

The open LATEX template, AMCOS\_booklet, used to as template for this booklet is available at  ${\tt https://github.com/maximelucas/AMCOS\_booklet}$ 

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

## **Contents**

About	1
International Conference on Astronomical X-Ray Optics	. 1
Organising committee	. 2
Scientific committee	. 2
Partner Institutions and Sponsors	. 2
Topics	. 3
Icons	. 3
Time schedule	5
Monday, 01 December	. 5
Tuesday, 02 December	. 6
Wednesday, 03 December	. 8
Thursday, 04 December	. 10
Friday, 05 December	. 11
X-ray Optics	13
Approaching high-resolution X-ray astronomy? From phase retrieval to achro-	
matic wavefront correction	
Christoph Braig	. 13
Standardizing X-ray Ground Calibration for X-ray Observatory Missions	1.4
Vadim Burwitz	. 14
Broadband Multilayer Coatings for High-Energy Astrophysics: Optimization,	
Calibration, and Facility	1 -
Kirtankumar Pravin Dixit	. 15
Manufacturing the mirror modules for NewAthena	1 -
David Girou	. 15
Development and fabrication of EUV diffraction gratings	1.0
Fabien Grisé	. 16
Optimization of Grazing Incidence X-ray Optics for Special Applications	1.0
Rene Hudec	. 16
The peculiar optics of Laue-lenses	17
Niels Lund	. 17
Updates on the Off-plane Grating Rocket Experiment (OGRE)	17
Randall McEntaffer	. 17
Novel technologies for laboratory Wolter type X-ray optics	10
Ladislav Pína	. 18
Development of the focusing mirrors onboard eXTP	18
T ALLI 1 4 ALLI	1~

	Historical X-ray images selected for UNESCO's Memory of the World Register  Thorsten Döhring	19
	One decade of joint Bavarian-Czech cooperation on astronomical X-ray optics	
	Thorsten Döhring	19
	Peter Friedrich	20
<b>X</b> -	ray Space Missions	21
	The XGIS Instrument on Board THESEUS: Design and Development Overview Riccardo Campana	21
	Follow-up X-ray telescope onboard Tianguan satellite  Yong Chen	22
	Design of the Spectroscopic Focusing Array-Imaging (SFA-I) on the eXTP Satellite	22
	Weiwei Cui  Routine observations of gamma-ray transients by nanosatellites: the story of	22
	GRBAlpha and VZLUSAT-2  Marianna Dafčíková	23
	Behind the scenes of eROSITA: how we transmit the data  Konrad Dennerl	23
	ASTRABAX: Balloon based radiation measurements in the stratosphere	0.4
	Thorsten Döhring	24
	Rene Hudec	24
	Wei Li	25
	The Einstein Probe mission  Zhixing Ling	25
	Probing the dynamic universe with the GRINTA hard X-ray mission	0.0
	Lorenzo Natalucci	26
	Ivan Reading	26
	Studying the Binary Neutron Star Merger Population with Joint GW/EM  Detections  James Rodi	27
	Astrophysics with SXI/SMILE	
	Vojtech Simon	27
	Tianran Sun	27
	Demonstration of long-term ageing of silicon photomultipliers in space on GRBAlpha and VZLUSAT-2 CubeSats	
	Jakub Řípa	28

X-ray Detectors and Test Facilities	29
Design and test of an time-varying X-ray source for eXTP-SFA X-ray telescope  Can Chen	29
Recent achievements of the BEaTriX X-ray facility: results and future perspectives	23
Daniele Spiga	29
Minerva beamline: Characterization of mirror modules for the NewAthena optics	
Joan Torras	30
SiC grids for blocking filters  James Tutt	30
EP4K: A Large-format sCMOS for EP/WXT and future X-ray missions  Qinyu Wu	31
Implementing Machine Learning Algorithms to Improve X-ray Detectors for Astronomical Applications	
Zhila Yazdanfar	31
X-ray Astrophysics	33
The search for soft sources in eROSITA data using isolated white dwarfs as an example	
Susanne Friedrich	33
Probing the Strong Gravity Region of Black Holes  Vladimir Karas	33
Scattering of X-rays by Interstellar Dust - A Review  Peter Predehl	34
Observing the recurrence times of outbursts in X-ray binaries by X-ray monitors	0.4
Vojtech Simon	34
Eva Sramkova	35
For whom the disc slowly precesses	
Gabriel Török	35
Norbert Werner	36
A Review of Machine Learning in Astronomical Plate Digitization and Survey  Data	
Tauseef Ahmad Zafar	36
Simulated observations of high-frequency variability in X-ray binaries: Spots	50
Tomáš Stanovský	37
Quasi-periodic modulation of neutron star boundary layer radiation I: Synthetic	
data	o=
Gabriel Török	37
Gabriel Török	38
Complex modelling of relativistic iron line profiles from accreting neutron stars Gabriel Török	38

Others	39
AXRO Introduction and historical background  Rene Hudec	39
Rene Hudec	39
List of Participants	41
Useful Information	43
Emergencies	43
Internet connection	43
Public transport	43
Smoking	44
Social event	45
Social Prague Trip	46
Last words	47

## International Conference on Astronomical X-Ray Optics

AXRO is an international conference dedicated to Astronomical X-Ray Optics, with a strong focus on presenting and discussing recent achievements, emerging technologies, and future developments relevant to upcoming X-ray astronomy missions.

In addition to technical contributions, the programme traditionally includes a session on the astrophysical aspects of X-ray telescopes and satellites, featuring review talks by leading scientists in the field, complemented by presentations from Czech researchers. Sessions dedicated to all areas of astronomical X-ray optics, X-ray detectors, and testing facilities form a central part of the conference. Recent and forthcoming X-ray space missions are also highlighted and discussed in detail.

The aim of the conference is to provide a forum for sharing and evaluating the latest technological innovations for X-ray astronomy. Future large-scale missions demand highly advanced and often unprecedented technologies, making interdisciplinary collaboration essential. AXRO therefore encourages open discussion on current capabilities, challenges, achieved results, and novel ideas. Topics include, but are not limited to, X-ray optics based on silicon wafers, advanced glass-forming techniques for precision X-ray mirrors, alternative technologies, and state-of-the-art metrology, measurement methods, and testing approaches.

Although the conference is centred on astronomical X-ray optics, we warmly welcome contributions from X-ray communities beyond astronomy. Many key aspects—such as the design, manufacturing, and testing of X-ray optics—are shared across disciplines, and the exchange of experience is valuable for all participants.

This year's held the 16th International Conference on Astronomical X-Ray Optics.



