EXPLORING THE HOT AND ENERGETIC UNIVERSE
The first scientific conference dedicated to the Athena X-ray observatory

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Athena Study Science Team
and the
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ABSTRACT BOOK

Oral Communications and Posters

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Chapter 1

Invited Talks

The formation and growth of the earliest supermassive black holes

Aird, J.
Institute of Astronomy, Cambridge

Understanding how supermassive black holes (BHs) form and grow in the very early ($z > 6$) Universe, when the first stars and galaxies were forming, is one of the major science aims of the Athena mission. The physical processes responsible for the initial formation of these BHs and their early growth via accretion - when they are seen as Active Galactic Nuclei (AGNs) - remain unclear. Large-scale optical/near-infrared imaging surveys have identified a few tens of luminous AGNs at $z > 6$, powered by extremely massive BHs, and place vital constraints on the range of possible formation and growth mechanisms. To make further progress, however, we must identify lower luminosity and obscured AGNs at $z > 6$, which represent the bulk of early BH growth. I will discuss recent measurements that trace the evolution of AGN population out to the highest possible redshifts ($z \sim 5 - 6$) using the latest X-ray surveys with Chandra and XMM-Newton. However, Athena will provide the superb sensitivity over a wide field-of-view that is required to identify the earliest ($z > 6$) growing BHs, trace their evolution within the early galaxy population, and determine the physical mechanisms that drive their formation and growth. Achieving these aims represents a major challenge that will push the capabilities of both Athena and supporting ground- and space-based observatories. I will present the prospects for a large Athena survey programme and discuss both the technical and scientific challenges that must be addressed in preparation for the Athena mission.

Athena as an observatory in the late 2020s

Barcons, X.
Instituto de Fisica de Cantabria (CSIC-UC), 39005 Santander, Spain

The scientific goals of Athena, as formulated under the Hot and Energetic Universe theme, have been conceived to address key aspects of astrophysics in the late 2020s. In addition, Athena will be able to address a number of other goals - dubbed observatory science - which will pervade virtually all corners of astrophysics. On the other hand, the synergies -discussed in this conference- that Athena should develop with other contemporary facilities like ALMA, E-ELT, JWST, Euclid, CTA and SKA, will greatly enhance the observatory dimension of Athena. In this presentation, I will highlight the role of Athena as an essential tool in European Astronomy at the late 2020s, beyond its own scientific objectives.

The Athena X-ray Integral Field Unit

Barret, D.[1]; den Herder, J.-W.[2]; Piro, L.[3] (On behalf of the X-IFU Consortium)
[1]*IRAP, France;* [2]*SRON, The Netherlands;* [3]*IAPS, Italy*

The X-ray Integral Field Unit (X-IFU) for Athena is based on Transition Edge Sensors (TES). In its baseline configuration, it is made of a monolithic array of 3840 single size TES cooled at $\sim$100 mK, thus providing a spectral resolution of 2.5 eV over a field of view of 5' equivalent diameter.

In this paper, I will recall the top-level instrument performance requirements and associated science drivers. The baseline instrument design will be presented before reporting on the on-going instrument activities (e.g. the TES array optimization exercise), that are preparatory to the phase A study and to the demonstration model development.

The X-IFU will be provided by an international consortium led by France, The Netherlands and Italy, with ESA member state contributions from Belgium, Finland, Germany, United Kingdom, Poland, Spain, Switzerland together with the United States and Japan.

The Athena Optics

Bavdaz, M.
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The core enabling technology for the high performance Athena mirror is the Silicon Pore Optics (SPO), a modular X-ray optics technology, which utilises processes and equipment developed for the semiconductor industry.

The presentation will provide an overview of the programmatic background, the status of SPO technology and gives an outline of the development roadmap and activities undertaken and planned by ESA.

The Athena Science Working Group 3.3

Bozzo, E.
ISDC - University of Geneva (Switzerland)

On behalf of the Athena SWG3.3, I will provide an overview of the working group activities and a description of the relevant Athena science requirements for which the group is organizing simulations campaigns.

The Landscape of Large Sky Surveys in the Athena Era

Brandt, W.
Penn State University

The transformation of astronomical research by the exponential growth of large sky surveys will be well advanced by the time of the Athena launch in 2028. At that point, e.g., the Large Synoptic Survey Telescope (LSST) should be more than halfway through its 10-year survey, and 2-3 additional generations of innovative smaller-scale projects will likely have been implemented. I will briefly describe the expected landscape of large sky surveys relevant to Athena, considering both ground-based (e.g., LSST, HSC, PS4, ZTF, LoFAR, ASKAP, MeerKAT, SKA, CTA, LIGO/VIRGO) and space-based (e.g., eROSITA, JWST, Euclid, WFIRST, HDST) projects. These will provide the essential multiwavelength data needed to execute some of Athena's central science goals, such as investigating the build-up of the first massive black holes. They will provide a plethora of exciting new targets for Athena spectroscopy, such as luminous quasars at $z = 7 - 10$ and high-redshift protoclusters. These surveys will (more than) fully exercise Athena's agility with thousands of nightly transients discovered across the entire sky.

Accretion and Ejection Power across the Universe

Cappi, M.
INAF/IASF-Bologna, Italy

I will review the evidence for accretion and ejection power in nearby AGNs, high-redshift QSOs and stellar-mass compact sources.

Understanding the build-up of SMBH and galaxies

Carrera, F.J.[1]; Georgakakis, A.[2]; Ueda, Y.[3]; Akylas, T.[4]; Lanzuisi, G.[5]
[1]*Instituto de Fisica de Cantabria (CSIC-UC), Santander, Spain;* [2]*MPE, Garching, Germany;* [3]*Kyoto University, Japan;* [4]*National Observatory of Athens, Athens, Greece;* [5]*INAF-Osservatorio Astronomico di Bologna, Bologna, Italy*

One of the main open questions in modern Astrophysics is understanding the coupled growth of supermassive black holes by accretion and their host galaxies via star formation, from their peak at redshifts $z \sim 1-4$ to the present time. The generic scenario proposed involves an early phase of intense black hole growth that takes place behind large obscuring columns of inflowing dust and gas clouds. It is postulated that this is followed by a blow-out stage during which some form of AGN feedback controls the fate of the interstellar medium and hence, the evolution of the galaxy.

X-rays are essential for testing this scenario as they uniquely probe AGN at both the early heavily obscured stage and the later blow-out phase. X-ray spectral analysis can identify the smoking gun evidence of heavily obscured black hole growth (e.g. intense iron Kalpha line). It therefore provides the most robust method for compiling clean samples of deeply shrouded AGN with well-defined selection functions and unbiased determinations of their intrinsic properties (accretion luminosity, obscuring column). X-rays are also the best window for studying in detail AGN feedback. This process ultimately originates in the innermost regions close to the supermassive black hole and is dominated, in terms of energy and mass flux, by highly ionised material that remains invisible at other wavelengths. The most important epoch for investigating the relation between AGN and galaxies is the redshift range $z \sim 1-4$, when most black holes and stars we see in the present-day Universe were put in place. Unfortunately, exhaustive efforts with current high-energy telescopes only scrape the tip of the iceberg of the most obscured AGN population. Moreover, Xray studies of the incidence, nature and energetics of AGN feedback are limited to the local Universe.

The Athena observatory will provide the technological leap required for a breakthrough in our understanding of AGN and galaxy evolution at the heyday of the Universe. The excellent survey capabilities of Athena/WFI (effective area, angular resolution, field of view) will allow to measure the incidence of feedback in the shape of warm absorbers and Ultra Fast Outflows among the general population of AGN, as well as to complete the census of black hole growth by detecting and characterising significant samples of the most heavily obscured (including Compton thick) AGN, to redshifts $z \sim 3-4$. The outstanding spectral throughput and resolution of Athena/X-IFU will permit measuring the energetics of those outflows to assess their influence on their host galaxies. The demographics of the heavily obscured and outflowing populations relative to their hosts are fundamental for understanding how major black hole growth events relate to the build-up of galaxies.

Synergy with ALMA and mm: early galaxies and star formation

Combes, F.
Observatoire de Paris, LERMA

ALMA is already probing the early universe, and the physics of star formation in galaxies with different lines and dust emission. One of the main issues to understand galaxy formation and the cosmic star formation density is to identify the feedback mechanisms, either due to supernovae or AGN. Starbursts and AGN are frequently co-existing in galaxies, and the X-ray domain is essential to disentangle both. Cold gas filaments, co-existing with X-ray gas, are tracing cooling flows in cool core clusters, and teach us about the feedback.

Athena Mission Performance

den Herder, J.-W.[1]; Piro, L.[2]; Rau, A.[3] (On behalf of the Athena Mission Performance Working Group)
[1]*SRON, The Netherlands;* [2]*IAPS, Italy;* [3]*MPE Garching, Germany*

The optimization of the Athena mission, the ESA's large X-ray observatory for 2028, is a key challenge. Critical elements for achieving the scientific performances are obviously the two instruments and the optics. However, additional aspects related to the overall mission performances are crucial as well, including the particle background environment (separate presentation), the calibration, the response time to Target of Opportunity requests, the functionality of the science ground segment, and the available high-quality data analysis tools. In addition, the full performance of the satellite will be modeled by an end-to-end simulator. In this presentation we will give an overview of the various systems and also present the Mock Observing Plan that is used to optimize the mission.

The work presented in this contribution is based on a collective effort of the Athena science community and is coordinated by the Athena Mission Performance Working Group.

The Astrophysics of Galaxy Groups and Clusters with Athena

Eckert, D.[1]; Ettori, S.[2]; Pratt, G.[3]
[1] *Geneva University;* [2] *Bologna Observatory;* [3] *CEA Saclay*

The intracluster medium filling galaxy groups and clusters is subject to a wealth of astrophysical phenomena which are best studied in X-rays. Thanks to its vastly improved capabilities compared to previous facilities, Athena will revolutionize the field by performing spatially-resolved studies of kinetic motions in the ICM (turbulence, bulk motions), studying the formation processes at work in the outskirts of clusters, and constraining the processes leading to the enrichment of the ICM in heavy elements. We will present the activities of SWG 1.2, which are summarized in the Athena supporting paper #2 (Ettori et al., arXiv:1306.2322).

Solar System and Exoplanets

Ezoe, Y. (On behalf of the Athena Solar System and Exoplanets Topical Panel)
Tokyo Metropolitan Univesity

Athena studies of the solar system and exoplanets will enormously advance our understandings on important themes in astrophysics, planetary and space plasma physics such as interactions of space plasmas and magnetic fields, ion and electron acceleration in the planetary magnetosphere, details of the charge exchange process, and physical/chemical evolution of planet atmospheres. We shall review the status of X-ray studies on the solar system and exoplanets, and show the potential of Athena.

The missing baryons and the warm-hot intergalactic medium

Kaastra, J.[1]; Finoguenov, A.[2]
[1]*SRON Netherlands Institute for Space Research;* [2]*University of Helsinki, Finland*

In this presentation we discuss the prospects for Athena to study the warm-hot intergalactic medium (WHIM). Theory predicts that most of the baryons reside in vast unvirialized filamentary structures that connect galaxy groups and clusters, but the observational evidence is currently lacking. Because the majority of the baryons are supposed to exist in a large-scale, hot and dilute gaseous phase, X-rays provide the ideal tool to progress our understanding. Observations with the Athena X-ray Integral Field Unit will reveal the location, chemical composition, physical state and dynamics of the active population of baryons.

