation is heavily affected by measurement errors: until now we have used serendipitous X-ray observations, but dedicated observations would significantly increase the precision of the distance estimates. I discuss the future role of XMM in this new field, showing (1) the fundamental contribution of the Serendipitous Source Catalogue and of large surveys, and (2) the breakthrough advancements we may achieve with the observation of a large number of SDSS quasars at high redshift: every 12-15 quasars observed at z 3 would be equivalent to discovering a supernova at that redshift.

Synergies with ALMA and mm/submm facilities

Helen Russell[1], Brian McNamara[2], Andy Fabian[1]
[1] *Institute of Astronomy, University of Cambridge*
[2] *University of Waterloo*

New sub-mm facilities, such as ALMA, have opened up exciting new areas of astrophysics. I will review some of ALMA's exciting discoveries from the first five years of science including observations of massive molecular gas flows at the centres of nearby galaxies. Feedback from a central active galactic nucleus is thought to regulate the growth of massive galaxies by suppressing gas cooling and star formation. I will also focus on the potential contribution that XMM-Newton observations could make to these fields over the next decade.

10+ more years of Chandra-XMM-Newton Synergy

Belinda Wilkes[1]
[1] *Chandra X-ray Center, Smithsonian Astrophysical Observatory, Cambridge, USA*

In this current golden age of X-ray astronomy, the frontiers of the X-ray Universe are continually expanding in multiple, often unexpected, directions, due to the extraordinary success and longevity of both ESA's XMM-Newton and NASA's Chandra X-ray Observatory. These two ground-breaking, major observatories are supported by a number of smaller, more focused missions which feed into and expand the discovery space of X-ray astronomy even further. With the prospect of another decade of observing, now is an excellent time to take stock of how far we have come, and to look forward to the future with a view to maximizing the scientific legacy of both XMM-Newton and Chandra. This not only involves optimizing the contents of the archives and the impact of the science results, but also laying the ground-work for the next generation of X-ray telescopes, led by ESA's Athena mission in the late 2020s.

I will summarize the synergy between XMM-Newton and Chandra, including complementary capabilities which facilitate coordinated observations and science programs, and overlapping capabilities which often provide the necessary confirmation (or not) of new, marginal and/or controversial results.

CHEERS: The Chemical Enrichment RGS Sample

Jelle de Plaa[1], François Mernier[1,2], Jelle Kaastra[1,2], Ciro Pinto[3], Norbert Werner[4], CHEERS collaboration[1]
[1] *SRON Netherlands Institute for Space Research, Utrecht, The Netherlands*
[2] *Leiden Observatory, The Netherlands*
[3] *Institute of Astronomy, Cambridge, UK*
[4] *Stanford University, Palo Alto, CA, USA*

The Chemical Enrichment RGS Sample (CHEERS) is aimed to be a sample of the most optimal clusters of galaxies for observation with the Reflection Grating Spectrometer (RGS) aboard XMM-Newton. It consists of 1.6 Ms of deep cluster observations of 11 objects obtained through a very large program and archival observations of 33 clusters and groups. The main goal is to measure chemical abundances in the hot Intra-Cluster Medium (ICM) of clusters to provide constraints on chemical evolution models. Especially the origin and evolution of type Ia supernovae is still poorly known and X-ray observations could contribute to constrain models regarding the SNIa explosion mechanism. With this sample of deep XMM-Newton observations, also other topics can be addressed. Within the CHEERS collaboration, we also study the turbulence and thermal properties of the hot ICM in the clusters. In this talk, we discuss the aims and the first results of the CHEERS project.

Chapter 3

Future X-ray missions

SMILE (Solar wind Magnetosphere Ionosphere Link Explorer): X-ray imaging of the Sun-Earth connection

Graziella Branduardi-Raymont[1], Chi Wang[2], and the SMILE Team[3]
[1] *MSSL - University College London, UK*
[2] *NSSC - Chinese Academy of Sciences, China*
[3] *http://www.mssl.ucl.ac.uk/SMILE/*

SMILE is a novel space mission, under development, dedicated to study the dynamic coupling of the solar wind with the Earth's magnetosphere in a global way never attempted before. From a highly elliptical Earth orbit SMILE will obtain X-ray images of the magnetosheath and polar cusps simultaneously with UV images of the Northern aurora, while making in situ solar wind/magnetosheath plasma and magnetic field measurements.

X-ray imaging of the dayside magnetosheath and cusps is now possible thanks to the relatively recent discovery of solar wind charge exchange X-ray emission, first observed at comets, and subsequently found to occur in the vicinity of the Earth's magnetosphere. SMILE will turn this unwanted background for astronomical observations into a diagnostic tool for the study of solar-terrestrial interactions, enabling us to trace and link the processes of solar wind injection in the magnetosphere with particle precipitation into the cusps and the aurora.

SMILE is the first fully collaborative space mission from inception to implementation and operations between ESA and the Chinese Academy of Sciences. This talk will present the science and impact that SMILE will deliver, together with an overview of its payload and of the mission's development.

Synergies with ALMA and mm/submm facilities

Helen Russell[1], Brian McNamara[2], Andy Fabian[1]
[1] *Institute of Astronomy, University of Cambridge*
[2] *University of Waterloo*

New sub-mm facilities, such as ALMA, have opened up exciting new areas of astrophysics. I will review some of ALMA's exciting discoveries from the first five years of science including observations of massive molecular gas flows at the centres of nearby galaxies. Feedback from a central active galactic nucleus is thought to regulate the growth of massive galaxies by suppressing gas cooling and star formation. I will also focus on the potential contribution that XMM-Newton observations could make to these fields over the next decade.

Chapter 4

Complementary issues & multi-wavelength synergies

An XMM-Newton Science Archive for next decade, and its integration into ESASky

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We will present a roadmap for the next decade improvements of the XMM-Newton Science Archive (XSA), as planned for an always faster and more user friendly access to all XMM-Newton data. This plan includes the integration of the Upper Limit server, an interactive visualization of EPIC and RGS spectra, on-the-fly data analysis, among other advanced features. Within this philosophy XSA is also being integrated into ESASky, the science-driven discovery portal for all the ESA Astronomy Missions. A first public beta release of the ESASky service has been already released at the end of 2015. It is currently featuring an interface for exploration of the multi-wavelength sky and for single and/or multiple target searches of science-ready data. The system offers progressive multi-resolution all-sky projections of full mission datasets using a new generation of HEALPix projections called HiPS, developed at the CDS; detailed geometrical footprints to connect the all-sky mosaics to individual observations; and direct access to science-ready data at the underlying mission-specific science archives. New XMM-Newton EPIC and OM all-sky HiPS maps, catalogues and links to the observations are available through ESASky, together with INTEGRAL, HST, Herschel, Planck and other future data.

Synergy between X-ray observations of the luminous Type IIn supernova SN 2005ip and optical integral field spectroscopy data from CALIFA and MUSE

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Type IIn supernovae (SNe IIn) are thought to originate from the core-collapse of massive stars enshrouded in hydrogen-rich circumstellar material (CSM). They are characterized by the presence of narrow emission lines on top of broad emission lines, which are interpreted as resulting from heavy mass loss prior to the explosion. X-ray emission can be produced in such extremely energetic processes, as a supernova explosion and AGN. We present the kinematic results of the ionized gas phase (Hα) observed in NGC 2905 when using optical data from CALIFA and MUSE instruments. The presence of two (narrow and broad) components is found where the Type IIn supernova SN 2005ip was discovered in 2005. This is one of the brightest X-ray SNe according to its intrinsic 0.2-10 kev luminosity ($\sim 1.5 \times 10^{41}$ erg/s). A rich forest of coronal lines observed in SN2005ip over all epochs are probably formed from the photoionization of dense gas by X-rays produced from shocks. The results derived from combining multi-wavelength (UV, optical and IR) observations with existing X-ray (XMM-Newton, Chandra) data are discussed to gain insight on the progenitor star, its mass-loss history and on the interaction of the (subsequent) SN with the circumstellar environment.

The effects of dust scattering on high-resolution X-ray absorption edge structure

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High energy studies of astrophysical dust complement observations of dusty interstellar gas at other wavelengths. With high resolution X-ray spectroscopy, dust scattering significantly enhances the total extinction optical depth and alters the shape of photoelectric absorption edges. This effect is modulated by the dust grain size distribution, spatial location along the line of sight, and the imaging resolution of the X-ray telescope. At soft energies, the spectrum of scattered light is likely to have significant features at the 0.3 keV (C-K), 0.5 keV (O-K), and 0.7 keV (Fe-L) photoelectric absorption edges. This direct probe of ISM dust grain elements will be important for (i) understanding the relative abundances of graphitic grains or PAHs versus silicates, and (ii) measuring the depletion of gas phase elements into solid form. We focus in particular on the Fe-L edge, fitting a template for the total extinction to the high resolution spectrum of three X-ray binaries from the Chandra archive: GX 9+9, XTE J1817-330, and Cyg X-1. We discuss ways in which spectroscopy with XMM can yield insight into dust obscured objects such as stars, binaries, AGN, and foreground quasar absorption line systems.

Characterization of the X-ray absorption in the Galactic ISM

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The physical conditions of the Galactic interstellar medium (ISM) can be studied in detail through the high-resolution X-ray spectroscopy provided by the grating instruments in both *Chandra* and *XMM-Newton*. Using an X-ray source, which acts as a lamp, one can analyze the absorption features that are imprinted in the spectra by the gas located between the observer and the X-ray source, which offers the opportunity to study physical properties of the ISM such as ionization degree, column densities, and elemental abundances.

We present a detailed analysis of the H, O, Ne, and Fe absorption in the X-ray spectra of 24 bright galactic sources obtained with the *Chandra* and *XMM-Newton* observatories. Implementing our new absorption model `ISMabs`, we have measured column densities, ionization fractions, and abundances for H, O, Ne, and Fe in the direction of each source. We find that the column densities tend to increase with source distance and decrease with galactic latitude, while the ionization fractions and abundances are mostly constant along every line of sight. Finally, we found that molecules and grains are not a major contributor to the absorption features in the O K-edge wavelength region.

The X-ray and radio views of the gamma-ray emitting Narrow-Line Seyfert 1 galaxy PKS 2004-447

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The discovery of an elusive sample of gamma-ray bright radio-loud narrow-line Seyfert 1 (γ-NLS1) galaxies revealed an intriguing new aspect of the AGN phenomenon. We study the radio-loudest γ-NLS1 galaxy, PKS 2004−447, as part of the multiwavelength monitoring program TANAMI. We show the first 8.4 GHz VLBI image, revealing a high brightness-temperature core and a prominent single-sided radio jet on parsec scales. New *Swift* and *XMM-Newton* observations reveal an unobscured flat X-ray spectrum, dominated by a single power-law component. In comparison to other γ-NLS1, PKS 2004−447 exhibits a unique flat X-ray spectrum and persistent steep radio spectrum with moderate amplitude and spectral variability in both bands. The total radio emission is coming from a region smaller than ~ 0.5 kpc, supporting a possible classification of PKS 2004−447 as a Compact Steep Spectrum (CSS) source.

INTEGRAL upper limits on gamma-ray emission associated with the gravitational wave event GW150914

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Using observations of the INTErnational Gamma-Ray Astrophysics Laboratory (INTEGRAL), we put tight upper limits on the gamma-ray and hard X-ray prompt emission associated with the gravitational wave event GW150914, discovered by the LIGO/Virgo collaboration. The omnidirectional view of the INTEGRAL/SPI-ACS has allowed us to constrain the fraction of energy emitted in the hard X-ray electromagnetic component for the full high-probability sky region of LIGO/Virgo trigger. Our upper limits on the hard X-ray fluence at the time of the event range from $F_\gamma = 2\times10^{-8}$ erg cm^{-2} to $F_\gamma = 10^{-6}$ erg cm^{-2} in the 75 keV - 2 MeV energy range for typical spectral models. Our results constrain the ratio of the energy promptly released in gamma-rays in the direction of the observer to the gravitational wave energy $\mathrm{E}\_\gamma/\mathrm{E}_{GW} < 10^{-6}$. We discuss the implication of gamma-ray limits on the characteristics of the gravitational wave source, based on the available predictions for prompt electromagnetic emission.
This work has been possible thanks to a Memorandum of Understanding with the LIGO-Virgo scientific collaboration and is presented on behalf of a larger collaboration.

