International Workshop on Astronomical X-Ray Optics

The open LaTeX template, AMCOS_booklet, used to as template for this booklet is available at

https://github.com/maximelucas/AMCOS_booklet

Prepared by Martin Urban for AXRO conference/workshop.
https://www.axro.cz

Contents

International Workshop on Astronomical X-Ray Optics

AXRO is International Workshop on Astronomical X-Ray Optics focused on presentation and discussion of recent and future technologies for future X-ray astronomy missions. One session is focused on astrophysical aspects of X-ray telescopes/satellites, where some review talks are typically given from leading scientists in this field plus some presentations of relevant Czech scientists. Other main sessions focus on all aspects of astronomical X-ray optics and recent and future X-ray space missions.

The goal of the workshop is to present and to discuss recent and future technologies for X-ray astronomy missions. These missions require the development of most innovative technologies, and we want to discuss in detail the possibilities, the results obtained so far, and new ideas. It is obvious that the requirements of future large space X-ray astronomy missions are so demanding that they need a truly interdisciplinary approach in a wide international collaboration. These technologies will include X-ray optics based on Si wafers, advanced glass forming for precise X-ray optics, but also other possible technologies and alternatives, as well as related advanced metrology, measurements and tests.

Albeit the conference is focussed on astronomical X-ray optics, we invite also participants from X-ray communities outside astronomy, as many aspects such as designing, manufacturing, and testing X-ray optics are similar for both communities, so sharing experience can be beneficial for all.

This year's held the 12th International Workshop on Astronomical X-Ray Optics.

Organizing committee

Veronika Maršíková	Rigaku Innovative Technologies Europe s.r.o.
Martin Urban	Czech Technical University in Prague
Ondrej Nentvich	Czech Technical University in Prague
René Hudec	Czech Technical University in Prague & Astronomical Institute of the Czech Academy of Sciences

Scientific committee

Rene Hudec	John Nousek	Richard Willingale	Rob Petre
William Zhang	Giovanni Pareschi	Stephen L. O'Dell	Ladislav Pina
Randall McEntaffer	Thorsten Döhring	Dan Schwartz	Paul Reid

Topics

AST X-ray Astrophysics

This session is focused on the astrophysical aspects of X-ray telescopes/satellites. Contributions from all fields of X-ray astronomy and astrophysics are invited here, both experimental as well as theoretical, especially those with relation and/or impact on space X-ray telescopes.

OPT X-ray Optics

Presentations discussing technologies for future space X-ray astronomy missions are encouraged. These missions require the development of most innovative technologies; the possibilities, the results obtained so far and details of new ideas are suitable topics for discussion. The recent situation in the field strongly demonstrates the urgent need for novel, cost-effective approaches and solutions.

MIS X-ray Missions

This session will include presentations of recent as well as new and future X-ray space missions and related scientific payloads.

Icons

Talk **Poster**

Monday, December 02

18:30–19:00	**Registration**
19:00–23:00	**Welcome reception**

Tuesday, December 03

09:00–09:30	**Registration**		
09:30–09:30	**Opening workshop and Welcome notes**		
09:30–09:35		**Rene Hudec**	Welcome
09:35–09:50		**Ondřej Šváb**	Ministry of Transport: Space Activities in the Czech Republic
09:50–10:00		**Michal Kuneš**	ESA BIC Prague: space applications
10:00–10:10		**Vladimir Karas**	Welcome and Introduction of Astronomical Institute
10:10–10:30		**Rene Hudec**	AXRO 2019 Introduction and Historical Background
10:30–10:45	**Coffee break**		

Session chair: Roman Krivonos

10:45–11:05	**AST**	**Vladimir Karas**	Acceleration of electrically charged particles along an escape corridor from an accretion disk
11:05–11:30	**AST**	**Michal Zajacek**	Motion of hot spots in the magnetosphere of the Galactic centre supermassive black hole (Sgr A*)
11:30–11:55	**AST**	**Jiří Kovář**	Levitating accretion discs – basic imitation by charged fluids circulation
11:55–13:15	**Lunch**		

Session chair: Charly Feldman

13:15–13:35	**AST**	**Roman Krivonos**	The ART-XC telescope on-board SRG
13:35–14:15	**MIS**	**Peter Predehl**	The X-ray telescope eROSITA on the Russian/German space mission SRG
14:15–15:30	**Coffee break + Poster Session**		

Session chair: Martin Jelínek

15:30–15:50	**AST**	**Maria D. Caballero-Garcia**	X-ray reverberation in AGN: clues onto the extended corona
15:50–16:20	**AST**	**Vojtech Simon**	Monitoring of the long-term activity of the soft X-ray transient Aquila X-1: Perspectives for THESEUS
16:30	**End of X-ray Astrophysics Session**		
16:30–19:00	**Free time (Individual visit of Christmas markets in downtown ;-))**		
19:00–21:30	**Dinner at "U Špirků"**		

Wednesday, December 04

09:00–09:10	**Registration**		

Session chair: Henryk Fiedorowicz

09:10–09:35	**OPT**	**Frank Siewert**	An ultra-precise KB-focusing mirror pair for European XFEL and its characterization
09:35–10:05	**OPT**	**Daniele Spiga**	New test and calibration X-ray facilities for the ATHENA X-ray telescope
10:05–10:25	**OPT**	**Ladislav Pína**	Study of the 2nd generation of the X-ray Multi-Foil optical system for rocket experiment
10:25–10:45	**Coffee break**		

Session chair: Frank Siewert

10:45–11:00	**OPT**	**Vladimír Dániel**	CubeSat X-ray telescope development
11:00–11:25	**OPT**	**Zhanshan Wang**	Development of X-ray imaging telescopes at IPOE
11:25–11:45	**OPT**	**Yanji Yang**	Status of X-ray Telescope onboard eXTP
11:45–12:00	**Coffee break**		

Session chair: Vladimír Dániel

12:00–12:25	**OPT**	**Maxim Markevitch**	Imaging of warm galactic halos with a potential normal-incidence X-ray mirror
12:25–12:45	**OPT**	**Andrzej Bartnik**	EUV optical systems for laser plasma produced (LPP) radiation sources: investigation of EUV induced plasmas
12:45–13:45	**Lunch**		
14:00–23:30	**Conference trip + dinner (see page no. 46)**		

Thursday, December 05

Session chair: Thorsten Döhring

10:00–10:25	OPT	**Vincenzo Cotroneo**	Novel coatings for soft reflectivity enhancement
10:25–10:45	OPT	**Daiki Ishi**	Metal-coated MEMS X-ray optics using atomic layer deposition
10:45–11:00	**Coffee break**		

Session chair: Enrico Bozzo

11:00–11:25	OPT	**Laurens Keek**	Stacking of mirrors for silicon pore optics
11:25–11:55	OPT	**Marcos Bavdaz**	Development of the ATHENA Optics
11:55–13:00	**Lunch**		

Session chair: Vincenzo Cotroneo

13:00–13:20	OPT	**Giorgia Sironi**	True Hard-X and soft-gamma imaging possible with Laue lenses? Double Laue diffraction optics at work
13:20–13:40	OPT	**Ikuyuki Mitsuishi**	Development of space electroformed-nickel optics
13:40–14:00	OPT	**Henryk Fiedorowicz**	Optical coherence tomography (OCT) with the use of soft X-rays as a tool for testing X-ray optics
14:00	**End of X-ray Optics Session**		
14:00–14:20	**Coffee break**		

Session chair: John Nousek

14:20–14:40	MIS	**Enrico Bozzo**	The ESA M5 mission candidate THESEUS
14:40–15:10	MIS	**Charly Feldman**	SMILE and Theseus - Future Lobster Eye missions
15:10–15:30	MIS	**Vladimír Tichý**	Silicon drift detectors and their application on XGIS instrument for the Theseus mission
15:30–16:45	**Coffee break + Poster Session**		

Session chair: Alan Garner

16:45–17:15	MIS	**John Nousek**	Teaching an Old Bird New Tricks - Chasing GWs with Swift
17:15–17:40	MIS	**Charly Feldman**	The SVOM MXT - Initial results of the first assembled Lobster Eye Optic
18:00	**End of Day**		

Friday, December 06

Session chair: Peter Predehl

09:00–09:20	**MIS**	**Alan Garner**	Advancing Soft X-ray Polarimetry with REDSoX
09:20–09:40	**MIS**	**Zhixing Ling**	The developments of lobster eye telescope onboard Einstein Probe mission
09:40–10:00	**MIS**	**Yong Chen**	Status of EP-FXT
10:00–10:15	**Coffee break**		