The Assessment Phase Activities for ATHENA

Lumb, D.; Ayre, M.
Science Support Office, ESTEC, ESA

The Athena mission concept has been proposed by the community in response to science themes of the Hot and Energetic Universe. Unlike other, competitive, mission selection exercises this "Large" class observatory mission has essentially been pre-selected. Nevertheless it has to be demonstrated that Athena meets the programmatic constraints of 1Bn euro cost cap, and a readiness level appropriate for formal mission adoption by the end 2019. This should be confirmed througha Phase A study conducted with two parallel industry activities. We describe the technical and programmatic content of these and latest progress in space and ground segment definition.

The Athena project and the future plan of the X-ray astronomy in Japan

Matsumoto, H.[1] (On behalf of the Athena Working Group of ISAS/JAXA)
[1]*Nagoya University, Japan*

High-Energy AstroPhysics Association in Japan (HEAPA) officially decided to contribute to the success of Athena based on our expertise through the development of ASTRO-H, Suzaku, and other satellites. The Athena Working Group (WG) of ISAS/JAXA was set up and the WG applied to the call for the MoO mission of ISAS/JAXA. In this talk, we would like to explain the Japanese contribution to the Athena satellite. Also we would like to talk about the future plan of Japanese X-ray astronomy missions. For example, Diffuse Intergalactic Oxygen Surveyor (DIOS) and Next-Generation Hard X-ray Telescope (NGHXT) will be introduced, and the relation between the Athena project and those missions will be given.

Wide Field Imager Instrument for ATHENA

Meidinger, N.[1]; Nandra, K[1]; Rau, A.[1]; Plattner, M.[1]
[1]*Max-Planck-Institute for extraterrestrial physics, Garching, Germany*

The Wide Field Imager focal plane instrument on ATHENA will combine unprecedented survey power through its large field of view of 40 arcmin with a high count-rate capability (> 1 *Crab*). The energy resolution of the silicon sensor is state-of-the-art in the energy band of interest from 0.1 keV to 15 keV. At energy of 6 keV for example, the full width at half maximum of the line shall be not worse than 150 eV until the end of the mission. The performance is accomplished by a set of DEPFET active pixel sensor matrices with a pixel size well suited to the angular resolution of 5 arc sec (on-axis) of the mirror system.Each DEPFET pixel is a combined detector-amplifier structure with a MOSFET integrated onto a fully depleted 450 micron thick silicon bulk. Two different types of DEPFET sensors are planned for the WFI instrument: A set of large-area sensors to cover the physical size of 14 cm x 14 cm in the focal plane and a single gateable DEPFET sensor matrix optimized for the high count rate capability of the instrument. An overview will be given about the presently developed instrument concept and design, the status of the technology development, and the expected performance. An outline of the project organization, the model philosophy as well as the schedule will complete the presentation about the Wide Field Imager for ATHENA.

The close environments of supermassive black holes

Miniutti, G.
Centro de Astrobiologia (CAB), Spain

Most of the action in Active Galactic Nuclei (AGN) occurs within a few tens of gravitational radii from the supermassive black hole, where energy is mostly released in X-rays, emitted via Comptonization of the accretion disc photons by hot electrons in a corona and partly reflected by the accretion disc itself. Thanks to its large effective area and excellent energy resolution, Athena contributions in the understanding of the physics of accretion in AGN will be fundamental and unique in many respects. Athena will allow us to map the disc-corona system by studying, for instance, the time lags between reflected and primary photons. These lags have been recently discovered by XMM-Newton, but only Athena will have the sensitivity required to fully exploit this technique. Athena will also be able e.g. to determine robustly the spin of the black hole in nearby sources (and to extend these measurements beyond the local Universe), to establish the nature of the soft X-ray components, and to map the circumnuclear matter within the AGN inner parsec with unprecedented details. We review here the broad spectrum of Athena contributions in this field.

Luminous extragalactic transients

O'Brien, P.[1]; Jonker, P.[2]
[1] *University of Leicester;* [2] *SRON Netherlands Institute for Space Research*

The ESA Athena X-ray observatory mission will combine exceptionally high throughout with high spectral-energy resolution and will revolutionise many aspects of high-energy astrophysics. Many of the most powerful transient sources, including gamma-ray bursts and tidal disruptions events, are bright X-ray sources. Athena will be designed to have a fast-response capability permitting efficient observations of many transients. We will summarise the proposed capability of the mission and illustrate science programs to study transients ranging from the most distant GRBs to nuclear activity in nearby galaxies.

The hot Universe: from cosmological filaments to clusters

Ohashi, T.
Tokyo Metropolitan University

We will review how X-ray measurements can show us fundamental processes of the structure formation in the Universe. Groups and clusters are key objects, and their thermal and chemical properties at varioud redshifts to be measured with Athena will tell us how these systems have been formed and grown over the cosmological time scale. Regions surrounding and connecting clusters are the active front of these evolution processes, and the high spectral resolution of Athena will show us their spatial and thermal structures through measurment of X-ray emission lines. The spectroscopy data will also show us the dynamics and non-thermal features of the gas, enabling us to look into how the whole energy is distributed among different forms.

The Athena Background

Piro, L.[1]; Lotti, S.[1]; Macculi, C.[1]; Molendi, S.[2]; Eraerds, T.[3]; Laurent, P.[4]
[1]*IAPS/INAF, Rome, Italy;* [2]*IASF/INAF, Milano, Italy;* [3]*MPE, Garching, Germany;* [4]*CEA, France*

Estimating, reducing and controlling the residual particle background is fundamental for achieving the objectives of several science topics of Athena, in particular those connected with background dominated observations of faint and/or diffuse sources. This requires assessing the particle environment in L2, propagating the various particle components throughout the mirror, spacecraft, and instruments via proper modelling and simulations of various physical processes, implementing design and h/w measures at instrument and mission level to reduce the un-rejected background and identifying proper calibration methods to control the background variations. Likewise, an adequate knowledge of the XRB, made of components that may vary spatially or temporally, is required as well.

Here we will review the present status of the background knowledge, and summarize the activities on-going within Athena at various levels.

Evolution of groups and clusters of galaxies

Pointecouteau, E.[1,2]; Allen, S.[3,4,5]; Ota, N.[6] (On behalf of the Athena SWG-1.1)
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The Athena mission will implement the Hot and Energetic Universe science theme which poses the question of "How does ordinary matter assemble into the large-scale structures we see today?". Groups and Galaxy clusters are key laboratories to understand the role of the various physical processes governing the baryonic matter from the kilo-parsec scale of super-massive black holes to the mega-parsec one of the clusters outskirts on assembling and evolving large scale structures. I will focus on the study of the galaxy groups and clusters evolution with the Athen a mission. We will review the status of current constraints and will discuss the perceptives out to the mission launch time in 2028.

Astrophysics of feedback in local AGN and star-forming galaxies

Ponti, G.[1]; Ptak, A.[2]; Tsuru, T.G.[3]; et members of swag 2.3
[1] *Max Planck institute for Extraterrestrial Physics (MPE), Garching bei München, Germany;* [2] *NASA Goddard Space Flight Center;* [3] *Department of Physics, Kyoto University*

Accretion onto supermassive black holes at the centre of many galaxies can generate radiation, jets and winds powerful enough to modify the properties of the interstellar medium and of the galactic star formation. Ultimately, in a process called feedback, this can influence the rate of gas accretion onto the supermassive black hole. Also powerful starburst galaxies, through winds, are thought to have a deep impact onto the host galaxy. We will review the current status of evidence for the presence of the feedback process in active galactic nuclei and star-forming galaxies as well as the prospects for Athena.

Star formation and evolution as seen with Athena

Rauw, G.[1]; Sciortino, S.[2]; Hornschemeier, A.[3]; SWG 3.2
[1] *University of Liege;* [2] *Osservatorio Astronomico di Palermo;* [3] *NASA Goddard Space Flight Center*

Stars over a wide range of masses and evolutionary stages are nowadays known to emit X-rays. This X-ray emission probes the most energetic phenomena occurring in the circumstellar environment of these stars, and provides precious insight on magnetic phenomena or hydrodynamic shocks. Owing to its unprecedented capabilities, Athena will open up an entirely new window on these phenomena. Athena will not only allow us to study many more objects with an unprecedented spectral resolution, but will also pioneer the study of the dynamics of these objects via time-resolved high-resolution spectroscopy. These studies will lead to a deeper understanding of yet poorly understood processes which have profound impact in star formation and evolution, including at earlier times in the Universe. They also are important to understanding feedback processes on Galactic scale.

Studying AGN feedback in galaxy clusters and groups

Sanders, J. (On behalf of the Athena topical panel for AGN feedback in galaxy clusters and groups)
Max Planck Institute for Extraterrestrial Physics (MPE)

In the centres of clusters of galaxies and groups the central active galactic nuclei are playing a vital role in preventing the rapid cooling of the surrounding hot atmosphere. Important scientific questions remain unanswered, however. These include (1) What is the mechanism by which the energy from jets is dissipated and distributed through intracluster or intragroup medium? (2) How is the AGN fuelling regulated? (3) What is the cumulative impact of powerful radio galaxies on baryons over cosmic time? With its high spectral resolution, good spatial resolution and large effective area, Athena promises to make important progress in answering these questions. For the first time it will measure both the spatially-resolved velocity distribution and thermodynamics of the cluster core region, allowing us to measure all the energetic contributions to feedback and cooling in the hot plasma. We describe how Athena will address these areas, as described in our supporting paper for the Athena mission proposal on AGN feedback in galaxy clusters and groups.

US contributions to the Athena mission

Smith, R.
Smithsonian Astrophysical Observatory, Cambridge MA

The science of the Hot and Energetic Universe, as embodied in the IXO mission, was highly ranked by the 2010 Decadal Review of Astronomy and Astrophysics. NASA therefore strongly supports the Athena mission, and plans significant contributions to the X-IFU, such as the micro-calorimeter array, that should enable more capabilities than in the original Athena proposal. NASA and US scientists are also examining, with ESA, possible contributions to other aspects of Athena. I will discuss the status and progress towards these contributions, both planned and potential.

Synergies between X-ray and Gamma-ray observations of cosmic particle accelerators

Uchiyama, Y.
Rikkyo University, Tokyo, Japan

During the last decade, gamma-ray telescopes, AGILE and Fermi in space as well as the ground-based TeV telescopes including H.E.S.S., MAGIC, and VERITAS, have made tremendous achievements, which have contributed to our understanding of the non-thermal Universe. In most cases, gamma-ray data alone do not carry enough information about high-energy astrophysical sources, and therefore they must be complemented by multi-wavelength observations. Particularly important are X-rays of synchrotron origin, because they are produced in gamma-ray sources by accelerated electrons with TeV energies. In the cases of supernova remnants, pulsar wind nebulae, and AGN jets, synchrotron X-ray emission can constrain models of corresponding gamma-ray production via inverse-Compton scattering. Moreover, extreme cosmic accelerators generally involve very hot gases that radiate thermal X-ray emission, and perhaps also involve significant turbulent motions that should be detectable with upcoming ASTRO-H, and ultimately with Athena.