## **Organising committee**

**Veronika Maršíková** Rigaku Innovative Technologies Europe s.r.o.

Martin UrbanCzech Technical University in PragueOndřej NentvichCzech Technical University in Prague

**René Hudec** Astronomical Institute of the Czech Academy of Sciences &

Czech Technical University in Prague

### Scientific committee

René Hudec Astronomical Institute of the Czech Academy of Sciences &

Czech Technical University in Prague

John Nousek The Pennsylvania State University

Peter PredehlMax Planck Institute for Extraterrestrial PhysicsVadim BurwitzMax Planck Institute for Extraterrestrial Physics

William Zhang NASA Goddard Space Flight Center

**Ladislav Pina** Rigaku Innovative Technologies Europe s.r.o.

Randall McEntafferThe Pennsylvania State UniversityThorsten DöhringTechnische Hochschule AschaffenburgDan SchwartzSmithsonian Astrophysical Observatory

## **Partner Institutions and Sponsors**













## **Topics**



### X-ray Astrophysics

This session focuses on the astrophysical aspects of X-ray telescopes and satellites. Contributions from all areas of X-ray astronomy and astrophysics—both experimental and theoretical—are welcome, particularly those with relevance to, or impact on, space-based X-ray observatories. The primary emphasis is on potential X-ray sources studied using telescopes and satellite missions.



### 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 features presentations on recent, ongoing, and future space missions and their scientific payloads within the X-ray domain. Contributions from all mission classes (L-class, M-class, S/F-class, and others) are welcome. We invite reports on new scientific results, mission developments, as well as proposals for upcoming missions.



#### **DTF** X-ray Detectors & Test Facilities

Contributions related to detectors and facilities for X-ray applications are very welcome. Presentations may cover new detection principles, innovative methods, or improvements to existing technologies. This session also includes test facilities, their measurement capabilities, testing methodologies, and notable results obtained using these infrastructures.

## **Icons**







## Time schedule

## Monday, 01 December

13:00-13:20	Registration		
13:25–13:30	Rene Hudec	Opening workshop	

### Session chair: Peter Friedrich

13:30–13:50	ОРТ	Yanji Yang	Development of the focusing mirrors onboard eXTP
13:50-14:20	ОРТ	David Girou	Manufacturing the mirror modules for NewAthena
14:20-14:50	ОРТ	Ladislav Pina	Optimization of Grazing Incidence X-ray Optics for Special Applications
14:50-15:10	OPT	Niels Lund	The peculiar optics of Laue-lenses
15:10-15:30	15:30 Coffee break		

#### Session chair: Randall McEntaffer

15:30-15:50	ОРТ	Fabien Grisé		Development and fabrication of EUV diffraction gratings
15:50–16:20	ОРТ	Ladislav Pina		Novel technologies for laboratory Wolter type X ray optics
16:20-16:40	ОРТ	Kirtankumar Dixit	Pravin	Broadband Multilayer Coatings for High-Energy Astrophysics: Optimization, Calibration, and Facility

17:30-23:00	Welcome reception
-------------	-------------------

# Tuesday, 02 December

09:00-09:20	Registration
-------------	--------------

9:25	Welcome Addresses by Distinguished Guests	
	Rene Hudec	Astronomical Institute of the CAS & Czech Technical University in Prague
	Zbyněk Škvor	Vice-Rector of the Czech Technical University in Prague
	Michal Bursa	Director of Astronomical Institute of the Czech Academy of Sciences

## **Session chair: Rene Hudec**

09:45-10:10	Rene Hudec	AXRO Introduction and historical background
10:10-10:35	Jiří Svoboda	Overview of the Czech participation in ESA space projects
10:35–10:55	Coffee break	

### **Session chair: David Girou**

10:55–11:25	ОРТ	Randall McEntaffer	Updates on the Off-plane Grating Rocket Experiment (OGRE)
11:25–11:55	ОРТ	Vadim Burwitz	Standardizing X-ray Ground Calibration for X-ray Observatory Missions
11:55–12:15	ОРТ	Christoph Braig	Approaching high-resolution X-ray astronomy? From phase retrieval to achromatic wavefront correction
12:15-13:45	Lunch		

## Session chair: Vadim Burwitz

13:45–14:10	DTF	Joan Torras	Minerva beamline: Characterization of mirror modules for the NewAthena optics
14:10-14:40	DTF	Daniele Spiga	Recent achievements of the BEaTriX X-ray facility: results and future perspectives
14:40-15:00	DTF	Can Chen	Design and test of an time-varying X-ray source for eXTP-SFA X-ray telescope
15:00-15:30	Coffee break		

## Session chair: Daniele Spiga

15:30-15:55	DTF	James Tutt	SiC grids for blocking filters
15:55–16:15	DTF	Qinyu Wu	EP4K: A Large-format sCMOS for EP/WXT and future X-ray missions
16:15–16:45	DTF	Zhila Yazdanfar	Implementing Machine Learning Algorithms to Improve X-ray Detectors for Astronomical Applications

16:15	End of day
-------	------------

# Wednesday, 03 December

09:00-09:10	Registration
-------------	--------------

## Session chair: Thorsten Döhring

09:15-09:45	MIS	Vojtech Simon	Astrophysics with SXI/SMILE
09:45-10:05	MIS	Ivan Reading	Optics Modelling for the SMILE/SXI Mission
10:05-10:25	MIS	Tianran Sun	X-ray imaging of the magnetosphere via the SMILE mission
10:25-10:45	Coffee break		

## Session chair: Ivan Reading

10:45-11:15	MIS	Rene Hudec	The Transient High-Energy Sky and Early Universe Surveyor (THESEUS)
11:15–11:35	MIS	Riccardo Campana	The XGIS Instrument on Board THESEUS: Design and Development Overview
11:35–12:05	MIS	Lorenzo Natalucci	Probing the dynamic universe with the GRINTA hard X-ray mission
12:05-13:35	Lunch		

## Session chair: Lorenzo Natalucci

13:35–13:55	MIS	Weiwei Cui	Design of the Spectroscopic Focusing Array-Imaging (SFA-I) on the eXTP Satellite
13:55–14:15	MIS	Zhixing Ling	The Einstein Probe mission
14:15–14:35	MIS	Wei Li	Status and Design of the eXTP SFA-T Camera
14:35–15:05	MIS	Thorsten Döhring	ASTRABAX: Balloon based radiation measurements in the stratosphere
15:05–16:45	Poster session + Coffee break		

## Session chair: Jakub Řípa

16:45–17:05	MIS	James Rodi	Studying the Binary Neutron Star Merger Population with Joint GW/EM Detections
17:05–17:25	AST	Norbert Werner	MUNI contribution to the study of galaxy clusters with XRISM
17:25–17:45	AST	Tauseef Ahmad Zafar	A Review of Machine Learning in Astronomical Plate Digitization and Survey Data

18:00-22:00	Dinner
-------------	--------

# Thursday, 04 December

### Session chair: Peter Predehl

08:45-09:05	MIS	Marianna Dafčíková	Routine observations of gamma-ray transients by nanosatellites: the story of GRBAIpha and VZLUSAT-2
09:05-09:30	MIS	Jakub Řípa	Demonstration of long-term ageing of silicon photomultipliers in space on GRBAlpha and VZLUSAT-2 CubeSats
09:30-10:00	MIS	Konrad Dennerl	Behind the scenes of eROSITA: how we transmit the data
10:00-10:25	MIS	Yong Chen	Follow-up X-ray telescope onboard Tianguan satellite
10:25-10:45	Coffee break		