Session chair: Zhanshan Wang

10:15–10:40	**MIS**	**Gulab Dewangan**	AstroSat and UV/X-ray observations
10:40–11:00	**MIS**	**Yuichiro Ezoe**	Light-weight X-ray telescope missions in Japan
11:00–11:20	**MIS**	**Yong Chen**	Introduction to Space High Energy Astronomy Missions of China
11:20–11:40	**MIS**	**Rene Hudec**	Imaging X-ray instruments for cubesatellites
11:40	**End of X-ray Missions Session**		
11:40–11:50			Concluding remarks
11:50–12:00		**Rene Hudec**	Concluding address
12:00–13:00	**Lunch**		
13:00	**End of workshop**		

Program valid on: November 26, 2019, 12:00.
The latest version can be found at: `https://www.axro.cz`

Acceleration of electrically charged particles along an escape corridor from an accretion disk

AST

Vladimir Karas
Astronomical Institute of the Czech Academy of Sciences, Czech Republic

We further study the mechanism of efficient acceleration of particles near a rotating black hole. We show the onset of chaos and the enhanced Lorentz factors that are achieved by particles escaping in the non-axisymmetric geometry of the magnetic field inclined with respect to the rotation axis. Besides the strong gravity of the massive source, which is represented by Kerr metric, we consider the presence of a weak, ordered, large-scale magnetic field. An axially-symmetric model consisting of a rotating black hole embedded in an aligned magnetic field is generalized by allowing an oblique direction of the field having a general inclination, with respect to the rotation axis of the system. The inclination of the field acts as an additional important aspect that influences the motion of charged particles as it breaks the axial symmetry of the system and cancels the related integral of motion.

Levitating accretion discs – basic imitation by charged fluids circulation

AST

Jiří Kovář
Faculty of Philosophy and Science, Silesian University in Opava, Czech Republic

Studying charged fluids circling in strong gravitational and magnetic fields, we can find them forming various interesting equilibrium structures. As simple toroidal structures (tori) settled in the equatorial plane, they mimic standard equatorial thick accretion discs with negligible loss of mass. However, thanks to the proper combination of gravitational and electromagnetic interactions, it turns out that the structures can also hover about the equatorial plane, forming the so-called levitating tori, or the levitating polar clouds. We present the basic physical model allowing for the theoretical construction of these unique structures, which could exist in the Universe under particular astrophysical conditions. In more details, we assume a charged perfect fluid encircling rotating black hole immersed in an asymptotically uniform magnetic field, or the one being accompanied by the dipole-type magnetic field.

Monitoring of the long-term activity of the soft X-ray transient Aquila X-1: Perspectives for THESEUS

Vojtech Simon
Astronomical Institute of the Czech Academy of Sciences, Czech Republic

We show the possibilities of monitoring the long-term X-ray activity (especially of transients) on the example Aql X-1. Monitors of X-ray emission are important instruments for observing the activity on the long timescales (even of years). We show that the X-ray spectrum (especially its hardness) largely varies during some phases of the outbursts. Each outburst is a unique phenomenon as regards the time evolution of X-ry flux and the transitions between the states. The X-ray light curve of the outburst thus largely varies for the range of the observed energies and also for the individual monitors if they use narrow observing bands. To obtain the activity of the source in a very broad X-ray band, we use simultaneous monitoring with the monitors ISS/MAXI (2-15 keV) and Swift/BAT (15-50 keV). We show that observing in the 2-50 keV band enables us to resolve the complex spectral changes which occur during the outbursts. This also has the big perspectives for the planned X-ray instrument XGIS (2 keV-20MeV) and SXI (0.3-6 keV) onboard the satellite THESEUS for analyses of various emission mechanisms which operate during the activity of the sources like Aquila X-1.

Motion of hot spots in the magnetosphere of the Galactic centre supermassive black hole (Sgr A*)

Michal Zajacek
Center for Theoretical Physics, Poland

We will focus on the phenomenon of short phases of the higher activity of the Galactic center, so-called flares. Recently, the occurrence of flares was directly observationally connected with the orbits of bright spots around the compact radio source Sgr A* (Gravity collaboration, 2018). These so-called hot-spots move close to the innermost stable circular orbit and therefore are unique probes of the strong-gravity regime. In particular, we study the effect of the electromagnetic interaction on the motion of flares and how this can be used to constrain the mutual black hole spin-magnetic field orientation. Our results indicate that the Galactic centre black hole as well as the surrounding magnetosphere possess opposite charges of the similar order of magnitude (see Zajacek+2018, Tursunov+2019, submitted).

The ART-XC telescope on-board SRG

Roman Krivonos
Space Research Institute (IKI), Russia

The Galactic diffuse X-ray emission (GDXE) is an unresolved X-ray emission that fills the Galactic center and extends over 100 degrees along the Galactic plane. The nature of the GDXE has been under scientific debate since its discovery more than 30 years ago. The main question was: is GDXE truly diffuse or is it composed from a large number of unresolved point sources? Thanks to many dedicated studies carried out on orbital telescopes over the last decade, GDXE is believed to arise from unresolved populations of X-ray binary systems. However, the identity of the dominant class of accreting objects in the Galactic center, bulge, and ridge remains unclear. Using NuSTAR 's large aperture for unfocused photons and its wide X-ray energy range, we probe the diffuse broad-band continuum of the inner 1-3 degrees of the Galactic bulge (Perez et al., 2019), and compare with previous measurements of the inner 10 pc and inner 100 pc of the Galactic center using the same instrument. In my talk, I will present the results of this study, along with a brief overview of GDXE.

X-ray reverberation in AGN: clues onto the extended corona

Maria D. Caballero-Garcia
Astronomical Institute of the Czech Academy of Sciences, Czech Republic

X-ray reverberation in Active Galactic Nuclei, believed to be the result of the reprocessing of coronal photons by the underlying accretion disc, has allowed us to probe the properties of the inner-most regions of the accretion flow and the central black hole. Our current model (KYNXILREV) computes the time-dependent reflection spectra of the disc as a response to a flash of primary power-law radiation from a point source corona located on the axis of the black hole accretion disc (lamp-post geometry). Full relativistic effects are taken into account. The ionization of the disc is set for each radius according to the amount of the incident primary flux and the density of the accretion disc. In this work we apply the latest version of the code for reverberation to the most (continuously) observed Seyfert-1 AGN with XMM-Newton, that is IRAS 13224-3809. This is probably the best source for tackling the use of reverberation codes but it is also an extremely variable one. The latter makes the analysis of separate datasets necessary, because of its important spectral state evolution.

AST

Retrospection on the round trip of iridium through the universe

Thorsten Döhring
TH Aschaffenburg, Germany

All iridium atoms in the universe are initially born via the r-process in extreme cosmic events. On Earth iridium is quite rare. However, there is a remarkable iridium anomaly found in the Cretaceous-Tertiary boundary layer, where the amount of iridium increases by a few orders of magnitude. This effect is explained by the impact of a heavy meteoroid about 65 million years ago. At Aschaffenburg University iridium coatings are developed as reflection layers for space based X-ray telescopes. Iridium is also used as cover material for the thermonuclear batteries of the Voyager space probes - which are just leaving our solar system. So the cosmic journey of iridium is really a fascinating round trip from stars to Earth and back into space again.

An ultra-precise KB-focusing mirror pair for European XFEL and its characterization

Frank Siewert
Helmholtz Zentrum Berlin / BESSY-II, Germany

Recently, the European X-Ray Free Electron Laser (XFEL) has successfully produced its first X-ray photon pulse trains. This unique photon source will provide up to 27 000 photon pulses per second for experiments in different fields of science. In order to accomplish this, ultra-precise mirrors of dedicated shape are used to guide and focus these photons along beamlines of up to 930 m in length from the source in the undulator section to the desired focal point at an experimental station. We will report on a Kirkpatrick-Baez-mirror pair designed to focus hard-X-rays in the energy range from 3 to 16 keV to a 100 nm scale at the SPB/SFX instrument of the European XFEL. Both mirrors are elliptical cylinder-like shaped. The figure error of these 1 m long mirrors was specified to be better than 2 nm pv in terms of the height domain; this corresponds to a slope error of about 50 nrad rms (at least a best effort finishing is requested). This is essential to provide optimal experimental conditions including preservation of brilliance and wavefront. Such large and precise optics represents a challenge for the required deterministic surface polishing technology, elastic emission machining in this case, as well as for the metrology mandatory to enable a precise characterization of the topography on the mirror aperture. Besides the slope errors, the ellipse parameters are also of particular interest. The mirrors were under inspection by means of slope measuring deflectometry at the BESSY-NOM slope measuring profiler at the Helmholtz Zentrum Berlin. The NOM measurements have shown a slope error of 100 nrad rms on a aperture length of 950 mm corresponding to a residual figure deviation 20 nm pv for both mirrors. Additionally we found a strong impact of the mirror support conditions on the mirror shape finally measured. We will report on the measurement concept to characterize such mirrors as well as to discuss the achieved results.