In this talk, we review recent results from the gamma-ray observations of both galactic and extragalactic sources in which efficient particle acceleration is found to be operating, emphasizing the importance of the synergies between X-ray and gamma-ray observations. We discuss recent progress on our understanding of particle acceleration mechanisms at work in gamma-ray sources, and address key problems to be tackled by future large missions in the X-ray and gamma-ray domains, namely, Athena and CTA.

Mapping the many faces of accretion with Athena

Uttley, P.
University of Amsterdam, The Netherlands

Stellar mass black holes in X-ray binary systems are accretion laboratories, which show in days-months a variety of states, marked by strong evolution in spectral shape and variability properties. This spectral and timing evolution further couples to changes in outlow properties, as the main mechanical output route transitions from a jet to a wind and back. This evolution must correspond to dramatic changes in the structure of the innermost accretion flow, which can tell us about how accretion works in strong gravity and how powerful outflows are formed. However, it has been difficult to interpret these changes unambiguously in terms of a coherent physical picture, since we have no way of directly imaging these systems.

I will discuss how Athena's combination of high throughput, spectral resolution and soft response will allow us to reverberation-map the inner accretion flow around stellar mass black holes as well as (potentially) the associated mechanical outflow, and settle many of the outstanding questions in accretion and outflow physics. This revolution will have important implications for understanding the energetic universe on much larger scales.

Chapter 2

Contributed Talks

Detecting Missing Baryons Around the Milky Way and External Galaxies

Bregman, J.
University of Michigan

Gas at the virial temperature of the Milky Way, about 2E6 K has been detected in O VII and O VIII with XMM and Chandra. With proper design, Athena will be able to detect many more of these lines, including both the O VII Ka and Kb line, which are important diagnostics of opacity. We have calculated the line strengths and profiles for various Milky Way sight lines and show that these observations will determine the Doppler b parameter and improve the metallicity determinations, with likely increases from the current value of 0.3 solar. If hot halos similar to the Milky Way exist around other spiral galaxies, we show that Athena will be able to detect them to projected distances of about 100 kpc.

Star Formation & the Star Formation History of the Universe: Exploring & Adding the X-Ray Point of View

Burgarella, D.[1]; Ciesla, L.[2]; Boquien, M.[3]; Buat, V.[1]; Roehlly, Y.[1]
[1]*Laboratoire d'Astrophysique de Marseille, Aix-Marseille University, France;* [2]*CEA, Saclay, France;* [3]*Univ. of Antofagasta, Chile*

To estimate the star formation rate of galaxies, we can use a wide range of star formation tracers: continuum measurements in most wavelength domains, lines, supernovae and GRBs... All of them have pros and cons. Most of the monochromatic tracers are hampered but the effects of dust. But, before being able to estimate the star formation rate, we first need to obtain a safe estimate to the dust attenuation. The advantage of the X-ray wavelength range is that we can consider it as free from the effect of dust.

In this talk, we will estimate how many galaxies we could detect with ATHENA to obtain the star formation density. For this, I will use my recent Herschel paper where the total (UV + IR) star formation rate density was evaluated up to $z \sim 4$ and provide quantitative figures for what ATHENA will detect as a function of the redshift and the luminosity.

ATHENA will need predictions that are in agreement with what we observe in the other wavelength ranges. I will present the code CIGALE (http://cigale.lam.fr). The new and public version of CIGALE (released in April 2015) allows to model the emission of galaxies from the far-ultraviolet to the radio and it can make prediction in any of these wavelength ranges. I will show how galaxy star formation rates can be estimated in a way that combines all the advantages of monochromatic tracers but not the caveats. It shoudl be stressed that we can model the emission of AGNs in the FUV-to-FIR range using several models. Finally, I will explain why we seriously consider to extend CIGALE to the x-ray range to predict the X-ray emission of galaxies including any AGN.

The Interstellar medium in the era of Athena

Costantini, E.[1]; de Vries, C.[1]; Zeegers, S.[1]
[1] *SRON, Netherlands Institute for Space Research*

X-rays are a powerful tool to study the interstellar medium, a field which has been historically explored almost exclusively at longer wavelength. I will present important results from the present generation high resolution instruments which show that in the X-ray band all phases can be successfully studied: from hot and warm gas in and above the Galaxy disk to the diffuse cold gas and dust in the disk. I will also illustrate how the Athena-XIFU will open up new science windows, allowing us for the first time to study, for instance, the densest regions of our Galaxy, near the Galactic Center, or explore the interaction between the multi-temperature gas phases within our and other galaxies.

Microlensing Constraints on Quasar Emission Regions: Athena's Perspective

Dai, X.
University of Oklahoma

Gravitational microlensing provides a unique tool to study the emission regions of quasars from the smallest X-ray emission region to the larger BLR region. I will review the recent progress of the field focusing on the constraints on the non-thermal X-ray emission, based on our Chandra long-term monitoring results (over 3 Msec) of a sample of lenses. We discover for the first time chromatic microlensing differences between the soft and hard X-ray bands in the X-ray continuum emission. Our results indicate that the coronae above the accretion disk thought to generate X-rays have a non-uniform electron distribution, and the hard X-ray emission region is smaller than the soft region in two cases tracking the event horizon of black holes. We detect metal emission lines for almost all X-ray images in all lenses. We measure larger equivalent line widths in lensed quasars compared to a large sample of normal non-lensed AGNs of similar luminosities. We conclude that the iron line emission region is smaller than that of the X-ray continuum, possibly resulting from strong gravitational lensing near the black hole. Both the X-ray and optical emission region sizes scale with the black hole mass with similar slopes, but with a much smaller normalization for the X-ray emission. With the order of magnitude increase of effective area by Athena, I will discuss the perspective of quasar microlensing in the Athena era.

Fast X-ray flashes; signs of a tidal disruption of a white dwarf by an IMBH?

Jonker, P.[1]; Glennie, A.[2]; Fender, R.[2]; O'Brien, P.[3]
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Tidal disruption events are our prime source of information on the large population of otherwise dormant black holes. We will highlight the recent results on tidal disruption flares by intermediate-mass black holes obtained from XMM and Chandra observations. We will discuss the predicted spectra of tidal disruption events as could be followed up by Athena after an external trigger. Furthermore, we will show the prospects for tidal disruption flares and supernova shock break-out sources discovered serendipitously by Athena, highlighting the huge potential for Athena in these rich and fast growing fields.

What are we learning about distant clusters from XXL

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The XMM XXL survey and its multi-wavelength follow-up have enabled the detection and characterisation of clusters to $z \sim 2$ in the context of a complete and uniform dataset. I will present some recent results from XXL on the evolution of the cluster X-ray properties and their scaling relations, comparisons between the cluster populations detected via their X-ray emission or via their galaxy properties, and implications of Chandra follow-up observations for the contaminating AGN population in X-ray selected distant clusters. I will discuss the implications that our work from XXL has for the study of distant clusters with Athena.

Radio AGN feedback on galaxy scales: what can Athena show us?

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Over the last decade, we have used Chandra and XMM-Newton to study galaxy-scale, moderately powerful, jet-driven outflows in systems such as Centaurus A, NGC 3801, NGC 6764, Mrk 6, and the Circinus galaxy. Although they are difficult to observe from a technical standpoint, these outflows, with scales of tens to hundreds of kpc, have proven to be far more ubiquitous than previously suspected. Most importantly, they can transfer a substantial amount of energy to the ISM of the host galaxy, with the potential to radically and directly affect its gas dynamics and star formation processes. We review some of our past results to assess which outflow signatures Athena will be able to resolve, both spatially and spectroscopically, and what new light Athena can shed on these outflows, which are key to understanding AGN feedback on galaxy scales.

ATHENA solution for the cooling flow problem in clusters of galaxies

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The hot gas in the cores of many clusters and groups of galaxies has a cooling time shorter than 1Gyr. It is possible to probe cooling flows through the detection of cool Fe XVII and O VII emission lines. We recently detected for the first time O VII in a sample of nearby elliptical galaxy and galaxy group showing cooling of gas below 0.4 keV with high-resolution XMM-Newton grating spectra. Fe XVII and O VII appear to be produced by the same gas and provide cooling rates in agreement with theoretical predictions. In clusters of galaxy O VII as well as cooling below 0.4 has not yet been detected and Fe XVII lines also show a remarkable deficit compared to the predictions from radiative cooling flow models. AGN feedback, galactic mergers and sloshing are thought to give rise to heating and turbulence which may prevent cooling in clusters. It is possible to measure the turbulence of the hot gas in clusters by estimating the velocity widths of their X-ray emission lines. There are instrumental effects on the current X-ray satellites that significantly limit the line widths measurement and only upper-limits are so far obtained. The micro-calorimeter detectors aboard the future X-ray mission will overcome these limits and open a new frontier on the spatially-resolved measurements of turbulence in extended objects and the understanding of the interplay between feedback and cooling in clusters of galaxies. In this talk I will review the current state of art and the goals that will be reached with ASTRO-H and ATHENA.

X-IFU Simulations of Starburst Galaxies

Ptak, A.; SWG 2.3
NASA/GSFC

Superwinds are a key mechanism for distributing metals in starbursts galaxies and providing stellar "feedback" that regulates star formation. Most of the energy in superwinds is in the hot X-ray phases that are very tenuous and therefore difficult to observe directly. The X-IFU on Athena will have the sensitivity to directly probe superwinds through velocity broadening and Doppler shifts in X-ray emission lines. The high spectral resolution of the X-IFU will identify regions that are dominated by shocks (non-equilibrium ionization) and charge exchange emission. Here we present X-IFU simulations of starburst galaxies using SIXTE, which will demonstrate the impacts of the background level, systematic error (particularly the gain calibration) and the FoV design.

Evolution of entropy profile in simulated clusters

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Our new set of simulations reproduce the observed dichotomy between cool core and non-cool core clusters. The objects, simulated with an improved hydrodynamical scheme and a new BH feedback prescription, show variety of behavior in the entropy, temperature, gas density, metallicity profiles. In this presentation we will focus on the entropy profiles and its evolution. Forecasts for Athena's observations will be drawn.

A new cosmological probe based on X-ray surveys of quasars

Risaliti, G.; Lusso, E.
INAF - Arcetri Observatory

We present a new method to test the cosmological model at high z, and measure the cosmological parameters, based on the non-linear correlation between UV and X-ray luminosity in quasars. While the method can be successfully tested with the data available today, a deep X-ray survey matching the future LSST and Euclid quasar catalogs is needed to achieve a high precision. Athena could provide a Hubble diagram for quasar analogous to that available today for supernovae, but extending up to $z > 6$.

Prospects for the direct WHIM detection by ATHENA

Soltan, A.M.[1]; Rozanska, A.[1]
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We discuss constraints of the hot baryons content in the Universe by studying the Warm/Hot Intergalactic Medium (WHIM) soft X-ray emission. Chances for a detection of the thermal flux generated by the WWHIM using the WFI on board the ATHENA telescope are examined. Taking our earlier estimates of the Bremsstrahlung emission generated by a single WHIM halo surrounding a field galaxy (Soltan, 2006), the exposure time of ~ 50 ks would be required to achieve a signal-to-noise ratio of 1 in the energy band 0.3 - 0.5 keV. By stacking several such exposures the $S/N > 3$ is easily attainable.