The lamppost model of accreting black holes

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Niedzwiecki, Zdziarski & Szanecki (2016, ApJL, submitted) have studied the lamppost model, in which the X-ray source in accreting black-hole systems is located on the rotation axis close to the horizon. We point out a number of inconsistencies in the widely used lamppost model relxilllp. They appear to invalidate those model fitting results for which the source distances from the horizon are within several gravitational radii. Furthermore, we note that if those results were correct, most of the photons produced in the lamppost would be trapped by the black hole, and the source luminosity as measured at infinity would be much larger than that observed. This appears to be in conflict with the observed smooth state transitions between the hard and soft states of X-ray binaries. The required increase of the accretion rate and the associated efficiency reduction present also a problem for AGNs. Then, those models imply the luminosity measured in the local frame much higher than the dissipated power due to time dilation and redshift, and the electron temperature significantly higher than that observed. We show that these conditions imply that the fitted sources would be out of the pair equilibrium.

ESASky: a new Astronomy Multi-Mission Interface

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ESA is working on a science-driven discovery portal for all its astronomy missions at ESAC called ESASky. The first public release of this service will be shown, featuring interfaces for sky exploration and for single and multiple targets. It requires no operational knowledge of any of the missions involved. A first public beta release took place in October 2015 and gives users world-wide simplified access to high-level science-ready data products from ESA Astronomy missions plus a number of ESA-produced source catalogues. XMM-Newton data, metadata and products were some of the first to be accessible through ESASky. In the next decade, ESASky aims to include not only ESA missions but also access to data from other space and ground-based astronomy missions and observatories.

From a technical point of view, ESASky is a web application that offers all-sky projections of full mission datasets using a new-generation HEALPix projection called HiPS; detailed geometrical footprints to connect all-sky mosaics to individual observations; direct access to the underlying mission-specific science archives and catalogues. The poster will be accompanied by a demo booth at the conference.

Chapter 5

Solar system & exo-planets

What triggered the early planet formation processes in HL Tau?

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T Tauri stars are in the pre-main sequence phase of stellar evolution. These stars convert their own gravitational potential energy to light, but their cores do not have enough temperature for nuclear reactions like a main sequence star. T Tauri stars are surrounded by a circumstellar disk, hot plasma and dust. Some T Tauri stars host protoplanetary objects in their circumstellar disk such as HL Tau. In this case HL Tau system is a good example for stellar evolution and planet formation. But HL Tau's protoplanetary objects were formed earlier than planet formation theories' expectations. With this purpose, this study will discuss "What triggered the early planet formation processes in HL Tau system?" with XMM-Newton and Chandra observations of HL Tau system.

Chapter 6

Stars, CVs etc.

XMM-Newton Observations of TW PIC in comparison with the Archival SWIFT and RXTE data

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We present $\sim$ 40 ks (2 observations) of XMM-Newton data of the magnetic cataclysmic variable candidate TW Pic, suggested as an Intermediate Polar (IP) at a low inclination angle. The XMM EPIC spectrum (pn+MOS) can be best modeled by an absorption for interstellar medium (tbabs) along with partial covering absorber (pcfabs) and a multi-temperature plasma emission component (cevmkl). In addition, we find two Gaussian lines at 6.4 and 6.7 keV. We find intrinsic absorption differences between two observations with a difference of 54 days at 90% confidence level. If the interstellar absorption in the direction of the source is assumed (Willingale et al. 2013 or Dickey & Lockman 1990), there is soft excess which may be modeled with a blackbody emission $kT_{BB} \sim$ 90 eV that has been recovered from some soft IPs. We will also present power spectral analysis using the EPIC and OM data. We will utilize the serendipitous SWIFT observations obtained $\sim$ 60 days prior to the first XMM-Newton observation and an earlier RXTE observation in 1999 for comparisons on energy and power spectral analysis.

The Galactic supersoft X-ray binary RXJ0925.7-4758 (MR Vel)

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Close binary supersoft X-ray sources (CBSS) are believed to be an accreting white dwarf (WD) in a close binary with near-main-sequence companion, which can provide large mass accretion rates (110-7 - 610-7M yr-1). During such high accretion rates, hydrogen shell burning consumes hydrogen at the same rate as the WD accretes. Using most recent proton capturing reaction rates and beta-decay rates the cyclic reactions have been studied. In the present work, effort has been made to explain the observed characteristics of the source RXJ0925.7-4758 considering the above mentioned model. The calculated values of Luminosity (8.561037erg/sec) and Effective temperature (94.19 eV) tally well with the observed ones. The Color temperature of RXJ0925.7-4758 near the photosphere has been determined as 106 eV. Photo ionisation code CLOUDY has been used to explain the observed absorption edges in the spectrum of RXJ0925.7-4758. Key words: White Dwarf, Supersoft X-ray sources, Color temperature, Absorption edges.

Probing the clumpy winds of giant stars with high mass X-ray binaries

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Line-driven winds from early type stars are structured, with small, overdense clumps embedded in tenuous hot gas. High mass X-ray binaries (HMXBs), systems where a neutron star or a black hole accretes from the line-driven stellar wind of an O/B-type companion, are ideal for studying such winds: the wind drives the accretion onto the compact object and thus the X-ray production. The radiation from close to the compact object is quasi-pointlike and effectively X-rays the wind.

The structured nature of these winds results in absorption variability on short timescales: current instruments can resolve significant changes on timescales of kiloseconds and below in bright sources such as Cygnus X-1 and Vela X-1. We show that time resolved high-resolution spectroscopy can reveal the structure of the winds, including the temperature gradient of the clumps, and discuss prospects for HMXB wind observations with X-ray calorimeters onboard Hitomi and Athena. We further show how a combination of newest lab reference values with statistical inference via Bayesian hierarchical modeling can help us constrain the line shifts and thus the dynamics of the wind components.

Unresolved Soft X-ray Emissions from the Galactic Plane

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Although the soft X-ray photons coming from the outside of the Galactic plane originated from the Milky Way X-ray halo and the CXB are blocked totally by the dense ($\sim 10^{21-23}$ cm^{-2}) neural material, the soft X-ray sky below 1 keV is spatially smooth after subtracting the local structure, suggesting an excess X-ray emission which makes up for the decrease in the Galactic plane. Masui et al. (2009) discovered a broad emission feature near 0.9 keV in the spectrum of a region located in the Galactic plane and suggested stars in a line-of-sight direction. To reveal spectral characteristics of the peculiar soft X-ray emission in the Galactic plane, we conducted imaging and spectral analysis for all Suzaku archival data and picked up 16 blank sky fields. Finally, we detected similar spectral features observed in Masui et al. (2009) from all the regions and demonstrated similarity in their temperatures ($kT \sim$0.6-1.3 keV) and differences in their intensities (a factor of $\sim$10). We investigated a contribution from point sources using XMM and found the point sources are not a dominant component of the peculiar soft X-ray emissions ($<\sim$40 %). Multiwavelength data were also used in order to discuss the origin.

Results from DROXO. IV. EXTraS discovery of an X-ray flare from the Class I protostar candidate ISO-Oph 85

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X-ray emission from Young Stellar Objects (YSOs) is a key ingredient to understand their evolution, as the evolution of protoplanetary disks. However, a very limited (and controversial) amount of X-ray results is currently available.
Within the EXTraS (Exploring the X-ray Transient and variable Sky) project, a search for transients and variability in the whole XMM-Newton data archive, we discover faint transient X-ray emission from a source whose counterpart is ISO-Oph 85, a strongly embedded YSO in the ρ Ophiuchi star forming region. We analyze the X-ray emission observed by XMM-Newton. In order to constrain the evolutionary stage of ISO-Oph 85 we combine infrared, sub-millimeter, millimeter and optical data.
The object ISO-Oph 85 is with good confidence a Class I YSO. The flare we detect is one of the rare evidences of magnetic activity at this early evolutionary phase, possibly associated to reconnection events involving magnetic fields of the protostar itself and of its circumstellar disk.
This result shows how time-resolved analysis is fundamental in order to characterize the X-ray emission from YSOs, and the potential of the EXTraS project.

The connection between stellar rotation and X-ray activity in the sample of Kepler mission

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The magnetic field of convective main sequence stars is assumed to be produced via a dynamo-like mechanism involving stellar convection and differential rotation.
A direct measure of the stellar magnetic field is often problematic: the X-ray activity is a good proxy for the magnetic field.
Exploring the relation between the X-ray emission and the rotation period of stars it is possible to characterize the evolution of stellar dynamos.
We select all the main sequence stars observed by the Kepler mission and detected in the 3XMM-DR5 catalogue. With its high cadence and photometric precision in optical light curves, Kepler allows a precise estimation of the rotation period from the fluctuations in optical luminosity.
We characterize the spectral type and the physical parameters of each star in our sample fitting the spectral energy distribution, and derive the rotation period and the optical variation of amplitude in the rotation cycles. We calculate the X-ray luminosity in different energy bands. Exploiting the products of the EXTraS (Exploring the X-ray Transient and variable Sky) project, we search for flares in X-rays and optical light curves, compare the energy and timing properties of simultaneous X-ray/optical flares, and perform an X-ray spectral analysis on the brightest sources.

X-ray cycles and magnetic activity of solar-like stars

Jan Robrade[1]
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Since the beginning of its operation XMM-Newton carries out a monitoring program to study coronal cyclic behavior in stars similar to our Sun. I present highlights and recent results from the X-ray monitoring campaign, that observes neighboring stellar systems like Alpha Centauri and 61 Cygni. Cyclic activity phenomena and coronal properties are discussed and put into context of X-ray emission from the Sun and solar-type stars. As an outlook, future perspectives of stellar X-ray studies with a focus on the eROSITA all-sky survey are presented.

Stellar X-ray accretion signatures

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Accretion is observed in a wide range objects with partially overlapping properties. In this contribution, we study accretion in young stars, where we can directly observe the accretion shock on the stellar surface in the X-ray regime. High-resolution grating spectroscopy allows us to infer the properties of the accretion streams. I will present results from our recent 250 ks XMM-Newton/Chandra program targeting the prototypical T Tau system such as strong X-ray variability despite constant mass accretion, abundances typical for accreting stars, but line ratios typically not found in accreting stars. Finally, I will compare these results with other systems focusing on potentially different accretion modes.

X-rays from Pre-Main Sequence Stars: Recent Results and Future Challenges

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I will summarize recent results of X-ray observations of pre-main sequence (PMS) stars, focusing on XMM-Newton RGS and Chandra HETG observations of RY Tau. These observations provide the best grating spectra obtained so far of a jet-driving T Tauri star. I will also identify key questions regarding the origin and nature of X-ray emission from PMS stars that have emerged from 16 years of XMM-Newton and Chandra observations and which present challenges for the next decade.