OPT

CubeSat X-ray telescope development

Vladimír Dániel
Výzkumný a zkušební letecký ústav, Czech Republic

The project of 2D X-ray Lobster Eye telescope development to fit CubeSat form factor will be presented. The aim of the Cubesat telescope is to observe known an unknow X-ray sources such as supernovae, active galactic nuclei or X-ray afterglows of GRBs. The technologies for the X-ray telescope CubeSat demonstrator were selected suitable for CubeSat carrying the requirement of low power, low dimension, low mass and also low cost. The entrance aperture of 2D optics module is planned to be at least 69×69 mm, which represents 47 cm^2. The field of view of this system is at least of 6×6 arcdegrees. As a focal detector the low power consumption no cooled Timepix3 pixel detector, operating in the energy range between 3-60 keV was selected. The new features of detector carrying the option of fast stream data reading with low dead time are very suitable for x-ray telescope mission.

OPT

Development of X-ray imaging telescopes at IPOE

Zhanshan Wang
Institute of Precision Optical Engineering, Tongji University, China

The X-ray imaging telescope has been developed at Institute of Precision Optical Engineering (IPOE) of Tongji University since 2007. We have made a great progress on mirror fabrication, coating deposition, optical assembly and telescope's characterization. This presentation will provide an overview of our progress. By now we can routinely produce cylindrical thin glass mirror substrates with angular resolution of about 30". To improve the effective area, coatings with two or three material layers were designed and obtained a high reflectivity at 0.5-10 keV. During the optical assembly, an in-situ measurement system and 3-dimentional ray-tracing program have been developed to guide the assembly process in real time. Several prototypes have been fabricated and two of them were calibrated at PANTER X-ray test facility. The angular resolution and effective area were given.

Development of space electroformed-nickel optics

OPT

Ikuyuki Mitsuishi
Division of Particle and Astrophysical Science, Graduate School of Science, Nagoya University, Japan

For future X-ray missions, higher angular resolution X-ray optics keeping its lightness are essential to achieve better observation sensitivity and finally more exiting scientific goals. For X-ray optics on board previous missions, it has long been known that there is an anticorrelation due to engineering issues between their angular resolution and lightness. Thus, in order to break the relationship, we have been developing X-ray optics based on our original electroforming techniques which have been established for ground-based applications. Electroforming is a technology that can transfer to a substrate with high accuracy by plating the nano-level structure of a super-precision master and makes it easier to fabricate Wolter type-I shaped two-stage full-shell mirrors. As the first trial, we fabricated a cylindrical electroformed-nickel sample with length, diameter, and thickness of 60, 60, and 1 mm. We measured axial and circumferential profiles of the inner surface and achieved $\sim 0.07/0.3\,\mu$m in rms/PV for the best 30 mm axial direction and $\sim 1/3\,\mu$m in rms/PV for the circumferential directions. We will show the details of our recent status and future plans.

Development of the ATHENA Optics

OPT

Marcos Bavdaz
European Space Agency, Netherlands

The Advanced Telescope for High ENergy Astrophysics mission (ATHENA) is the second large class mission on the ESA Science Programme. It is the next generation X-ray observatory, and will embark ambitious and complex high performance detector instruments and the largest X-ray optics ever flown in space. The X-ray optics technology was specifically developed for ATHENA, in order to fulfill the demanding requirements of ATHENA. The Silicon Pore Optics (SPO) combines low mass with high performance, taking benefit from the superb qualities of mono-crystalline Silicon and investments done in the semiconductor industry. The talk will report on the development of the ATHENA optics, providing an overview of the technology development activities being implemented together with industrial and institutional partners.

OPT

EUV optical systems for laser plasma produced (LPP) radiation sources: investigation of EUV induced plasmas

Andrzej Bartnik
Military University of Technology, Poland

In this work investigations of EUV-induced, low temperature plasmas with relatively high electron density were performed. Experiments were performed using laser-produced plasma (LPP) EUV sources. The sources were based on a 10 Hz NdYAG laser system delivering pulses of energy up to 10 J with a pulse duration of 1–10 ns. The EUV ionizing radiation was focused using grazing incidence collectors based on multifoil or ellipsoidal mirrors optimized for specific wavelength ranges. Additionally, an EUV focusing system based on a set of two paraboloidal mirrors was also used for a detection system deployed for measurements of weak EUV signals from the low temperature plasmas. In our experiments various gases were injected into the interaction region, perpendicularly to an optical axis of the irradiation system, using an auxilary gas puff valve. Irradiation of the gases resulted in ionization and excitation of atoms and molecules forming the EUV induced plasmas. Spectra in EUV and VUV ranges were measured using grazing incidence, flat-field spectrographs (McPherson, H+P Spectroscopy respectively). Spectra in UV/Vis range were measured using an Echelle Spectra Analyzer ESA 4000. The spectra were composed of spectral lines corresponding to radiative transitions in atoms, molecules, atomic or molecular ions. The ionic and atomic spectral lines were identified based on NIST database. The molecular spectra were identified based on literature data. For computer simulations of the molecular spectra measured in the VUV/UV/VIS range various codes like LIFBASE, Specair or PGOPHER were deployed. Apart from that, the electron temperatures of plasmas created in different gases were estimated employing a Boltzmann plot method. Temporal measurements in the EUV range were performed using the detection system based on the paraboloidal mirrors, dedicated filters and AXUV detectors.

Imaging of warm galactic halos with a potential normal-incidence X-ray mirror

OPT

Maxim Markevitch
NASA GSFC, United States

We describe our ongoing effort to build a normal-incidence X-ray mirror for soft X-rays. Our science goal is the OVII emission line at E=574 eV (rest frame), which is expected to be the dominant signal from the theoretically predicted extended warm gas halos around massive galaxies – a major component of the Universe's missing baryons. The mirror would employ a multilayer coating with hundreds of layers with a period 11-12A. Such a small period requires new coating techniques. We are trying Atomic Layer Deposition that, at least theoretically, can produce layers of the requisite sharpness and flatness. A thick glass normal-incidence mirror would act simultaneously as a narrow-band (1-3 eV) energy filter, picking up the redshifted OVII line from the much brighter (and non-redshifted) Milky Way foreground, and as an imager with angular resolution possibly approaching that of the optical reflectors. We will show first experimental results from our coating trials, as well as a mission concept that fits in the SmallSat envelope.

Metal-coated MEMS X-ray optics using atomic layer deposition

OPT

Daiki Ishi
Department of Physics, Tokyo Metropolitan University, Japan

Several types of micropore optics have been proposed and developed for light-weight and high-resolution X-ray telescopes. We have been developing silicon micropore X-ray optics using micro-electro mechanical systems (MEMS) technologies (Ezoe et al. 2010 MST). Sidewalls of 20 m-width micropores etched through a 300 m-thick silicon wafer are utilized for X-ray reflection mirrors. Since silicon is not suitable for X-ray reflection, noble-metal coatings on high-aspect micropores are necessary. To enhance X-ray reflectivity for our MEMS X-ray optics, we investigate atomic layer deposition (ALD) as coating techniques. It is characterized by good-conformality on three-dimentional structures with high-aspect ratios. To date, we demonstrated X-ray reflection with Ir- and Pt-coated silicon micropore optics using thermal ALD (Ogawa et al. 2013 Appl. Opt.; Takeuchi et al. 2018 Appl. Opt.). However, the surface roughness after metallic coatings needed to be further improved. Recently, we tested another process, i.e., plasma ALD, and achieved better surface roughness on Pt-coated ones. Furthermore, we have begun coating of Co and Ni for soft X-rays below 2 keV. In this talk, we report on characterization of metal-coated MEMS X-ray optics and future works such as light-element coatings on heavy metals, e.g., SiC on Pt.

