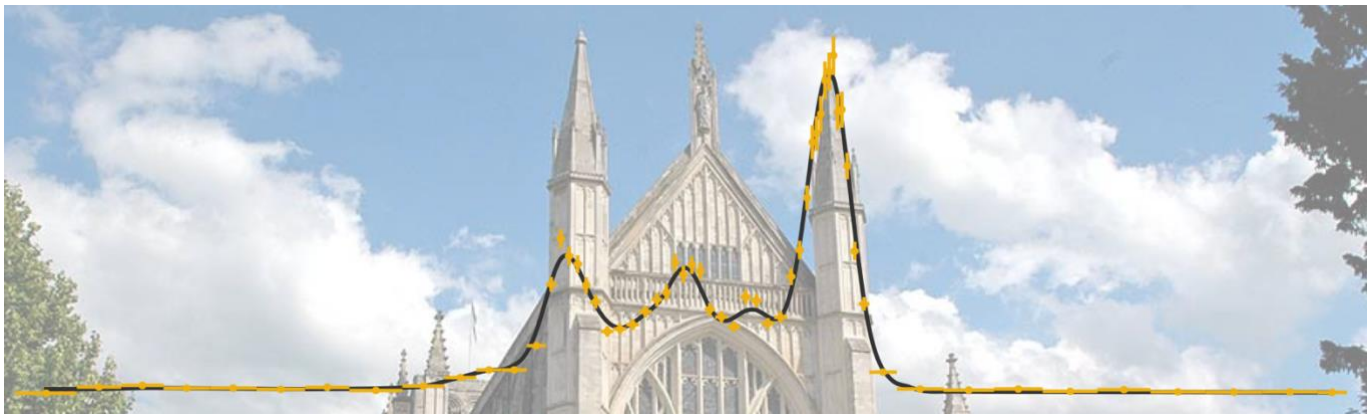

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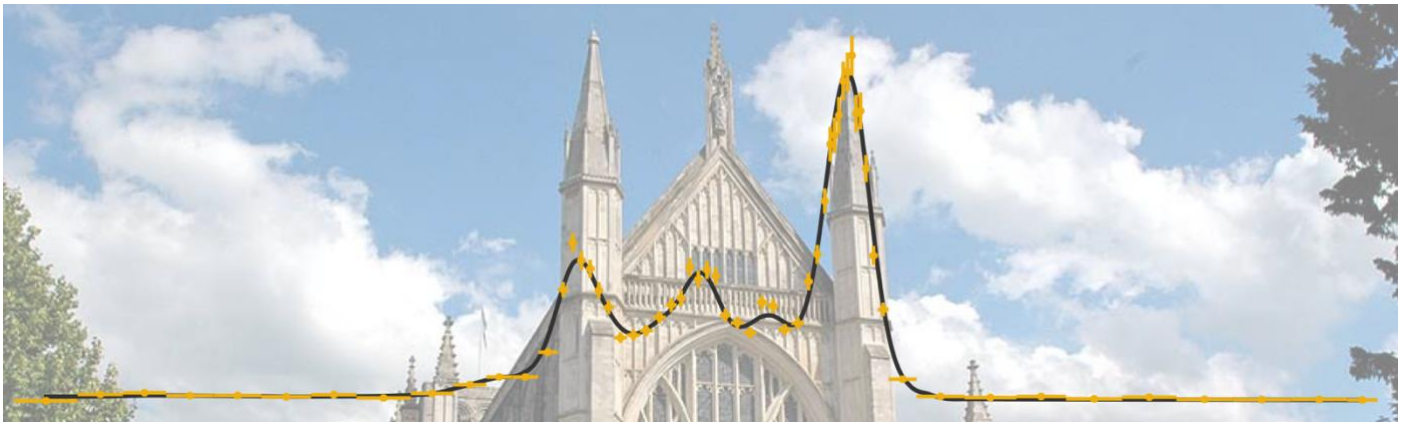


XCalibur 2019
Abstract Book

Winchester

15 – 18 July 2019

Contents

1 Motivation

An unprecedented new window into observational cosmology and astrophysics was opened by the Hitomi X-ray mission, which used microcalorimeter technology to deliver X-ray observations of cosmic sources with $< 5\,\mathrm{eV}$ spectral resolution. This regime represents a game-change in X-ray astronomy, enabling novel plasma physical condition and metallicity diagnostics, together with searches for fundamental new emission signatures such as the much-debated $\sim 3.5\,\mathrm{keV}$ dark matter decay lines expected in the X-ray regime.

The new *X-Ray Imaging and Spectroscopy Mission* (*XRISM* - jointly funded by JAXA/NASA/ESA) is due to launch in the early 2020s. Beyond that, we can look forward to *Athena*, and possibly *ARCUS*, *Super-DIOS* or similar missions, in the 2030s to open this new regime wider.

The XCalibur 2019 workshop aims to bring together international experts (with non-experts very welcome) on X-ray spectroscopy to provide a forum for discussing the novel science enabled by these missions, to formulate the best way of exploiting the large new parameter space, and to strategize future observations. We also intend to have pedagogical reviews, as well as a Hitomi analysis hackathon session, which should be particularly beneficial for young scientists and non-experts in the field of high resolution X-ray spectroscopy. We hope to have an informal atmosphere with plenty of discussion time.

There is no better host city for this workshop than the historic town of Winchester, home to that great symbol of medieval mythology: the Round Table associated with King Arthur, wielder of the legendary Excalibur. The beautiful venue of the Winchester Guildhall allows for about 100 participants, and funding support may be available for a selected number of young scientists.

Social events will include a visit to historic Stonehenge.

Overview

The workshop will focus on several broad themes:

- Physics of Extreme Hot Plasmas
- Compact Objects and Gravity
- Life Cycle of Baryons
- Energy flows and Feedback
- The Search for Dark Matter and New Physics
- Community Preparation for XRISM and Athena

2 Organisers

Scientific Organising Committee

Aya Bamba (Tokyo) • Pasquale di Bari (Southampton) • Maria Diaz Trigo (ESO) • Poshak Gandhi (Southampton) • Matteo Guainazzi (ESA) • Ian Jones (Southampton) • Richard Mushotzky (Maryland) • Christopher Reynolds (Cambridge) • Makoto Tashiro (Saitama)

Local Organising Committee

Peter Boorman • Matthew Middleton • Claire Greenwell • Poshak Gandhi • Ian Jones (Southampton)

3 Presenters

Invited Speakers

Didier Barret (IRAP/CNRS) • Graziella Branduardi-Raymont (Mullard Space Science Laboratory - UCL) • Chris Done (University of Durham) • Craig Heinke (University of Alberta) • Jelle Kaastra (SRON) • Erin Kara (MIT) • Julia Lee (Harvard) • Fabrizio Nicastro (INAF - OAR) • Makoto Tashiro (Saitama University, ISAS/JAXA) • Francesco Tombesi (University of Rome Tor Vergata) • Yoshihiro Ueda (Kyoto University) •