Peculiar neutron star Calvera in optical and X-rays

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Calvera is an unusual isolated neutron star discovered in X-rays at high Galactic latitude with pure thermal spectrum typical for neutron stars of “The Magnificient Seven” group. On the other hand, its rotation period and spin-down rate are typical for ordinary rotation-powered pulsars (RPP). However, Calvera was not yet detected in other spectral domains. All these make it difficult to associate it with any known neutron star class. We report the results of deep optical observations of Calvera field with GTC. No counterpart was found up to $g<27.5$ In addition, we re-analyzed all the available archival X-ray data. Using posterior predictive check method (Protassov et al. 2002) we confirm the presence of the spectral absorption feature at 0.6–0.8 keV marginally suggested earlier (Shevchuk et al. 2009; Zane et al. 2011). We also show that X-ray spectrum of Calvera is consistent with emission from the bulk of an NS surface covered with hydrogen atmosphere with non-uniform temperature. In this case, the source is located at about 2 kpc. This rather large distance naturally explains absence of any non-thermal emission and optical non-detection of Calvera and suggests that it is an ordinary RPP located high above the Galactic plane.

Chapter 7

Compact Objects I: BH and Neutron star systems, SN/GRBs

Very faint X-ray binaries with XMM-Newton

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A population of very faint X-ray binaries has been discovered in the last years thanks to the improvement in sensitivity and resolution of the new generations of X-ray missions. These systems show anomalously low luminosities, below 10^{36} ergs/sec, challenging our understanding of accretion physics and binary evolution models, and thereby opening new windows for both observational and theoretical work on accretion onto compact objects.

XMM-Newton is playing a crucial role in the study of this dim family of objects thanks to its incomparable spectral capabilities at low luminosities. I will review the state-of-the-art of the field and present our XMM results in both black hole and neutron star objects. Finally, I will discuss the possibilities that the new generation of X-ray telescopes offer for this research line.

Modelling of ionization instability driven outbursts in Low Mass X-ray Binaries

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It is shown that outbursts observed in X-ray lightcurves of the transient sources can be well explained by an accretion disk instability mechanism. The instability is caused by hydrogen partial ionization in the outer part of the disk. When the unstable front moves toward the central object, classical outburst appears with duration from 30 up to 400 days. The shape of an outburst can be very regular like fast rise exponential decay profile (FRED) very characteristic for ionization instability mechanism or irregular suggesting that, beside FRED, additional flickering occurs. We use the model which predicts time dependent evolution of ionization instability in an accretion disk around black hole, assuming viscosity parameter to be proportional to the gas pressure. As a result, modelled lightcurves fit to the observed lightcurves, indicating that disk instability occurs in those source.

Phase-dependent absorption features in X-ray spectra of XDINSs

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A detailed pulse phase spectroscopy using all the available XMM-Newton observations of X-ray dim isolated neutron stars (XDINSs) have revealed the presence of narrow and strongly phase-dependent absorption X-ray features. The first discovered was in the X-ray spectrum of the nearby XDINS RX J0720.4-3125. The line seems to be stable in time over a timespan of 12 years and is present in 20% of the pulsar rotation. Because of its narrow width and its strong dependency on the rotational phase, the spectral line is probably due to proton cyclotron absorption in a $\sim 10^{14}$ G confined magnetic structure (with a field strength about 7 times the dipolar field of this pulsar). Performing the same analysis to all archival XDINS data, a new possible candidate was found in the X-ray spectrum of RX J1308.6+2127. This absorption feature shows the same phase dependency and energy as the first one, revealing the presence of a high-B structure close to the stellar surface. This result supports the proposed scenario of XDINSs being aged magnetars, having still a strong non-dipolar crustal B-field component.

IGR J17451-3022: a dipping and eclipsing low mass X-ray binary

Enrico Bozzo[1]
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We report on the available X-ray data collected by INTEGRAL, Swift, and XMM-Newton during the first outburst of the INTEGRAL transient IGR J17451-3022, discovered in 2014 August. The emission of the source during the 9 months-long outburst was dominated by a thermal component (kT1.2 keV), most likely produced by an accretion disk. The XMM-Newton observation carried out during the outburst revealed the presence of multiple absorption features in the soft X-ray emission that could be associated to the presence of an ionized absorber lying above the accretion disk, as observed in many high-inclination low mass X-ray binaries. The XMM-Newton data also revealed the presence of partial and rectangular X-ray eclipses (lasting about 820 s), together with dips. The latter can be associated with increases in the overall absorption column density in the direction of the source. The detection of two consecutive X-ray eclipses in the XMM-Newton data allowed us to estimate the source orbital period at Porb=22620.5(1.8,+2.0) s (1 c.l.).

The long XMM-Newton observational campaign on IGR J17544-2619

Enrico Bozzo[1]
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eIn this talk we present the results obtained from the long XMM-Newton observational campaign on the prototype supergiant fast X-ray transient (SFXT) IGR J17544-2619. This is the longest continuum observation in the soft X-rays of an SFXT. The source underwent a bright outburst during the observation and displayed a total dynamic range of about 1E4 in the X-ray luminosity (0.5-10 keV energy range). We discuss the implications of these observational results for the theoretical models proposed so far to interpret these unique and extreme sources.

The X-ray outburst of the Galactic Centre magnetar SGR 1745-2900 during the first 1.5 year

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At a projected separation of 0.1 pc from the supermassive black hole at the Center of the Milky Way, Sgr A*, the transient magnetar SGR J1745-2900 holds the record as the closest neutron star to a black hole ever observed. SGR J1745-2900 has been the object of an intensive monitoring campaign in the X-rays for about 1.5 years since the outburst onset, from April 2013 until September 2014. Detailed analysis of the data has revealed an extremely slow flux decay compared to the other known transient magnetars, making this source rather unique. The extremely slow cooling is currently challenging the state-of-the art neutron star crustal cooling models. If the outburst evolution is indeed due to crustal cooling, as predicted and observed for all other magnetar outbursts in the past 10 years, then magnetic energy injection needs to be continuous over at least the first ~ 200 days, something so far never observed for sources of the class. Alternatively, heating of the star surface may result from strong magnetospheric currents confined within a gradually shrinking magnetic bundle which impact upon the surface. However detailed numerical simulations are needed to confirm this possibility.

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

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The EXTraS project is extracting the hitherto unexplored temporal domain information buried in the serendipitous data collected by XMM-Newton/EPIC since its launch. This includes a search for fast transients, missed by standard image analysis, as well as a search and characterization of variability (both periodic and aperiodic) in hundreds of thousands of sources, spanning more than nine orders of magnitude in time scale and six orders of magnitude in flux. Phenomenological classification of variable sources will also be performed. All our results, together with new analysis tools, will be made available to the community in an easy-to-use form at the end of 2016, with prospects of extending the analysis to future data. EXTraS products will have a very broad range of applications, from the search for rare events to population studies, with a large impact in almost all fields of astrophysics. This will boost the scientific exploitation of XMM data and make EPIC the reference for time-domain astronomy in the soft X-rays. The EXTraS project (2014-2016), funded within the EU/FP7 framework, is carried out by a collaboration including INAF (Italy), IUSS (Italy), CNR/IMATI (Italy), University of Leicester (UK), MPE (Germany) and ECAP (Germany).

Long term Temporal and Spectral Evolution of Point Sources in Nearby Elliptical Galaxies

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We present the results of an archival study of all the point sources detected in the lines of sight of the elliptical galaxies NGC 4472, NGC 4552, NGC 4649, M32, Maffei 1, NGC 3379, IC 1101, M87, NGC 4477, NGC 4621, and NGC 5128, with both the Chandra and XMM-Newton observatories. Specifically, we studied the temporal and spectral evolution of these point sources over the course of the observations of the galaxies, mostly covering the 2000 - 2015 period. In this poster we present the first results of this study, which allows us to further constrain the X-ray source population in nearby elliptical galaxies and also better understand the nature of individual point sources.

A test of truncation in the accretion discs of X-ray Binaries.

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The truncated-disc model is generally used to help explain the change between the soft and hard states in X-ray Binaries, where the standard accretion disc is truncated in the inner regions and replaced by a radiatively inefficient accretion flow. There is still disagreement though in the extent of this truncation, particularly in at what point truncation begins. Here we analyze XMM EPIC-pn spectra in both the soft and hard states for a number of galactic XRBs, along with RGS data and the latest absorption and emission models to get an independent fit for the ISM column densities for each source. Specifically, we assume the 'canonical' model where the luminous accretion disc extends down to the innermost stable orbit at 6r_g, and construct a spectral model accounting for thermal, reflection and Compton processes ensuring consistent geometrical properties of the models. Rather than attempting to infer the inner disc location from spectral fitting and/or reflection models, we instead attempt a direct test of whether a consistent model will fit assuming no truncation. We discuss the implications for emission models of XRBs.

Glancing through the accretion column of EXO 2030+375

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The current generation of X-ray instruments is revealing more and more details about the complex magnetic field topology and the geometry of the accretion flows in highly magnetized accretion powered pulsars. We took advantage of the large collecting area and timing capabilities of the EPIC cameras to investigate the accretion geometry onto the magnetized neutron star in the high mass X-ray binary EXO 2030+375 during the rise of one of the source outburst. The X-ray luminosity was 2×10^{36} erg/s and the timing analysis revealed the presence of a narrow dip-like feature in its pulse profile that was never reported before. The width of this feature corresponds to about one hundredth of the neutron star spin period. From the results of the phase-resolved spectral analysis we suggest that this feature can be ascribed to the self-obscuration of the accretion stream passing in front of the observer line of sight. We inferred from Suzaku observation carried out in 2007 that the self-obscuration of the accretion stream might produce a significantly wider feature in the neutron star pulsed profile at higher luminosities ($>\sim 2\times10^{37}$ erg/s). The presence of such feature is so far unique among all known high mass X-ray binaries hosting strongly magnetized neutron stars.

Coronal geometry at low mass-accretion rates from XMM and NuSTAR spectra

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At very low Eddington luminosities the structure and physics of the accretion flow around a black hole are still debated, in particular in the inner most regions. By making sensitive measurements of the relativistic blurring of the X-ray reflection spectrum we investigate these physics, a task for which XMM-Newton, in combination with hard X-ray coverage provided by NuSTAR or Hitomi, is ideally suited and will continue to be unique for years to come. I will present results from XMM and NuSTAR observations of the radio-galaxy Cen A and of the X-ray binary GRS 1739-278 during the decline of its outburst. While Cen A shows a prominent iron line, the broad-band spectrum shows no evidence of reflection. This lack of reflection can best be explained by a jet origin of the hard X-rays or a significantly truncated accretion disk. The iron line can be self-consistently explained when assuming an optically thick torus surrounding the super-massive black-hole. The broad-band X-ray spectrum of GRS 1739-278 can be well described by a simple power-law or Comptonization continuum. A weak relativistic reflection model results in a small but significant improvement of the statistical quality of the fit. This relativistic model indicates a strongly truncated disk.

The soft X-ray spectrum of transient pulsars in the Small Magellanic Cloud

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The Small Magellanic Cloud is characterized by a high number of transient accreting pulsars, which can reach luminosities up to 10^{38} erg s^{-1} during their outbursts. Due to the low Galactic interstellar absorption in the SMC direction, these sources offer a unique opportunity to investigate the soft end of the X-ray spectrum in accreting pulsars. In the last two years we observed with XMM-Newton the large outburst of two of these transient pulsars (RX J0059.2-7138 and SMC X-2). Thanks to the high throughput and spectral resolution of XMM, these observations allowed us to investigate at an unprecedented level of detail their spectral and timing properties at soft X-ray energies. We found that both sources show a pulsed emission also at low energies, and that they are characterized by a thermal component which dominates the source spectrum below 0.5 keV; moreover, we discovered several emission and absorption features, which are very likely produced by photoionization of plasma located above the inner regions of the accretion disc.