New test and calibration X-ray facilities for the ATHENA X-ray telescope

OPT

Daniele Spiga
INAF - Brera Astronomical Observatory, Italy

The large diameter, the long focal length, the high angular resolution, and the assembly complexity of the ATHENA X-ray telescope make the test procedures and the calibration campaign more challenging than ever. In order to tackle these tasks, ESA recently sponsored two X-ray facilities in Italy. BEaTriX (the Beam Expander Testing X-ray facility) is an X-ray beamline, being assembled at OAB and expected to start operation in late 2020, which will be a prototype to perform the functional tests of SPO mirror modules for ATHENA. BEaTriX will generate a uniform, 17 cm x 6 cm wide beam at the fixed energies of 4.51 keV and at 1.49 keV, making it possible to characterize the angular resolution and the effective area of SPO modules, at a rate able to sustain the SPO production and return a fast feedback on their optical performances. The other X-ray facility, VERT-X, will enable the X-ray calibration of the completed mirror assembly (MA) of ATHENA. VERT-X will scan an X-ray beam, collimated by a highly-precise Wolter-I mirror, in front of the complete MA of ATHENA, covering it uniformly with a polychromatic spectrum (0.1-12 keV). The MA will be placed horizontally in order to minimize optical distortions due to gravity, and the focused beam will be collected at the top of the vertical vacuum system by a sensitive pixel detector, therefore enabling the direct calibration in PSF and EA of the complete MA. In this presentation, the current status and the design of the two facilities will be presented.

Novel coatings for soft reflectivity enhancement

OPT

Vincenzo Cotroneo
INAF - Brera Astronomical Observatory, Italy

Metallic coatings made of high-density noble metals (e.g. Ir, Pt or Au) are usually employed in grazing incidence reflecting optics for X-rays. Due to the large value of critical angle for total reflection, these materials offer a range of reflection extended to higher energies, but also present a series of M absorption edges at 2-4 keV which limit the reflectivity in this range and below. This is why the search for alternative coatings, able to improve the reflection in the soft energy range, is particularly relevant to the development of future telescopes, Athena (ESA), Lynx (NASA) and eXTP (CAS). It is well known that a low density coating (e.g. carbon or B4C) can enhance the reflectivity in the softer band (below 2 keV), even if commonly employed technologies are difficult to apply to all mirror fabrication technologies (notably, silicon pore optics). It was also recently proposed that the use of a thin chromium layer on top of the reflecting layer can greatly enhance the reflectivity in the 2-4 keV band. We discuss how, in future telescopes, the combination of these coatings can be used to enhance the reflectivity below 4 keV, and present novel solutions (carbon-like coatings realized by dip or vapour phase deposition) for the deposition of low-density coatings.

Optical coherence tomography (OCT) with the use of soft X-rays as a tool for testing X-ray optics

Henryk Fiedorowicz
Military University of Technology, Institute of Optoelectronics, Poland

Optical coherence tomography (OCT) is a well-established interferometric imaging technique providing high resolution cross-sectional views of objects (tomograms). The axial resolution of OCT is limited to about 1 μm when using infrared and optical wavelengths. The obvious way to improve resolution is to shorten the wavelength of the probing light. Optical coherence tomography using broad bandwidth radiation in the nanometer spectral range (extreme ultraviolet and soft X-rays) has been recently proposed [1]. This OCT variant, referred to as XCT, allows the reduction of axial resolution from micrometers to a few nanometers. The XCT imaging with axial resolution better than 8 nm was demonstrated using extreme ultraviolet and soft X-rays from a synchrotron [2]. Tomographic imaging with an axial resolution of about 22 nm has been recently demonstrated using extreme ultraviolet from a laser-driven light source based on high-order harmonic generation (HHG) [3]. In this paper we present preliminary studies on XCT using broadband soft X-ray radiation from a compact laser plasma light source based on a gas puff target [4]. The laser plasma source was optimized for efficient soft X-ray emission in the spectral range from 1.5 nm to 5 nm. The XCT measurements of a multilayer structure with 10 nm period and 40 % bottom layer thickness to period ratio, with an axial resolution of about 2 nm and detect multilayer interfaces up to a depth of about 100 nm. The experimental data are in agreement with OCT simulations. The new imaging technique can be useful for testing X-ray optics based on multilayer structures. Project is supported under the Polish-German scientific collaboration programme Beethoven by NCN (UMO 2016/23/G/ST2/04319) oraz DFG (PA 730/5).

[1] G. Paulus, Ch. Rödel, Short-wavelength coherence tomography, Patent No.: US 7,656,538
[2] S. Fuchs, Ch. Rödel, A. Blinne, U. Zastrau, M. Wünsche, V. Hilbert, L. Glaser, J. Viefhaus, E. Frumker, P. Corkum, E. Förster, G. Paulus, Nanometer resolution optical coherence tomography using broad bandwidth XUV and soft x-ray radiation, Scientific Reports 6 (2016) 20658
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OPT

Stacking of mirrors for silicon pore optics

Laurens Keek
cosine, Netherlands

Future X-ray observatories such as Athena (ESA) and Arcus (NASA candidate mission) require optics with a large effective area and a relatively low mass. Silicon Pore Optics (SPO) are being developed to meet these requirements in a cost-effective manner. Silicon wafers from the semiconductor industry are cut into mirror plates. Custom robotics are employed to bend the plates into the design shape of the mirrors and to stack them, creating the building blocks of modular optics. We discuss the ongoing development efforts to improve the stacking process, which focuses on two aspects. First, the improvement of the optical quality of stacks. Secondly, streamlining the production process to meet the speed and quality requirements of mass production for the production of a full optic for Athena.

OPT

Status of X-ray Telescope onboard eXTP

Yanji Yang
Institute of High Energy Physics, Chinese Academy of Sciences, China

eXTP employes 13 Wolter I golden nickel telescopes. During the passing year, eXTP Phase B study has been permitted, We have established a joint optical design team for optical design, within Institute of High Energy Physics, Xi'an Institute of Optics and Precision Mechanics of CAS and Osservatorio Astronomico di Brera. As the Phase B starts, we have 2 sets of the optics design, and will decide which one to use finally. Further, The smallest mandrel of OAB design has been tried to be polished, coated, and demolded, in Harbin Institute of Technology, and some optical and mechanical test are planned.

OPT

Study of the 2nd generation of the X-ray Multi-Foil optical system for rocket experiment

Ladislav Pína
Rigaku Innovative Technologies Europe s.r.o., Czech Republic

Penn State University launched a Water Recovery X-ray Rocket (WRXR) on the 4th of April 2018. In the WRXR there were two payloads: the first being an X-ray spectroscope from Penn State University and the second being the Rocket EXperiment (REX), which successfully tested a wide-field X-ray optical system, based on 1D and 2D X-ray Multi-Foil Lobster-Eye (LE) optics (LE MFO), for the first time in a rocket setup and the second time in space. This paper details the 2nd generation of LE MFO optics which will optimize all of the optical parameters for rocket experiments and prepares the LE optics for instrument manufacturing. This new optical design will be based on ray-tracing and the knowledge gained from the previous experiment. The optical system will be optimized for the monitoring of nebula and/or X-ray source, which can be imaged with X-rays energies between 0.5 – 30 keV.

True Hard-X and soft-gamma imaging possible with Laue lenses? Double Laue diffraction optics at work

OPT

Giorgia Sironi
INAF-Osservatorio Astronomico di Brera, Italy

While for soft and hard X-rays focusing X-ray telescopes based on Wolter I grazing incidence optics provide high flux sensitivity observation of the sky with imaging capabilities, hard X-/ soft gamma-ray astronomical observations above 80 keV are still at present performed by means of collimated/modulated apertures on large size cameras. By the way this kind of direct view detection suffers both of a moderate flux sensitivity (due to the physical impossibility to operate large size systems together with the high background flux due to the lack of focalization) and of an angular resolution not better that a few arcmin and in any case unable to resolve details of diffuse sources. Focusing optics through diffractive crystals in transmission configuration (Laue lenses) have been proposed to study the 80 keV – 1 MeV energy pass-band since a few decades ago. However their use have been so far limited to laboratory prototypes or short balloon experiments mainly due to the high alignment accuracy required for the realization of a Laue optics that consists of thousands of crystals. Such limitations are nowadays surpassed thanks to the technological progresses on both material science and metrology. Furthermore, strong aberrations for off-axis sources are expected with single diffraction optics. Recently, simulations and experimental tests suggested the possibility to exploit two successive diffractions from bent crystals in order to achieve two-dimensional focusing. In this paper we will present the results of simulations that motivate the exploration of the double diffraction geometry and we report on the on going design activities and experimental results achieved so far related to the development of this innovative application for high energy astrophysics that can find possible uses also in other technological and scientific fiels.