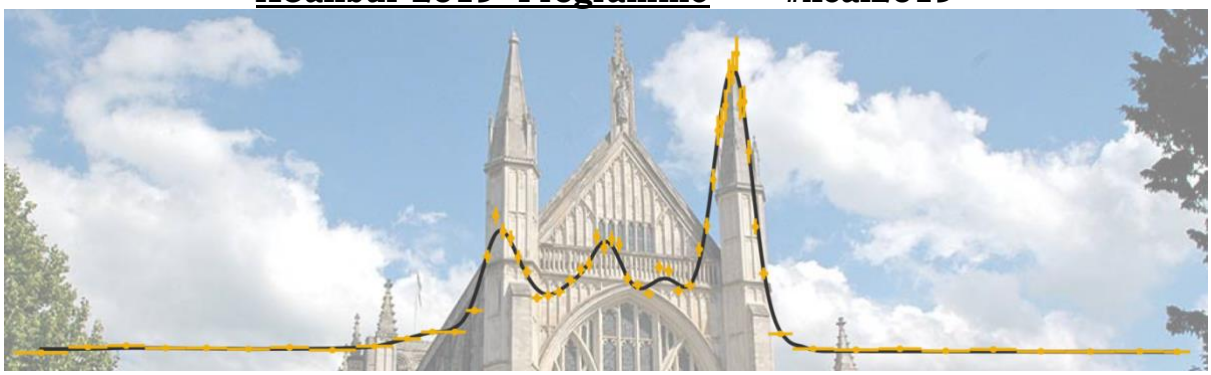
Oral Presenters

Mislav Balokovic (Harvard-Smithsonian Center for Astrophysics) • Ehud Behar (Technion) • Aru Beri (IISER Mohali) • Stefano Bianchi (University degli Studi Roma Tre) • Rozenn Boissay-Malaquin (MIT) • Murray Brightman (Caltech) • Keigo Fukumura (James Madison University) • Javier Garcia (Caltech) • Edmund Hodges-Kluck (University of Maryland/NASA GSFC) • Satoru Katsuda (Saitama University) • Jiren Liu (NAO) • Kazuo Makishima (Kavli IPMU, The University of Tokyo) • Misaki Mizumoto (University of Durham) • Koji Mukai (NASA/GSFC/CRESST and UMBC) • Jukka Nevalainen (Tartu University) • Francesca Panessa (INAF IAPS) • Ciro Pinto (European Space Agency) • Andy Pollock (University of Sheffield) • Randall Smith (SAO) • Lydia Stofanova (Leiden University, SRON) • Jiri Svoboda (Astronomical Institute of the Czech Academy of Sciences) • Ryota Tomaru (The University of Tokyo, IPMU) • Hendrik Ulbricht (University of Southampton) • Brian Williams (NASA GSFC) •

Poster Presenters

Christopher Bambic (Institute of Astronomy, Cambridge) • Yashpal Bhulla (Pacific Academy of Higher Education and Research University, Udaipur) • Peter Boorman (University of Southampton) • Sergei Dyda (Cambridge University) • Anjali Gupta (Columbus State Community College) • Paul Hemphill (MIT Kavli Institute) • Judith Ineson (University of Southampton) • Taiki Kawamuro (NAOJ) • Demosthenes Kazanas (NASA/GSFC) • Peter Kosec (Institute of Astronomy, University of Cambridge) • Michael Loewenstein (University of Maryland and NASA/GSFC) • Alfredo Luminari (University of Rome "Tor Vergata" & INAF - Rome Observatory) • Sourabh Nampalliwar (University of Tuebingen, Germany) • Michael A Nowak (Dept. of Physics, Washington University) • Denys Savchenko (Bogolyubov Institute for Theoretical Physics, Kyiv, Ukraine) • Ekaterina Sokolova-Lapa (Dr. Karl Remeis-Observatory (ECAP FAU)) • Corbin Taylor (University of Maryland) • Alessia Tortosa (Universidad Diego Portales) • Dom Walton (University of Cambridge) • Sam Waters (MSSL, UCL) •

XCalibur 2019 Programme **#xcal2019**



July 15-18, Winchester UK. **Sponsors: University of Southampton, STAG.**

Information for Presenters

Invited (I) and Review (R) talks are 25+5 minutes, and Solicited (S) talks at 17+3 minutes. The primary distinction in form is that review speakers have been requested to tune their talks more towards pedagogical overviews that can accommodate non-expert audiences. Contributed talks are 12+3 minutes.

Posters will be displayed throughout the workshop on the walls in the coffee/lunch space. The venue is better suited to portrait (vertical) orientation and A1 size, though other sizes and orientations can also be accommodated. Please get in touch with us if you have any questions in this regard.

A 1-minute oral presentation slot has been allocated for all poster presenters. These will be divided between two sessions: on the Monday and the Wednesday.

All poster presenters are requested to send us PDF versions by July 14, which can be advertised online in advance. And we similarly request that talks be sent to us over the course of the workshop.

Invited Speakers and Discussion Leaders

Kevork Abazajian (UCI) • Didier Barret (IRAP) • Alexey Boyarsky (SRON) • Graziella Branduardi-Raymont (UCL) • Massimo Cappi (INAF) • Maria Diaz-Trigo (ESO) • Chris Done (Durham) • Andrew Fabian (IoA) • Liyi Gu (Tokyo) • Craig Heinke (Alberta) • Jelle Kaastra (SRON) • Erin Kara (MIT) • Taiki Kawamuro (NAOJ) • Julia Lee (Harvard) • Misaki Mizumoto (JAXA) • Makoto Tashiro (Saitama) • Randall Smith (Harvard) • Francesco Tombesi (Roma) • Masahiro Tsujimoto (JAXA) • Yoshihiro Ueda (Kyoto)

Day 0: July 14 (Sun)

18:00-20:00 Informal Evening Drinks at The Bishop on the Bridge

Day 1: July 15 (Mon)

09:30-09:33	Welcome	

Current state-of-the-art, Plasma Physics and Dark Matter searches.

Morning Chair: M. Loewenstein

09:35-10:05	A. Fabian (I)	*Hitomi* results of the Perseus Cluster observations and related cosmological implications
10:05-10:20	C. Pinto	X-ray-solving AGN feedback in cluster of galaxies
10:20-10:35	K. Makishima	How do Galaxies Interact with Intra-Cluster Medium?
10:35-11:00	Tea/Coffee/Poster viewing	
11:00-11:30	J. Kaastra (R)	Atomic Data and Models: a Primer for high resolution X-ray spectroscopy
11:30-11:45	L. Stofanova	A new cooling curve due to the updates of collisional excitation processes in the plasma code SPEX
11:45-12:00	E. Hodges-Kluck	Combining High Spectral and Angular Resolution Data
12:00-14:00	Lunch/Poster viewing	

Afternoon Chair: K. Makishima

14:00-14:30	K. Abazajian (R)	Sterile Neutrinos
14:30-14:45	B. Williams	Lab astrophysics needs for *XRISM* and beyond
14:45-15:00	H. Ulbricht	Proposal to detect dark matter by a mechanical oscillator
15:00-15:15	Poster talks	
15:15-15:45	Tea/Coffee/Poster viewing	

15:45-16:30	Discussion Session 1 (Liyi Gu, Alexey Boyarsky)	
16:30-17:30	M. Tsujimoto & M. Mizumoto (I)	*Hitomi* hackathon

Day 2: July 16 (Tue)

Future state-of-the-art

Morning Chair: A. Pollock

09:30-10:00	M. Tashiro (I)	*XRISM*: Mission History and Status
10:00-10:30	D. Barret (I)	The *Athena* Mission: Status and Community Preparation
10:30-11:00	Tea/Coffee/Poster viewing	
11:00-11:15	R. Smith	*Arcus*: The Soft X-ray Grating Spectroscopy Explorer
11:15-11:30	C. Reynolds	The *Lynx* X-ray observatory
11:30-11:45	F. Panessa	The SKA and Athena synergy on AGN
11:45-12:05	G. Branduardi-Raymont (S)	Solar System Science possibilities at High Spectral Resolution
12:05-14:00	Lunch/Poster viewing	

ISM and IGM

Afternoon Chair: F. Panessa

14:00-14:30	J. Lee (R)	Cosmic Dust Studies at High Spectral Resolution
14:30-14:45	J. Liu	X-ray signatures of the polar dust in AGN
14:45-15:00	S. Katsuda	High-resolution X-ray spectroscopy of southeastern knots in Tycho's SNR with XMM-Newton/RGS
15:00-15:30	Tea/Coffee/Poster viewing	
15:30-16:00	F. Nicastro (R)	Inter Galactic Medium at high spectral resolution
16:00-16:15	J. Nevalainen	Searching for the hot WHIM
16:15-16:30	T. Kawamuro	A Chandra and ALMA Study of X-ray-irradiated Gas in the Central ~100 pc of the Circinus Galaxy
16:30-17:15	Discussion session 2 (M. Cappi, R. Smith)	