Follow-up of isolated neutron star candidates from the eROSITA survey

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Peculiar groups of X-ray emitting isolated neutron stars (INSs), which include magnetars, the "Magnificent Seven", and central compact objects in supernova remnants, escape detection in standard pulsar surveys. Yet, they constitute a key element in understanding extreme phenomena unobserved in the normal pulsar population. So far, their use in population studies in the galactic scale has been hindered by their scarcity. The forthcoming eROSITA mission, which will survey the X-ray sky at unprecedented sensitivity, spectral and angular resolution, is therefore timely for a better sampling of INSs that are silent in the radio and gamma-ray regimes. Based on Monte Carlo simulations of a population synthesis model, we discuss strategies for pinpointing the most promising candidates for follow-up observing campaigns, in particular with XMM-Newton and Chandra, already for the years following the eROSITA survey.

A new approach to observe toroidal magnetic fields of magnetars

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Over the last decade, observational evidence has amounted that magnetars harbor enormous surface dipole magnetic fields (MFs) of $B_{\rm d} = 10^{14-15}$G. Theoretically, we expect even stronger toroidal MFs $B_{\rm t}$ (e.g., Takiwaki+2009), which is observationally supported by a discovery of low-$B_{\rm d}$ magnetars (e.g., SGR 0418+5729; Rea+2013). Here, we will present a new approach to access $B_{\rm t}$ more directly.

Suzaku allows us to simultaneously observe a soft thermal component and a distinct hard X-ray tail of magnetars. Extensively analyzing two magnetars, 4U 0142+61 and 1E 1547.0-5408, we found that their hard X-ray pulses suffered from slow phase modulations (Makishima+2014, 2015). This can be interpreted as a manifestation of free precession, under an axial deformation by $\sim$0.01%. If this effect is attributed to the magnetic stress, $B_{\rm t} \sim 10^{16}$ G is inferred.

We further found that, within 6 years observation of 4U 0142+61, the modulation periods remained constant, while the amplitude gradually increased from < 0.4 to $\sim$1.3 sec. These results suggest the shift of the hard X-ray emission region (or direction).

Leveraging High Resolution Spectra to Understand the Disk and Relativistic Iron Line of Cygnus X-1

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In April 2008 we conducted an observation of the black hole candidate Cygnus X-1 that was performed simultaneously with every X-ray and gamma-ray satellite flying at that time, including Chandra-HETG. The HETG spectra are crucial for modeling the ionized absorbtion from the "focused-wind" of the secondary, which is present and must be accounted for in all of our spectra. These features, however, are unresolved in the non-gratings instruments (e.g., RXTE, Suzaku, Swift, XMM-EPIC, INTEGRAL). Similarly, we must account for differences in spatial resolution. The X-ray scattering dust halo, which is usually ignored in most analyses, is spatially resolved in the Chandra and XMM-Newton spectra, but is unresolved in the other instruments. Thus one must account for dust scattering loss in the high spatial resolution spectra, and the scattering back into our line of site for the low resolution spectra. In this work, we attempt to arrive at a joint model for these spectra, and further comment on the cross calibration of each of the X-ray instruments participating in this campaign.

Hard-to-soft state transition of the Neutron Star LMXB Aquila X-1

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Low-Mass X-ray Binaries (LMXBs) involving neutron stars (NS) often make transitions between the hard and soft states. As long known, the soft-state spectra can be explained by a softer disk emission plus a harder blackbody from the NS. The hard state can be described by the same model incorporating stronger Comptonization (Sakurai +14, Ono +16). Then, how do the model parameters change across the state transitions?

We were lucky enough to catch Aquila X-1 with Suzaku during a hard-to-soft state transition which occurred on $\sim$50 ksec, and witnessed smooth evolution of the model parameters. Across the transition, the Comptonization weakened, with the coronal temperature decreasing from $\sim$13 to $\sim$3 keV. Meantime, the inner disk radius decreased from $\sim$30 to $\sim$20 km, and so did the blackbody radius from $\sim$10 km (the whole NS) to $\sim$5 km; the flow from the disk to the NS surface became gradually confined to the equator. Over certain phases of the transition, we also detected an enigmatic spectral excess feature at 50-100 keV, which could be related to the state transition.

XMM-Newton reveals extreme winds in ultraluminous X-ray sources

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Ultraluminous X-ray sources are extragalactic, off-nucleus, point sources with X-ray luminosities above 10^{39} erg/s, thought to be powered by accretion onto compact objects. Viable solutions include accretion onto neutron stars with strong magnetic fields, stellar-mass black holes at or in excess of the Eddington limit or intermediate-mass black holes. The lack of sufficient energy resolution in previous analyses has prevented an unambiguous identification of any emission or absorption lines in the X-ray band, thereby precluding a detailed analysis of the accretion flow. In this talk, I will show the discovery of rest-frame emission and blueshifted ($\sim$0.2c) absorption lines arising from highly ionized gas in the deep high-resolution XMM-Newton spectra of two ultraluminous X-ray sources. The blueshifted absorption lines occurs in a fast outflowing gas, whereas the emission lines originate in slow-moving gas around the source. The compact object is therefore surrounded by powerful winds with an outflow velocity of about 0.2c as predicted by models of hyper-accreting black holes. Further, deep, XMM-Newton observations will reveal powerful winds in many other ultraluminous X-ray sources and provide important hints to estimate the energetics of the wind, the geometry of the system, and the black hole masses.

The luminosity function of X-ray sources in dwarf galaxies

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We present the X-ray luminosity functions (XLF) of the four dwarf spheroidal galaxies Leo I, Draco, Ursa minor, and Ursa major II and the dwarf elliptical galaxy Phoenix based on *XMM-Newton* observations. We show that there is a correlation between the star formation histories and the populations of X-ray sources in these galaxies. The XLFs of the old dwarf spheroidal galaxies with no recent star formation (Draco, Ursa minor, and Ursa major II) are dominated by sources with low luminosities of $10^{32} - 10^{34}$ erg s^{-1}, which are most likely white-dwarf systems and faint low-mass X-ray binaries (LMXBs). The XLFs of Phoenix and Leo I on the other hand are indicative of the X-ray source population in dwarf galaxies before they completely leave their star-forming ages.

Peculiar Lapse of Periodic Eclipsing Event at Low Mass X-ray Binary GRS 1747−312

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GRS 1747−312 is an LMXB located at a distance of 9.5 kpc from the Earth. During its outbursts, periodic eclipses are known to occur. Observations for the outbursts were performed with Chandra (2004) and Swift (2013). XMM-Newton observed its quiescent state in 2004. In addition, when Suzaku observed it in 2009, GRS 1747−312 was in a low luminosity state. All of the observations except for XMM-Newton included the time of the eclipses predicted. During the Chandra observation, we found a clear flux decrease at the predicted time of the eclipse. During the Suzaku observation, however, there were no clear signs for the eclipses. After that, Swift observation detected an eclipse at the predicted time again. The temporary lapse of the eclipses can be explained by a scenario: direct X-rays from a neutron star and an accretion disk are perfectly blocked by thick material, while the scattered X-rays from an extended corona were barely seen. In this condition, direct emission from the central region that can be screened by the companion star cannot be seen. Then we see no flux change at the time of the eclipse. Our spectral analysis supports this scenario.

XMM-Newton and NuSTAR joint observation of the periodic Supergiant Fast X-ray Transient IGR J11215-5952

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IGRJ11215-5952 is the only Supergiant Fast X-ray Transient showing periodic outbursts (every 165 days, the orbital period of the system). The driving mechanism causing the transient X-ray emission in this sub-class of High Mass X-ray Binaries is still a matter of debate, after 10 years from the discovery of the class. To disentangle between magnetar-like neutron stars from models requiring more usual neutron star magnetic fields (1E12G), we observed the SFXT pulsar IGRJ11215-5952 with XMM-Newton coordinated with NuSTAR on 2016, February 14, during the expected peak of the outburst, for a net exposure time of 20 ks. The source was indeed caught in outburst (1E36 erg/s), with several bright flares repeating quasi-periodically with timescales of a few thousand seconds, spanning a dynamic range of two orders of magnitude. The overlapping observation with both XMM-Newton and NuSTAR enabled the study of the simultaneous broad band spectrum from 0.3 to 78 keV. The work is still in progress, given the extreme variability of the X-ray emission. X-ray pulsations were detected at 187.14 s, consistent with the last XMM-Newton observation, performed in 2007. We will discuss XMM+NuSTAR results in light of the different models proposed to explain the SFXTs behavior.

X-Ray Sources in the Dwarf Spheroidal Galaxy DRACO

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We present the results of a spectral analysis of X - ray sources in Draco, a nearby dwarf spheroidal galaxy recently observed by XMM-Newton. While most of the sources exhibit properties consistent with AGN, few of them possess characteristics of LMXBs and CVs. We also discuss the possibility of the existence of a central IMBH in Draco.

Across the Eddington limit: examining disk spectra at high accretion rates

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The faintest ultraluminous X-ray sources (ULXs; $1\text{–}3 \times 10^{39}$ ergs^{-1}) typically have X-ray spectra which are disc-like, but subtly broader than expected for standard thin accretion discs. These so-called broadened discs (BDs) are thought to represent accretion at around the Eddington rate on to stellar remnant black holes. Here we report results from a comparison of XMM-Newton EPIC and Swift XRT data from black hole binaries (BHBs) in the thermal dominant state, at moderate Eddington ratios, with a sample of BD ULXs. We find that the BHB spectra are similar in shape to the BD ULXs, and differ mainly in luminosity, by a factor of ~ 10. This result could imply that the BD ULXs are actually sub-Eddington, and therefore most likely contain massive stellar remnant (~ 100 solar mass) black holes, which must be at close to maximal spin. Else, some additional physical mechanism is missing from current accretion disc models, which can broaden the observed spectrum at moderate Eddington ratios.

X-ray Sources in the Magellanic Clouds: analysis of 15 Years of XMM-Newton and Chandra Observations

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Using $\sim$ 160 XMM-Newton, $\sim$ 180 Chandra, and all weekly RXTE observations, we have generated a comprehensive library of the known pulsars in the Small and Large Magellanic Clouds (SMC, LMC). We classify various pulsar properties in the range of $\log L_X = 32 - 38$ erg s^{-1} and incorporate related parameters in theoretical models. With the high time-resolution data of the EPIC and Chandra cameras and the latest calibration files and software, our 15 year pipeline generates a suite of useful products for each pulsar detection: event lists, high time-resolution light curves, periodograms, spectra, and complete histories of the $\dot{P}$, the pulse fraction, etc., in the broad, soft (0.2-2 keV), and hard (2-12 keV) energy bands. After combining the observations from these telescopes, we found that 15 pulsars are clearly spinning up and another 15 pulsars are distinctly spinning down. We also used the faintest and brightest sources to map out the propeller line and the Eddington line, respectively. We compared the observed pulse profiles to geometric models of X-ray emission in order to constrain the physical parameters of the pulsars. We are preparing a public release of this library so that it can be used by other groups as well.

Chapter 8

Compact Objects II: Supermassive black holes

Combined X-Ray and mm-Wave Observations of Radio Quiet Active Galaxies

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A connection between the X-ray and radio sources in radio quiet active galaxies (AGNs) will be demonstrated. High radio frequency, i.e., mm-wave observations are promising probes of the X-ray emitting inner regions of the accretion disks in radio quiet AGNs. An argument for simultaneous observations in X-rays and in mm waves will be made, in order to promote these as one of the future science goals of X-ray and AGN astronomy in the next decade. Preliminary results from an exploratory campaign with several space and ground based telescopes will be presented.

The symbiosis of variable absorption and blurred reflection in the X-ray-absorbed Seyfert 1.5 galaxy NGC 4151

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We present results on time resolved spectroscopy of the Seyfert 1.5 galaxy NGC 4151. Suzaku, NuSTAR and XMM-Newton observations from mid 2011 until the end of 2012 reveal significant variability in absorption by intermediately ionized gas on various time-scales. The soft X-rays, on the other hand, stay rather constant, favoring emission from large-scale, diffuse gas. The soft emission lines are consistent with high resolution spectroscopic studies of the extended emission resolved with Chandra gratings. We extend on recent work by Keck et al., who modeled relativistically blurred, reflected disk emission in a 150 ks Suzaku/NuSTAR observation from 2012. They explored multiple emitting/reflecting components in the context of the "lamppost" geometry. We perform additional testing of blurred disk reflection in NGC 4151, using Suzaku and XMM-Newton observations. We use the latest version of RELXILL, which incorporates a fully angle-resolved treatment of ionized reflection in combination with a thermal Comptonization continuum.