Lobster eye optics: position determination based on 1D optics with a simple coded mask

OPT

Ondrej Nentvich
Czech Technical University in Prague, Czech Republic

Lobster eye X-ray optics in the one dimensional (1D) arrangement has advantages in higher reflectivity, especially for higher energies, compared to classical two dimensional (2D) Schmidtś arrangement. One dimensional optics can determine only one direction of the incoming beam. There is placed a strip in front of the optics for determining of the second direction. This strip is made of X-ray proof material which blocks the incoming beam and thus causes a gap in the line. Based on these facts, it is possible to determine the position of each point source which has enough signal to gap ratio. Unfortunately, the intensity of sources is not possible to assess by this method.

OPT

Optical inspection and assembly for the X-ray telescope

Min Cong
Institute of High Energy Physics, Chinese Academy of Sciences, China

Two auto-collimators are used to detect the posture of each focusing mirror, and then the focusing mirror will be glued to the hub. First, the two self-collimators are placed perpendicular to each other on a horizontal experiment platform, and the pentaprism is used to refract the emergent light which comes from the self-collimator to mirror on the focal plane, adjust the element in the optical path to make the light return to the self-collimator, another mirror is on the other side of the platform. Secondly, the focusing mirror is installed in the optical path, move the pentaprism and the mirror on the platform to lead the light which come form the collimators incident onto the focusing mirror, adjust the focusing mirror to make the incident light come back to the collimators by passing though the mirror on the focal plane and the mirror on the platform. In this way, the purpose of the focusing mirror can be detected by the two self-collimators to manufacture X-ray telescopes. This is not the final version

OPT

Soft X-ray spectrograph based on a diffraction transmission grating for investigation of laser produced plasmas

Mateusz Majszyk
Military University of Technology, Poland

High temperature plasmas produced by interaction of pulsed power lasers with matter, emit radiation in a wide wavelength range from soft X-rays (SXR) to visible light. All these plasmas, emit spectral lines in extreme ultraviolet (EUV) range. In case of ions with Z 6 lines from the SXR range can be detected. For measurements of the SXR spectra a spectrograph based on 2x3 mm transmission grating 5000 l/mm having 450 nm grooves with a 50 nm Si 3 N 4 residual substrate, manufactured by ZonePlates Ltd. The spectrograph is equipped with an entrance slit, mounted close to the plasma and the second one, in front of the grating. The spectral range is limited mainly by transmission of the residual layer and the resolution by the spectrograph geometry and widths of the slits. Spectra are recorded deploying a CCD detector. Initial tests were performed using the laser plasma produced SXR source, based on a double stream gas puff target, developed in Institute of Optoelectronics, Military University of Technology, Warsaw, Poland.

X-ray reflective multiple layer systems for astronomical mirrors

Veronika Stehlíková
Max Planck institute for extraterrestrial physics, Germany

During last two years, established cooperation between Czech Technical University in Prague and University of Applied Sciences in Aschaffenburg focused on studying potential of multiple reflective layers for space-born X-ray telescopes. To understand the sputtering process, which is used for creating homogenous layers with low microroughness of the surface, and the behaviour and quality of the layers themselfs, the work was divided into smaller steps. After tests of adhesivity and stability of layers followed the prove of reflectivity and comparison of real situation with the theoretical expectations. As addition, also microroughness test based on dispersion was performed. This poster presents a part of results from Panter facility and their comparison with theoretical simulations. Because we are not going to stop our development at this moment, it also shows the direction where we would like to proceed next time - using other kinds of substrates for the mirrors, like silicone, and study the behaviour of other multimaterial compositions, which could be benefitial for space usage, like mangan or tungsten.

Advancing Soft X-ray Polarimetry with REDSoX

MIS

Alan Garner
Massachusetts Institute of Technology, United States

We present an update on our work advancing soft X-ray polarimetry in support of the sounding Rocket Experiment Demonstration of a Soft X-ray Polarimeter (REDSoX) mission, as well as the status of a possible orbital version. REDSoX will utilize focusing optics, critical-angle transmission (CAT) gratings, laterally graded multilayer mirrors and CCDs to measure polarized soft X-rays below 1 keV. Much of the development for the proposed polarimetry and spectroscopy missions is performed in the MIT polarimetry beamline. Operating as a monochromator, the beamline has been used to measure the absolute efficiencies of the REDSoX prototype gratings as well as the Arcus Phase A gratings. The beamline is also capable of producing and measuring polarized soft X-rays in support of the development of REDSoX and other polarimetry missions. In preparation for future missions, we have begun tests to align the REDSoX prototype CAT gratings using internal MIT Kavli funds. Support for this work was provided in part by the National Aeronautics and Space Administration grant NNX15AL14G as well as a grant from the MIT Kavli Institute Research Investment Fund.

AstroSat and UV/X-ray observations

MIS

Gulab Dewangan
Inter-University Centre for Astronomy & Astrophysics, India

AstroSat is India's first multi-wavelength space astronomy mission that was launched on 28 September 2015. AstroSat carries five payloads that perform observations in the optical, ultraviolet, soft and hard X-rays. The five scientific payloads are (i) a Soft X-ray Telescope (SXT), (ii) three Large Area X-ray Proportional Counters (LAXPCs), (iii) a Cadmium-Zinc-Telluride Imager (CZTI), (iv) two Ultra-Violet Imaging Telescopes (UVITs) one for visible and near-UV channels and another for far-UV, and (v) three Scanning Sky Monitors (SSMs). AstroSat is a proposal-driven observatory with observing opportunities available to national and international scientists. This talk will present the current status of the instruments onboard Astrosat and the main results obtained including multiwavelength UV/X-ray observations.

MIS

Imaging X-ray instruments for cubesatellites

Rene Hudec
ASU AV CR & CTU, Czech Republic

The recent progress in cubesatellites technologies, based on platform instrumentation miniaturization as well as on advances in control engineering allows astrophysical payloads for these minisatellites to be considered including tandem flights as well as fleets of satellites. The BRITE constellation minisatellites for precise star brightness measurements in visible light represent an excellent example. Especially the satellite bus parts were recently substantially miniaturized, raising the question, namely, does the scientific payloads can be miniaturized as well? The cubesat standard size is 1-liter volume i.e. $10 \times 10 \times 10$ cm and its weight is typically about 1.3 kg. Multiple modules are possible, i.e. 3U = 3 modules/units i.e. $10 \times 10 \times 30$ cm, typically up to 12U. The recent technological progress allows use in astronomy and astrophysics, as well as in other sciences and applications, for the first time. In addition to the numerous commercial missions, the mini-satellites are in the development at many Universities, mostly with the involvement of students, so the educational aspects play a role there as well. I will present some ideas for miniature X-ray imaging instrumentation for cube satellites, including tandem flights and fleets. The first such X-ray monitor with Lobster Eye X-ray optics is already in space onboard the 1st Czech 2U/3U cubesatellite VZLUSAT. The tandem flight of two cubesatellites could be advantageous e.g. for small astronomical X-ray telescope with Kirkpatrik-Baez optics but there are interesting possibilities for fleets of minisatellites with X-ray optics as well.

MIS

Introduction to Space High Energy Astronomy Missions of China

Yong Chen
Institute of High Energy Physics, Chinese Academy of Sciences, China

I will present the status and plan of the following projects: 1) Insight-HXMT X-ray mission (launched on June 15th, 2017, mostly on X-ray binaries and GRBs); 2) GECAM (to be launched by the end of 2020, two small satellites covering full sky simultaneously on GRBs and other transients from several keV to MeV); 3) SVOM (to be launched by the end of 2021, carrying optical and X-ray telescopes, a wide FoV hard X-ray imager and three gamma-ray monitors, mostly on GRBs and other transients); 4) EP (to be launched by the end of 2022, carrying many wide FoV lobster-eye X-ray telescopes and two narrow FoV X-ray follow-up telescopes, mostly on tidal disruption events, GRBs and many other transients); 5) eXTP (a large X-ray observatory developed by a large Sino-European consortium for launch around 2025 or slightly later, carrying large arrays of X-ray timing, spectroscopy and polarimetry telescopes, as well as a wide field monitor); 6) HERD (a large cosmic-ray experiment onboard China's space station for operation around 2025, with unprecedented acceptance and energy range for direct measurements of cosmic-rays, electrons and gamma-rays in space). The latter two missions (eXTP and HERD) are also the key missions for the Exploring the eXtreme Universe (EXU) program, an international mega-science project proposed to the Ministry of Science and Technology (MOST).