Day 3: July 17 (Wed)

Compact Objects and Feedback

Morning Chair: M. Nowak

09:30-09:50	C. Heinke (S)	Neutron Stars
09:50-10:10	C. Done (S)	Winds from Binaries
10:10-10:25	K. Mukai	Density of the boundary layer in non-magnetic cataclysmic variables
10:25-10:40	R. Tomaru	The thermal-radiative disc wind in the low mass X-ray binary H 1743-322
10:40-11:10	Tea/Coffee/Poster viewing	
11:10-11:25	P. Hemphill	Accretion in Ultracompact X-ray Binaries: A Unified Picture of 4U 1626-67
11:25-11:40	A. Pollock	Long-Term Investments in the Winds of Massive Stars
11:40-12:10	F. Tombesi (I)	AGN Feedback
12:10-14:00	Lunch/Poster viewing	
14:00-14:15	K. Fukumura	Confronting UFO Models with Correlations from Magnetic View
Afternoon Feedback Session Chair: M. Middleton		
14:15-14:30	R. Boissay-Malaquin	The extreme velocities of the Ultra-fast Outflow components in the Quasar PDS 456
14:30-14:45	M. Mizumoto	The origin of UFOs in AGN
14:45-15:00	Poster talks	
15:00-15:30	Tea/Coffee/Poster viewing	

Compact Objects: Reflection

Reflection session chair: G. Lansbury

15:30-16:00	Y. Ueda (I)	AGN reflection

16:00-16:15	J. Garcia	High-Resolution X-ray Reflection Spectroscopy in the next Decade
16:15-16:30	M. Balokovic	Constraints on AGN Torus and Outflow Geometry from High-resolution X-ray Spectroscopy
16:30-17:15	Discussion session 3 (M. Diaz-Trigo, T. Kawamuro)	
19:00-21:00	Dinner at Winchester Cathedral Annex	

Day 4: July 18 (Thu)

Compact Objects: Continued

Morning Chair: D. Walton

09:30-10:00	E. Kara (I)	Tidal Disruption Events
10:00-10:15	M. Brightman	Uncovering and studying neutron stars powering ultraluminous X-ray sources with high resolution X-ray spectroscopy
10:15-10:30	J. Svoboda	Steep X-ray reflection emissivity profiles in AGN as the result of radially structured disc ionization
10:30-11:00	Tea/Coffee/Poster viewing	
11:00-11:15	E. Behar	X-ray Emission Lines in AGN and What They Can Tell Us About The BLR
11:15-11:30	S. Bianchi	Evidence for radiation pressure compression in the X-ray narrow-line region of Seyfert galaxies
11:30-12:00	Final community discussion and summary (SOC)	
12:00	***End of Workshop***	
12:00-18:00	Excursion to Stonehenge	

Poster Programme: displayed all days; talks on listed days

C. Bambic	Limits on Turbulent Propagation of Energy in Cool-Core Clusters of Galaxies	Mon
S. Dyda	Viscous Effects on Misaligned Disc Precession	Mon
P. Kosec	A highly ionised disc wind in Hercules X-1	Mon
M. Loewenstein	Chemical Evolution of the Perseus Cluster Core	Mon
D. Savchenko	Surface brightness profile of the 3.5 keV line in the Milky Way halo	Mon
E. Sokolova-Lapa	X-rays from neutron star atmospheres at low accretion rates	Mon
S. Waters	Photoionisation modelling of the emission line regions in the nucleus of NGC 7469	Mon
P. Boorman	New Insights Into AGN Obscuration with XRISM	Wed
J. Ineson	IC vs. ICM: distinguishing between X-ray emission from radio galaxy lobes and their host galaxy groups	Wed
A. Luminari	Unveiling the physics and the geometry of X-ray outflows with the WINE model	Wed
S. Nampalliwar	eXtreme gravity with X-rays	Wed
M. Nowak	The Hunt for UFOs with Chandra-HETGS	Wed
C. Taylor	Modelling the Black Hole Reflection Spectrum with Fenrir	Wed
D. Walton	An extreme ultrafast outflow in the Seyfert 2 galaxy IRAS 00521-7054	Wed

Poster abstract submission remains open until 2019 July 10:
http://www.astro.soton.ac.uk/xcal2019/

4 Abstracts

Current state-of-the-art, Plasma Physics and Dark Matter searches.

Andy Fabian

Hitomi results of the Perseus Cluster observations and related cosmological implications

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Ciro Pinto

European Space Agency

Chris Bambic, Jeremy Sanders, Andy Fabian, Michael McDonald, Helen Russell, Haonan Liu, Chris Reynolds

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X-ray-solving AGN feedback in cluster of galaxies

It is not clear how exactly AGN feedback affects galactic evolution. High star formation and plasma cooling rates in some clusters cast doubts on the feedback efficiency. High-resolution X-ray spectroscopy of the massive Phoenix cluster enabled us to detect for the fist time mild-ionization emission lines, revealing gas below 2 keV at a cooling rate of several hundred solar masses per year. This is high enough to produce the filamentary molecular gas via instabilities during the buoyant rise. The line widths indicate turbulence below the level required to propagate heat throughout the cluster core, which can explain the coexistence of large amounts of cool gas and star formation despite a powerful AGN. However, similar clusters seem to contradict this scenario possibly due to a different feedback mode. I will provide a state-of-art overview of the constraints on heating-cooling balance in clusters as well as future perspectives and requirements for the new *XRISM* and *Athena* missions.

Kazuo Makishima

Kavli IPMU, The University of Tokyo

Liyi Gu (RIKEN)

How do Galaxies Interact with Intra-Cluster Medium?

In every cluster of galaxies, the member galaxies are moving through the Intra-Cluster Medium (ICM), and should interact with it via, e.g., ram-pressure effects. However, this fact has not been properly considered either by optical observers nor X-ray researchers. Here, we show that a correct understanding of the interactions between these two components provides a key to the cluster evolution, and can explain the observed cosmological in-fall of galaxies (Gu *et al.* 2014, 2016), the low and uniform turbulence velocity observed with *Hitomi*, the long-sought heating source of ICM at the cluster core, the uniform metal enrichment of the ICM, and even the spatial/temporal environmental effects on galaxies. This novel paradigm will be greatly expanded by future high-resolution X-ray spectroscopy with *XRISM*, which enables us to test a prediction that massive member galaxies should drag the local ICM.

Jelle Kaastra

SRON

Atomic Data and Models: a Primer for high resolution X-ray spectroscopy

In this presentation I will review the basic physical processes that contribute to the formation of an X-ray spectrum under different physical conditions. I will indicate the role of the relevant atomic processes and the limitations imposed by the finite accuracy of these data.

Lydia Stofanova

Leiden University, SRON

A new cooling curve due to the updates of collisional excitation processes in the plasma code SPEX

The process of the radiative cooling is important in galaxy clusters and other astrophysical sources. Most of their baryonic mass is in the form of a very hot diluted plasma emitting X-rays in either a form of bremsstrahlung or line radiation. In plasma codes such as SPEX we take into account the atomic physics and model the radiative cooling. However, there are many discrepancies between different plasma codes mainly at lower temperatures (below 10 keV). Understanding these differences is important for interpreting the measurements from the upcoming X-ray missions such as *XRISM* and *Athena*. In this talk I focus on the update of the cooling curve in SPEX in comparison with its previous version also known as the MEKAL code. The updates of the cooling curve are created for the collisional excitation process. The differences for some ions can be as high as a few orders of magnitude for very low temperatures (~ 1 eV) where the resonant excitation was included in the new version of SPEX.