### **Session chair: Konrad Dennerl**

10:45-11:20	AST	Peter Predehl	Scattering of X-rays by Interstellar Dust - A Review
11:20-11:45	AST	Susanne Friedrich	The search for soft sources in eROSITA data using isolated white dwarfs as an example
11:45–12:15	AST	Vojtech Simon	Observing the recurrence times of outbursts in X-ray binaries by X-ray monitors
12:15-13:25	Lunch		

### Session chair: Riccardo Campana

13:25–13:45	AST	Vladimir Karas	Probing the Strong Gravity Region of Black Holes
13:45-14:10	AST	Eva Sramkova	LSD trips to the time-variable neighbourhood of black holes and neutron stars
14:10-14:35	AST	Gabriel Török	For whom the disc slowly precesses

14:50-21:00	Social Event (see page 45)
-------------	----------------------------

## Friday, 05 December

09:00-13:00

Social Prague Trip (see page 46)



**End of workshop** 



## X-ray Optics

# Approaching high-resolution X-ray astronomy? From phase retrieval to achromatic wavefront correction

#### **Christoph Braig**

Institut für angewandte Photonik e.V., Germany

We draw a bow over developments in X-ray optics in the last two decades, relevant to highresolution imaging, and sketch a potential path to future space telescopes in that energy range. In terms of aberrations and focal length, (Wolter) mirrors and diffractive-refractive transmission optics complement each other: near diffraction-limited (milli-arcsec or less) capabilities of the latter come at the expense of an inexpedient lens-detector distance of at least 100 km. Nonetheless, the predicted performance of "hybrid" doublets inspired their realization on a small scale: a(po)chromatic assemblies operate at synchrotron and free-electron laser facilities. Such lenses transform the planar wavefront to a sphere – or vice versa, when a zone plate is applied to test an X-ray telescope. Like in microor spectroscopy, figure errors of the mirror shape manifest themselves in blurry focal spots. Besides refractive phase plates to compensate for the wavefront deformation, an all-diffractive method modifies the Fresnel grooves where the narrow spectral bandwidth is acceptable. In any case, the reflective surface profile should be determined in-situ and at wavelength. We present a sensitive but robust technique to unveil perturbations of an axisymmetric XUV or X-ray mirror. Developed for a cm-sized ellipsoid, the method compares two CCD measurements of defocused intensity distributions. An algorithm extracts the geometrical phase precisely, limited only by the pixel size. As an advantage vs. other wavefront sensors, besides relaxed requirements on coherence, no radiation is lost at masks or gratings, beneficial for use at faint laboratory sources. For our tabletop setup, the wavefront error of 50 nm (rms) can be corrected by a "reflection zone plate". We conclude with work in progress, conceptualizing "achromatic wavefront correction" by combining adapted grating- and prism-like components to correct the figure error of X-ray mirrors across an energy bandwidth accessible by a CCD or CMOS camera.





### Standardizing X-ray Ground Calibration for X-ray Observatory Missions



#### **Vadim Burwitz**

Max-Planck-Institut for Extraterrestrial Physics, Germany



X-ray ground calibration facilities are essential for developing, testing and calibrating optical systems, detectors and fully integrated telescopes. As missions strive for finer angular resolution and tighter error budgets, there is an increasing demand for methodologies to be harmonised across facilities and for the link between measurements and physicsbased models to be strengthened. To this end, we are establishing a new IACHEC Ground Calibration Working Group with four practical goals: 1) cross-calibrating X-ray test facilities using a common reference optic; 2) benchmarking ray-tracing packages against a shared reference optic model; 3) verifying analysis methods against a curated master dataset; and 4) providing guidance for ground calibration plans for forthcoming missions. This allows where necessary and possible, the distribution of calibration activities between facilities. Expected outcomes include shared standards, traceable error budgets and validated tools that will bolster confidence in pre-launch performance predictions. We will present exemplary cross-facility measurements of an eXTP mirror optic and an ATHENA mandrel optic, covering on- and off-axis PSF (half-energy width/encircled energy), effective area and vignetting. These measurements will then be comapared with ray-tracing predictions in order to quantify facility-to-facility systematics and validate the optics models and analysis pipelines.

# Broadband Multilayer Coatings for High-Energy Astrophysics: Optimization, Calibration, and Facility

#### Kirtankumar Pravin Dixit

NASA Marshall Space Flight Center, United States

High-angular-resolution, broadband X-ray optics are central to missions spanning 2-200 keV. This work presents an integrated approach that links a hybrid simulation—machine-learning framework for inverse design of depth-graded multilayer (DGM) coatings with targeted experiments and facility development. The model is trained on a large library of physics-based reflectivity simulations. It predicts key DGM parameters, bilayer count, thickness bounds, and grading profile, to maximize average reflectivity within a specified energy band and grazing-incidence angle, and it generalizes across material pairs and geometries while avoiding repeated re-optimization. translate predictions into manufacturable prescriptions and quantify interface quality, a calibration study probes a Ni/C design optimized for 50-80 keV at 0.15°. Periodic multilayers (N = 5) with fixed bilayer spacings sampling the DGM bounds (35, 50, 65 Å) are deposited on silicon substrates via DC magnetron sputtering and assessed by 8.048 keV X-ray reflectometry over angular scans up to 2°, enabling growth-parameter tuning and comparison with simulations. Building on this calibration, a depth-graded Ni/C multilayer targeting 50-80 keV reflection has been deposited. In parallel, a vertical dual-linear magnetron sputtering chamber is being commissioned to support scalable deposition with a path toward high-angular resolution, hard X-ray full-shell optics. The combined pipeline aims to deliver high-performance DGM coatings for future high-energy astrophysics missions.

# Manufacturing the mirror modules for NewAthena

**David Girou** 

cosine, Netherlands

NewAthena is the next-generation X-ray telescope being developed by the European Space Agency (ESA) as an L-class mission, planned for adoption in 2027 and launch around 2038. Covering the  $0.2-10\,\mathrm{keV}$  range, it will feature the largest X-ray optic ever built: a  $2.6\,\mathrm{m}$  diameter,  $12\,\mathrm{m}$  focal length system with more than  $1\,\mathrm{m}^2$  effective area at  $1\,\mathrm{keV}$ . The optic is enabled by Silicon Pore Optics (SPO), developed by ESA, cosine, and partners, which assemble up to 600 mirror modules into a single lens. This talk presents the status of SPO production and the path to mass manufacturing.











### Development and fabrication of EUV diffraction gratings

#### Fabien Grisé

The Pennsylvania State University, United States



The NASA Extreme Ultraviolet Explorer (EUVE) launched in 1992 was the first and last dedicated space telescope to operate in the EUV band. In addition to a whole sky survey, this successful mission collected the spectra of hundreds of objects but ultimately spectroscopy was limited by the sensitivity and resolving power of the spectrometer ( $\sim 1\,\mathrm{cm^2}$  and  $R{\sim}300$ ). The EUV range is however important to understand the physical processes happening in million degree plasmas such as in hot white dwarf atmospheres, accretion processes, the interstellar medium and others. In addition, EUV radiation drives the atmospheric escape of all planets and is therefore critical to measure in order to understand the impact of host stars on the habitability potential of their exoplanets. Since the 1990s, technological advances have been made and are now enabling a renaissance for EUV missions, thanks in part to the possibilities offered by nanofabrication techniques to create high-efficiency diffraction gratings tailored to that wavelength range. We will summarize the recent advances made in the fabrication of such high-efficiency diffractive optics, their use case for upcoming NASA missions and their applicability in the X-ray regime.