Light-weight X-ray telescope missions in Japan

MIS

Yuichiro Ezoe
Tokyo Metropolitan University, Japan

Toward an era of x-ray astronomy, next-generation x-ray optics are indispensable. There is a well-known trade-off relation between the angular resolution and the mass normalized by the effective area among these three methods. In order to break this relation, new mirror fabrication methods are demanded. To meet the demand for telescopes lighter than, we are developing what we call MEMS x-ray optics based on micromaching technologies. The technologies include dry etching of thin silicon wafers, high temperature annealing for smoothing, hot plastic deformation of silicon wafers and atomic layer deposition of noble metals. Two small satellite missions GEO-X and ORBIS use this type of optics. In this talk, we show these missions together with recent development of the MEMS X-ray optics.

SMILE and Theseus - Future Lobster Eye missions

MIS

Charly Feldman
University of Leicester, United Kingdom

The University of Leicester (UoL) is involved in several missions using the novel micro-channel pore optics (MPOs) in a Lobster Eye optic configuration, including SVOM, SMILE, Einstein Probe and Theseus. SMILE is an ESA-Chinese, Earth Magnetosphere mission due for launch in November 2023, where UoL is the PI institute of the Soft X-ray Instrument (SXI). Theseus is an ESA M5 concept mission currently in a Phase A study and projected to launch in 2032. UoL is also the PI institute for the Theseus SXI, including optics and detector development. Presented are details of each mission including the current status of the overall mission and the UoL activities.

Silicon drift detectors and their application on XGIS instrument for the Theseus mission

MIS

Vladimír Tichý
INAF-OAS, Italy

THESEUS (Transient High Energy Sky and Early Universe Surveyor) is a space mission concept selected by ESA for a Phase 0/A study as one of the three candidates M5 missions in the framework of the Cosmic Vision programme. It is designed to vastly increase the discovery space of high energy transient phenomena over the entirety of cosmic history, with particular emphasis on the use of GRBs for exploring the early Universe and providing a substantial contribution to multi-messenger astrophysics. To achieve this scientific objectives, the THESEUS payload combines a transient trigger system based on two instruments, the XGIS, that is a wide field deep sky monitor in a broad energy band (2 keV-10 MeV), and the SXI (0.3-5 keV), that thanks to its focusing capabilities in the soft X-ray band provides a large field of view and high angular resolution, with an on board near-IR telescope for immediate transient identification and redshift determination. The X-Gamma ray Imaging Spectrometer (XGIS) instrument comprises 2 cameras pointed at offset directions in such a way that their FOV partially overlap. Each camera has imaging capabilities in the energy band (3 -150 keV) thanks to the combination of an opaque mask superimposed to a position sensitive detector. Furthermore the detector plane energy range is extended up to 10 MeV without imaging capabilities. Key of the design of XGIS are Silicon drift detectors (SDD)taht can operate both as direct low energy X-ray detector and as readout device of the scintillation light of a scintillator. We breafly describe the THESEUS payload and show the structure of XGIS instrument and its expected parameters.

Status of EP-FXT

MIS

Yong Chen
Institute of High Energy Physics, Chinese Academy of Sciences, China

The Einstein Probe (EP) mission is a advanced mission of China for all-sky monitoring to discover and study high-energy transients and variability in the soft X-ray band. It will finish the Phase-B study by the end of this year. In this year, the design of the Follow-up X ray Telescope (FXT) has been again optimized, from one mirror and 2 cameras with a switch facility, to 2 mirrors and 2 cameras. The Structural Thermal Model of FXT has been assembled in IHEP, transported to IAMC in Shanghai, and join in the mechanical test of the satellite. And the readout electronincs for camex of pnCCD has also been tested successfully. After the mechanical and thermal tests, EP mission will enter the Phase C (qualification model phase).

Teaching an Old Bird New Tricks - Chasing GWs with Swift

MIS

John Nousek
Penn State University, United States

From its inception Swift was designed to be highly flexible and responsive. At launch this meant that Swift could dynamically respond to new Gamma-Ray Bursts with all three instruments on a near immediate timescale based on a fully autonomous response onboard the spacecraft. This autonomy allowed a very rapid and flexible response to ground control via highly compact and efficient commanding in response to Target of Opportunity (ToO) requests. Unlike many other missions Swift can routinely respond to ToO within an hour or two, and record responses have been less than ten minutes. A major limitation for these ToO responses was the need to either utilize ground passes over Earth based tracking stations (typically 10 opportunities per day), or by using the forward link to the Tracking Data Relay Satellite System (TDRSS). TDRSS links require a manual intervention to be scheduled, and the creation of a pass plan to create the commanding required also required human intervention. After consultation with NASA's TDRSS scheduling, we have developed new ground software which can both schedule TDRSS links, and create the commanding necessary, based only on the scientific decision making of deciding whether a ToO is approved. We expect that in the near future we will grant blanket approval for certain rigously defined opportunties. Follow-ups to high quality LIGO-Virgo neutron star merger candidates are examples of cases where we expect Swift will be able to routinely carry out follow-ups in less than 30 minutes. This capability is unprecedented and we expect to apply it to a wide range of Swift Transient Astronomy targets.

The ESA M5 mission candidate THESEUS

MIS

Enrico Bozzo
University of Geneva, Switzerland

THESEUS is a mission concept proposed in response to the ESA call for medium-size mission (M5) within the Cosmic Vision Programme and selected by ESA on 2018 May 7 to enter an assessment phase study. The mission is designed to vastly increase the discovery space of the high energy transient phenomena over the entirety of cosmic history. Its primary scientific goals will address the Early Universe ESA Cosmic Vision themes "How did the Universe originate and what is made of?" (4.1, 4.2 and 4.3) and will also impact on "The gravitational wave Universe" (3.2) and "The hot and energetic Universe" themes. This is achieved via a unique payload providing an unprecedented combination of: 1) wide and deep sky monitoring in a broad energy band (0.3keV - 20 MeV); 2) focusing capabilities in the soft X-ray band providing large grasp and high angular resolution; and 3) on board near-IR capabilities for immediate transient identification and redshift determination. In this talk we will review the status of the mission current assessment phase being carried out in collaboration with ESA as part of the M5 competition.

MIS

The SVOM MXT - Initial results of the first assembled Lobster Eye Optic

Charly Feldman
University of Leicester, United Kingdom

The SVOM MXT will use a narrow-field-optimised Lobster Eye optic comprised of a set of micro-pore optic plates (MPOs) for gamma ray burst (GRB) location and measurement. The 1 m focal length qualification model (QM) MXT optic is the first fully populated Lobster Eye optic to be X-ray tested. We present the test results obtained at the University of Leicester and at Panter, MPE, giving the point spread function, energy response and effective areas, as well as results from the thermal tests and focal length determination. We also present our modelling, which incorporates the aberrations seen from the individual MPOs to determine the PSF of the assembled optic, and predicts the performance of the QM optic with incredible accuracy.

MIS

The X-ray telescope eROSITA on the Russian/German space mission SRG

Peter Predehl
Max-Planck-Institut für extraterrestrische Physik, Germany

On July 13,2019 at 14:41 CEST the X-ay space observatory Spectrum-Roentgen-Gamma (SRG) was successfully launched from the Baikonur cosmodrome. It carries two X-ray telescopes, ART-XC, which was developed under the lead of the space research institute IKI, Moscow and eROSITA, which was developed and built by a consortium of German institutes under the direction of the Max-Planck-Institute for Extraterrestrial Physics (MPE) and with support from the German Space Agency at DLR. Meanwhile (November 2019) SRG has reached the halo orbit around L2, 1,5 million kilometers from Earth. eROSITA is in its calibration and performance verification phase, and this early data confirm the excellent performance of the instrument. Starting in December, eROSITA will carry out eight complete X-ray surveys over the next four years, creating the first complete sky map in the medium X-ray range. At lower energies it will approximately 25 times more sensitive than the previous ROSAT mission. In addition it has much better spectroscopic capabilities. The main scientific goal of eROSITA is to map the large scale structure of the universe and to find out how these structures grow in the course of cosmic time. Clusters of Galaxies which track this structure are filled with millions of degrees of hot plasma and can be detected directly by an X-ray telescope. eROSITA is designed to detect 100.000 clusters of galaxies to reconstruct also the history of their growth. This, in turn, will tell us about the amount and perhaps the nature of the enigmatic dark energy and dark matter.