Edmund Hodges-Kluck

University of Maryland/NASA GSFC

Andrew Ptak, Rob Petre, Brian Williams

Combining High Spectral and Angular Resolution Data

XRISM and *Athena* will provide high resolution spectra of many diffuse sources, such as galaxies, with only moderate angular resolution. These spectra will therefore contain contributions from point sources and complex, arcsec-scale gaseous structures. This issue was addressed in the *Hitomi* Perseus observation, but the strategies to tackle it will differ in other fields. I will present a few case studies in how to take advantage of high angular resolution *Chandra* data and high spectral resolution *XRISM* and *Athena* data, including mapping the velocity and abundance structure in starburst galaxies, accounting for variability in the point-source flux.

Brian Williams

NASA GSFC

Laboratory Astrophysics Needs for XRISM and Beyond

The *X-ray Imaging and Spectroscopy Mission* (*XRISM*) is an international collaboration led by JAXA and involving major participation from NASA and ESA that will address some of the most important questions in present-day astrophysics through high resolution X-ray spectroscopy. These measurements rely on accurate modeling interpretation of X-ray spectra, which in turn rely on a set of laboratory measurements and calculations. *Hitomi* showed that more work is urgently needed on both fronts. To this end, the *XRISM* Science Team has formed the *XRISM* Laboratory Astrophysics Working Group, which is dedicated to identifying the highest priority measurements and the laboratory measurements needed to achieve them, as well as studying how modeling software should account for laboratory and atomic modeling uncertainties. I will deliver a status report on our progress, which includes identifying the most urgent measurement needs, and our plans for future study.

Hendrik Ulbricht

University of Southampton

Proposal to detect dark matter by a mechanical oscillator

We will argue that a recently proposed nanoparticle matter-wave interferometer, originally conceived for tests of the quantum superposition principle, is sensitive to detect low-mass dark matter particles by the effect of collisional decoherence. We further show constraints for a classical mechanical oscillator of sufficient mass and if precisely measured in position, to be used to directly detect the acceleration by a dark matter wind upon impact.

Future state-of-the-art

Makoto Tashiro

Saitama University, ISAS/JAXA

XRISM team

XRISM: Mission history and status

The *X-ray Imaging and Spectroscopy Mission* (*XRISM*) is planned to resume high resolution X-ray spectroscopy with imaging once realized but unexpectedly terminated by a mishap of *Hitomi*. On the basis of the first results and lessons learned of *Hitomi*, JAXA and the international collaboration realizes the recovery mission focusing on large scale flows of energy and matter in the universe with the high-resolution X-ray spectroscopy. *XRISM* carries a 6x6 pixelized X-ray micro-calorimeter array on the focal plane of an X-ray mirror assembly, and an aligned X-ray CCD camera covering the same energy band but a wider field of view. This paper introduces the mission history, science objectives, mission concept, and current status of the project.

Didier Barret

IRAP/CNRS

The Athena Mission: Status and Community Preparation.

Athena is the second large mission of the ESA Cosmic Vision program. It is designed to address the Hot and Energetic Universe science theme. It will combine high throughput high resolution X-ray spectroscopy and wide field imaging. Here I will report on the status of the *Athena* mission, as it moves towards the so-called Mission Formulation Review: a point in time when the main characteristics of the mission will be set.

Randall Smith

SAO

The Arcus Team

ARCUS: The Soft X-ray Grating Spectroscopy Explorer

The *ARCUS* mission is designed to provide high-resolution soft (12 – 50 Å) X-ray spectroscopy with unprecedented sensitivity. Its capabilities include spectral resolution > 2500 and effective area of $\sim 300\,\mathrm{cm}^2$. The top three science goals for *ARCUS* are (1) to measure the effects of structure formation imprinted upon the hot baryons that lie in extended halos around galaxies, groups, and clusters, (2) to trace the propagation of outflowing mass, energy, and momentum from the vicinity of the black hole to extragalactic scales as a measure of their feedback and (3) to explore how stars, circumstellar disks and exoplanet atmospheres form and evolve. *ARCUS* uses grazing-incidence silicon pore X-ray optics developed for ESA *Athena* mission and diffracts X-rays with high-efficiency Critical-Angle Transmission (CAT) gratings which are imaged with flight-proven CCD detectors and electronics. The power and telemetry requirements on the spacecraft are modest and mission operations are straightforward.

Francesca Panessa

INAF IAPS

The SKA and Athena synergy on AGN

Four main physical processes are involved in the production of radio emission in AGN: jet, wind, star-formation and coronal emission. All of them are X-ray emitters too. The *Athena* X-ray observatory will be launched when the complete SKA array will be fully operative. The combination of these two facilities will provide fundamental improvements, revolutionizing our comprehension of the main physical actors in galaxy nuclei. The observables provided by the SKA high angular resolution (down to milli-arcsecond scales) combined with those provided by the unprecedented *Athena* spectral energy resolution will clarify the role of star-formation, particle acceleration, coronal emission and ionizing winds and their impact on the host galaxy.

Graziella Branduardi-Raymont

Mullard Space Science Laboratory - UCL

X-ray studies of the solar system at high spectral resolution

XMM-Newton and *Chandra* have prompted remarkable advances in X-ray studies of solar system bodies by probing the magnetospheric dynamics of giant planets, solar wind - planet interactions, planetary atmospheres and satellites surface compositions. The results from these studies have provided outstanding new knowledge of how the solar system works, as well as generated many new questions. While synergy with in situ measurements has added a new dimension to the search for answers, higher spectral resolution in combination with enhanced sensitivity in the X-ray band will provide the next revolutionary step up in elucidating the complex physics underlying the relationships among solar system bodies and between them and the Sun. This talk will give an overview of where we are in this search for knowledge and where we aspire to get to with the new missions coming on line in the near and distant future.

ISM and IGM

Julia Lee

Harvard

Bruce Ravel

Cosmic Dust Studies at High Spectral Resolution through X-ray Eyes

With its ability to penetrate through atoms, X-rays enable a powerful direct probe of both gas and dust to reveal information on composition and element-specific gas-to-dust ratio over orders of magnitude in absorption and temperature to provide complementary knowledge to the wealth of information gathered in other wavebands. I will discuss what we can, and have been able to achieve with extant X-ray missions, and expectations for how we can take these studies to the next phase with planned future missions. Laboratory data and codes to facilitate these studies will also be discussed.

Jiren Liu

NAO

X-ray signatures of the polar dust in AGN

Recent mid-infrared interferometry observations of nearby active galactic nuclei (AGN) revealed that a significant part of the dust emission extends in the polar direction, rather than the equatorial torus/disk direction as supposed by the traditional unification model. This polar dusty gas could produce significant X-ray emission, especially for the Si Kα line at 1.74 keV. We found that below 5 keV, the polar-gas-scattered continuum and fluorescence photons are $5-10$ times stronger than those produced by the equatorial torus/disk in edge-on viewing angles for obscured AGN. The reason is that the polar emission does not suffer from heavy absorption by the dense equatorial gas. The polar-gas-scattered X-ray emission can be used to constrain properties of the polar dust.

Satoru Katsuda

Saitama University

Brian J. Williams, et al.

High-resolution X-ray spectroscopy of southeastern knots in Tycho's SNR with XMM-Newton/RGS

We present preliminary results of our *XMM*-Newton/RGS observation of the southeastern ejecta knots in Tycho's supernova remnant. The RGS successfully resolved numerous emission lines including O He-alpha, O Ly-alpha, and Fe L lines. Line broadening was measured to be $\sim 3\,\mathrm{eV}$ for the O He-alpha and $\sim 4.5\,\mathrm{eV}$ for Fe L lines. If we attribute these broadenings to pure thermal Doppler effects, then we obtain $\mathrm{kT_O}$ and $\mathrm{kT_{Fe}}$ to be $\sim$400 keV and 1.5 MeV, respectively. These temperatures can be explained by collisionless shock heating with shock velocity of $\sim 3600\,\mathrm{km\,s^{-1}}$. This is inconsistent with (slightly smaller than) a forward shock speed of $\sim 4300\,\mathrm{km\,s^{-1}}$, suggesting that the knots are heated by a reverse shock. The relative abundance of intermediate-mass elements to oxygen in the knots is more consistent with that expected in a classical W7 model (a single-degenerate scenario) than a violent merger of two white dwarfs (a double-degenerate scenario).