Magnified Views of Relativistic Outflows in Gravitationally Lensed Quasars

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We presents results from X-ray observations of relativistic outflows in lensed quasars. The lensing magnification of the observed objects provides high signal-to-noise X-ray spectra of quasars showing the absorption signatures of relativistic outflows at redshifts near a crucial phase of black hole growth and the peak of cosmic AGN activity. We summarise the properties of the wide-angle relativistic outflow of the $z = 1.51$ NAL quasar HS 0810 detected in recent deep XMM-Newton and Chandra observations of this object. We also present preliminary results from a mini-survey of gravitationally lensed mini-BAL quasars performed with XMM-Newton.

Unveiling the AGN activity in multiple SMBH systems: the remarkable case of SDSS J0959+1259

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In this talk we will present results from the MAGNA (Multiple AGN Activity) project focused on the detection and study of multiple supermassive BH systems. We aim at studying the physical properties of multiple AGN candidates in interacting/disturbed systems from both an observational and a theoretical point of view. The final goal is to understand the possible mechanisms that could relate the triggering of AGN activity with the different stages of galaxies mergers. The MAGNA project includes the study of several samples of dual AGN, extracted from different wavebands, supplied by an extensive set of multiwavelength observations granted to our team by MUSE, XMM, VLA as well as available in archives. This strategy allowed us to identify a galaxy compact group (CG SDSS J0959+1259) that appears exceptional having a high concentration of nuclear activity. We present here the multi-wavelength study of this CG through XMM, SDSS and BUSCA data. The XMM analysis extends and modifies the previous identification of the members of this group, which is composed of 3 Compton thin AGN, 2 LINERs and 3 star forming region.

Discovery of a fast transient outflow in the Seyfert 1 galaxy NGC 985

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Obscuration events in active galaxies are key to understand the physical conditions and the dynamics of the gas in the vicinity of their central super-massive black hole. Using recent joint observations with XMM-Newton and the Hubble Space Telescope of the nearby Seyfert 1 galaxy NGC 985, we have monitored the pass-by of obscuring material across our line of sight, traveling at 6000 km/s. This kind of event has been recorded previously in only a handful of cases. The properties of this transient absorber suggest that it may originate very close to the broad line region, possibly in an accretion disk wind.

Moreover, by analyzing past archival observations of NGC 985, we found evidence that this obscuration process is recurrent. The analysis of the RGS spectra of this source at different epochs reveals that some of the components of the persistent warm absorber vary in response to the changes in the ionizing flux caused by this transient obscurer. In this way, we are able to derive stringent upper limits on the location of the warm absorber.

Black Hole Spin Measurements in Lamp Post Geometry

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We analyze a sample of high signal-to-noise spectra from the XMM and NuStar archives based on the sample of bare AGN introduced by Walton et al. (2012). The relativistically blurred reflection off an ionized accretion disk is modelled using the angle resolved RELXILL code, which also allows to describe the irradiation of the disk in a lamp post geometry. By combining this advanced reflection model with Suzaku and joint XMM and NuSTAR observations, both outstanding in signal-to-noise and spectral coverage, we can put tight constraints on the spin parameter and we are able to constrain the height of the primary photon source in the lamp post geometry.

XMM-Newton reveals matter accreting onto the central supermassive black hole of NGC 2617

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NGC 2617 (z=0.042) underwent a strong broad-band outburst during 2013/14, concurrently switching from being a Seyfert 1.8 to be a Seyfert 1.0 sometimes during the previous 10 years. Thanks to the combination of the large effective area and the good spectral resolution of the EPIC-pn onboard XMM-Newton, striking insights about the very inner accretion flow of this AGN have been revealed. In particular, persistent Fe K absorption redshifted by ∼35,000 km/s was solidly detected in two observations spaced by one month: a highly ionised flow of mass toward the central supermassive black hole of NGC 2617 has started to be traced. So far NGC 2617 is a quasi-unique observational example: what are the perspectives of enlarging these studies in the future? Thanks to current large and prolonged optical surveys like the SDSS/BOSS, many optically changing-look AGN" like NGC 2617 are being discovered month after month: XMM-Newton has the ideal instruments to perform a proper X-ray study of such objects in the near future. I will assess the impact of XMM-Newton on studying the dynamics of the inner accretion flow in AGN in a systematic way and in synergy with near- and mid-future X-ray instruments such as (ASTRO-H)Hitomi and ATHENA.

A benchmark study of Active Galactic Nuclei: Decoupling luminosity and evolution in the SEDs of AGN

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AGN activity is now widely believed to be an important phase in the evolution of every massive galaxy in the Universe. However, the picture is still not clear, with investigations at different wavelengths producing many differences of opinion as to the amount of radiation that is absorbed and reprocessed by dust, how this is related to the host galaxy and whether the triggering mechanism behind the AGN activity is also responsible for star formation.

A drawback of previous surveys is that they are fundamentally limited by the degeneracy between redshift and luminosity in flux-density limited samples. We have constructed well-defined samples of radio-quiet and radio-loud quasars, along with radio galaxies. These samples are defined to span a factor of > 100 in optical and radio luminosity at a single cosmic epoch (z∼1.0). Combining multi-wavelength observations (e.g. XMM-Newton, Spitzer, Herschel, SDSS, VLA), we aim to create a detailed picture of how the SEDs of AGN change as a function of luminosity, orientation and radio-loudness which is crucial for improving our understanding of virtually all aspects of the AGN phenomenon. This will also provide a benchmark sample from which other AGN surveys will benefit, in particular when computing bolometric luminosities and accretion rates.

Determination of the coronal properties of a very luminous quasar at z=1.77

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We present an analysis of the joint XMM-Newton and NuSTAR observations of the extremely luminous ($L_X > 10^{46}$ erg/s) radio-quiet quasar QSO B2202-209, at redshift z = 1.77. At this redshift, the shift of the high-energy cutoff in the observer frame compensates for the relative faintness of the source, allowing an estimate of the coronal temperature analogous to the ones done for local, low luminosity but very bright AGN. Assuming a Comptonisation model, we estimated the coronal temperature to be $kT_e = 130^{+7.9}_{-7.4}$ keV and $kT_e = 136^{+8.4}_{-8.7}$ keV for a spherical and a slab geometry, respectively. The coronal temperature is comparable to the ones derived for local AGN, despite a difference of more than two orders of magnitude in X-ray luminosity and black hole mass.

Variability of the soft X-ray excess in IRAS 13224–3809

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We study the soft excess variability of the narrow line Seyfert 1 galaxy IRAS 13224–3809. We applied the 'flux–flux plot' (FFP) method to the five archival XMM-Newton observations. We found that the FFPs are highly affected by the choice of the light curves' time bin size, due to the fast and large amplitude variations, and the intrinsic non-linear flux–flux relations in this source. We constructed FFPs in 11 energy bands below 1.7 keV, and considered the 1.7–3 keV band, as representative of the primary emission. The FFPs are well fitted by a 'power-law plus a constant' model. The constants are positive in three out of five observations, consistent with zero in one observation, and negative below 1 keV in another. The best-fit slopes are flatter than unity at energies below ~ 0.9 keV, suggesting the presence of intrinsic spectral variability. A power-law-like primary component, variable in flux and spectral slope ($\Gamma \propto N_{\rm PL}^{0.1}$) and a soft-excess component, varying with the primary continuum ($F_{\rm excess} \propto F_{\rm primary}^{0.46}$), can explain the FFPs. In fact, this can create positive 'constants', even when a stable spectral component does not exist. The negative and null constants, unexplainable by spectral variability, may signify the presence of an intrinsic variable, warm absorber.

X-ray Spectral / Timing Analysis of PG 1211+143 with XMM-Newton and NuSTAR

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I will summarise some of the important spectral/timing results of a deep 630ks XMM-Newton observation of the QSO PG1211+143 - the archetypal source for ultra-fast outflows. In this long observation, in addition to confirming the presence a highly-ionized, high-velocity component of the wind (v = 0.14c), we find well-correlated X-ray variations across the XMM-Newton bandpass, exhibiting strong frequency- and energy-dependence. We confirm the presence of the high-frequency soft lag (1e-4Hz) and, for the first time, detect a significant hard lag in this source, extending down to frequencies of 1e-5Hz (typical time delay = 3ks). We find that the hard lag displays the log-linear energy dependence typical of X-ray binary systems, although it also displays peculiar variability between orbits. Additionally, I will present the power spectrum / rms spectra and also discuss the results of our search for optical/UV/X-ray correlations in the context of disc reprocessing. Finally, I will present the results of a simultaneous NuSTAR observation. Here, we find much tighter constraints on the continuum when performing a dual fit than we do from fitting NuSTAR alone. This will be discussed in terms of relativistic reflection models and I will use this to emphasise the power of simultaneous XMM-Newton+NuSTAR observations.

The curious case of the ultra fast wind in IRAS17020+4544: perspectives for the next decade

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Outflowing winds from AGN may carry significant amount of mass and energy out to their host galaxies. I will present recent results on the newly discovered ultra fast outflow observed in the Seyfert 1 Galaxy IRAS17020+4544 by XMM-Newton. The exquisite data quality collected by the RGS instrument allowed us to detect a complex structure of the wind: for the first time, we could identify five components with different outflow velocities (in the range 0.08-0.11c) and distinct (moderate) ionization states. One of the outflow components may carry sufficient energy to substantially suppress star formation, and heat the gas in the host galaxy making IRAS17020+4544 a very interesting case for feedback by a moderately luminous Active Nucleus hosted in a spiral galaxy. This result comes after 15 years of XMM observations and it poses several open questions. Are moderate ionization X-ray ultra-fast winds so infrequent in AGN? What mechanism gives rise to the stratified structure of the wind? Is feedback from a spiral Galaxy truly unusual? How can we detect more winds of this type in the next decade? These and more questions will be reviewed and discussed in my presentation.

Spectro-temporal diagnostics to evaluate physical structure around the AGN

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X-ray energy spectra from the AGN exhibit a lot of emission/absorption lines, which have been studied in detail by grating devices such as RGS on XMM-Newton. Variability of these spectral lines is considered to reflect physical conditions of the line emitting/absorbing matter. Thus, we study root-mean-square (RMS) spectra of several AGN observed with RGS to diagnose physical structures around these AGN. As a result, we have found clear peaks/dips in the RMS spectrum of NGC 4051, which can be modeled with variable absorption lines and non-variable emission lines. Several absorbers with different ionization states are required, where a lower-ionized ($\log \xi = 1.5$) absorber shows larger variability and a higher-ionized ($\log \xi = 2.5$) absorber shows little variability. These results directly give hints on physical structure around the AGN. We also show simulated RMS spectra of several AGN with Hitomi SXS, which is a more powerful diagnostic tool than RGS.

On the Origin of the Soft X-ray excess in radio quiet AGN

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Known since the 80s, the origin of the soft X-ray (< 2 keV) emission in excess to the high energy (2-10 keV) power law extrapolation, the so-called soft X-ray excess, is still highly debated. Two models are commonly discussed: relativistically blurred ionized reflection or thermal comptonisation. In some objects the observation of UV-soft X-ray correlation and the absence of clear signature of relativistic broadening, suggests comptonization as the dominant process. We successfully tested this hypothesis during the 2009 broad band monitoring campaign of Mkn 509. The deduced properties of the comptonizing plasma suggest a warm ($\sim$1 keV), moderately thick (tau$\sim$10-20) corona covering a large part of the accretion disk. Interestingly, the disc-corona energetics agree with a passive accretion disc, most of the accretion power being released in the warm corona. In this talk I will present the results obtained applying the same method to a sample of objects selected to have: a) 3 XMM observations b) at least 3 OM filters in use and c) a low (<1.e22 cm-2) neutral absorption. They all agree with a powerful warm corona above a passive or almost passive accretion disk. I will discuss the methodology and the important implications of the results.