# Optimization of Grazing Incidence X-ray Optics for Special Applications

#### Rene Hudec

Czech Technical University in Prague, Czech Republic



Grazing incident X-ray and EUV optics (GIXO) find applications in astrophysics, laboratory hot plasma research, EUV lithography and in various imaging and spectroscopy laboratory systems. The basic design rules of grazing-incidence X-ray optics, including raytracing and mirror testing, are presented. Rotationally Symmetric Parabolic, Ellipsoidal, and Wolter mirrors as related to EUV and Soft X-ray sources were studied in detail. Source size, spectral range, magnification, geometry, materials and geometrical limitations are used as input data for calculations. Examples of mirrors designed with use of computer calculations and their experimental characterization are also included.

### The peculiar optics of Laue-lenses

#### **Niels Lund**

DTU Space, Denmark

Laue-lenses may improve the signal to noise (S/N-) ratio in the sub-MeV gamma domain by one to two orders of magnitude relative to direct-view instruments like COMPTEL and COSI. But the lenses are only effective for point sources; for extended sources the S/N-ratio drop off rapidly. The drop in the S/N-ratio is not caused by a reduction of the diffraction efficiency of the lens crystals, but by an unavoidable deterioration of the focusing quality for off-axis photons related to Bragś law and Darwinś model for mosaic crystals. The use of Laue lenses will significantly improve the detectability of soft gamma

emission from suspected sources localized at other wavelengths. The much-improved S/N-ratio will allow for timing and spectral studies inaccessible for direct-view instruments.

Guidelines for the construction of future Laue-lens systems will be presented.





# Updates on the Off-plane Grating Rocket Experiment (OGRE) Randall McEntaffer

the Pennsylvania State University, United States

The Off-plane Grating Rocket Experiment (OGRE) is a NASA suborbital rocket mission for high-performance X-ray spectroscopy. The nominal payload utilizes lightweight, polished-Si optics fabricated by NASAś Goddard Space Flight Center, a reflection grating array fabricated at Penn State with key industrial collaborations, and an EM-CCD based camera fabricated by XCAM in collaboration with the Open University. In preparation for the nominal mission, we will fly a pathfinder rocket that swaps the polished-Si telescope out for the JET-X telescope. This is one of three telescopes originally made for Spectrum-x-gamma with one currently flying on Swift and one slated for Pathfinder-OGRE, being lent by the Italian Space Agency. Furthermore, given the large mass of the payload, an additional telescope option is being considered, short-focal-length Silicon pore optics. Here we report on the progress of the OGRE program, overview of the Pathfinder-OGRE mission, and updates on the nominal payload.







### Novel technologies for laboratory Wolter type X-ray optics

#### Ladislav Pína

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



Wolter type X-ray optics have been developed for many years for space applications/uses. We present and discuss the main results of the project focussed on the innovate replication technology for the production of replicated X-ray optics for the laboratory and synchrotron applications with small apertures of 10 to 40 mm. The achieved shape accuracy was better than 100 nm (RMS) over a 50 mm length and the micro-roughness was better than 2 nm (RMS) over a  $10x10~\mu m$  area. Functional vacuum compatible samples with 3 various reflective layers (Au, Ni, Ru) were designed, manufactured and tested within the project. These layers are subsequently replicated, i.e. they are transferred to the inner wall of the self-supporting replica by an electroplating replication method. The innovation of the technology was represented by the introduction of 4i CNC nanotechnology. The potential application areas are laboratory, synchrotron, x ray lithography, laser plasma, x ray imaging and spectroscopy.



# Development of the focusing mirrors onboard eXTP

Yanji Yang

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

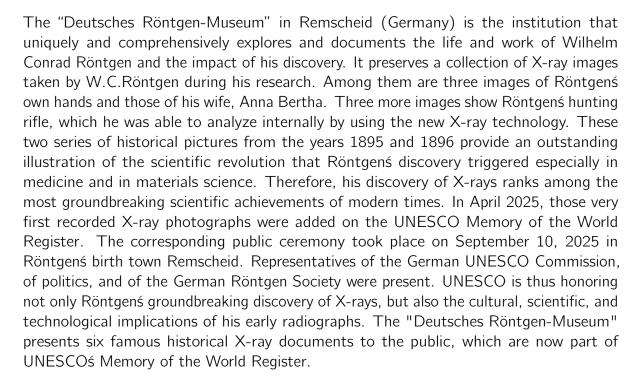


The eXTP mission has finished the phase B study. In 2025, we have finished another phototype of the mirror module employing the pure nickel as the reflective layer, during the testing of the phototypes manufactured by Media Lario and us, we found additional loss of the effective area by 10%. In this way, we have rechecked the margin of the design of the effective area, and added 5 inner shells into the mirror module to increase about 40 cm². Moreover, the thickness to radius ratio has also increased to 0.002 to manufacture the mirror shells with higher yield rates. The structural testing model and the SFA qualication model will be manufactured in the next year.

# Historical X-ray images selected for UNESCO's Memory of the World Register

#### **Thorsten Döhring**

TH Aschaffenburg, Germany



# One decade of joint Bavarian-Czech cooperation on astronomical X-ray optics

#### Thorsten Döhring

TH Aschaffenburg, Germany

Since ten years, Aschaffenburg University of Applied Sciences and the Czech technical university in Prague are now cooperating. During the recent decade, eleven joint projects have been executed, mainly targeting the development of astronomical X-ray optics. The bilateral cooperation also included the exchange of PhD students and scientists, cost compensation for conference participations, and the sponsoring of scientific conferences (AXRO and IBWS). The scientific output up to date are more than twenty joint publications and many individual conference contributions of the project partners in addition. The Bavarian-Czech Academic Agency (BTHA) has funded all of these projects. It is the goal of the Bavarian-Czech Academic Agency to support the academic collaboration in research and education and to contribute to an increased cooperation of the two neighboured countries Bavaria and Czech Republic in general. We will give a review on one decade of our Bavarian-Czech cooperation and on the scientific results of our joint projects on astronomical X-ray optics.











## Qualification of prototype X-ray optics modules for AXIS

#### Peter Friedrich

Max-Planck-Institut für extraterrestrische Physik, Germany



The Advanced X-ray Imaging Satellite (AXIS) is proposed as a next-generation X-ray observatory that combines high resolution over a large field of view with a large lightcollecting area. AXIS utilises the latest developments in the construction of lightweight, segmented X-ray optics made of single-crystal silicon and relies on the manufacture of large-format CCDs with small pixels and a high readout rate as well as good spectral resolution for the detector. The mission was proposed by the University of Maryland and MIT as part of NASAs Probe programme and has been selected for a Phase A study. The launch is scheduled for 2032. The Max Planck Institute for Extraterrestrial Physics (MPE) is supporting the project in the design and qualification of the AXIS X-ray telescope. Initial X-ray optical tests on breadboard optics were already carried out in 2023 in the PANTER X-ray facility. As part of AXIS Phase A, optics modules with 16-18 mirror layers shall undergo a test programme comprising multiple X-ray tests as well as vibration and thermal tests. In parallel, structural and thermal calculations are performed, on the one hand in connection with the tests at module level and on the other hand for the complete X-ray optics, in order to be able to predict their performance under space conditions and to be able to counter any problems that arise by adapting the design.