The violent universe in the central 300 pc of the Galaxy: an XMM-Newton survey of the region

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The central 300 pc of our Galaxy are a major laboratory for high energy astrophysics. In particular, they harbour the closest supermassive black hole (SMBH) and are the site of a sustained star formation activity. The energy released by the supernovae on the ambient medium must be very strong and can impact the Galaxy on very large scale, e.g. powering the Fermi bubbles. Similarly, albeit extremely faint nowadays, the SMBH must have experienced episodes of intense activity in the past which can influence significantly the central regions and beyond. For example, the observation of time-varying Fe K line emission at 6.4 keV in several regions of the Galactic Centre (GC) strongly suggests that the SMBH experienced a period of intense activity in the relatively recent past, which is reflected with a time delay by molecular clouds in the region. The light-front of this intense emission is currently propagating and provides invaluable information on the SMBH last high state and its duty cycle.

We present a deep XMM-Newton survey of the central 2^o of our Galaxy performed recently. We study the morphology of the thermal plasma produced by supernova remnants and place constraints on the SN rate in the region. Comparing with previous surveys, we also study the evolution of the morphology of the Fe Ka emission in the central 300 pc over a period of about 10 years produced by the echoes from the SMBH and discuss the impact on its past activity. This large project and other recent observations have also provided new results on the present Sgr $A^\star$ flaring activity that will be reviewed and presented in the contest. Athena perspectives on this science will be discussed.

The Athena Serendipitous Survey

Watson, M.
University of Leicester, UK

Athena's unprecedented collecting area and excellent angular resolution, coupled with the large field of view of the WFI camera, guarantees that Athena has a major potential for serendipitous science which will complement planned survey observations. With an anticipated mean exposure time of 50 ksec, each Athena WFI pointing (expected to be $\sim$ 40% of the total) will reach a flux limit close to 10^{-16}erg cm^{-2}s^{-1} in the soft band, yielding $\sim$3500 source detections. Over the course of the mission, each year of observing time will yield a harvest of >600,000 sources, more than 10 times larger than obtained with XMM-Newton. This paper will outline the prospects for the Athena serendipitous survey and the challenges posed by the identification and multi-wavelength follow-up.

Observable Effects of Exoplanets on Stars

Wolk, S.[1]; Poppenhaeger, K.[1]; Pillitteri, I.[1]
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We discuss observational evidence for magnetic star-planet interactions (SPI) observed in X-rays and UV. Hot Jupiters can significantly affect the activity of their host stars through tidal and magnetic interaction, leading to both increased and decreased stellar activity levels. In the HD189733 system, not only is the star rotating faster than would be indicated by the activity of the stellar secondary, X-ray and UV flares are found preferentially in a very restricted range of planetary phases. We explain such recurrent, phased variability with the support of MHD simulations (Matsakos et al. 2015): planetary gas is launched forming a stream of gas that gets compressed and accrete onto the star. A very long flare, of order the planetary distance, is also suggestive. Further, the X-ray transit was surprisingly deep – three times the depth of the optical transit. This can be traced back to thin outer atmosphere layers of the planet, which are transparent at optical wavelengths but opaque to X-ray photons. We discuss advances that will be made by Athena due to greater signal to noise and energy resolution.

Chapter 3

Posters

Accretion in young stars: measure of the stream velocity of TW Hya from the X-ray Doppler shift

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High-resolution X-ray spectra are a unique tool to investigate the accretion process in young stars. In fact X-rays allow to investigate the accretion-shock region, where the infalling material is heated by strong shocks due to the impact with the denser stellar atmosphere. Here we show for the first time that it is possible to constrain the velocity of the accretion stream by measuring the Doppler shift of the emitted X-rays. To this aim we analyzed the deep Chandra/HETGS observation of the accreting young star TW Hya. We selected a sample of emission lines free from significant blends, fitted them with gaussian profiles, computed the radial velocity corresponding to each line, and averaged these velocities to obtain an accurate estimate of the global velocity of the X-ray emitting plasma. After correcting for Earth's motion, we compared this observed velocity with the photospheric radial velocity. In order to check this procedure we applied the same technique to other Chandra/HETGS spectra of single stars, whose X-rays are due only to coronal plasma. While spectra of pure coronal sources provide Doppler shifts in agreement with the known stellar radial velocity, we found that the X-ray spectrum of TW Hya is red-shifted by 30-40 km/s with respect to the stellar photosphere. This proves that the X-ray emitting plasma on TW Hya is moving with respect to the stellar surface, definitively confirming that it originates in the accretion-shock region. The observed velocity suggests that the base of the accretion region is located at low latitudes of the stellar surface.

European user support activities for ASTRO-H

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The Japanese mission ASTRO-H will be the next major X-ray satellite to operate after its launch in 2016. ASTRO-H will carry several instruments observing simultaneously that will provide broad-band coverage from 0.3 to 600 keV, while the Soft X-ray Spectrometer will offer high spectral resolution in the soft X-ray domain. Europe actively participates in the ASTRO-H mission, and European astronomers will have access to observing time. The European user support activities will be spread across two centers: The Science Operations Center (SOC), located at ESAC (Spain), and the European Science Support Center (ESSC), located at the University of Geneva (Switzerland). The tasks of the SOC will be focussed on supporting the European user community in the use of the allocated time for ASTRO-H, through handling annual calls for observing proposals and related activities. The tasks of the ESSC will be focussed on supporting the European scientific community with respect to the analysis of ASTRO-H data. The activities of the European ASTRO-H SOC and ESSC, together with a summary of ASTRO-H and its capabilities, will be presented at a booth.

Status of X-ray microcalorimeter detector development for the X-IFU

Bandler, S.R.[1]; Adams,J.S.[1]; Betancourt, G.L.[1]; Chervenak, J.A.[1]; Chiao, M.P.[1]; Eckart, M.E.[1]; Finkbeiner, F.M.[1]; Kelley, R.L.[1]; Kilbourne, C.A.[1]; Moseley, S.J.[1]; Porter, F.S.[1]; Sadleir, J.E.[1]; Smith, S.J.[1]; Wassell, E.J.[1]; Doriese, W.B.[2]; Fowler, J.W.[2]; Hilton, G.C.[2]; Reintsema, C.D.[2]; Schwartz, D.A.[2]; Swetz, D.S.[2]; Ullom, J.N.[2]; Irwin, K.D.[3]; den Hartog, R.D.[4]; van der Kuur, J.[4]; Gottardi, L.[4]; den Herder, J.-W.[4]; Jackson, B.[5]; Barret, D.[6]
[1]*NASA/GSFC;* [2]*NIST/Boulder;* [3]*Stanford;* [4]*SRON/Utrecht;* [5]*SRON/Groningen;* [6]*IRAP*

In this presentation we describe the status of our development of X-ray microcalorimeter arrays for the X-ray Integral Field Unit instrument (X-IFU). We describe options for meeting the requirements for the focal plane array. The most basic configuration consists of an array of approximately 4000 Transition Edge Sensors (TES) on a pitch of approximately 250 microns, each reading out a single X-ray absorber. Alternative array configurations utilizing different TES properties are also being developed with different sizes, spectral resolution, energy range and count rate capabilities. In particular, a geometry combining a small pixel array in the center and a large pixel array around it appears very attractive. We will present the status of developments towards meeting these requirements.

The MACSIS project: Scaling relations of massive galaxy clusters

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Galaxy clusters are seeded by density fluctuations in the early Universe and grow via hierarchical collapse to become the most massive virialised objects we observed today. They are powerful probes that study both cosmology and astrophysical processes. Their internal structure at the current epoch is the result of a non-trivial interplay between gravitational collapse and the energy fed into the intra-cluster medium (ICM) by star formation and active galactic nuclei (AGN). These processes shape the ICM during its formation at high redshift, but current observations of galaxy clusters are limited to $z < 0.5$. The resolution and sensitivity of *Athena+* will allow it to study galaxy clusters in unprecedented detail. It will constrain cluster properties, such as its entropy, temperature and gas fraction, out to $z \sim 2$, enabling it to investigate the progenitors of today's massive clusters and observing the evolution of the properties of the ICM for the first time. Athena+ will produce a significant change in our understanding of the formation of galaxy clusters. Recently the theoretical modelling of clusters has advanced significantly and issues, such as the 'cooling catastrophe', have been overcome by including feedback from star formation and AGN. We present the MAssive ClusterS and Intercluster Structures (MACSIS) project. The MACSIS project is a representative sample of 390 of galaxy clusters, with $M_{\mathrm{FOF}} > 10^{15}\,M_{\odot}$, re-simulated using the cosmo-OWLS model (Le Brun et al. 2014, McCarthy et al. in prep.) to extend it to the most massive and rarest objects. We demonstrate that this sample reproduces the scaling relations, with intrinsic scatter, observed with current instruments at low redshift. Under the hierarchical paradigm, the progenitors of these systems will be the first objects to collapse at high redshift and we examine to $z = 2$ how the scaling relations of these massive objects evolve with redshift. Finally, we investigate methods of defining a relaxed subsample of clusters and study the bias introduced by restricting the analysis to relaxed haloes only.

Catching a glimpse of the X-ray emission from galaxies in the early Universe by studying nearby low-metallicity galaxies

Basu-Zych, A.[1]; Hornschemeier, A.[1]; Lehmer, B.[2]; Ptak, A.[1]; Yukita, M.[2]
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Deep studies of X-ray emission from galaxies, such as the Chandra Deep Field-South 4 Ms (soon to be 7 Ms) survey, have allowed us to peer back in history at X-ray binary formation and evolution over cosmic timescales. X-ray stacking observations of $z = 1 - 4$ star-forming galaxies reveal that the metallicity evolution of the Universe drives the evolution of the 2-10 keV X-ray luminosity per star formation rate (SFR), which is dominated by high mass X-ray binaries (HMXBs). By finding local ($z = 0.02 - 0.2$), rare, analogs of these high redshift galaxies, we have found further evidence that the X-ray emission per SFR is elevated compared to typical local star-forming galaxies and this appears to be due to the lower metallicities of these galaxies. Theoretically, metal poor stars produce weaker stellar winds, which results in higher numbers of more massive binaries and therefore leads to higher X-ray luminosities in metal poor populations. Since galaxies in the early universe (and their binaries) formed in a more pristine universe, with few metals, the analogs that we have been studying have cosmological significance. X-ray emission from X-ray binaries and hot gas within galaxies at these early epochs is expected to be important for heating and reionization of the Universe. We will present our current results on the study of HMXB populations in nearby metal-poor starbursts. These primordial analog galaxies represent a challenge for current X-ray facilities, but with modest exposures with Athena, we will obtain high-resolution X-ray spectra permitting detailed study of their properties. We use simulations of the X-ray spectra from these galaxies with Athena to explore the potential capability for measuring column densities (n_H) and metallicities, as well as line shifts to detect outflows that may ultimately enrich the intergalactic medium (IGM).