XMM-Newton, powerful AGN winds and galaxy feedback

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The discovery that ultra-fast ionized winds - sufficiently powerful to disrupt growth of the host galaxy - are a common feature of luminous AGN is major scientific breakthrough led by XMM-Newton. An extended observation in 2014 of the prototype UFO, PG1211+143, has revealed an unusually complex outflow, with distinct and persisting velocities detected in both hard and soft X-ray spectra. While the general properties of UFOs are consistent with being launched - at the local escape velocity - from the inner disc where the accretion rate is modestly super-Eddington (King and Pounds, Ann Rev Astron Astro- phys 2015), these more complex flows have raised questions about the outflow geometry and the importance of shocks and enhanced cooling. XMM-Newton seems likely to remain the best Observatory to study UFOs prior to Athena, and further extended observations, of PG1211+143 and other bright AGN, have the exciting potential to establish the typical wind dynamics, while providing new insights on the accretion geometry and continuum source structure. An emphasis on such large, coordinated observing programmes with XMM-Newton over the next decade will continue the successful philosophy pioneered by EXOSAT, while helping to inform the optimum planning for Athena

AGN spectral states from simultaneous UV and X-ray observations by XMM-Newton

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The accretion on super-massive black holes is believed to be similar to the accretion on stellar-mass black holes. It has been suggested by Koerding et al. (2006) and Sobolewska et al. (2008) that different types of Active Galactic Nuclei (AGN) correspond to different spectral states of X-Ray Binaries. We extend previous works by comparing strictly simultaneous UV and X-ray measurements of AGN obtained by the XMM-Newton satellite. The thermal disc component is estimated from the UV flux while the non-thermal flux is constrained from the 2-10 keV X-ray luminosity. For sources with available radio-flux measurements, we investigate how the spectral hardness is related to their radio power, radio spectral slope and morphology. Our results suggest that the AGN may spectrally evolve in a similar way as X-ray binaries, however, several problems still remain unclear.

Can supermassive black holes influence the evolution of their host galaxies?

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Powerful winds driven by active galactic nuclei (AGN) are often invoked to play a fundamental role in the evolution of both supermassive black holes (SMBHs) and their host galaxies, quenching star formation and explaining the tight SMBH-galaxy relations. A strong support of this "quasar mode" feedback came from the recent X-ray observation of a mildly relativistic accretion disk wind in an ultraluminous infrared galaxy and its connection with a large-scale molecular outflow observed in the IR with Herschel, suggesting a direct link between the SMBH and the gas out of which stars form. Spectroscopic observations, especially in the X-ray band, suggest that such accretion disk winds may be common in local AGN and quasars. However, their origin and characteristics are still not fully understood. Detailed theoretical models and simulations focused on radiation, magnetohydrodynamic (MHD) or a combination of these two processes, to investigate the possible acceleration mechanisms and dynamics of these winds. XMM-Newton provided a fundamental contribution to these studies and it will still provide the highest effective area in the critical Fe K band of the spectrum until the launch of Athena. Very important improvements are expected from the high energy resolution of the Hitomi X-ray Observatory.

Measuring the Innermost Stable Circular Orbits of Supermassive Black Holes

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We present a promising new technique (g-distribution method) for measuring the innermost stable circular orbit (ISCO), the inclination angle (i), and the spin of a supermassive black hole. The g-distribution method involves measurements of the distribution of the energy shifts of the relativistic iron line emitted from the accretion disk of a supermassive black hole that is microlensed by stars in a foreground galaxy and a comparison of the measured g-distribution with microlensing caustic simulations. The method has been applied to the gravitationally lensed quasars RX J1131−1231 ($z_s = 0.658$, $z_l = 0.295$), QJ 0158-4325 ($z_s = 1.29$, $z_l = 0.317$), and SDSS 1004+4112 ($z_s = 1.73$, $z_l = 0.68$). For RX J1131−1231 our initial results indicate an ISCO radius of < 5 gravitational radii and $i < 65$ degrees. Further monitoring of lensed quasars will provide tighter constraints on their inclination angles, ISCO radii, and spins.

Chapter 9

The time domain

BLike: a Library for Background Subtraction at Low Statistics

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It is often the case, at least in X-ray astronomy, that both signal and background estimates must be taken in a Poisson-dominated regime. I will present a Bayesian approach to signal estimation and background subtraction in the low counts regime, with a few examples from XMM-Newton. Starting from very simple and natural priors it is possible to infer a posterior probability distribution for the source flux. BLike is a library that offers a simple python API for working with these profiles, displaying light curves or spectra, including detections and upper limits, and fitting models to the data. BLike is used within the EXTraS ("Exploring the X-ray Transient and variable Sky") project, from which the test cases I will show are drawn. Its code and documentation will be released to the community in 2017, and will be available to the user through the next decade.

Highlighting XMM-Newton's Role in Time Domain Studies of Neutron Star and Black Hole X-ray binaries in Nearby Galaxies

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XMM-Newton's combination of large effective area, superior event timing, and wide field imaging have provided a powerful capability for time-domain studies of nearby X-ray binary populations. In its first 15 years XMM has accomplished groundbreaking monitoring surveys for X-ray binaries; complemented by RXTE, Chandra, and Nustar. Over the next decade XMMs capabilities will complement a new generation of missions including Astrosat, Hitomi, and NICER. This paper highlights the role of XMM-Newton in combination with other missions, in exploring the HMXB populations of the Small Magellanic Cloud and IC 10. Both are nearby dwarf starburst galaxies, yet their ages and evolutionary scenarios are very different, the consequences of which have led to contrasting X-ray binary populations. In the SMC the definitive sample of X-ray binary pulsars assembled by RXTE is revealing fundamental accretion physics when probed by XMM. Finding and characterizing IC 10s youthful X-ray binaries required the combination of XMM together with Chandra and Nustar. Key results include the revelatory finding of an X-ray irradiated wind masking the mass-function in the WR+BH binary X-1 and the measurement of the BH's spin. Such studies have wide relevance to stellar/galactic evolution, implications for black hole masses and formation channels for BH+BH binaries.

A novel approach to model EPIC variable background

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In the past years XMM-Newton revolutionized our way to look at the X-ray sky. With more than 200 Ms of exposure, it allowed for numerous discoveries in every field of astronomy. Unfortunately, about 35% of the observing time is badly affected by soft proton flares, with background increasing by orders of magnitudes hampering any classical analysis of field sources. One of the main aim of the EXTraS (Exploring the X-ray Transient and variable Sky) project is to characterise the variability of XMM-Newton sources within each single observation, including periods of high background. This posed severe challenges. I will describe a novel approach that we implemented within the EXTraS project to produce background-subtracted light curves, that allows to treat the case of very faint sources and very large proton flares. EXTraS light curves will be soon released to the community, together with new tools that will allow the user to reproduce EXTraS results, as well as to extend a similar analysis to future data. Results of this work (including an unprecedented characterisation of the soft proton phenomenon and instrument response) will also serve as a reference for future missions and will be particularly relevant for the Athena observatory.

The EXTraS project: Automated source classification of new transient sources

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The EXTraS project explores the entire XMM-Newton EPIC database in the time domain by systematically analysing short and long term variability and periodicity of X-ray sources. An important objective of this study is the phenomenological characterization and automated classification of all detected variable sources. We present the preliminary results of the automated classification chain of new X-ray transients based on the 3XMM-DR4 catalogue, which serves as a training sample. Besides a phenomenological characterization of the X-ray spectra we performed a multiwavelength counterpart search to compile broadband spectra for further classification. At the beginning of 2017 the EXTraS project will deliver all software/pipelines to the community, providing a tool to extend the catalogs and characterize new X-ray sources.

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

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The EXTraS project (Exploring the X-ray transient and variable sky) is an EU/FP7-Cooperation Space framework programme that aims to bring together a diverse set of time-domain analyses of XMM-Newton X-ray data and make them available to the public in a coherent manner. Through a combination of pointed observations and slew scans, XMM-Newton has repeatedly observed many regions of the sky, in a few cases up to ∼50 times, ∼70000 sources being observed more than once. While non-uniformly spaced and often sparse, these snapshots provide scientifically valuable information on the photometric behaviour of sources on longer term (hours to ∼ a decade) timescales. Here we describe the collation of XMM-Newton data for long-term variability from the 3XMM-DR5 catalogue, the slew survey and upper-limit information from the associated XMM-Newton products, and the analysis being performed on the ensuing light curves. We also present emerging examples of some newly identified long-term variable sources to highlight the value of this element of the EXTraS project. These longer baseline light curves can (i) unveil variable sources that appear stable in individual observations, (ii) reveal exotic and transient sources and (iii) complement short-term variability information from elsewhere in the EXTraS project by probing slower physical phenomena.

Characterizing the Aperiodic Variability of 3XMM Sources using Bayesian Blocks

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I will present Bayesian blocks algorithm and its application to XMM sources, statistical properties of the entire 3XMM sample, and a few interesting cases. While XMM-Newton is the best suited instrument for the characterization of X-ray source variability, its most recent catalogue (3XMM) reports light curves only for the brightest ones and excludes from its analysis periods of background flares. One aim of the EXTraS ("Exploring the X-ray Transient and variable Sky") project is the characterization of aperiodic variability of as many 3XMM sources as possible on a time scale shorter than the XMM observation. We adapted the original Bayesian blocks algorithm to account for background contamination, including soft proton flares. In addition, we characterized the short-term aperiodic variability performing a number of statistical tests on all the Bayesian blocks light curves. The EXTraS catalogue and products will be released to the community in 2017, together with tools that will allow the user to replicate EXTraS results and extend them through the next decade.

Searching for the most elusive X-ray transients with XMM-Newton

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Thanks to its unprecedented grasp in the 0.2-12 keV range and more than 16 years of operations, XMM-Newton EPIC is the best instrument to discover X-ray transient sources on timescales shorter than a few hours. However, many transients are missed by standard analysis procedures either because they are buried in the background of the full observation or because they occurred in high particle background time intervals. In the framework of EXTraS, an EU funded project aimed at the full exploitation of the EPIC data in the time domain, we developed a software pipeline to perform time-resolved source detection of EPIC archival data, leading us to the discovery of many new transient sources. After the software optimization and a careful screening of the results, the full transient catalogue and the software tools necessary to extend this search to forthcoming data will be made publicly available through an interactive archive and a science gateway, respectively. I will present the most interesting scientific cases we have already identified, ranging from flares of young stellar objects to extragalactic transients, their impact on our understanding of transient phenomena and the prospects for extending this analysis until the end of the XMM-Newton mission.

Chapter 10

Diffuse emission I: SNRs, WHIM

A Detailed Spatial Study of X-ray Properties in Superbubble 30 Dor C with XMM-Newton

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The superbubbles (SBs) are thought to be powered by the fast stellar winds and supernova explosions in OB associations. 30 Dor C is a SB with strong non-thermal X-ray emission (e.g. Bamba et al. 2004). Recently, very-high-energy γ-rays are detected toward the northwest shell of 30 Dor C and hense cosmic-ray protons and/or electrons are efficiently accelerated up to 10 TeV (H.E.S.S Collaboration et al. 2015). 30 Dor C is one of the best targets for study of the CRs acceleration. In this work, we investigated X-ray spectral properties of the SB with a high spatial resolution of ∼10 pc using available XMM-Newton observation data. Even with this spatial resolution, thermal emission was found only in the east regions. In contrast, the spectra in the west regions can be described with an absorbed non-thermal model without the thermal emission. We also found that the photon index and 2-10 keV intensity of non-thermal emission show variations of 2.0-3.5 and (0.6-8.0)$\times 10^7$ erg s^{-1} cm^{-2} str^{-1}, respectively. The results are possibly caused by the spatial variation of the CRs acceleration efficiency and/or the circumstellar environment. In my presentation, we discuss the origin of thermal components in the east regions and the CRs acceleration.