## X-ray Space Missions

# The XGIS Instrument on Board THESEUS: Design and Development Overview

# MIS

### Riccardo Campana

INAF/OAS, Italy

compact device.

The X and Gamma-ray Imaging Spectrometer (XGIS) is the high-energy monitor proposed for THESEUS (Transient High-Energy Sky and Early Universe Surveyor), a candidate mission within ESA M7 program aimed at exploring the transient high-energy sky for investigating the Early Universe and advancing in multi-messenger astrophysics. XGIS is designed to detect and localize transient X-ray and gamma-ray sources across a broad energy range ( $2 \, \text{keV} - 10 \, \text{MeV}$ ), enabling high-resolution timing and spectroscopy.

The instrument consists of two identical cameras, employing coded mask techniques to image the sky in the range 2–150 keV, while acting as a half-sky monitor in the 150 keV–10 MeV energy range. Its innovative detection system is based on Silicon Drift Detectors (SDDs) optically coupled to CsI(TI) scintillator bars. This configuration, combined with a low-noise distributed electronics system (ORION-ASICs), enables spectroscopy over an unprecedentedly wide energy band within a single, modular, and

The design of XGIS emphasizes modularity and robustness, with each camera integrating 100 detector modules that require extensive development, testing and qualification. The ongoing development of XGIS includes performance testing of the silicon sensors and the ORION readout chain, alongside optimization of the mechanical assembly. These efforts will lead to the construction of a second demonstrator module for XGIS, supported by ESA funding.

In this poster we present the XGIS architecture and performance, and we will summarize the technological advancements since M5 Phase A, highlighting progresses made in the current M7 Phase A in terms of technological readiness.



### Follow-up X-ray telescope onboard Tianguan satellite

#### Yong Chen

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



Tianguan Satellite is a Chinese X-ray observatory dedicated to time-domain astronomy and high-energy astrophysics. The Follow-up X-ray Telescope, with its Chinese name "Fengxingtian", is one of the core payloads on the Tianguan Satellite.

Fengxingtian is a China-led X-ray astronomical telescope, with the European Space Agency (ESA) and the Max-Planck Institute for Extraterrestrial Physics (MPE) participating through international cooperation. It consists of two identical telescope units, adopting multi-layer nested Wolter-I type X-ray focusing mirrors, and its focal plane is equipped with the latest PNCCD provided by MPE. A micro helium pulse tube has been developed to cool the PNCCD, achieving an on-orbit temperature stability of  $\pm 0.08^{\circ}$ C.

Having been in orbit for nearly two years, Fengxingtian has maintained stable operation and excellent performance. Characterized by a large field of view, high sensitivity, and low background noise, it can not only observe point sources but also deliver remarkable results in diffuse source observations, making significant contributions to the research of transient sources and astronomical observatory science.



# Design of the Spectroscopic Focusing Array-Imaging (SFA-I) on the eXTP Satellite

#### Weiwei Cui

Institute of High Energy Physics Chinese Academy of Sciences, China

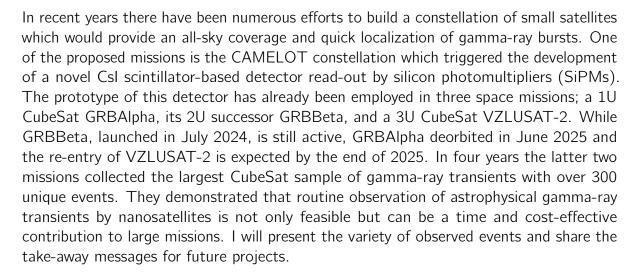


The enhanced X-ray Timing and Polarimetry (eXTP) mission represents Chinaś next-generation flagship X-ray astronomy satellite, designed to advance high-precision studies of timing, spectroscopy, and polarimetry of cosmic X-ray sources. One of its main scientific payload is the Spectroscopic Focusing Array-Imaging (SFA-I), a high-performance payload optimized for high signal-to-noise ratio measurements in imaging, spectral, and timing domains. The SFA-I consists of a Wolter-I type X-ray focusing mirror assembly and a focal plane camera. The telescope system features a focal length of 5.25 meters. The focal-plane detector is based on a PNCCD sensor developed by the Max Planck Institute for Extraterrestrial Physics (MPE), thermally stabilized by a helium pulse tube refrigerator. The SFA-I is designed to achieve a field of view greater than  $12 \times 12$ , an effective area of at least 550 cm<sup>2</sup> @ 1.5 keV and 330 cm<sup>2</sup> @ 6 keV, and an energy resolution better than 180 eV @ 1.5 keV. These capabilities position SFA-I as a important component for high-sensitivity X-ray observations in the eXTP mission.

# Routine observations of gamma-ray transients by nanosatellites: the story of GRBAlpha and VZLUSAT-2

#### Marianna Dafčíková

Masaryk University, Czech Republic



# MIS



# Behind the scenes of eROSITA: how we transmit the data Konrad Dennerl

Max-Planck-Institut für extraterrestrische Physik, Germany

Transmitting X-ray CCD data down to the lowest accessible energies poses significant challenges, as charge released by the absorption of a single photon may spread over several pixels, and accurate energy reconstruction requires the transmission of all charge components. Since many of these charge components lie close to the instrumental noise, it is unavoidable to transmit also some noise. The noise level is steeply rising towards low energies and requires to set a low energy threshold for the transmission. It may also exhibit substantial pixel to pixel variations, so that pixel-specific low energy thresholds are required to balance telemetry usage. Guided by the goal that the instrumental performance should not be limited by telemetry, we have developed an efficient data compression algorithm which takes all this into account. After having passed thorough tests on ground, this algorithm was activated soon after launch and has since then been used for the transmission of all the scientific eROSITA data.







# **ASTRABAX:** Balloon based radiation measurements in the stratosphere

#### Thorsten Döhring

TH Aschaffenburg, Germany



The ASTRABAX ("Aschaffenburg Stratospheric Balloon Experiment") project team uses a multimodal platform to study radiation exposures in the upper atmosphere. The multimodal setup inside the balloons gondola allows flexibility to address current research questions with low expenditure in costs and manpower. Recently, two stratospheric balloons were flown to characterize the stratospheric radiation environment. The focus of the physical experiments is the observation of the UV-C spectral region using miniature UV-VIS spectrometers and cosmic ray dosimetry with a Geiger counter. The platform also contains samples of biological cells that are simultaneously exposed to low-dose radiation of different compositions of high-energy particles, gamma rays, and UV radiation. Investigations in such natural environment are of importance for human space flights, for comparable exposures on other objects of the solar system, and for astrobiology.