Screening and validation of EXTraS data products

Carpano, S.
MPE, MPG

The EXTraS project (Exploring the X-ray Transient and variable Sky) is aimed at fully exploring the serendipitous content of the XMM-Newton EPIC database in the time domain. The project is funded within the EU/FP7-Cooperation Space framework and is carried out by a collaboration including INAF (Italy), IUSS (Italy), CNR/IMATI (Italy), University of Leicester (UK), MPE (Germany) and ECAP (Germany). The several tasks consist in characterise aperiodic variability for all 3XMM sources, search for short-term periodic variability on hundreds of thousands sources, detect new transient sources that are missed by standard source detection and hence not belonging to the 3XMM catalogue, search for long term variability by measuring fluxes or upper limits for both pointed and slew observations, and finally perform multiwavelength characterisation and classification. Screening and validation of the different products is essential in order to reject flawed results, generated by the automatic pipelines. We present here the screening tool we developed in the form of a Graphical User Interface and our plans for a systematic screening of the different catalogues.

Athena X-IFU event reconstruction software SIRENA

Ceballos, M.T.[1]; Cobo, B.[1]; Peille, P.[2]; Wilms, J.[3]; Brand, T.[3]; Dauser, T.[3]; Bandler, S.[4]; Smith, S.[4]
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This contribution describes the status and technical details of the SIRENA package, the software currently in development to perform the on board event energy reconstruction for the Athena calorimeter X-IFU. This on board processing will be done in the X-IFU DRE unit and it will consist in an initial triggering of event pulses followed by an analysis (with the SIRENA package) to determine the energy content of such events. The current algorithm used by SIRENA is the optimal filtering technique (also used by ASTRO-H processor) although some other algorithms are also being tested. Here we present these studies and some preliminary results about the energy resolution of the instrument based on simulations done with the SIXTE simulator (http://www.sternwarte.uni-erlangen.de/research/sixte/) in which SIRENA is integrated.

Search for serendipitous TNO occultation events in X-rays with Athena

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Trans-Neptunian Objects (TNOs), which include Kuiper Belt Objects (KBOs) and yet-to-discover Oort Cloud Objects, are an important population of members of the solar system. Its population properties, such as size distribution, carry information imprinted during the early epoch of the solar system formation. TNOs smaller than about ten kilometers are not directly observable. Their existence, however, may be detected through occultation events of background targets that they cause. Search for such serendipitous occultation events have been conducted in optical and X-ray bands. Since the Fresnel scale is about 30 times smaller in X-rays, using X-ray occultation events one may explore TNOs smaller than that can be done in optical bands. Here I will report X-ray sources suitable for such a study with Athena observations. The estimated Athena detection rate of occultation events, based on different model a ssumptions of TNO size distribution, will also be presented.

Bright Source Capabilities of the Athena WFI and X-IFU Instrument

Dauser, T.[1]; Brand, T.[1]; Wilms, J.[1]; Peille, P.[2]; Bandler, S.[3]; Cobo, B.[4]; Ceballos, M.T.[4]; den Hartog, R.[5]; Meidinger, N.[6]; de Plaa, J.[5]; Rau, A.[6]; Smith, S.[3]; Smith, R.[7]
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We are using end-to-end simulations to quantify the bright source capabilities of the Athena WFI and X-IFU instrument. For this purpose source images and spectra are used as input to fully simulate the predicted events on the detector, which are then converted to event lists, spectra, and images. This contribution will explain the different pile-up effects for both instruments and analyse their impact on the efficiency of the detector and the spectral shape. With this approach we are able to estimate limiting fluxes, below which spectra are not significantly affected by pile-up effects. Additionally, the direct impact of pile-up on estimated parameters for core science cases such as measuring the spin of black holes or absorption by the WHIM is investigated.

X-ray Reverberation with Athena

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Reprocessing of the primary X-ray continuum in the accretion disc produces reverberation lags which are powerful tools to map the close environments of accreting black holes. X-ray reverberation lags have been measured in radio quiet active galactic nuclei (AGN), giving constraints of a few rg on the distance between the corona and the accretion disc. However, determining the disc-corona geometry requires data of much better quality. The Athena X-ray observatory will make a breakthrough in this field. The large effective area will allow us to obtain high signal-to-noise lag measurements, and to detail the temporal response of the accretion disc to coronal variability. Through simulations of Wide Field Imager (WFI) light curves, we show that time lag measurements will allow us to distinguish among different corona geometries, and to provide independent constraints on the black hole spin.

Iron line time lags spectrum modelling with ATHENA

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Numerous X-ray ”negative” time-lag measurements in AGN have been reported in the past five years using mainly XMM-Newton data in the 0.3-10 keV energy range. These time-lags are believed to be due to the light travel time delays between the direct X-ray continuum emission and the reprocessed emission from the inner radii of the accretion disc. Information on the black hole spin, height of the X-ray source and inclination of the sytem can be obtained by detailed modeling of the time lags spectra, using theoretical models. Given the unceratinty regarding the origin of the soft X-ray emission emission in AGN, it is desirable that this modelling will be performed to time lag spectra of the iraon line band (and the Compton hump component at energies above $\sim 10-20$ keV). We have performed a detailed study of the statistical properties of traditional time-lag estimators, using extensive simulations in the case of constant delay, power-law and “reverberation”- like model time-lag spectra. Using the results from this study, model transfer functions for an X-ray reverberation scenario in the case of the “lamp-post” geometry, as well as simulated ATHENA light curves, we will present the results from a detailed investigation of the ATHENA’s capability to allow a detailed modeling of the expected iron line time lag spectra.

The search for Compton-thick AGN in the ATHENA era

Georgantopoulos, I.
IAASARS, National Observatory of Athens

We are presenting the latest knowledge on the number of very highly obscured Compton-thick AGN: 1) in the local Universe as it is revealed from the SWIFT/BAT all sky survey 2) at higher redshifts from the Chandra deep fields (CDFS, COSMOS). Probability distributions are taken into account in the classification of a source as a Compton-thick AGN. We compare with X-ray background synthesis models. The largest uncertainties lie in the classification of a source as Compton thick owing to the limited photon statistics. We explore the ATHENA/WFI capabilities on unambiguously characterising a source as Compton-thick.

Athena's Constraints on the Dense Matter Equation of State from Quiescent Low Mass X-ray Binaries

Guillot, S.
Pontificia Universidad Catolica de Chile

The study of neutron star quiescent low-mass X-ray binaries (qLMXBs) will address one of the main science goals of the Athena x-ray observatory. The study of the soft X-ray thermal emission from the neutron star surface in qLMXBs is a crucial tool to place constrains on the dense matter equation of state. I will briefly review this method, its strength and current weaknesses and limitations, as well as the current constraints on the equation of state from qLMXBs.

The superior sensitivity of Athena will permit the acquisition of unprecedentedly high signal-to-noise spectra from these sources. It has been demonstrated that a single qLMXB, even with high S/N, will not place useful constraints on the EoS. However, a combination of qLMXBs spectra has shown promises of obtaining tight constraints on the equation of state. I will discuss the expected prospects for observations of qLMXBs inside globular clusters – those that Athena will be able to resolve. I will also present the constraints on the equation of state that Athena will be able to obtain from these qLMXBs and from a population of qLMXBs in the field of the Galaxy, with distance measurements provided by Gaia.

Jet-Powered Feedback in the Athena Era

Heinz, S.
University of Wisconsin-Madison

Jets and winds are the most efficient ways for black holes to transfer accretion energy to their surroundings. If the environment is sufficiently dense or the jets sufficiently weak, most of the energy will be dissipated on Galaxy scales, whereas more powerful jets may travel outside of the host galaxy and get stopped on galaxy cluster scales. In either case, the energy dissipated is sufficient to strongly affect the thermodynamic evolution of the host medium, making black holes important agents in the evolution of cosmic structure.

Athena is ideally suited for the study of black hole feedback on cluster scales. I will present predictions for signatures of feedback visible to Athena from recent MHD simulations of jet feedback on cluster scales, through observations of shocks and X-ray cavities. Measurements of shock and cavity kinematics and detailed measurements of gas temperatures around cavities will provide sensitive probes of the efficiency of feedback.

X-ray variability in AGN: LINER vs. Seyfert 2

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Although variability is a general property characterizing active galactic nuclei (AGN), it is not well stablished if the changes occur in the same way in every nuclei . The main purpose of this work is to study the X-ray variability pattern(s) in low luminosity AGN in a large sample, including 18 low ionization nuclear emission line regions (LINERs) and 26 type 2 Seyferts (Sy2), using the public archives in Chandra and/or XMM-Newton. Spectra of the same source gathered at different epochs were simultaneously fitted to study long term variations, whereas the variability patterns were studied allowing different parameters to vary during the spectral fit. Whenever possible, short term variations from the analysis of the light curves and long term UV flux variability were studied. Short term variations are not found at X-rays, but variations in timescales of months/years is very common in both families. The main driver of the long term X-ray variations seems to be related to changes in the nuclear power in both LINERs and Sy2, but other variability patterns cannot be discarded in a few cases, because changes of the column density or at soft energies are also found.

The X-ray variations occur in the same way in LINERs and type 2 Seyferts, i.e., related to the nuclear continuum, but they might have different accretion mechanisms. As absorption variations and changing-look sources are not observed in LINERs, but UV nuclear variations are common, we speculate that the BLR and the torus might disappear in these sources.

Coronae and Winds from Irradiated Disks in X-ray binaries

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X-ray and UV line emission in X-ray binaries can be accounted for by a hot corona, formed through irradiation of the outer disk by radiation produced in the inner accretion flow. The same irradiation can produce a strong outflow from the disk at sufficiently large radii. Outflowing gas has been recently detected in several X-ray binaries via blue-shifted absorption lines. However, some observations (particularly those of GRO J1655-40) imply wind densities significantly higher than theoretically predicted from such "thermal winds". This discrepancy does not mean that these winds cannot explain blue-shifted absorption in other systems, nor that they are unimportant as a sink of matter. Motivated by the inevitability of thermal disk-winds and wealth of data taken with current observatories such as Chandra, XMM-Newton and Suzaku, as well as the future AstroH and Athena missions, we decided to investigate the requirements to produce denser winds. Using physical arguments, hydrodynamical simulations and absorption line calculations, we find that modification of the heating and cooling rates by a factor of a few results in an increase of the wind density of up to an order of magnitude and the wind velocity by a factor of about two. This means that the mass loss rate from the disk can be one, if not even two orders of magnitude higher than the accretion rate onto the central object. These results suggest that thermal winds may well produce observable features, and since such high mass loss rates would likely destabilize the disk, these observations could be critical in better understanding state change in these systems. We present the method and results from our initial investigations, along with follow up work in which we combine a radiative transfer code with the hydrodynamics code to firstly validate our initial results, and also produce high quality spectra for comparison with current and future observations. We will also discuss how our code will be applied to QSOs to investigate line driven winds in the context of geometrical unification.

X-ray view of pulsar wind nebulae: What we can learn with Athena?

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Observations with Chandra and XMM-Newton X-ray observatories have significantly advanced our understanding of pulsar winds and pulsar wind nebulae (PWNe). Their results provide invaluable guidance for future X-ray missions. Deep, high-resolution imaging in X-rays reveals the fine structure of pulsar winds, such as termination shocks in the equatorial wind, polar jets with moving knots, cometary-shaped bow shocks, and more complex structures seen on different scales. The spatially-resolved X-ray spectroscopy allows measurements of the particle injection spectrum in the vicinity of the termination shock and enables investigations of the spectral evolution as a function of distance from the pulsar. Multiple observations of the same PWNe have demonstrated that the PWNe can be highly variable on various timescales. I will review most recent interesting results, including deep Chandra observations of the Vela PWN and several long pulsar tails, Chandra/HST/VLA/ALMA observations of the Crab PWN, far-UV and X-ray observations the J0437–4715 bow shock, and dynamic extended feature associated with the gamma-ray binary B1259–63. I will explicitly demonstrate (using specific objects as examples) what Athena will be able to do for pulsar wind studies.