Tycho: ambient medium structure by analysis of the supernova remnant

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The radio (VLA) and X-ray (Chandra) maps of the remnant of the Tycho supernova (SN1572) are used to study the interstellar medium (ISM) density and magnetic field gradients in the ambient medium surrounding the remnant. The analysis uses also the GeV gamma-ray spectrum derived from the recent Fermi data, the radio fluxes from different radio instruments, X-ray spectrum from Suzaku and TeV gamma-ray spectrum from VERITAS. The inferred orientation of ISM density gradient is verified by comparing it to the VLA maps of interstellar medium surrounding the remnant, while the revealed orientation of the magnetic field gradient is checked by measurements of the magnetic field strength in a number of local regions around the shock. The two approaches are applied in order to estimate the magnetic field strength, involving analysis of the temporal variations of the X-ray synchrotron radiation from the shock and modeling the radial X-ray external shock profiles. As a result we reveal that the magnetic field gradient in vicinity of Tycho is almost parallel to the Galactic plane while the interstellar plasma density gradient is almost perpendicular to it. One should note that different approaches adopted in this study lead to fully compatible results.

The thermal and non-thermal X-rays in the young shell-like SNR RCW 86: the key role of the dense interstellar gas

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RCW 86 is a young (∼1800 yrs) TeV γ-ray shell-like SNR which emits both thermal and non-thermal X-rays. The thermal X-rays are unique since the other three known TeV γ-ray SNRs [RX J1713.7−3946, RX J0852−4622, and HESS J1731−347] emit only non-thermal X-rays. We have made a detailed study of the interstellar gas in CO(J = 2–1, 1–0) and HI emissions and have identified for the first time the associated neutral gas over a density regime of 10–10^4 cm^{-3}. The gas distribution shows a cavity coinciding with the X-ray shell. A detailed comparison reveals that the thermal X-rays are located toward clear density enhancements of HI while the non-thermal X-rays are located in lower density HI gas. The thermal X-rays are likely due to the shock heated HI gas of density ∼10 cm^{-3} in the cavity created by the accretion wind of a possible SN progenitor white dwarf. We argue that the non-thermal X-rays are emitted by the accelerated CR electrons via DSA whereas part of the non-thermal X-rays are likely enhanced by the shock-cloud interaction with the dense HI gas in the southwestern part of the shell.

Investigating the galactic Supernova Remnant Kes 78 with XMM-Newton

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The galactic supernova remnant Kes 78 is associated with a HESS gamma-ray source and its X-ray emission has been recently revealed by Suzaku observations which have found indications for a hard X-ray component in the spectra. We analyzed an XMM-Newton EPIC observation of Kes 78 and studied the spatial distribution of the physical and chemical properties of the X-ray emitting plasma. The EPIC data unveiled a very complex morphology for the soft X-ray emission. We performed image analysis and spatially resolved spectral analysis finding indications for the interaction of the remnant with a local molecular cloud. Finally, we investigated the origin of the hard X-ray emitting component.

Searching for X-ray emission from the large-scale structure filaments between clusters

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One of the remaining issues in cosmology is the missing baryon problem. The problem is that about half of baryons have not yet been detected observationally in the local Universe. Numerical hydrodynamic simulations predict that ~30-40 % of the total baryons resides in the filaments between clusters of galaxies in the present epoch with physical properties of a temperature of 10^{5-7} K and a density of 10^{-6} - 10^{-4} cm^{-3} as the so called warm-hot intergalactic medium (WHIM). Therefore to constrain the physical characteristics of the WHIM observationally is very important in terms of our understanding of the evolution of baryons in the Universe. To investigate its physical parameters of the WHIM associated with a pair of clusters, we searched cluster catalogues based on SDSS and ROSAT All Sky Survey. We picked up a cluster pair with small enough angular separation and finally observed them deeply with XMM (>150 ks). We found one of the pair possesses complex morphology elongating to another with a temperature of ~3.5 keV. Even though a clear excess component in the surface brightness profile between the pair was not observed, we investigated the hot gas properties connecting the two clusters.

Modeling post-explosion anisotropies of ejecta in SNR Cassiopeia A

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

X-ray observations of Galactic H.E.S.S. sources: an update

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X-ray diagnostics of TeV sources continues to be an important tool to identify the nature of newly detected sources as well as to pinpoint the physics processes that are at work in these highly energetic objects. The contribution aims at giving a review of recent studies that we have performed on TeV sources with H.E.S.S. and XMM-Newton and also other X-ray facilities. Here, we will mainly focus on Galactic objects such as gamma-ray binaries, pulsar wind nebulae, and supernova remnants (SNRs). Particular emphasis will be given to SNR studies, including recently identified SNRs such as HESS J1731-347 and HESS J1534-571 as well as a revisit of RX J1713.7-3946.

Detailed studies of shock-cloud interaction toward the young supernova remnants

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In young supernova remnants (SNRs; ∼2000 yrs), the study of the interaction between the shock waves and the inhomogeneous interstellar gas is a key element in understanding the SNR evolution, cosmic-ray acceleration, and multi-wavelength emission. In particular, TeV γ-ray and synchrotron X-ray bright SNRs, RX J1713.7−3946, RX J0852.0−4622, and N132D have been considered good candidates for an efficient cosmic-ray accelerator via shock-cloud interaction (Sano et al. 2013, 2015a; Fukui 2013). In RXJ1713, we performed imaging and spectral analysis of the *Suzaku* X-rays and compared it with the interstellar gas distribution (Sano et al. 2013; 2015b). The shock interaction with dense gas clumps enhances turbulence and magnetic fields up to mG around the clumps, which was observed as limb-brightening of the synchrotron X-rays and hard spectra with photon indexes of less than 2.4. Moreover, turbulence and magnetic field amplifications may promote an additional acceleration of cosmic-ray electrons. In contrast, the synchrotron X-rays also become bright toward diffuse gas regions due to the high shock velocity. In this talk, we introduce the recent results of shock-cloud interaction toward RX J1713.7−3946, RX J0852.0−4622, and N132D using the *Suzaku*, *XMM-Newton*, *Chandra* X-rays, and interstellar gas datasets.

Chapter 11

Diffuse emission II: Large-scale outflows, Clusters of Galaxies

Towards combined analysis of the most distant massive galaxy clusters with XMM and Chandra

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We present a detailed study of the gas and dark matter properties of the 5 most massive and distant, $z \sim 1$, clusters detected via the Sunyaev-Zel'Dovich effect. These massive objects represent an ideal laboratory to test our models of structure evolution in a mass regime driven mainly by gravity. This work presents a new method to study these objects, where informations coming from XMM-Newton and Chandra instruments are efficiently combined. The combination of Chandra fine spatial resolution and XMM-Newton effective area allows us to efficiently investigate the properties of the Intra Cluster medium in the core and probe cluster outskirts. The resulting combined density profiles are used to fully characterize the thermodynamic and physical properties of the gas. Evolution properties are investigated from comparison with the REXCESS local galaxy cluster sample. In the context of the joint analysis of future Chandra and XMM large programs, we discuss the current limitations of this method and future prospects.

Quenching the X-ray spectrum of hot halos with AGN outflows and turbulence

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I highlight recent advancements in the astrophysics of AGN outflow feedback and diffuse hot gas. Thanks to XMM RGS resolution, we know that the X-ray cores of clusters, groups, and massive galaxies have a strong deficit of soft X-ray emission compared with the classic cooling flow prediction: $dL_{\rm x}/dT \propto (T/T_{\rm hot})^{2\pm1}$. Using 3D hydrodynamic simulations, I show that such deficit arises from the tight self-regulation between thermal instability condensation and AGN outflow feedback. Multiphase filaments condense out of the hot plasma, they rain onto the central SMBH, and boost the AGN outflows via chaotic cold accretion. The sub-relativistic outflows thermalize in the core via shocks and turbulence, releasing more heat in the inner cooler phase, thus inducing the observed soft X-ray decline. I discuss how we can leverage XMM capabilities in the next decade by probing turbulence, conduction, AGN accretion and outflows via the information contained in X-ray spectra and surface brightness. I focus on the importance of selecting a few objects with Ms exposure and how we can unveil multiphase halos through the synergy between simulations and multiwavelength observations.

The XMM view of the outskirts of galaxy groups

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I will present the results of XMM observations on the outskirts of the bright galaxy group NGC 5044 addressing mass, entropy and metal abundances. I will discuss the results that XMM can achieve by exploring the outskirts of groups providing a complementary and fundamental piece of informations to the scenario emerging for the more massive clusters of galaxies.

A metal-rich elongated structure in the core of the group

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Based on XMM-Newton, Chandra, and optical DR10-SDSS data, we investigate the metal enrichment history of the group NGC4325. To complete the analysis we used chemical evolution models and studied the optical spectrum of the central dominant galaxy through its stellar population analysis to analyse its role in the metal enrichment of the IGM. While the temperature, pseudo-pressure, and pseudo-entropy maps showed no inhomogeneities, the iron spatial distribution shows a filamentary structure in the core of this group, which is spatially correlated with the central galaxy, suggesting a connection between the two. The analysis of the optical spectrum of the central galaxy showed no contribution by any recent AGN activity. Our results suggest that oxygen has been produced in the early stages of the group formation, becoming well mixed and leading to an almost flat profile. Instead, the iron distribution is centrally peaked, indicating that this element is still being added to the IGM specifically in the core by the SNIa. A possible scenario to explain the elongated metal-rich structure in the core of the NGC4325 is a past AGN activity, in which our results suggest an episode older than $\sim 10^7 - 10^8$ yrs and younger than 5×10^8 yrs.

Characterizing Planck SZ detected clusters with X-ray observations

Lorenzo Lovisari[1], William Forman[1], Christine Jones[1], Ralph Kraft[1], Scott Randall[1], Felipe Santos[1]
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Galaxy clusters are a powerful tool to constrain cosmological parameters. An accurate knowledge of the scaling relations between X-ray observables and cluster mass is a crucial step because it will enable us to compare the theoretical predictions with the real data and with the cosmological models. A complete sample is required for any meaningful study of the scaling properties, otherwise potentially important biases (e.g. Malmquist bias, cool-core and merger fractions) cannot be corrected. The Planck mission provided a nearly complete mass-limited sample of clusters of galaxies. From XMM-Newton and/or Chandra observations of the 165 Planck ESZ clusters at z <0.35, we derived the total mass, gas mass, X-ray luminosity, temperature, and morphology of each cluster. We will show how the cluster properties and morphologies differ for X-ray and SZ selected samples. In particular we will show that the Planck sample has a smaller fraction of cool-core clusters than X-ray selected samples. We will show the derived X-ray scaling relations for the Planck SZ selected sample. Finally, we will show the preliminary results of the cluster mass function.