# The Transient High-Energy Sky and Early Universe Surveyor (THESEUS)

#### Rene Hudec

Czech Technical University in Prague, Czech Republic



L. Amati, E. Bozzo, R. Hudec on behalf of the THESEUS consortium. The Transient High-Energy Sky and Early Universe Surveyor (THESEUS) is a mission concept developed by a large European collaboration under study by ESA since 2018 and currently one of the three candidate M7 mission for a launch in the late 30s. THESEUS aims at fully exploiting Gamma-Ray Bursts for investigating the Cosmic Dawn and as key phenomena for multi-messenger astrophysics. By providing an unprecedented combination of X-/gamma-ray monitors, on-board IR telescope and spacecraft autonomous fast slewing capabilities, THESEUS will be a wonderful machine for the detection, multi-wavelength characterization and redshift measurement of any kind of GRBs and many classes of X-ray transients, including high-redshift GRBs for cosmology (primordial low-mass/luminosity galaxies, first stars, cosmic re-ionization) and electromagnetic counterparts to sources of gravitational waves. Moreover, THESEUS will enable extreme and fundamental physics through unprecedented breakthrough measurements of GRB prompt and afterglow emission, as well as the detection and multi-eavelength characterization of many classes of high-energy transients. In all thses respects, THESEUS will thus provide an ideal synergy with the very large astronomical facilities of the future working in the e.m. (e.g., ELT, CTA, SKA, Athena) and multi-messenger (e.g., Einstein Telescope, Cosmic Explorer, km3NET). Talk will be presented on behalf of the THESEUS consortium by R. Hudec.

## Status and Design of the eXTP SFA-T Camera

#### Wei Li

Institute of High Energy Physics, China

The enhanced X-ray Timing and Polarimetry mission-eXTP is a scientific space mission designed to study the state of matter under extreme conditions of density, gravity and magnetism. One of the payloads is the Spectroscopic Focusing Array (SFA), an X-ray focusing telescope array. Its primary function is to achieve " spectroscopictemporal" measurements with a high dynamic range and high signal-to-noise ratio. SFA consists of six Wolter-I grazing-incidence X-ray telescopes engineered for spectral, timing, and imaging studies within the 0.5 to 10 keV energy spectrum. Each telescope setup consists of a mirror module, an electron deflector, a filter wheel, and a focal plane camera. To achieve high energy resolution while controlling the overall complexity and cost of the satellite, silicon drift detectors (SDDs) are used, which have relatively easily achievable temperature control requirements. Five focal plane cameras are equipped with SDD, earning their telescopes the designation SFA-T (" T" for " Timing"), highlighting the SDDs&039; superior timing precision. Each of the SFA-T payload includes one filter wheel, one detector shielding box, and one detector box. Each SFA-T telescope includes a 19-cell SDD array, whose energy resolution is better than 180 eV@ 6 keV. The SDD detectors will be developed and contributed to the eXTP project by the Max Planck Institute for Extraterrestrial Physics (MPE). It offers a time resolution of 10 microseconds, and the dead time is anticipated to be under 5% for a source intensity around 1 Crab. We have completed all works of Phase B for the eXTP mission and transitioned to Phase C, where we are currently designing the Electrical and Functional Model and the Structural Thermal Model of the SFA-T camera.

### The Einstein Probe mission

#### **Zhixing Ling**

National Astronomical Observatories, Chinese Academy of Sciences, China

The Einstein Probe (EP) mission is designed to detect mainly high-energy transients and variables, at unprecedented sensitivity and spatial resolution in the soft X-ray band, and to perform quick and deep follow-up observations in X-rays. EP is an international collaborative mission led by the Chinese Academy of Sciences, with partners of ESA, MPE and CNES. EP was launched on January 9, 2024. EP had completed the commissioning and in-orbit calibrations by July 2024. Since then, EP has started the nominal science operations phase. This talk will introduce the instrument performance, the science operations, and preliminary results with emphasis on the transients and variables detected. The Cycle 1 data will be released by the end of 2025.











## Probing the dynamic universe with the GRINTA hard X-ray mission

#### Lorenzo Natalucci





Recent observations of the transient sky at all wavelengths are increasingly revealing the importance of the multi-messenger and multi-wavelength approach. The GRINTA hard X-ray observatory, proposed for launch around the middle of the next decade, is conceived as a small mission with good sensitivity, excellent angular resolution and fast follow-up capability for studying transient sources at timescales from ms to hours, at the same time ensuring optimal integration with multi-messenger networks. The GRINTA mission will carry two complementary payloads to cover in total the 5-10,000 keV band, that will detect and localize gamma-ray bursts covering  $\sim$  half the sky and will be able to perform imaging surveys with sub-arcmin resolution. GRINTA is aimed at a launch around the middle of next decade, to operate in synergy with the most powerful electromagnetic, gravitational wave and neutrino observatories.



## Optics Modelling for the SMILE/SXI Mission

#### Ivan Reading

University of Leicester, United Kingdom

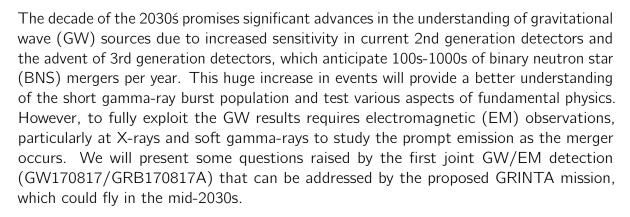


An understanding of the expected point spread function of the SMILE/SXI instrument is valuable to enable modelling of the expected imaging results using Leicesterś SXI End-to-End Simulator (SXI\_SIM) and to predict the likely influence of strong x-ray sources from outside the nominal field of view due to higher reflection count modes. We will share a simple (spatially constant) PSF estimate based on limited empirical data of the central PSF (from the testing phase) which has been extended by simulated data to add the effect of higher reflections. We will also present the result of using extensions to the QSOFT simulation software to simulate spatial variation in the PSF generated across a wide field of view thus incorporating the expected vignetting effects due to the detector extent, the MPO array extent, the MPO support frame and occlusion by the inner and outer baffle structures of the straylight system at a given energy.

# Studying the Binary Neutron Star Merger Population with Joint GW/EM Detections

#### James Rodi

INAF-IAPS, Italy



## Astrophysics with SXI/SMILE

### Vojtech Simon

Astronomical Institute, the Czech Academy of Sciences, Czech Republic

We show that a Soft X-ray Imager (SXI) onboard the ESA-CAS satellite SMILE will be able to observe various types of mass accreting compact objects in the universe. We show that neutron stars accreting matter from their companions in binaries are promising targets for evaluating the possibilities of SXI. We present the typical features of the long-term activity of various X-ray binaries in the SXI/SMILE field of view. We also show that binaries with steady-state thermonuclear reaction onboard accreting white dwarfs, located in the Magellanic Clouds, are promising targets for SXI observations. We discuss how SXI can contribute to this branch.