Centrally peaked Fe-rich supernova remnants in the Large Magellanic Cloud with Athena

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Recently, a new class of evolved supernova remnants (SNRs) with centrally peaked Fe-rich emission has been identified in the Magellanic Clouds. The Fe-rich cores result from reverse shock-heated ejecta, the composition of which is consistent with a type Ia explosion, and are spectrally evident as very pronounced Fe L-shell emission lines. Observations with the current generation of X-ray facilities show that the interior Fe-rich plasmas exhibit long ionisation ages, requiring higher central densities than expected from standard type Ia models. It has been suggested that the high interior densities are the result of seeding of the circumstellar medium by the stellar companion leading up to the explosion, which could be facilitated by the most massive “prompt” type Ia progenitor systems. Thus far, these studies have focussed on integrated Fe-rich interior emission since these objects are too faint to allow spatially resolved spectral analysis. In addition, the spectral resolution of the current generation CCD detectors cannot resolve the individual lines in the Fe L-shell complex and spectral analysis is hampered by continuing uncertainties in the atomic data for Fe L-shell lines. Spatially resolved, high spectral resolution studies would reveal in detail the plasma conditions in the Fe-rich interior, shedding light on the possible progenitor systems of these objects, as well as providing a test of the Fe L-shell atomic data. The Fe L-shell line complex is known to be a powerful temperature, density, and ionisation condition diagnostic, and the effective area of Athena, coupled with the high spectral resolution of the X-IFU, provide access to this science space. The detections of such objects has grown significantly in recent years due to the XMM-Newton Very Large Programme survey of the Large Magellanic Cloud (LMC) and our ROSAT LMC SNR candidate follow-up programme. In this talk I will review the current sample of centrally peaked Fe-rich SNRs observed with XMM-Newton and illustrate how the Athena X-IFU can allow an unprecedented probe into the Fe-rich plasmas in these objects.

Athena mission operations concept with a special view on ToO

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The operations concept of the Athena X-ray observatory is currently in its Phase 0/A. It has to satisfy two opposing requirements: cost effective operations (i.e. preplanned and minimised coverage) on the one hand and quick reaction to Targets of Opportunity (ToO) on the other hand. We present a possible scenario of operations combining the mission requirements with the gained expertise from missions like Herschel/Planck with respect to L2 operations as well as XMM-Newton and Integral expertise evaluating the possibility and feasibility of special operations for ToO. In order to satisfy the reaction time for a ToO of 4 h the operations concept is a spacecraft High Gain Antenna always pointed to Earth and configured for TC reception. This enables the use of small ground stations for ToO communications. This and the general features of the mission operations ground segment will be presented in detail.

Properties of Compton thick AGN and their host galaxies, and prospects for the Athena mission

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I will present the results we published in a couple of recent papers (Lanzuisi et al. 2015, A&A 573A 137, Lanzuisi et al. 2015, arXiv 1505.01153) on the properties of X-ray selected Compton Thick (CT, $NH > 10^{24} cm^{-2}$) AGN, in the 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. 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. We will also present estimates on the detectability of such extreme sources up to redshift $\sim 6-7$ with Athena. Combining the most up to date models for the Luminosity Function of CT AGN at high z, aggressive data analysis techniques on faint sources, and the current Athena survey design, we demonstrate that we will detect, and recognize as such, a small (few to ten) but incredibly valuable sample of CT AGN at such high redshift.

The reduction techniques of the particle background for the ATHENA X-IFU instrument at L2 orbit: Geant4 and the CryoAC

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We present the particles background reduction techniques aimed at increasing the X-IFU sensitivity which is reduced by primary protons of both solar and Cosmic Rays origin, and secondary electrons. The adopted solutions involve Monte Carlo simulation by both Geant4 toolkit related to the "expected" background at L2 orbit through the payload mass model and the ray tracing technique to evaluate the soft protons components focussed by the optics to the main detector, and the development of an active Cryogenic AntiCoincidence detector and a passive electron shielding to meet the scientific requirements.

The infrared as a means to identify extremely obscured active galactic nuclei

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When actively accreting, a super-massive black-hole will show a characteristic spectrum which may greatly dominate over that of its host. In this active galactic nucleus (AGN) phase, however, in the presence of large contents of gas and dust, the AGN-induced high-energy radiation may become elusive. The near-to-mid-infrared (nmIR) spectral range offers a means to trace this absorbed energy, since it will be "reprocessed" and emitted at these wavelengths by dust heated to high temperatures ($\sim 100 - 1500$ K). We report on the work pursued by Messias et al. (2012, 2014) exploring this spectral-range to select obscured AGN, which remain elusive at shorter wavelengths, and characterising the selected AGN population in terms of luminosity, obscuration level, and redshift. Although the work focus on the spectral range and filter-set covered by James Webb Space Telescope (JWST), planned to be launched 10 years before Athena, it sets a point-of-view worth considering for Athena observing strategy.

X-ray emitting ejecta in the Tycho's SNR, new results and future perspectives for Athena X-IFU

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The characteristic ejecta-dominated X-ray emission of young supernova remnants allows us to probe the products of the explosive nucleosynthesis processes and provides important information about the physics of the supernova explosions. By analyzing the set of XMM-Newton observations of the Tycho's SNR, we revealed a stratification of the chemical abundances in the ejecta and strong anisotropies in the distribution of Ca and Fe. Our results provide strong constraints on the distribution of iron-peak nuclei in the ejecta and are in agreement with the predictions of multi-D models of delayed-detonation Type Ia supernovae. We also detected the Ti K-line complex in the spectra extracted from regions with strong Fe and Cr emission. However, it is difficult to unambiguously derive the distribution of the Ti emission with the moderate resolution of CCD spectrometers. We simulated a 50 ks observation of Tycho's SNR performed with Athena X-IFU and found that it will provide a major leap forward in our knowledge of the shocked ejecta by allowing us to map the distribution of Ti with high spatial resolution and high statistical significance.

Connecting the high- and low-energy Universe: dust processing inside supernova remnants

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The recent detection of large amounts of dust ($> 10^7$ $M_\odot$) at very high redshift ($z > 6$) raises a fundamental question about the origin of such dust. The main dust producers, i. e., the stars populating the Red Giant Branch and the Asymptotic Giant Branch (RGB and AGB stars) did not have time to evolve. From an evolutionary point of view, young supernovae (SNe) could represent a viable source of dust in high-redshift galaxies, however, a critical issue still needs to be adressed. While recent observations have demonstrated that supernovae are indeed efficient dust factories, at the same time SNe represent the major agent responsible for dust destruction. Supernova blast waves propagating into the interstellar medium destroy the dust residing there, while the fresh dust produced by the supernova itself is threatened by the reverse shock which propagates through the expanding ejecta towards the center of the remnant. We focus here on this second destruction mechanism, with the aim of quantifying the amount of dust able to survive the heavy processing by the reverse shock and to reach the interstellar medium.

We present our results for the textbook supernova remnant Cassiopeia A (Cas A). Using recent X-ray and infrared observations, we have developed a model for the evolution of the remnant and the simultaneous processing of the dust by the reverse shock, and derived the expected amount of surviving dust. In addition, we will briefly illustrate the impact of the capabilities of the Athena mission on the variety of astrophysical problems involving the processing of dust particles in extreme environments characterized by the presence of shocked X-ray emitting gas. These range from individual supernova remnants, to starburst super winds up to AGN outflows and the hot intra-cluster medium. The study of dust processing by a shocked gas truly connects the high-energy Universe with the low-energy Universe, and Athena will play a major role in it.

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

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The apparently diffuse X-ray emission characteristically concentrated in the plane of our Galaxy, the Galactic Ridge X-ray emission (GRXE), is currently believed to result from the superposition of a large number of faint Galactic X-ray sources. We argue that the GRXE should also have an additional truly diffuse component, arising from the scattering of the radiation of bright X-ray binaries (XBs) by the interstellar medium. We estimate the contribution of this component using both known Galactic XBs and a simulated population of XBs, which takes into account the possibility of a higher average Galactic X-ray luminosity in the past ~ 30000 years. We find that the contribution of this component, in the case of observed XBs, should be at least $10-30\%$ of the GRXE flux on the Galactic plane, and that it might even be the dominant contribution to the GRXE in the case of simulated XBs. Recently Warwick et al 2014, using the XMM-Newton slew-survey, confirmed that current observations of the low-luminosity X-ray sources in the Galaxy indeed seem to be consistent with a contribution of 10% or more from a scattered component.

Obtaining more accurate quantitative constraints on the relative contribution of the different components of the GRXE would allow us to obtain important information on different classes of X-ray sources in the Galaxy. Observational signatures of the broad-band scattered component could prove particularly important in this task. Such signatures include: the different scale height of the scattered and discrete component, due to the fact that the latter is expected to trace the gas distribution in the Galaxy, while the latter follows the distribution of the Galactic stellar population; and prominent small angular scale fluctuations resulting from additional scattering in proximity of dense molecular clouds, which are indeed observed and which cannot be accounted for by considering statistical variations in the number of low-luminosity sources in a given line of sight (Warwick et al 2014). In my talk, I will review these observational signatures, and discuss what the constraint of the relative contribution of the scattered component can teach us about the Galactic XB population, of which direct and exhaustive studies are extremely difficult.

Dynamic energy/power spectra derived from X-ray spectra and light curves

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The key data product of an X-ray observation is an events table with information of calibrated position, energy, and arrival time for each individual X-ray photon. Many X-ray sources are variable and clues for origins for variations can be found in spectral changes along with light curve variations. This is commonly done by extracting spectra from certain episodes of variability such as low-states/high-states. I present a systematic approach of a dynamic X-ray spectrum, a 3-dimensional representation of wavelength/energy, time, and intensity. It is constructed from a series of spectra extracted from adjacent short time intervals, displayed as wavelength (or energy) versus time and a colour code for intensity. The same concept can be used for dynamic power spectra, displaying the evolution of periodic oscillations in an X-ray light curve. Dynamic energy/power spectra constructed from XMM-Newton and Chandra data have revealed some surprises such as short-lived emission lines during a flare, softening owed to changes in the absorption column of OI, or transient short-period oscillations in various supersoft sources. Some examples are shown to illustrate the diagnostic power of these diagrams.

Magnetorotational instability in galaxy clusters: looking forward to ATHENA

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Clusters of galaxies are embedded in halos of weakly magnetized plasma at the system's virial temperature. Though mainly pressure supported, such intracluster medium (ICM) might rotate significantly. Currently available measures of X-ray emission lines, X-ray isophote flattening and hydrostatic mass bias leave ample room for rotational motions. If the ICM rotates significantly, its stability properties are substantially modified and, in particular, the magnetorotational instability (MRI) can play an important role. We present simple models of rotating cool-core clusters and we demonstrate that the MRI can be the dominant instability over significant portions of the clusters, with possible implications for the dynamics of the cool cores. The direct measures of the ICM rotation that will be obtained with ATHENA will allow us to gauge the importance of the MRI for the evolution of galaxy clusters.