Chemical enrichment in the hot intra-cluster medium seen with ***XMM-Newton*/EPIC**

François Mernier[1,2], Jelle de Plaa[1], Ciro Pinto[3], Jelle Kaastra[1,2], Peter Kosec[3], Yu-Ying Zhang[4], Junjie Mao[1,2], Norbert Werner[5,6]
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The intra-cluster medium (ICM), permeating the large gravitational potential well of galaxy clusters and groups, is rich in metals, which can be detected *via* their emission lines in the soft X-ray band. These heavy elements (typically from O to Ni) have been synthesized by Type Ia (SNIa) and core-collapse (SNcc) supernovae within the galaxy members, and continuously enrich the ICM since the cosmic star formation peak ($z \simeq 2$–3). Because the predicted chemical yields of supernovae depend on either their explosion mechanisms (SNIa) or the initial mass and metallicity of their progenitors (SNcc), measuring the abundances in the ICM can help to constrain supernovae models. In this study, we use *XMM-Newton*/EPIC to measure the abundances of 9 elements (Mg, Si, S, Ar, Ca, Cr, Mn, Fe and Ni) in a sample of 44 cool-core galaxy clusters, groups and ellipticals (the CHEERS catalog). Combining these results with the O and Ne abundances measured using RGS, we establish an average X/Fe abundance pattern in the ICM, and we determine the best-fit SNIa and SNcc models, as well as the relative fraction of SNIa/SNcc responsible for the enrichment.

EPIC 2.0: a second youth for XMM-Newton's workhorse.

Silvano Molendi[1]
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While much has been achieved with the EPIC experiment on board XMM-Newton, in several areas, we can get even more. In this presentation I will discuss results we have recently obtained, including those from an "all archive" analysis of the EPIC background. I will show how these, along with others, can be used to improve measures of diffuse low surface brightness sources. I will also illustrate how the work we are doing on EPIC is contributing to the design of experiments on the next Large European X-ray mission: Athena.

Mass-to-Light-Ratios of the galaxy clusters and groups observed with Suzaku

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We analyzed 15 nearby ($z < 0.06$) clusters and groups observed with Suzaku out to $\sim 2\, r_{500}$. We derived Fe abundance profiles in the ICM, electron density, cumulative gas mass and Fe mass. We also collected K-band luminosities of galaxies and calculated the ratio of the cumulative gas mass and Fe mass in the ICM to the K-band luminosity (gas-mass-to-light ratio and iron-mass-to-light ratio, respectively). The Coma, Perseus, and medium systems have relatively flat radial profiles of the metal abundances at 0.3 solar within 0.5–1 r_{500}, and ~ 0.2 solar beyond r_{500}. The gas-mass-to-light-ratios and iron-mass-to-light-ratios ratios increase with radius out to r_{500} and become flatter beyond the radius. The weighted average of the iron-mass-to-light ratios of the clusters at 1.6 r_{500} agrees with the expectation with the Salpeter initial-mass-function of stars, and we do not need a top-heavy slope. In contrast, groups and poor clusters have lower gas-mass-to-light ratios and lower iron-mass-to-light ratios than that of rich systems, with the higher entropy excess. Above these results, we discuss an early metal enrichment in galaxy clusters and groups.

XMM-Newton analysis of a newly discovered, extremely X-ray luminous galaxy cluster at high redshift

Sophia Thoelken[1], Tim Schrabback[1]
[1] *Argelander Institute for Astronomy, Bonn University*

Galaxy clusters, the largest virialized structures in the universe, provide an excellent method to test cosmology on large scales. The galaxy cluster mass function as a function of redshift is a key tool to determine the fundamental cosmological parameters and especially measurements at high redshifts can e.g. provide constraints on dark energy. The fgas test as a direct cosmological probe is of special importance. Therefore, relaxed galaxy clusters at high redshifts are needed but these objects are considered to be extremely rare in current structure formation models. Here we present first results from an XMM-Newton analysis of an extremely X-ray luminous, newly discovered and potentially cool core cluster at a redshift of z=0.9. We carefully account for background emission and PSF effects and model the cluster emission in three radial bins. Our preliminary results suggest that this cluster is indeed a good candidate for a cool core cluster and thus potentially of extreme value for cosmology.

Baryon content and dynamic state of galaxy clusters

Daniel Q. Wang[1]
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We are carrying out a panchromatic observing program to study the baryon content and dynamic state of galaxy clusters. In this talk, I will present results primarily from XMM-Newton observations of optically-selected clusters in the redshift range of 0.1-0.4. These clusters are selected because of their fortuitous alignment with background far-UV-bright QSOs, which thus allows for Ly-alpha and O VI absorption line spectroscopy with HST/COS, probing physical processes of the evolving intracluster medium, freshly accreted from the intergalactic medium and/or stripped out of individual galaxies, as well as the gaseous halos of individual cluster galaxies. Interestingly, such clusters tend to be dynamically young and often consist of merging subcluster pairs at similar redshifts. These subclusters themselves typically show substantial substructures, including strongly distorted radio lobes, as well as large position offsets between the diffuse X-ray centroids and the brightest galaxies. A comparison of the hot gas and stellar masses of each cluster with the expected cosmological baryonic mass fraction indicates a significant room for other gas components. I will also briefly examine the limitations of both optically and X-ray selected clusters, as well as how they may be used in a complementary fashion.

Chapter 12

Surveys & Cosmology

The 3XMM spectral fit database

Ioannis Georgantopoulos[1], Amalia Corral[1], Mike Watson[2], Francisco Carrera[3], Natalie Webb[4], Simon Rosen[2]
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I will present the XMMFITCAT database which is a spectral fit inventory of the sources in the 3XMM catalogue. Spectra are available by the XMM/SSC for all 3XMM sources which have more than 50 background subtracted counts per module. This work is funded in the framework of the ESA Prodex project. The 3XMM catalog currently covers 877 sq. degrees and contains about 400,000 unique sources. Spectra are available for over 120,000 sources. Spectral fist have been performed with various spectral models. The results are available in the web page http://xraygroup.astro.noa.gr/ and also at the University of Leicester LEDAS database webpage ledas-www.star.le.ac.uk/. The database description as well as some science results in the joint area with SDSS are presented in two recent papers: Corral et al. 2015, A&A, 576, 61 and Corral et al. 2014, A&A, 569, 71. At least for extragalactic sources, the spectral fits will acquire added value when photometric redshifts become available. In the framework of a new Prodex project we have been funded to derive photometric redshifts for the 3XMM sources using machine learning techniques. I will present the techniques as well as the optical near-IR databases that will be used.

The Wide-Area X-ray Survey in the Legacy Stripe 82 Field

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We are carrying out a wide-area X-ray survey in the Sloan Digital Sky Survey Stripe 82 field to uncover how luminous, obscured AGN evolve over cosmic time and the role they play in galaxy evolution. Stripe 82 is a legacy field with a high level of spectroscopic completeness and rich multi-wavelength coverage from the ultraviolet to far-infrared, including *Spitzer* and *Herschel* imaging. Our Stripe 82X survey currently reaches 31 deg^2, with $\sim$6200 X-ray point sources detected at $\geq 5\sigma$ level. I will review the characteristics of this survey, on-going programs to target obscured AGN candidates, and how we can use the lessons learned from the synergistic multi-wavelength coverage to develop strategic plans for future surveys and missions. Finally, I will comment on how extending the Stripe 82X survey area to 100 deg^2 will provide unprecedented insight into the high-L (Lx $> 10^{45}$ erg/s), high-z ($z > 2$) AGN population.

Compton Thick AGN in the XMM-COSMOS field

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I will present results we published in two recent papers (Lanzuisi et al. 2015, A&A 573A 137, Lanzuisi et al. 2015, A&A 578A 120) on the properties of X-ray selected Compton Thick (CT, NH>10^{24} cm^{-2}) AGN, in the XMM-COSMOS survey. We exploited the rich multi-wavelength dataset available in this field, to show that CT AGN tend to harbor smaller, rapidly growing SMBH with respect to unobscured AGN, and have a higher chance of being hosted by star-forming, merging and post-merger systems. We also demonstrated the detectability of even more heavily obscured AGN (NH>10^{25} cm^{-2}), thanks to a truly multi-wavelength approach in the same field, and to the unrivaled XMM sensitivity. The extreme source detected in this way shows strong evidences of ongoing powerful AGN feedback, detected as blue-shifted wings of high ionization optical emission lines such as [NeV] and [FeVII], as well as of the [OIII] emission line. The results obtained from these works point toward a scenario in which highly obscured AGN occupy a peculiar place in the galaxy-AGN co-evolution process, in which both the host and the SMBH rapidly evolve toward the local relations.

An X-ray study of the lower-luminosity LIRGs from GOALS

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We present Chandra observations for a sample of 59 Luminous Infrared Galaxies (LIRGs) from the lower luminosity portion of the Great Observatory All-sky LIRG Survey (GOALS). The GOALS is a multiwavelegth study of the most luminous IR-selected galaxies in the local Universe, and this X-ray study, complimenting the previous work on the higher-luminosity sample, benefits from the imaging and spectroscopic data from HST, Spitzer and Herschel. With combined X-ray and mid-infrared diagnostics, AGN are found in 33% of the galaxies in the sample, a fraction lower than that found for the higher luminosity sample. The correlation study of far-IR and X-ray emission shows that the GOALS galaxies without traces of AGN appear to be underluminous in X-ray, compared to the previously studied star-forming galaxies with lower star formation rates. Results on X-ray spectral study of the sample will also be presented.

A million X-ray detections

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Part of the XMM-Newton Survey Science Centre responsibilities include producing an X-ray catalogue of all X-ray sources detected with XMM-Newton. The latest version, 3XMM, takes advantage of improvements made to the source characterisation, reducing the number of spurious detections, but providing better astrometric precision, greater net sensitivity, as well as spectra and timeseries for a quarter of all catalogue detections. The data release 5 (3XMM-DR5, April 2015) is derived from the first 13 years of observations with XMM-Newton. 3XMM-DR5 includes 565962 X-ray detections and 396910 unique sources, detected as many as 48 times. 3XMM-DR5 is therefore the largest X-ray source catalogue. 3XMM-DR6 will be made available during 2016 and will augment the catalogue with 70000 X-ray detections. Over the next decade the catalogue will reach 1 million X-ray detections, including galaxy clusters, galaxies, tidal disruption events, gamma-ray bursts, stars, stellar mass compact objects, supernovae, planets, comets and many other systems. Thanks to the wide range of data products for each catalogue detection, the catalogue is an excellent resource for finding populations of sources as well as new and extreme objects. Here we present results achieved from searching the catalogue and discuss improvements that will be provided in future versions.

The 2 Ms Chandra Deep Field-North Survey and the 250 ks Extended Chandra Deep Field-South Survey: Improved Point-Source Catalogs

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We present improved point-source catalogs for the 2Ms CDF-N and the 250ks E-CDF-S, implementing a number of recent improvements in Chandra source-cataloging methodology. For the CDF-N/E-CDF-S, we provide a main catalog that contains 683/1003 X-ray sources detected with wavdetect at a false-positive probability threshold of 1E-5 that also satisfy a binomial-probability source-selection criterion of $P < 0.004/P < 0.002$. Such an approach maximizes the number of reliable sources detected: a total of 196/275 main-catalog sources are new compared to the A03 CDF-N/L05 E-CDF-S main catalogs. We also provide CDF-N/E-CDF-S supplementary catalogs that consist of 72/56 sources detected at the same wavdetect threshold and having P of 0.004-0.1/0.002-0.1 and $K\_s < 22.9/K\_s < 22.3$ counterparts. For all $\approx$ 1800 CDF-N and E-CDF-S sources, including the $\approx$ 500 newly detected ones, we determine X-ray source positions utilizing centroid and matched-filter techniques; we also provide multiwavelength identifications, apparent magnitudes of counterparts, spectroscopic and/or photometric redshifts, basic source classifications, and estimates of observed AGN and galaxy source densities around respective field centers. Simulations show that both the CDF-N and E-CDF-S main catalogs are highly reliable and reasonably complete. Background and sensitivity analyses indicate that the on-axis mean flux limits reached represent a factor of $\approx 1.5 - 2.0$ improvement over the previous CDF-N and E-CDF-S limits.

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