## X-ray imaging of the magnetosphere via the SMILE mission

#### **Tianran Sun**

Tianran Sun, China

The Solar wind-Magnetosphere-Ionosphere Link Explorer (SMILE) mission, a pioneering collaborative project between the European Space Agency and the Chinese Academy of Sciences, is set to revolutionize our understanding of solar wind-magnetosphere interactions. SMILE will employ a wide-field Soft X-ray Imager (SXI) to globally visualize the Earthś dynamic magnetosphere in response to solar wind variations. This technique exploits the solar wind charge exchange (SWCX) process, which generates soft X-ray emissions when highly-charged ions from the solar wind interact with neutral atoms in the Earthś exosphere. These emissions allow us to remotely sense large-scale structures with a novel approach, such as the magnetopause, cusps, and bow shock. This presentation will detail the development and capabilities of SMILE, including the recent progress of the whole mission and the Modeling Working Group (MWG).















# Demonstration of long-term ageing of silicon photomultipliers in space on GRBAlpha and VZLUSAT-2 CubeSats

### Jakub Řípa

Masaryk University, Czech Republic



GRBAlpha and VZLUSAT-2 CubeSats have been successfully operating and conducting scientific measurements in low Earth orbit for approximately four years. Both CubeSats had onboard gamma-ray detectors based on Csl(Tl) scintillator readout by silicon photomultipliers (SiPMs). SiPMs are becoming popular for scintillator-based gamma-ray detectors on CubeSats due to their low operating voltage, small size, linear response to low light intensity and fast response. However, SiPMs are prone to radiation damage, resulting in an increase in the dark count rate. Therefore, it is important to characterise their long-term performance in the space environment. We will report on the long-term changes in dark count rate and low-energy threshold of Hamamatsu S13360-3050 PE SiMPs. We have demonstrated that SiPMs can be used in the low Earth environment on a mission lasting beyond three years, and gamma-ray detectors on nanosatellites can routinely detect gamma-ray bursts.

## X-ray Detectors and Test Facilities

# Design and test of an time-varying X-ray source for eXTP-SFA X-ray telescope

## DTF

#### Can Chen

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



The enhanced X-ray Timing and Polarimetry (eXTP) mission is a scientific space mission aimed at studying the state of matter under extreme conditions of density, gravity, and magnetism. The Spectroscopy Focusing Array (SFA), one of the two types of scientific instruments of the eXTP mission, is designed for spectral and timing observations in the 0.5 to 10 keV energy range. The SFA comprises 6 telescopes, 5 of which are identical. Each of these 5 telescopes mainly consists of one mirror assembly with a focal length of 5.25 m and a monolithic 19-pixel Silicon Drift Detector (SDD) array that acts as the focal plane detector. In order to evaluate the timing performance of the SFA telescopes, an time-varying X-ray source based on a grid pole-controlled X-ray tube was designed and integrated into in the 100-m X-ray Test Facility in China. This time-varying X-ray source can generate pulsed X-rays with short duration (e.g., 100 ns) or any X-ray light curve. In this report, we will present the design of the time-varying X-ray source and the test results of not only the SFA telescopes but also some already launched X-ray telescopes (GECAM, EP), including time resolution, time accuracy calibration (in Pulse mode), and time-varying response (in Light Curve mode).

# Recent achievements of the BEaTriX X-ray facility: results and future perspectives

# DTF

#### Daniele Spiga

INAF - Brera Astronomical Observatory, Italy



The BEaTriX X-ray facility is now operational at INAF-Brera Astronomical Observatory, at the Merate seat. This innovative and one-of-the-kind X-ray facility generates a broad  $(6~\text{cm}\times17~\text{cm})$ , parallel, highly-polarized and uniform X-ray beam at the energy of 4.51~keV, in order to perform the systematic characterization of the NewAthena mirror modules in terms of angular resolution and effective area. We report in this talk the latest commissioning tests on a real mirror module and we compare the results with those achieved at other X-ray facilities, such as PANTER. We also report the advancements in the construction of the second short-arm beamline at the 1.49~keV energy, including the new X-ray source, the monochromators and the beam expanding crystals. We also report on the oncoming developments to increase the flexibility of the facility.



# Minerva beamline: Characterization of mirror modules for the NewAthena optics

#### Joan Torras

Sincrotró ALBA, Spain



The Minerva Beamline at the ALBA synchrotron is a dedicated soft X-ray (1 keV) metrology beamline designed to support the development, testing, and fabrication of the optics for the upcoming NewAthena X-ray space observatory, a mission led by the European Space Agency (ESA). The primary objective of Minerva is the optical characterization, alignment, and assembly of silicon mirror stacks into complete Mirror Modules (MM), which will form the telescope main optics. These stacks are based on Silicon Pore Optics (SPO) technology developed by the Dutch company cosine. The present work will provide an overview of the design, capabilities, and metrological performance of the Minerva beamline, emphasizing its suitability for space-grade X-ray optics validation in terms of stability and precision. Recent results from the characterization of MM performed at Minerva will be presented, including the agreement between the modeling of the optical parameters and the data obtained. In addition, ongoing developments towards future implementation of MM assembly process will be discussed.



### SiC grids for blocking filters

#### James Tutt

Penn State University, United States



Insights from previous X-ray missions like Chandra have shown that contamination build-up on cold focal plane detectors is a problem that needs to be mitigated in future orbital missions. These contamination concerns can be addressed with the use of free-standing blocking filters that can be heated to room temperature via the filter support mesh. Using SiC grids, it is possible to manufacture large, high-throughput grids that can be held at room temperature with a lower power consumption than traditional grids. In this presentation, we present large SiC grids with geometries that increase X-ray filter strength, transmittance, and temperature uniformity, with up to 128 mm apertures. This size is suitable for AXIS, newAthena, or a future Lynx style mission. A key part of the research is to understand how the temperature profile of the SiC grids behave when in a radiative cooling environment and determine the power needed to return the grids to room temperature. Here, we describe the planned research to prove this grid technology in flight-like conditions in order to increase technology readiness level.

### EP4K: A Large-format sCMOS for EP/WXT and future X-ray missions

## DTF

#### Qinyu Wu

National Astronomical Observatories, Chinese Academy of Sciences, China

EP4K is a  $4k \times 4k$ , 15-um-pixel, back-illuminated scientific CMOS detector optimized for the Einstein Probe Wide-field X-ray Telescope (EP/WXT). It delivers low read noise, low dark current, low image-lag, high frame-rate readout, and uniform response suitable for soft-X-ray imaging spectroscopy. With pixel-level gain calibration, EP4K can achieve a markedly sharpened spectral performance —  $\sim 125 \, \text{eV}$  FWHM at  $4.5 \, \text{keV}$ . The aluminum-coated implementation integrates effective optical blocking while preserving in-band X-ray throughput and core detector metrics. Radiation testing and long-duration aging also show its stable performances. These results and the inflight performance validate EP4K as a mature/candidate detector for EP/WXT and future soft-X-ray missions.