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

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The proximity of SN 1987A and the wealth of observations collected at all wavelenght bands since its outburst allow us to study in details the transition of a supernova (SN) in a supernova remnant (SNR) and the link between the morphological properties of a SNR and the complex phases in the SN explosion. Here we investigate the interaction between the remnant of SN 1987A and the surrounding circumstellar medium (CSM) through three-dimensional hydrodynamic modeling. The aim is to identify the imprint of SN 1987A on the X-ray emission of its remnant and to determine the contribution of shocked ejecta and shocked CSM to the detected X-ray flux, thus providing clues on both the ejecta and the density structure of the inhomogeneous CSM. Our model describes the evolution of the blast wave from the breakout of the shock wave at the stellar surface till its transition from SN to SNR, making predictions on the future observations of SN 1987A with the instruments on board Athena. Our model is able to reproduce altogheter the main observables of both the progenitor supernova (e.g. the bolometric lightcurve during the first 250 days) and of its remnant (X-ray lightcurves and spectra during the following 26 years of evolution), providing for the first time an accurate description of the structure of ejecta and of the CSM around the progenitor.

The X-IFU end-to-end simulations performed for the TES array optimization exercise

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The focal plane assembly of the Athena X-ray Integral Field Unit (X-IFU) includes as the baseline an array of ~ 4000 single size calorimeters based on Transition Edge Sensors (TES). Other sensor array configurations could however be considered, combining TES of different properties (e.g. size). In attempting to improve the X-IFU performance in terms of field of view, count rate performance, and even spectral resolution, two alternative TES array configurations to the baseline have been simulated, each combining a small and a large pixel array. With the X-IFU end-to-end simulator, a sub-sample of the Athena core science goals, selected by the X-IFU science team as potentially driving the optimal TES array configuration, has been simulated for the results to be scientifically assessed and compared. In this contribution, we will describe the simulation set-up for the various array configurations, and highlight some of the results of the test cases simulated.

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

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We present the results of an analysis of the archival XMM-Newton EPIC data (203ks for pn and 556/574ks for MOS1/MOS2) and the Chandra X-ray Observatory ACIS data (89ks) of the brightest X-ray supernova remnant (SNR) in the Large Magellanic Cloud (LMC) N132D. N132D has been classified as an "O-rich" remnant based on the UV and optical spectra which show emission from C, O, Ne, Mg, and Si. These spectra of the central optical knots do not show any emission from elements with Z higher than Si, yet the nucleosynthesis models predict significant quantities of these higher Z elements. Our spectral analysis of the deep XMM data clearly shows emission lines from S, Ar, Ca, and Fe, with indications of other possible features between Ca and Fe. We use a combination of the high resolution images from Chandra and the sensitive spectra from XMM to disentangle the emission from swept-up interstellar material and a possible hot ejecta component. We interpret these results in the context of a 3,000 year old remnant from a massive progenitor that has exploded into a cavity created by the progenitor. We also present simulations of the Athena X-ray Integral Field Unit (X-IFU) spectrum of N132D. We use the model spectrum developed by the International Astronomical Consortium for High Energy Calibration (IACHEC) based on the high-resolution data acquired by the Reflection Gratings Spectrometer (RGS) on XMM as the input spectrum for the X-IFU simulations.

AHEAD: Integrated Activities in the High Energy Astrophysics Domain

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AHEAD (Integrated Activities in the High Energy Astrophysics Domain) is a forthcoming project approuved in the framework of the European Horizon 2020 program (Research Infrastructures for High Energy Astrophysics). The overall objective of AHEAD is to integrate national efforts in high-energy Astrophysics and to promote the domain at the European level, to keep its community at the cutting edge of science and technology and ensure that space observatories for high-energy astrophysics, with particular regard to Athena, are at the state of the art. AHEAD will integrate key research infrastructures for on-ground test and calibration of space-based sensors and electronics and promote their coordinated use. In parallel, the best facilities for data analysis of high-energy astrophysical observatories will be made available to the European community. The technological development will focus on the improvement of selected critical technologies, background modeling, cross calibration, and feasibility studies of space-based instrumentation for the benefit of future high energy missions like Athena, and the best exploitation of existing observatories. AHEAD will support the community via grants for collaborative studies, dissemination of results, and promotion of workshops. A strong public outreach package will ensure that the domain is well publicized at national, European and International level. Networking, joint research activities and access to infrastructures as devised in AHEAD, will serve to establish strong connections between institutes and industry to create the basis for a more rapid advancement of high-energy astrophysical science, space oriented instrumentation and cutting-edge sensor technology in Europe. This enables the development of new technologies and the associated growth of the European technology market with a dedicated technology innovation package, as well as the creation of a new generation of researchers.

Connection between accretion state and FeK winds in neutron stars

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High resolution X-ray spectra of accreting stellar mass Black Holes (BH) reveal the presence of accretion disc winds, traced by high ionisation FeK lines. These winds appear to have an equatorial geometry and to be observed only during disc dominated states in which the radio jet is absent. Accreting Neutron Star (NS) systems also show equatorial high ionisation absorbers. However the presence of any correlation with the accretion state has not been previously tested. We have studied EXO0748-676 and AXJ1745.6-2901 the two high-inclination accreting NS with the best XMM-Chandra monitoring. Not one of twenty X-ray spectra obtained in the hard state revealed any significant Fe K absorption line. Intense Fexxv and Fexxvi are always clearly detected during the 10 soft state observations. The variability of the absorption features does not appear to be due to plasma over-ionisation in the hard state. This suggests that the connection between Fe K absorption and states (and anticorrelation between the presence of Fe K absorption and jets) is also valid for EXO0748-676 and AXJ1745.6-2901 and therefore it is not a unique property of BH systems but a more general characteristic of accreting sources.

Isolated neutron stars as seen by Athena

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The X-ray emission from the surfaces of isolated neutron stars and from the neutron star's immediate surroundings is not well understood. Partly, this is due to a lack of spectral resolution and sensitivity of current X-ray detectors. In our poster, we present simulations of neutron star X-ray emission as Athena may see it. We employ the latest Athena instrument response and up-to-date neutron star atmosphere models. This will allow us to evaluate the impact Athena can have on the investigations of neutron star properties, such as the composition of their surface layers, their magnetic fields, and the physics of their magnetospheres and ambient matter.

Unraveling ICM Physics and AGN Feedback with Very Deep Chandra Observations of the Galaxy Group NGC 5813

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We present results based on very deep (650 ks) Chandra observations of the galaxy group NGC 5813. This system shows three pairs of collinear cavities, with each pair associated with an elliptical AGN outburst shock. Due to the relatively regular morphology of this system, and the unique unambiguous detection of three distinct AGN outburst shocks, it is particularly well-suited for the study of AGN feedback and the AGN outburst history. The implied mean kinetic power is roughly the same for each outburst, demonstrating that the average AGN kinetic luminosity can remain stable over long timescales (roughly 50 Myr). The two older outbursts have larger, roughly equal total energies as compared with the youngest outburst, implying that the youngest outburst is ongoing. We find that the radiative cooling rate and the mean shock heating rate of the gas are well balanced at each shock front, suggesting that AGN outburst shock heating alone is sufficient to offset cooling and establish AGN/ICM feedback within at least the central 30 kpc. This heating takes place roughly isotropically and most strongly at small radii, as is required for feedback to operate. We suggest that shock heating may play a significant role in AGN feedback at smaller radii in other systems, where weak shocks are more difficult to detect. We find non-zero shock front widths that are too large to be explained by particle diffusion. Instead, all measured widths are consistent with shock broadening due to propagation through a turbulent ICM with a mean turbulent speed of roughly 70 km/s. Significant contributions to our understanding of AGN feedback and ICM physics, partially via studies similar to the one described here, will be one of the major achievements of the Athena mission.

A Catalogue of X-ray BL Lacs: Statistics applied to the study of X-ray spectra

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An XMM-Newton catalogue of 163 BL Lacs has been assembled based on the cross-correlation of the XMM-Newton archive with the 1374 BL Lac objects listed in the 13th edition of the Veron-Cetty and Veron (2010) catalogue. Phenomenological BL Lac emission models have been fitted systematically to all the X-ray spectra in order to characterize the X-ray properties of the sample.

We present the results of a study that investigates the use of different statistical methods for fitting X-ray spectra. With the fitting statistics defined, we compare the results of using two phenomenological models to characterize the X-ray emission, powerlaw versus log-parabolic, and look into the implications of using one versus the other in terms of model parameters.

Dwarf spheroidal galaxies in the Local Group

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The Local Group of galaxies consists of the large spiral galaxies Milky Way, M31, and M33, and a large number of dwarf galaxies. Most of the galaxies are dwarf spheroidal (dSph) galaxies, which are the least luminous galaxies with the largest mass-to-light ratios. In general, dSphs show no recent star formation, which means that they are ideal laboratories to study the old, pristine stellar populations formed in the earlierst epochs of chemical enrichment of the Universe. Observations with today's X-ray telescopes have revealed X-ray sources in the fields of the dSphs that are satellites of our Milky Way. The study of X-ray source population in these galaxies and their X-ray luminosity function will help us to understand the source population in galaxies at the early stages of galaxy evolution. Moreover, the existence of X-ray binaries in these galaxies, if confirmed, would indicate that these galaxies are able to retain their compact objects, which are believed to obtain high kick-velocities at their birth in asymmetric supernova explosions. Therefore, the search for and the study of X-ray sources in dSph galaxies in the Local Group will enable us to constrain the mass of dark matter in these galaxies and test different models of the formation and growth of galaxies out of primordial dark-matter halos.

I will discuss, how, owing to the large effective area, large field of view and high spatial and time resolution, Athena and its WFI will make it possible to obtain unprecedented observational data of the stellar populations in primordial galaxies and dark-matter halo distribution in our Local Group through the study of high-energy sources.

On the nature of Fermi gamma-ray sources

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Since its launch in 2008, the Large Area Telescope (LAT) on board the Fermi Gamma-ray Space Telescope has been surveying the sky at energies above 100 MeV. The latest catalog of gamma-ray sources (known as 3FGL), using four years of data, contains over 3,000 sources. Approximately one third of these sources have no known astrophysical counterpart (the so-called "unassociated" sources). While many of these are likely to belong to known classes of gamma-ray emitters (e.g. Active Galactic Nuclei (AGN) or pulsars), other more exotic explanations have been proposed, such as the annihilation of dark matter particles. I will present an overview of the current status of the GeV sky, as seen by Fermi, and discuss some of the latest efforts to uncover the nature of some of these sources.

X-ray absorption studies of young stars

Schneider, C.
ESTEC/ESA

Young stars are surrounded by large amounts of circumstellar material, which can be studied using its absorption signatures. Optical/infrared extinction traces only the dust while X-ray absorption is also sensitive to the gas content along the line-of-sight. Therefore, X-ray studies provide important clues on the gas-to-dust ratio of circumstellar material. I will present X-ray absorption studies, which reveal large changes the gas-to-dust ratio of circumstellar matter, from gas-rich during early stellar evolution to dust-rich at later stages.