Fabrizio Nicastro

INAF - OAR

Inter Galactic Medium at high spectral resolution

I will first review the baryon census in the local Universe and show that serious missing-mass problems are present at all scales. I will then present the possible solutions offered by hydro-dynamical simulations for the formation of structures, and show how theory reconciles these different-scale problems in the framework of a single missing-baryon problem. Finally, I will review the history of the hunt for the missing baryons over the past 20 years, and will present the most recent results both on the largest and smallest possible scales in the Universe. Finally, I will comment on the implications of these new results for future high resolution X-ray missions.

Jukka Nevalainen

Tartu University

E. Tempel, J. Ahoranta, A. Finoguenov

Searching for the hot WHIM

I discuss the recent results on detecting and modelling the X-ray absorption signals from the Warm Hot Intergalactic Medium WHIM using high resolution spectrometers RGS and LETG onboard *XMM*-Newton and *Chandra*. I emphasise the X-ray search for the hottest WHIM at the locations of the FUV-detected warm WHIM. I discuss the detection of the Cosmic Web filaments, the expected reservours of the hot WHIM, in the Sloan Digital Sky Survey SDSS. I describe our efforts to use the SDSS filament info as WHIM finding maps for the future instruments onboard *ARCUS*, eRosita and *Athena*.

Taiki Kawamuro

NAOJ

A Chandra and ALMA Study of X-ray-irradiated Gas in the Central ∼100 pc of the Circinus Galaxy

AGN effects on host galaxies are an interesting topic. The AGN is usually X-ray luminous, and therefore its X-ray irradiation is unavoidable for the host galaxy. We thus recently studied properties of X-ray-irradiated gas in the central ∼100 pc of the Circinus galaxy (a Compton-thick AGN host) at 10-pc resolution using *Chandra* and ALMA. Based on the *Chandra* data, we created an image of the 6.4 keV Fe Kalpha line, tracing X-ray-irradiated dense gas. The ALMA data revealed the detailed spatial distribution of dense molecular gas, which was compared to the iron line image. The molecular gas emission appeared faint in regions with bright iron emission. Based on a non-local thermodynamic equilibrium model, we found molecular gas densities in such regions low enough to be interpreted by X-ray dissociation. Furthermore, inactive star-formation therein suggested that the X-ray emission has potential to suppress star-formation.

Compact Objects and Feedback

Craig Heinke

University of Alberta

Measuring the Neutron Star Equation of State with High-Resolution X-ray Spectroscopy

High-resolution X-ray spectroscopy will provide several opportunities to improve our understanding of the physics of neutron star interiors. Neutron star interiors are at much higher density than terrestrial experiments, so empirical studies of neutron stars are necessary to constrain physics of dense matter. Neutron star radii are particularly important to constrain. High-resolution X-ray spectroscopy would offer several opportunities: Quiescent neutron stars radiating heat from previous accretion episodes provide radius constraints, but their temperature measurements suffer degeneracy with the interstellar absorption, removed if the absorption edges are individually resolved. Some quiescent neutron stars may show spectral features from low-level continuing accretion, which can measure the surface redshift, and thus constrain compactness. Finally, thermonuclear X-ray bursts sometimes show spectral features from burning products, which if resolved can measure redshift.

Chris Done

University of Durham

Winds in galactic binary systems

Blueshifted absorption lines are seen in high inclination black hole binary systems in their disc dominated states, showing these power an equatorial disc wind. While some contribution from magnetic winds remain a possibility, thermal and thermal-radiative winds are expected to be present. We show results from radiation hydrodynamic simulations which show that the additional radiation force from atomic features (bound-free and lines) are important along with electron scattering. Together, these increase the wind velocity at high inclinations, so that they quantitatively match the observations. We show how higher resolution spectra from *XRISM* can lead to breakthrough in our understanding of the velocity structure, and address remaining challenges about how the accretion flow produces the winds.

Koji Mukai

NASA/GSFC/CRESST and UMBC

Density of the boundary layer in non-magnetic cataclysmic variables

In the Astro-H White Paper on white dwarfs, Mukai *et al.* (2014) discussed the utility of high resolution X-ray spectroscopy to determine the density of the post-shock region in magnetic cataclysmic variables (CVs). Here we discuss the density of the post-shock region (the boundary layer) in non-magnetic CVs. According to the prevailing theory of the disk, the Keplerian part of the disk has a very low radial drift velocity, which should result in a very high density for the boundary layer. The existing HETG data are of low statistical quality but there are hints of the forbidden lines in the He-like triplets of Fe and Mg in SS Cyg and U Gem in quiescence. If we confirm this result with *XRISM* data, we will know that the CV boundary layer has lower densities than the theory predicts, probably because of much larger radial drift velocities of the Keplerian disk. Such a result will force us to update the disk models.

Ryota Tomaru

The University of Tokyo, IPMU

Chris Done, Ken Ohsuga, Mariko Nomura, Tadayuki Takahashi

The thermal-radiative disc wind in the low mass X-ray binary H 1743-322

Blueshifted absorption lines are seen in high inclination black hole binary systems in their disc dominated states, showing these power an equatorial disc wind. While some contribution from magnetic winds remain a possibility, thermal and thermal-radiative winds are expected to be present. We show results from radiation hydrodynamic simulations which show that the additional radiation force from atomic features are important along with electron scattering. Together, these increase the wind velocity at high inclinations, so that they quantitatively match the observations in H 1743-322, unlike purely thermal winds which are too slow. We highlight the role played by shadowing of the outer disc from the inner disc Compton heated layer, and show that the increase in shadow from the higher Compton temperature after the spectral transition to the hard state leads to strong suppression of the wind. Thermal-radiative winds explain all of the spectral features in this simplest wind system.

Paul Hemphill

MIT Kavli Institute

Norbert Schulz, Deepto Chakrabarty, Herman Marshall

Accretion in Ultracompact X-ray Binaries: A Unified Picture of 4U 1626-67

Ultracompact X-ray binaries (UCXBs) are binaries with a neutron star accretor and an orbital period less than 80 minutes. Here, I focus on our comprehensive review of *Chandra* observations of the unique UCXB 4U 1626-67, the only known UCXB to host a strongly-magnetized accreting pulsar. Our sophisticated modeling of the X-ray gratings spectra finds intriguing results: we observe strong, double-peaked emission lines of neon and oxygen, consistent with an accretion disk made up of a collisionally-ionized, two-temperature, pure Ne/O plasma. This is in tension with several expectations: the X-ray pulsar was expected to produce a photoionized plasma, not collisional; the temperature structure is difficult to produce within the small range of orbital distances implied; and the composition of the donor is out of line with any standard white dwarf model. However, we believe we have come up with a coherent picture of this source that reconciles most of these conflicts, which I will present.

Andy Pollock

University of Sheffield

M.F. Corcoran, NASA/GSFC

Long-Term Investments in the Winds of Massive Stars

Some of the most arresting results from last generation high-resolution X-ray spectroscopy concerned single and binary hot stars. The investigations, for example, of wind and shock dynamics and elemental abundances which have been confined to a relatively few brilliant examples, such as eta Carinae and WR 140, will able to be extended in the future to a whole new set of stars some of whose low-resolution spectra have already throw into question basic assumptions about the physical conditions under which X-rays can be produced. It should also be possible head-on to confront theories of stellar evolution with the abundances inferred from the X-ray spectra of massive stars in the low-metallicity environments of the Magellanic Clouds.