The developments of lobster eye telescope onboard Einstein Probe mission

MIS

Zhixing Ling
National Astronomical Observatories, Chinese Academy of Sciences, China

The Einstein Probe (EP) is a small satellite dedicated to time-domain astronomy to monitor the sky in the soft X-ray band. It is a mission led by the Chinese Academy of Sciences and developed in its space science programme with international collaboration. Its wide-field imaging capability is achieved by using established technology of the micro-pore lobster-eye X-ray focusing optics. Complementary to this is deep X-ray follow-up capability enabled by a Wolter-I type X-ray telescope. EP is also capable of fast transient alerts triggering and downlink, aiming at multi-wavelength follow-up observations by the world-wide community. In this talk, we will briefly present the developments of Wide-Field Telescope, a Lobster-eye telescope, covering a FOV larger than 3600 square degrees, including the optics assembly, the focal plane detectors as well as the expected performances.

MIS

NANOCOMPOSITES FOR RADIATION PROTECTION IN SPACE

Nadia Licciardello
International Iberian Nanotechnology Laboratory (INL), Portugal

Today's space applications are pushed forward by new technologies that enable smaller dimensions, less complexity and lower cost of satellites. This conference contribution discusses an innovative approach for the radiation protection of satellite components against cosmic particles. Traditionally, solid tungsten foils or lead foils are used to protect the radiation-sensitive electronics in this field. In a miniature satellite, however, these high-density materials can contribute significantly to the critical overall mass. Our inspiration for lowering the mass-density of radiation-protective materials comes from X-ray protection in medical applications whereby composites, such as metal foams or polymer matrices loaded with particles of high-Z elements, have been investigated. An analogous approach for space applications introduces the additional requirement of structural and mechanical stability under thermal cycling. Accordingly, we design and study temperature-cycling-resistant polymer-based (mainly polyurethane- and silane-based) composites containing particles of high-Z elements (such as W, Bi, or Mo). The presence of the metallic particles contributes to radiation shielding, while the polymeric matrix provides the desired mechanical properties: flexibility under thermal cycling and low density. In parallel, solid films of high-Z elements and having thickness comparable to the size of the particles used in the nanocomposites are deposited by magnetron sputtering. The properties of the radiation protective films obtained by these two different techniques will be compared and the X-ray protective properties and temperature cycling resistance will be discussed. Nanocomposite-based radiation-protective coatings will be tested in a corresponding payload experiment onboard of the upcoming Portuguese satellite INFANTE.
This abstract is a result of the project "BAPORECO – Bavarian-Portuguese research collaboration", (BAYFOR grant no. BayIntAn_HSAB_2019_122), and of the project "INFANTE: Satellite for maritime applications and communications from constellations" (POCI-01-0247-FEDER-024534), supported by the Operational Thematic Program for Competitiveness and Internationalization (POCI), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF).

Project CATEX: X-ray monitoring of catastrophic events in the Universe

Thorsten Döhring
TH Aschaffenburg, Germany

MIS

The proposed joint German-Czech project CATEX (Catastrophic events in the Universe: the X-ray view) is a feasibility study for a novel space experiment focussed on monitoring and investigation of catastrophic events in the Universe. It uses the innovative combination of an uncooled pixel detector (Timepix) and a Lobster-eye optic with optimised X-ray mirror coatings. The advantages of this kind of telescope are a wide field of view and low power consumption, together with an improvement of the detection range. The projects aim is a complex feasibility study of an advanced wide field X-ray telescope for monitoring and research of the catastrophic events - as well as of other variable and transient sources - in the Universe. The theoretical and experimental study will include all important parts of the future system from an optimization of the mirror coatings, the design the optical module, the analysis of potential observation targets, the design of the detection system under variable vacuum conditions, the development of algorithms for processing the X-ray images of Lobster eye optics, and methods of their visualization. The results of these studies and experiments will provide new knowledge about the behaviour of individual components and can be used for the development of advanced scientific satellite payloads for an X-ray monitoring of astronomical objects. The CATEX project proposal is currently under evaluation at the funding agencies DFG and GAČR.

Thermal vacuum testing of Timepix3 detector

Martin Urban
Czech Technical University in Prague, Czech Republic

MIS

We present results of the thermal vacuum testing of Timepix family-based detector with respect to the effects on its properties and behaviour under non-standard conditions. Readout ASIC chip bump-bonded with semiconductor detector was thermally coupled to a small aluminium block. This block was thermally stabilised using a PID controller and a three-stage Peltier element. This arrangement, located in the vacuum chamber, allows the detector to be tested under defined temperature settings ranging from -30 °C (resp. -40 °C) to +80 °C. Results of this testing help to strengthen the knowledge regarding the behaviour of the base part of the detector under extreme conditions where temperature stabilisation of the detector is very difficult or energy-consuming. The experiments were performed on a detector chip equipped with a 300 μm thick Si sensor.

AXRO Introduction and Historical Background

Rene Hudec
ASU AV CR & CTU, Czech Republic

I will present an introduction to the 12th AXRO International workshop on X-ray optics as well as historical background presenting the history of these workshops and also general history as well as the recent status of development of X-ray optics in the Czech Republic. There is a long tradition of X-ray optics development dated back to 1970 with numerous X-ray optical technologies and techniques designed developed and tested. In recent years these efforts focussed on alternative and cost-effective solutions based on innovative substrates such as thin glass sheets and/or silicon wafers. Novel X-ray optical designs included also wide-field optical systems of Lobster Eye type in Schmidt arrangement as well as Kirkpatrick-Baez modules.

List of Participants

Andrzej Bartnik	Poland
Marcos Bavdaz	Netherlands
Enrico Bozzo	Switzerland
Maria D. Caballero-Garcia	Czech Republic
Yong Chen	China
Min Cong	China
Vincenzo Cotroneo	Italy
Gulab Dewangan	India
Vladimír Dániel	Czech Republic
Thorsten Döhring	Germany
Yuichiro Ezoe	Japan
Charly Feldman	United Kingdom
Henryk Fiedorowicz	Poland
Alan Garner	United States
Roland Graue	Germany
Rene Hudec	Czech Republic
Adolf Inneman	Czech Republic
Daiki Ishi	Japan
Martin Jelinek	Czech Republic
Ge Jin	China
Vladimir Karas	Czech Republic
Laurens Keek	Netherlands
Jiří Kovář	Czech Republic
Roman Krivonos	Russia
Nadia Licciardello	Portugal
Zhixing Ling	China
Mateusz Majszyk	Poland

Maxim Markevitch	United States
Veronika Maršíková	Czech Republic
Ikuyuki Mitsuishi	Japan
Ondrej Nentvich	Czech Republic
John Nousek	United States
Peter Predehl	Germany
Ladislav Pína	Czech Republic
Frank Siewert	Germany
Vojtech Simon	Czech Republic
Giorgia Sironi	Italy
Daniele Spiga	Italy
Veronika Stehlíková	Germany
Vladimír Tichý	Italy
Martin Urban	Czech Republic
Zhanshan Wang	China
Yanji Yang	China
Michal Zajacek	Poland
Werner Zeilinger	Austria

Emergencies

There are several important numbers:

112 The general emergency telephone number
158 Police
155 Healthcare
150 Fire Brigade

Internet connection

Wi-Fi will be available during the conference.

SSID:
PASS:

There is also access to the **Eduroam network** in the conference venue.

Public transport

The nearest public transport stop to the villa Lanna is Hradčanská (Green metro line - A, tram 1, 2, 8, 18, 20, 24, 25, 26).
You need to buy a ticket before you board a bus, tram or metro. Tickets are sold from machines at metro stations and tram stops, at newsstands, ... Public transport tickets can be used on any type of public transportation and allow transfers between lines and type of transport. All tickets must be validated which means that you must insert them into the yellow stamping machine inside trams and buses or at the metro stations when you first use it. Tickets do not need to be re-validate when transferring services or starting a new journey within the validity period.