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

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EXTraS (EU-FP7 framework) is the first systematic search for (and characterization of) all variable soft X-ray sources at all time scales in the whole archive of observations collected by the EPIC instrument on-board XMM-Newton since its launch in 1999, looking for transients, aperiodic, periodic and long-term variability. The project includes the phenomenological classification of all detected variable sources, extending and improving the 3XMM catalalogue. All results will be released in a public archive, together with new software tools.

Can we use energy spectra to differentiate QPO model?

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The presence of QPOs in the PDS of x-ray binaries is quite ubiquitous and is often model as a structure orbiting in the disk. While we have been using timing and PDS to determine the presence and explore the possible origin of QPOs, they are, up to now, absent of the spectral analysis. Here we are using a simple analytical model to mimic the hot structure of several QPO model to determine if ATHENA will be able to distinguish between them.

The Hard X-ray Luminosity Function of High-Redshift AGN

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We present the hard-band ($2-10$ keV) X-ray luminosity function (HXLF) of a large AGN sample (141) at $3 < z < 5$ selected from X-ray surveys of different size and depth, in order to sample different regions in the $L_X - z$ plane. The sample is characterized by a very high redshift completeness ($\sim 98\%$). The HXLF is fitted in the luminosity range $logL_X \sim 43-45$ with analytical models through a maximum likelihood procedure. The evolution of the HXLF is well described by a pure density evolution, with the AGN space density declining by a factor of ~ 10 from $z=3$ to 5. We also estimated the intrinsic fraction of AGN obscured by a column density $logN_H > 23$ to be 0.54 ± 0.05, with no strong dependence on luminosity. This fraction is higher than the value in the Local Universe, suggesting an evolution of the luminous ($L_X > 10^{44} erg\, s^{-1}$) obscured AGN fraction from $z=0$ to $z>3$. The best-fitting model, together with results collected from similar works in the literature, will then be used to estimate the number of high-redshift AGN which will be detected in different ranges of redshift and luminosity by the Athena extragalactic surveys.

Local cloud simulations: a new tool for modeling the AGN environment

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Spectral line formation in active galactic nuclei (AGN) likely takes place in relatively small regions of a multi-phase environment, as it has been established that AGN have small covering and filling factors. These regions, where large changes in the temperature and ionization of the gas occur over relatively short distances, are called clouds. A natural mechanism to produce multiphase media is provided by the thermal instability (TI), but the classic treatment of TI leaves open the question of how clouds formed via TI can be accelerated to the high velocities necessary to explain the width of the observed emission lines. Our recent work has demonstrated how to self-consistently model both cloud formation and acceleration using local simulations that track the development of TI into the nonlinear regime. During the cloud formation process, ions recombine and the bound-bound opacity to ultraviolet (UV) photons increases substantially. Since the radiation field in AGN is not isotropic, the cloud will be accelerated outward primarily by a radiation force due to resonance lines. If the cloud remains optically thin to the UV line photons, it will not be subject to immediate destruction and can therefore reach velocities that are a significant fraction of the sound speed. In the case of a planar cloud with constant conductivity, the cloud reaches a Mach number of ~ 0.5 before it is destroyed by the Rayleigh-Taylor and Kelvin-Helmholtz instabilities.

Here we extend this study to further explore the potential of local cloud simulations. We vary the initial conditions to form clouds with different initial shapes and sizes, study the effects of a realistic ($\kappa \propto T^{5/2}$) conductivity, adopt various different heating and cooling prescriptions appropriate for the AGN environment, and consider preliminary 3D simulations. We find overall that our initial results are indeed robust in the sense that clouds can be significantly accelerated before they are destroyed. However, we find that destructive processes are more efficient for round clouds compared to planar clouds, for realistic conductivity compared to constant conductivity, and for 3D compared to 2D. These results suggest that discrete clouds, if they exist, are highly dynamical and transient objects. Efforts to produce synthetic spectra based on these local cloud simulations are underway.

Detailed observations of sloshing cold fronts in clusters of galaxies - implications for the physics of the intra-cluster medium

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I will present the results of very deep, legacy class, Chandra observations of some of the nearest, best resolved cold fronts in the sky, in the Virgo and Ophiuchus clusters. In both systems, the widths of the cold fronts are remarkably small (of the order of the Coulomb mean free path in Virgo) and the temperature gradients are large (reaching 1.75 keV per kpc in Ophiuchus), indicating that diffusion, conduction and mixing are suppressed. Such transport processes can be naturally suppressed by magnetic fields aligned with the cold front. In both clusters, parts of the cold fronts show indications for the presence of Kelvin-Helmholtz instabilities (KHI) on length scales of a few kpc. Based on comparison with simulations, the presence of KHI would imply that the effective viscosity of the intra-cluster medium is suppressed by more than an order of magnitude with respect to the isotropic Spitzer-like temperature dependent viscosity. Underneath the cold front in the Virgo Cluster, we observe quasi-linear features that are ~ 10 per cent brighter than the surrounding gas and are separated by ~ 15 kpc from each other in projection. Comparison to tailored numerical simulations suggests that the observed phenomena may be due to the amplification of magnetic fields by gas sloshing in wide layers below the cold front, where the magnetic pressure reaches $\sim 5-10$ per cent of the thermal pressure, reducing the gas density between the bright features.

A Detailed Probe of Accretion Physics through X-ray Reflection and Reverberation

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Accretion onto supermassive black holes in active galactic nuclei is known to power some of the most luminous objects we see in the Universe, which through their vast energy outputs must have played an important role in shaping the large scale structure of the Universe we see today. Much remains unknown, however, about the fine details of this process; exactly how energy is liberated from accretion flows onto black holes, how the 'corona' that produces the intense X-ray continuum is formed and what governs this process over time.

I will outline how the detection of X-rays reflected from the discs of accreting material around black holes by the present generation of large X-ray observatories, shifted in energy and blurred by relativistic effects in the strong gravitational field close to the black hole, has enabled measurements of the inner regions of the accretion flow in unprecedented detail. In particular, exploiting the shift in energy of atomic emission lines by relativistic effects as a function of location on the disc has enabled the measurement of the illumination pattern of the accretion flow by the X-ray continuum from which the geometry of the emitting region can be inferred and how the detection of time lags between the primary and reflected X-rays owing to the additional path the reflected rays must travel between the corona and the disc places further constraints on the nature of the emitting corona. These techniques allow the evolution of the corona that accompanies transitions from high to low X-ray flux to be studied, giving clues to the physical process that forms and powers the intense X-ray source and uncovering evidence for the potential launching of jets.

I will discuss the great steps forward in understanding accretion physics that can be made with the Athena X-ray observatory, combining detailed analysis of observations with predictions and models from general relativistic ray tracing simulations. In particular, I will discuss how high resolution X-ray spectra can probe the geometry and physics of both the X-ray emitting corona and the accretion disc itself and how this next generation observatory will enable detailed energy-resolved measurements of X-ray reverberation which will produce not just a static picture but a dynamic one of the processes by which energy is injected into and propagates through the corona and accretion flow to power some of the most luminous objects we see in the Universe.

End-to-End Simulations for Athena

Wilms, J. et al (TBC)
ECAP

Realistic simulations of astrophysical sources will be used throughout the mission definition and implementation of Athena to ensure that the mission as implemented is capable to reach its scientific goals. This contribution describes the status of the end to end simulator developed for Athena. At this stage, the simulator already contains physics based models for the photon detection and read out mode for the WFI and the X-IFU (including nonlinearities due to bright sources), and is capable of simulating Athena observations of complex X-ray sources, including extended sources that also exhibit spatial variability of their X-ray spectrum and/or time variability). The simulator input is compatible to the simx simulator for Astro-H, while the output of the end to end simulations is compatible with standard data analysis tools. The contribution will discuss the design of the simulation environment and highlight Athena's capabilites using selected examples drawn from typical uses of Athena such as observations of deep fields, galaxy clusters, supernova remnants, and bright Galactic X-ray binaries.

The simulator code is available from http://www.sternwarte.uni-erlangen.de/research/sixte/, a web interface can be found at http://hydrus.sternwarte.uni-erlangen.de/∼athenasim.

X-raying the most luminous QSOs in the universe

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I will report on the on-going Wise All Sky Survey/SDSS selected hyper-luminous (WISSH) quasars survey. It consists of a sample of ~ 90 Type 1 reddened quasars at $z \sim 2-3$. They represent the most luminous ($L_{bol} > 10^{14} L_{sun}$) quasars at their number density peak and, remarkably, show widespread signs of outflows in the UV/optical spectrum. This is the frst systematic and multi-wavelength study of these unique sources at the brightest end of the AGN luminosity function. In this talk, I will present the X-ray properties of the WISSH quasars based on both proprietary and archival data, and their implications in the context of the AGN/host galaxy co-evolutionary scenario. Furthermore, I will also report on the improvement provided by the Athena/X-IFU in our understanding of these extreme sources, the feedback mechanism at work, and in characterizing them as a population. This project is relevant to the activities carried out in the SWG2.2 "Understanding the build-up of SMBH and galaxies".

Prospects for studies of extragalactic X-ray binary populations with Athena

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University of Crete, Greece

Populations of extragalactic X-ray binaries are an invaluable tool for studying the formation and evolution of compact objects in binary stellar systems. Thanks to a deep census of their populations obtained with the Chandra and XMM-Newton observatories, we have been able to discover rare sources, and constrain key parameters related to the evolution of X-ray binaries. The next leap forward in this direction, in the forseeable future, will be provided by the Athena observatory. I will discuss how X-ray observations of galaxies in the local Universe, with different sensitivity and resolution, can be used to extend our current understanding of X-ray binary populations, and constrain the nature of X-ray binaries in different environments.

X-ray cluster surveys and the optical spectroscopic follow-up challenge

Zhang, Y.-Y.
AIfA at the University of Bonn

The talk will concentrate on the perspective of using galaxy clusters for cosmology. I will address two aspects under this topic: (i) mass calibrations and cosmological constraints using an X-ray defined cluster sample, and (ii) the systematic uncertainties in the mass estimates using upcoming optical spectroscopic follow-up surveys for the X-ray cluster sample. I will also present the investigations performed according to the 4MOST survey configuration, which demonstrates the potential for mass calibrations for X-ray defined samples.

The complex evolution of AGN outflows

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One of Athena's primary goals is investigating the physics of AGN feedback on galaxy scales, as well as the influence this feedback has upon galaxy star formation histories, transport of gas and heavy elements to galactic outskirts and formation of hot diffuse gas envelopes around galaxies. In order to investigate these processes, we must have a good understanding of the interaction between AGN winds and the surrounding medium, the formation and evolution of AGN-driven outflows.

I will present results of numerical simulations, based on the wind-driven outflow model, showing that AGN outflows cool down and fragment rapidly and that some regions of the interstellar medium are more likely to be compressed rather than expelled by a passing outflow. These processes create additional complexity, both in terms of gas morphology and its energetics, which can complicate the interpretation of observational data. Furthermore, the choice of numerical resolution and feedback recipes can have decisive influence upon the results of numerical simulations. I will suggest ways to improve the simulations, so that they give more accurate predictions for Athena observations and help interpreting them in light of the complex processes occurring at the interface between AGN winds and the interstellar medium.

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