Francesco Tombesi

University of Rome Tor Vergata

Investigating AGN feedback with X-ray spectroscopy

Powerful winds driven by active galactic nuclei (AGN) are often invoked to play a fundamental role in the evolution of both supermassive black holes (SMBHs) and their host galaxies, affecting star formation and leading to the tight SMBH-galaxy relations. Strong support for this mode of AGN feedback came from X-ray spectroscopic observations of mildly relativistic disk winds in several active galaxies and their connection with large-scale ionized/neutral/molecular outflows observed at other wavelengths. Systematic X-ray spectroscopic analyses of highly ionized Fe K absorption lines suggest that such outflows may be common in local AGN, and they are starting to be found also in a sizable sample of high-z quasars. However, their origin, driving mechanisms and overall characteristics are still not fully understood. Revolutionary improvements are expected from the spectroscopic capabilities of *XRISM* and the *Athena* X-ray observatory, in synergy with other major multi-wavelength facilities.

Keigo Fukumura

James Madison University

Demos Kazanas, Chris Shrader, Francesco Tombesi, Ehud Behar

Confronting UFO Models with Correlations from Magnetic View

Blueshifted absorption features at near-relativistic velocities ($v \sim 0.1c$), known as ultra-fast outflows (UFOs) seem to be ubiquitously present in many AGN X-ray spectra. In two near-Eddington sources, PDS 456 and IRAS 13224-3809, the detected UFO property (e.g. column and velocity) are conjectured to exhibit potential correlations with X-ray luminosity Lx that is attributed to variations in radiation pressure as Lx varies. In this work, we show, by our disk-wind models coupled to photoionization calculations with xstar, that magnetically-driven winds of Compton-thick plasma can produce likely correlations in the context of magnetohydrodynamics (MHD) where radiation plays little role in shaping these fast outflows.

Rozenn Boissay-Malaquin

MIT

Ashkbiz Danehkar, Herman L. Marshall, Michael A. Nowak

The extreme velocities of the Ultra-fast Outflow components in the Quasar PDS 456

I will present the spectral analysis of *Chandra*/HETGS and *NuSTAR* observations of the quasar PDS 456 from 2015, together with *XMM*-Newton/*NuSTAR* data from 2013-2014 and *Chandra*/HETGS data from 2003. We analyzed the 3 different epochs looking for absorption features corresponding to highly ionized blueshifted absorption lines from H- and He-like ions of Fe and Ni, and other elements (O, Ne, Si, and S) in the soft band. We confirm the presence of a persistent ultra-fast outflow (UFO) with a velocity of vout = -0.24 – -0.29c, previously detected in several works. We also report the detection of an unusual additional faster component with a relativistic velocity of vout = -0.48c. We implemented photoionization modeling to characterize the physical properties of the different kinematic components of the UFO and of the partial covering absorber detected in PDS 456. These two relativistic components of the UFO are powerful enough to impact the host galaxy of PDS 456 through AGN feedback.

Misaki Mizumoto

University of Durham

Mariko Nomura, Ken Ohsuga, Chris Done

The origin of UFOs in AGN

UltraFast Outflows (UFO) are seen in some active galactic nuclei (AGNs), with blueshifted absorption lines of highly ionised iron ion. AGN typically has a UV-bright accretion flow, so UV line driving is an obvious candidate for launching these winds. However, it requires that material in the acceleration zone has substantial UV opacity, in conflict with the observed very high ionisation state of the wind. We use a state of the art UV line driven wind simulation (full radiation hydrodynamics), and demonstrate that there are some lines of sight which only intercept fast and highly ionised material. The cooler material required for the acceleration is out of the line of sight, close to the disc, shielded from the X-rays by a failed wind. We show that resonance line scattering in the wind can reproduce the broad Fe-K feature seen in the lag-energy spectra. New data from the microcalorimeters will allow us to test this, paving the way for a physical model of the mass loss rate of UFOs.

Compact Objects: Reflection

Yoshihiro Ueda

Kyoto University

Revealing the Nature of AGN "Torus" with High Resolution X-ray Spectroscopy

To reveal the properties of obscuring material in supermassive black holes, often called "torus", is important to understand feeding and feedback mechanisms of active galactic nuclei (AGNs). X-ray observations are a powerful tool for studying AGN tori, because, unlike radio line and infrared continuum emission, X-rays can trace all matter including gas and dust at various physical conditions. In this talk, we review our current understanding on the nature of AGN tori. Then, we introduce the results applying a new X-ray clumpy torus model (XCLUMPY, Tanimoto *et al.* 2019) to broadband X-ray spectra of nearby AGNs, and discuss their implications. Finally, we present simulations and prospects focused on high resolution X-ray spectroscopy.

Javier Garcia

Caltech

High-Resolution X-ray Reflection Spectroscopy in the next Decade

The X-ray emission from accreting compact objects is often accompanied by a reflection spectrum, which shows signatures of energetic photons being reprocessed by the material within the accretion disk. Given their abundance and fluorescence yield, K-shell lines from iron are the most prominent in the X-ray reflected spectrum. These and other spectral profiles can be grossly broadened and skewed due to relativistic effects near the compact object. By modeling the reflection spectrum it is possible to learn about the disk composition, ionization state, and dynamics; and it is one of the best means to estimate the BH spin and the properties of the corona. I will review the most important theoretical and observational aspects of reflection spectroscopy, and its applicability to stellar-mass BHs and neutron star systems, as well as to supermassive BHs in AGN. I will discuss outstanding issues in the field, and the prospects to new high-resolution and large collecting area missions.

Mislav Balokovic

Harvard-Smithsonian Center for Astrophysics

Constraints on AGN Torus and Outflow Geometry from High-resolution X-ray Spectroscopy

Despite the long history of studies of active galactic nuclei (AGN), the basic nature of their tori, which hide the central engine of obscured AGN, remains unclear. Many of their basic characteristics, including their size, clumpiness, dynamics, and relation to the accretion disk, the broad-line region and the host galaxy are poorly known. Making use of the newly developed libraries of model broadband X-ray spectra, we have recently been able to constrain geometry of the obscuring torus in a number of local obscured AGN. Based on those constraints, I will present predictions for fluorescent line emission observable with future X-ray calorimeters onboard *XRISM* and *Athena*. While broadband X-ray spectroscopy can provide unique insights into the anatomy of an AGN, sensitive high-resolution X-ray spectra with resolved velocity profiles of fluorescent emission lines will be needed to probe the dynamics and the relationship between the obscuring torus and the ubiquitous AGN-driven outflows.

Compact Objects: Continued

Erin Kara

MIT

Tidal Disruption Events

The disruption of a star from the strong tidal forces of a supermassive black hole can cause the stellar debris to fall back towards the black hole at super Eddington rates. Efficient circularization of the debris can lead to the formation of an accretion disc with luminosities close to or potentially exceeding Eddington limit. Most super-Eddington accretion flow models (including recent magnetohydrodynamic simulations) predict large scale height, optically thick equatorial winds at relativistic velocities. In this review, I will emphasis what we have learned about TDE outflows from high-resolution X-ray spectroscopy and what science will be enabled by future missions like *XRISM* and *Athena*.

Murray Brightman

Caltech

Uncovering and studying neutron stars powering ultraluminous X-ray sources with high resolution X-ray spectroscopy

We recently presented the detection of a narrow absorption feature at 4.5 keV in the *Chandra* spectrum of an ultraluminous X-ray source (ULX) in M51. The energy of this feature is not consistent with any instrumental feature, or atomic transition, and the most compelling explanation is that it is a cyclotron resonance scattering feature (CRSF) produced by the powerful magnetic field of a neutron star. Not only does a CRSF identify the accretor as a neutron star, it allows a direct measurement of the magnetic field strength, and potentially the geometry of the magnetic field and the surface gravity of the neutron star. Although these features have not been found in any other ULX spectra to date, the detection opens the possibility that these features could be present in other ULXs, but missed due to low spectral resolution and/or signal to noise of the existing CCD data. Future high spectral resolution and high throughput missions have the potential to uncover them.