Individual tickets for 1 person

TYPE OF THE TICKET		Adult
Tickets	Basic 90 min.	32 CZK
	Short-term 30 min.	24 CZK
	1 day 24 hod.	110 CZK
	3 days 72 hod.	310 CZK

Conference trip

14:00	Bus departure from the conference venue
15.00 - 15:45	Tycho de Brahe exhibition, chateau in Benátky nad Jizerou
16:30 - 17:30	Klášter brewery tour
18:00 - 22:00	Conference dinner in Restaurant Skála
23:30	Bus arrival to conference venue

Tycho de Brahe exhibition

This exhibition is about Tycho Brahe, the famous physicist and astronomer, who stayed at the chateau in Benátky nad Jizerou in the years 1599 - 1600. Due to his stay, and especially for his astronomical research, numerous building alterations were made on the second floor of the chateau, where he and his family lived. Astronomical instruments were also installed in several rooms as well as a chemical laboratory. According to tradition, Brahe performed his observations on the first floor of the chateau in a room with a high window. The meridian is still there. An interactive exhibition on prehistoric and medieval astronomy is also dedicated to the legacy of Tycho Brahe in the Museum.

Tycho de Brahe exhibition

Klášter brewery tours

Are you interested in how beer is prepared in Klášter Hradiště nad Jizerou? We offer a guided tour of of the historical brewery during which you will find out interesting facts about the process of brewing and how beer is produced and also understand the mysterious history is this place. Tour includes visiting the brewhouse, the fermenting house and lager cellars where the tour is finished by beer tasting.

A flashlight or mobile phone flashlight may be of some benefit during the visit.

Conference dinner in Restaurant Skála

Historical premises of brewery and restaurant Skála (="rock") date back to mid 12th century - at that time the Cistercian Order chose to build their montstrous monastery at the location of today's brewery Klášter (="monastery"). History of this place can be felt outside and inside of its premises.

The restaurant interiors were hand-carved into the rock by the monks who were building the monastery. Until today, you can still see visible cleats for supporting beams. According to historical data, the construction of the monastery took 38 years. For long centuries, these carved caves were used by lay brothers as temporary housing and a shelter from uninvited guests.

Given the constant temperature, the "cave" was used by Klášter brewery as ideal place for a malt house. Beautiful cucumber scent could be smelled in the area nearby.

Unfortunately, in the more recent history when the brewery fell under Velké Popovice, the malt house was indiscreetly cancelled due to centralisation measures which were being taken at that time. For some time, the place was used for storing food, especially fruit which lasted fresh for a long time given the ideal temperature and humidity.

New age for these premises started in the 90s' of last century when Klášter brewery built a restaurant, which since then, it has been a popular destination for many visitors.

It is hard to believe but one of the reasons that ín the beginning of the 12th centrury the Cistercian Order chose this location for building a monstrous monastery was because, according to them, positive energy rises from the earth here. The very entrance into this unique restaurant is described by some sensitive individuals as a sort of passage into a different space-time.

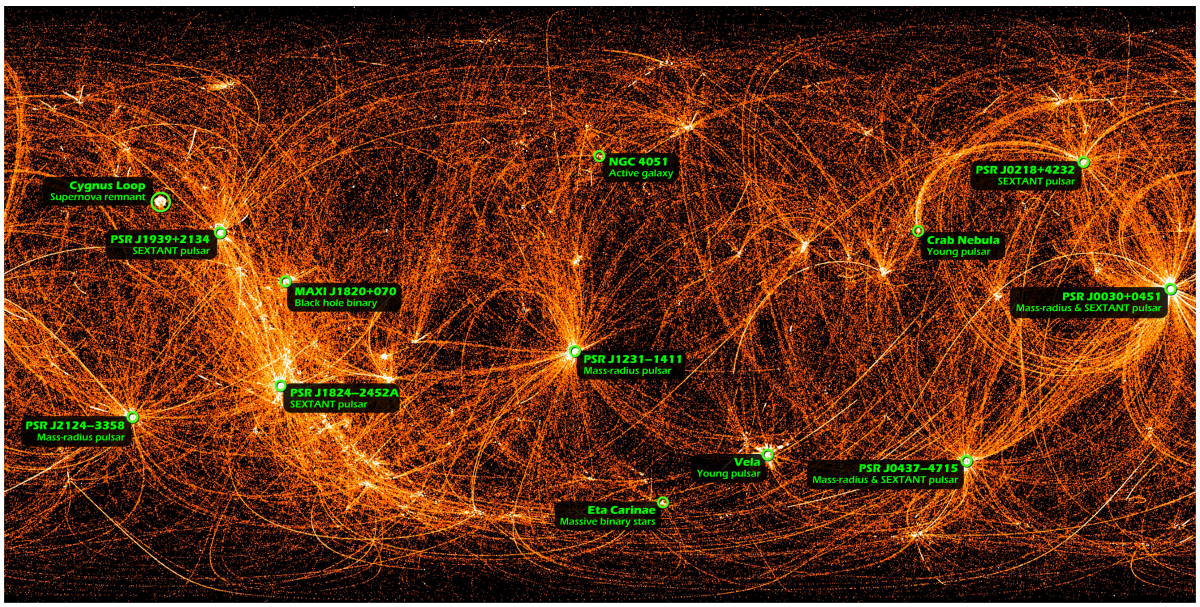
Klášter brewery

Restaurant Skála

NICER's Night Moves Trace the X-ray Sky

In this image, numerous sweeping arcs seem to congregate at various bright regions. You may wonder: What is being shown? Air traffic routes? Information moving around the global internet? Magnetic fields looping across active areas on the Sun?

In fact, this is a map of the entire sky in X-rays recorded by NASA's Neutron star Interior Composition Explorer (NICER), a payload on the International Space Station. NICER's primary science goals require that it target and track cosmic sources as the station orbits Earth every 93 minutes. But when the Sun sets and night falls on the orbital outpost, the NICER team keeps its detectors active while the payload slews from one target to another, which can occur up to eight times each orbit.



This image of the whole sky shows 22 months of X-ray data recorded by NASA's Neutron star Interior Composition Explorer (NICER) payload aboard the International Space Station during its nighttime slews between targets. NICER frequently observes targets best suited to its core mission ("mass-radius" pulsars) and those whose regular pulses are ideal for the Station Explorer for X-ray Timing and Navigation Technology (SEXTANT) experiment. One day they could form the basis of a GPS-like system for navigating the solar system.

The map includes data from the first 22 months of NICER's science operations. Each arc traces X-rays, as well as occasional strikes from energetic particles, captured during NICER's night moves. The brightness of each point in the image is a result of these contributions as well as the time NICER has spent looking in that direction. A diffuse glow permeates the X-ray sky even far from bright sources.

The prominent arcs form because NICER often follows the same paths between targets. The arcs converge on bright spots representing NICER's most popular destinations — the locations of important X-ray sources the mission regularly monitors.

"Even with minimal processing, this image reveals the Cygnus Loop, a supernova remnant about 90 light-years across and thought to be 5,000 to 8,000 years old," said Keith Gendreau, the mission's principal investigator at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "We're gradually building up a new X-ray image of the whole sky, and it's possible NICER's nighttime sweeps will uncover previously unknown sources."

NICER's primary mission is to determine the size of dense remains of dead stars called neutron stars — some of which we see as pulsars — to a precision of 5%. These measurements will finally allow physicists to solve the mystery of what form of matter exists in their incredibly compressed cores. Pulsars, rapidly spinning neutron stars that appear to "pulse" bright light, are ideally suited to this "mass-radius" research and are some of NICER's regular targets.

Other frequently visited pulsars are studied as part of NICER's Station Explorer for X-ray Timing and Navigation Technology (SEXTANT) experiment, which uses the precise timing of pulsar X-ray pulses to autonomously determine NICER's position and speed in space. It's essentially a galactic GPS system. When mature, this technology will enable spacecraft to navigate themselves throughout the solar system — and beyond.

By Francis Reddy
NASA's Goddard Space Flight Center, Greenbelt, Md.
Media contact: Claire Andreoli
NASA's Goddard Space Flight Center, Greenbelt, Md.
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