Jiri Svoboda

Astronomical Institute of the Czech Academy of Sciences

Elias Kammoun, Vladimir Domcek, Michal Dovciak, Giorgio Matt

Steep X-ray reflection emissivity profiles in AGN as the result of radially structured disc ionization

Steep X-ray reflection emissivity has been reported in several X-ray observations of active galactic nuclei as well as X-ray binaries suggesting high compactness and close proximity of the X-ray coronae to the central black hole. The compactness of the X-ray source implies a strong radial dependence in the illumination and thus also the ionization of the accretion discs. However, common models used to fit the X-ray spectra often assume a constant ionisation of the disc and the measured steep emissivity profiles are solely attributed to the close position of the corona to the black hole. We show in our recent work (Kammoun *et al.*, 2019) that the radially-decreasing ionisation also significantly contributes to measurements of the steep emissivity and that the high spectral resolution of *Athena* X-IFU will allow us to search for deviations from the constant-ionisation models. This would give us strong hints on the local emissivity of the disc and thus on the geometry of the corona.

Ehud Behar

X-ray Emission Lines in AGN and What They Can Tell Us About The BLR

X-ray emission lines appear in many nearby Seyfert galaxies, but their context in the overall AGN picture remains unclear. I will give a few examples of emission line diagnostics that relate the X-ray line emission to the NLR, BLR, or in between. I will then focus on an interesting recent example in which we claim we have detected the BLR of a nearby Seyfert directly through its X-ray emission lines. Detailed X-ray spectroscopic analysis of the He- and H- like line fluxes and profiles will be demonstrated and discussed providing an unambiguous distance of a few 10^{15} cm from the continuum source. Those will be compared with optical and UV BLR of the same AGN, indicating the two overlap. This is an interesting (first?) direct X-ray measurement of a Seyfert Broad Line Region, where X-ray lines seem to originate from the UV/Optical BLR.

Stefano Bianchi

University degli Studi Roma Tre

Evidence for radiation pressure compression in the X-ray narrow-line region of Seyfert galaxies

The observed overlap between soft X-ray emission and the NLR in obscured AGN is commonly interpreted as evidence for a constant gas pressure multiphase medium. Radiation pressure compression (RPC) also leads to a density distribution, since a gas pressure (hence density) gradient must arise within each cloud to counteract the ionizing radiation pressure. RPC leads to a well-defined ionization distribution, and a differential emission measure (DEM) distribution with a universal slope of -0.9. In contrast, a multiphase medium does not predict the form of the DEM. The observed DEMs of obscured AGN with *XMM*-NewtonRGS spectra (the CHRESOS sample) are in striking agreement with the predicted RPC DEM, providing a clear signature that RPC is the dominant mechanism in the X-ray NLR. In contrast with the constant gas pressure multiphase medium, RPC further predicts an increasing gas pressure with decreasing ionization, which can be tested with future X-ray missions using density diagnostics.

Poster Presentations

Christopher Bambic

Institute of Astronomy, Cambridge

Christopher Reynolds, Andrew Fabian, Ciro Pinto

Limits on Turbulent Propagation of Energy in Cool-Core Clusters of Galaxies

The details of how energy is propagated from a central AGN throughout the intracluster medium (ICM) of galaxy clusters remains an open question. Using high resolution Reflection Grating Spectrometer measurements of turbulent line broadening, we show that for three clusters, the 90 per cent upper limit on turbulent velocities when accounting for instrumental broadening is too low to propagate energy radially to the cooling radius of the clusters within the required cooling time. These results constrain models of turbulent heating in AGN feedback by requiring a mechanism which can not only provide sufficient energy to offset radiative cooling but also resupply that energy rapidly enough to balance cooling at each radius. We propose that sound waves satisfy this constraint and discuss ongoing theoretical work on the efficient production of sound waves by AGN jets. *XRISM* will provide precise measurements of turbulent propagation velocities in a large sample of clusters.

Sergei Dyda

Cambridge University

Chris Reynolds

Viscous Effects on Misaligned Disc Precession

A possible explanation of high frequency QPO's is a radiatively hot accretion flow precessing due to the Lense-Thiring (LT) effect. A key physical question is how magnetic stresses allow angular momentum to flow in the disc and hence alter the LT, test particle assumption. We use magnetohydrodynamic simulations to study precession of misaligned discs in a classical background. We compare results for inviscid and viscous alpha discs using our grid based methods and to previous simulations of viscous discs using smooth particle hydrodynamics. We then compare results of viscous discs where viscosity is driven self-consistently via the MRI and characterize the importance of moving away from the thin-disc, isotropic alpha-disc viscosity to adequately model precessing disc systems.

Peter Kosec

Institute of Astronomy, University of Cambridge

Andrew Fabian, Ciro Pinto

A highly ionised disc wind in Hercules X-1

Hercules X-1 is one of the best studied accreting neutron star binaries with a wealth of archival data. I will present the discovery of a highly ionised disc wind in its X-ray spectrum when the source is in the high state. The wind detection is statistically significant in nearly all *XMM*-Newton observations, with velocities ranging from 300 to 900 $\mathrm{km\,s^{-1}}$. Observed features in the iron K band can be explained by both a forest of iron emission lines or by wind absorption. However, we also detect neon and oxygen absorption lines at the same systematic velocity in the high-resolution RGS grating spectra. The high ionisation degree of the outflowing material suggests that we are seeing the wind close to its launching point in the accretion disk, and we deduce that the mass outflow rate can be of the same order as the mass accretion rate onto the neutron star. This outflow could be the progenitor of the UV wind observed at comparable velocities. Possible launching mechanisms will be discussed.

Michael Loewenstein

University of Maryland and NASA/GSFC

Chemical Evolution of the Perseus Cluster Core

We apply chemical evolution modeling to the detailed abundance pattern in the Perseus Cluster derived from analysis of *Hitomi* high resolution spectroscopy in order to investigate the origin of the elements in the core of the Perseus Cluster. Contributions from distinct star formation epochs, and from different types of Type Ia supernova, are inferred. The most recent available nucleosynthetic yields are considered, and their consistency with the observations is assessed. The methodology presented is broadly applicable to the rich galaxy cluster abundance measurements to be made with upcoming high energy resolution X-ray missions.

Denys Savchenko

Bogolyubov Institute for Theoretical Physics, Kyiv, Ukraine

A. Boyarsky, D. Iakubovskyi, O. Ruchayskiy

Surface brightness profile of the 3.5 keV line in the Milky Way halo

We report a detection of 3.5 keV line in the Milky Way in 5 regions offset from the Galactic Center by distances from 10 arcmin to 35 deg. We build an angular profile of this line and compare it with profiles of several astrophysical lines detected in the same observations. We compare our results with other detections and bounds previously obtained using observations of the Milky Way.

Ekaterina Sokolova-Lapa

Dr. Karl Remeis-Observatory (ECAP FAU)

E. Sokolova-Lapa, M. Gornostaev, S. Falkner, J. Wilms, K. Postnov, R. Ballhausen, F. Fuerst

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X-rays from neutron star atmospheres at low accretion rates

The X-ray radiation during accretion onto the magnetized neutron star originates from regions with very high temperature and strong magnetic fields. The magnetic Compton scattering is responsible for the formation of cyclotron resonant scattering features (CRSFs) in spectra of X-ray pulsars. Advanced models for the emerging radiation that describe the spectral energy distribution of the accreting neutron stars have been developed recently. These models are mostly applicable for bright sources and often reproduce either continuum shape or CRSF. I will present the model of the neutron star polar cap emission at low accretion rate case when the accreting matter hits the neutron star atmosphere. We calculate polarized radiative transfer in the atmosphere with nonuniform temperature and density profiles and take into account gravitational light bending.

Sam Waters

MSSL, UCL

Graziella Branduardi-Raymont, Missagh Mehdipour, Mat Page, Ehud Behar, Jelle Kaastra & NGC7469 collaboration

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Photoionisation modelling of the emission line regions in the nucleus of NGC 7469

The Seyfert 1 galaxy NGC 7469 was the target of an extensive observing campaign with *XMM*-Newton in 2015. Analysis of the 640 ks RGS spectrum with the spectral fitting code SPEX and the physically self-consistent photoionisation model PION shows that the emission region is multi-phased, while also accounting for three warm absorber (WA) components. For the first time we characterise the emission features in the RGS spectrum in detail and derive estimates for the distances of the emission regions from the central engine. These are ~ 2.5 pc for the two narrow line components if we adopt a volume filling factor of 0.1, which makes the emission regions to be further out from the nuclear black hole than the WA. We discuss how adjusting the volume filling factor could resolve the differences with distance estimates obtained from variability arguments. Comparisons with other AGN, such as NGC 5548 and NGC 3783, for which we have also computed distances, will be presented.

Peter Boorman

University of Southampton

Poshak Gandhi, Mislav Balokovic, Daniel Stern, Fiona Harrison, Murray Brightman

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New Insights Into AGN Obscuration with XRISM

Circumnuclear gas obscuration is ubiquitous in AGN, yet very little is known about its physical nature. The next big leap in our understanding will come from resolving the most prominent AGN X-ray reflection feature – the narrow iron Kα fluorescence (Fe Kα) line. In this talk, I will present our discovery of the Compton-thick Iwasawa-Taniguchi effect – the anti-correlation of Fe Kα strength with bolometric luminosity for a large sample of 72 robustly classified heavily obscured Compton-thick AGN. This is unexpected since Compton-thick AGN should feature uniformly strong Fe Kα emission, and may indicate that current models dramatically underpredict their growth rates. Critically however, the highest spectral resolution attainable could not resolve the Fe Kα complex fully in any of our sources. I will hence show the constraints on AGN obscuration attainable with *XRISM* by resolving the narrow Fe Kα line – specifically gas cloud dynamics, geometries, compositions and ionisation.

Judith Ineson

University of Southampton

Judith Croston

IC vs. ICM: distinguishing between X-ray emission from radio galaxy lobes and their host galaxy groups

Upcoming X-ray spectroscopy missions will provide the accuracy to make detailed investigations of the intra-cluster medium, and targets will be provided by catalogues of galaxy clusters and groups. At present, the long exposure times required severely limit surveys of non-local galaxy groups. This will improve with the new generation of X-ray telescopes - *Athena* WFI surveys should detect groups out to $z \sim 2$. Radio-loud AGN are hosted by galaxy groups; they also produce X-ray inverse Compton (IC) emission from their lobes that can be confused with the thermal emission from the groups. This will need to be resolved when calculating group properties. We can predict radio galaxy populations using recent LOFAR surveys. We can also predict their IC emission and the properties of their host groups. We use these to look at the numbers and properties of groups where IC emission will be problematic, and where high-resolution spectroscopy may be needed to distinguish between the X-ray sources.

Alfredo Luminari

University of Rome "Tor Vergata" & INAF - Rome Observatory

F. Tombesi, F. Vagnetti (Univ. of Rome "Tor Vergata), E. Piconcelli (INAF - Rome), K. Fukumura (J. Madison Univ., USA), D. Kazanas (GSFC/NASA, USA)

Unveiling the physics and the geometry of X-ray outflows with the WINE model

Ultra-fast outflows (UFO) in the X-rays are often observed in AGNs. They seem to be launched at disk scales with relativistic speeds, representing a powerful tool to probe the innermost regions surrounding the SMBH. However, up to now very little is known about the physics behind them. The most viable launching mechanisms are radiative and MHD driving, with no clear observational constraint for one mechanism over the other. To gain new insights from the data, we developed a new spectral model including both absorption and emission from a photoionized wind. We applied a preliminary version of the model to the UFO in PDS456 (Luminari *et al.* 2018), where we also simulated *Athena* observations. The latest version includes the radiative transfer code XSTAR, to accurately model the photo-ionization structure of the outflow. The spectral diagnostics of the model will allow to fully exploit the unprecedented energy resolution of the upcoming X-ray observatories *XRISM* and *Athena*.

Sourabh Nampalliwar

University of Tuebingen, Germany

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eXtreme gravity with X-rays

Michael A Nowak

Dept. of Physics, Washington University

The Hunt for UFOs with Chandra-HETGS

Ultra-fast Outflows in AGN were first suggested based upon low spectral resolution CCD data in the $6-8\,\mathrm{keV}$ range, and were ascribed to absorption by highly ionized Fe. In this region, CCD resolution isn't dramatically below that of gratings. Further evidence for UFOs has been claimed from high spectral resolution observations with the XMM-Reflection Gratings Spectrometer, and has been extended to Ultra-Luminous X-ray sources. The $<2\,\mathrm{keV}$ region, however, is extremely crowded, and UFO models often posit multiple absorbers with a range of blueshifts. It is not clear that even RGS resolution suffices. I discuss two recent UFO studies using the *Chandra*-HETGS. We gain from improved resolution, but suffer from low effective area. First, for the AGN PG1211+143, we were able to verify the presence of an absorber outflowing at 0.06c. Next, for the ULX NGC 1313 X-1 we are still trying to determine if there is evidence for a UFO, and if not, do our observations contradict prior RGS studies?

Corbin Taylor

University of Maryland

Christopher Reynolds (Cambridge)

Modelling the Black Hole Reflection Spectrum with Fenrir

Modelling the X-ray reflection spectra of accreting black holes has allowed us to probe the properties of plasmas in strong gravity and of the compact objects themselves. Current reflection models ubiquitously make assumptions about the geometry of the inner accretion flow, treating the disk as having negligible thickness. In this talk, I will present a new reflection model, Fenrir, which models disks with realistic thickness, treating the disk geometric scale height as a free parameter. Such an approach allowing for more accurate spin measurements, an assessment of systematic effects in spin estimates, and the possibility of using reflection observations to probe accretion theory. This work showcases the importance of next-generation X-ray energy resolution, such as what can be found on X-Calibur, with Fenrir predicting steep cusps in the Fe K fluorescence line at moderate-to-high inclinations.

Dom Walton

University of Cambridge

Emanuele Nardini, Luigi Gallo, Mark Reynolds, Claudio Ricci, Thomas Dauser, Andy Fabian, Javier Garcia, Fiona Harrison, Guido Risaliti, Daniel Stern

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An extreme ultrafast outflow in the Seyfert 2 galaxy IRAS 00521-7054

I will present results from a deep observation of the Seyfert 2 galaxy IRAS 00521-7054 with *XMM*-Newton (175 ks) and *NuSTAR* (400 ks). Our broadband coverage allows us to disentangle the absorption and reflection in this complex source, and we find a strong contribution from relativistic disc reflection, implying the presence of a rapidly rotating black hole. We also find strong statistical evidence for absorption in an 'ultrafast' outflow, with a truly extreme outflow velocity of ~ 0.4c. Extensive simulations find the outflow to be detected in excess of 4-sigma significance. This is the second-fastest wind seen in absorption in any AGN to date. Under reasonable assumptions, we estimate that the outflow likely carries sufficient energy to drive significant galaxy-scale AGN feedback. I will discuss these results in the context of the high-resolution X-ray spectrographs due to fly on the *XRISM* and *Athena* observatories.

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5 Participants

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6 Notes