# Implementing Machine Learning Algorithms to Improve X-ray Detectors for Astronomical Applications

#### Zhila Yazdanfar

PhD student of Physics, Astronomy and astrophysics, Arak University, Iran, Islamic Republic of

•1)

**DTF** 

Recent advances in X-ray astronomy have highlighted the need for more accurate and efficient detector systems in space-based telescopes and laboratory testbeds. This research investigates the application of machine learning algorithms to improve the performance, calibration, and data analysis processes of X-ray detectors used in astronomical instrumentation. The study first introduces the theoretical background of X-ray detection, detector architectures, and conventional data processing techniques. It then presents supervised and unsupervised machine learning methods applied to real and simulated data obtained from X-ray detector systems. The algorithms are optimized for tasks such as noise reduction, energy calibration, and event classification, aiming to enhance detector sensitivity and spectral resolution. Experimental results demonstrate that integrating machine learning into the X-ray data pipeline can significantly improve accuracy and efficiency compared to traditional approaches. The findings suggest that these methods can play a crucial role in future X-ray astronomical missions by enabling more precise measurements and faster data processing, ultimately advancing the capabilities of X-ray astronomical optics.



### X-ray Astrophysics

# The search for soft sources in eROSITA data using isolated white dwarfs as an example

#### Susanne Friedrich

Max-Planck-Institut f. extraterrestrische Physik, Germany

The first all-sky X-ray survey was performed by the ROSAT X-ray observatory in the 0.1–2.4 keV energy range (Trümper 1982). It was not until almost 30 years later that an all-sky X-ray survey was to be carried out again with the SRG/eROSITA X-ray mission. Between December 2019 and December 2021, four all-sky surveys were completed. The sensitivity of eROSITA at soft energies is not as good as ROSATs. However, we have previously shown that it is possible to detect white dwarfs in eROSITA data: almost 300 white dwarfs from Gentile-Fusillo et al. (2021) were found in the current cumulative eROSITA all-sky data from the surveys 1–4, which are limited at lower energies to 0.2 keV (Friedrich et al. 2025). Some of already known white dwarfs, however, could only be detected by processing eROSITA data with a lower energy threshold of 0.1 keV instead of 0.2 keV. Simulations are currently underway with a lower energy threshold of 0.1 keV to optimize data processing. It is planned to reprocess the eROSITA data with this lower energy threshold of 0.1 keV to not only increase the number of white dwarfs detected in the X-ray range, but also to obtain more information about other soft sources, such as cataclysmic variables, isolated neutron stars, and AGN.

# Probing the Strong Gravity Region of Black Holes Vladimir Karas

Astronomical Institute of the Czech Academy of Sciences, Czech Republic

Upcoming missions will be able to combine X-ray spectral, timing, and polarimetric techniques to study the accretion/ejection processes near black holes, measure black hole mass and spin, and test Einsteinś theory of General Relativity against alternative viable theories in the strong field regime. The recent decade has seen a significant progress in our capabilities to test the nature of astrophysical black holes with X-rays, gravitational waves, and black hole imaging. The currently available constraints are still very limited but they can be improved with the next generation of observational facilities in the foreseeable future. The diversity of techniques, including the spectral, timing and polarimetric studies, will ultimately provide independent checks that can validate the methods and models.











### Scattering of X-rays by Interstellar Dust - A Review

#### Peter Predehl

Max-Planck-Institut für extraterrestrische Physik, Germany



Electromagnetic radiation is scattered by small dust particles in the interstellar medium. Unlike in the visible range, this occurs at small angles in the X-ray range. This offers the unique opportunity to measure both components of extinction, namely scattering and absorption, in a single observation, because X-ray sources behind sufficiently large dust column densities are surrounded by a diffuse halo whose morphology and spectrum contain information about the grain size distribution and composition of the dust, as well as the geometry of the intervening medium. In this review, I will summarize the fundamental physics of X-ray scattering—including the relevant cross sections, angular dependence, and energy scaling—and discuss how observations over the past decades, from ROSAT to eROSITA have contributed to our understanding of the interstellar medium. I will also highlight how scattering halos from time-variable or transient sources have enabled precise distance measurements to dust clouds and X-ray sources.



## Observing the recurrence times of outbursts in X-ray binaries by X-ray monitors

### Vojtech Simon

Astronomical Institute, the Czech Academy of Sciences, Czech Republic



Since the recurrence times Tc of outbursts in soft X-ray transients (SXTs) are not periodic and their typical length is months, years, or decades, X-ray monitors are needed to detect them and investigate their evolution. Significant values can be obtained even when the different monitors with various energy bands, available for the individual time segments (years or decades), are used (e.g., ASM/RXTE, MAXI/ISS, BAT/Swift). The observations show that changes of Tc between the neighboring (or nearby) outbursts were often much smaller than the length of Tc in a given object. Jumps of Tc only sometimes replaced them. Evolution of Tc in a given SXT shows a complex curve with episodes of increase and decrease. For example, the analysis of the recurrence time Tc of outbursts in Aql X-1, using the method of O-C residuals, revealed that the character of the O-C curves bears a striking similarity to that of dwarf novae observed in the optical band. It means that variations of Tc are large, but generally not chaotic, and long-term trends in the O-C curves can be resolved. The evolution of Tc shows several large jumps. The switches of Tc can occur within just a single epoch. Observing the variety of the X-ray evolution of many dwarf novae is still limited by the low sensitivity of the current X-ray monitors.

## LSD trips to the time-variable neighbourhood of black holes and neutron stars

#### Eva Sramkova

Gabriel Török

Intstitute of Physics, Silesian University in Opava, Czech Republic

Several competing simplified models have been proposed to explain the rapid quasi-periodic variability observed in X-ray radiation emitted by accreting black holes and neutron stars. These models usually only reproduce part of the observed phenomenology and face a number of challenges. In order to address these issues and identify ways to improve the individual models, we adapted the full relativistic ray-tracing code LSD, developed by Bakala et al. (2015, A&A). Based on this, we have developed an advanced, modular code that allows us to study radiation from various configurations of accretion systems. These include accretion disks, tori and inhomogeneous accreted matter, as well as the corona and the possible boundary layer on the surface of an accreting star. Here, we present the results of simulations of the behaviour of such systems, along with analyses of their observable manifestations. To enable comparison with the real variability of X-ray emission observed by space observatories, we also present synthetic data showing how these systems would appear when observed with the existing XRISM and upcoming newATHENA observatory.

## AST

### Silesian University in Opava, Czech Republic

For whom the disc slowly precesses

The vertical (Lense–Thirring) precession of the innermost accretion flows has been suggested as the cause of a particular type of low-frequency quasi-periodic variability (LF QPOs) observed in accreting neutron stars (NSs). In this context, LF QPOs have been discussed as a sensitive potential indicator of NS rotational properties and their equation of state, since the precession frequency vanishes for a non-rotating star. However, no observational evidence showing a clear trend of increasing QPO frequencies with increasing NS spin across a group of sources was found, which may falsify the model. We examined the expected precession frequencies within the innermost accretion region in detail. Taking the effects of stellar oblateness into account, we found that the precession frequency only increases within a short interval of increasing spin; then it drops and only increases again for even higher spins. We conclude that very different groups of accreting NSs — slow and fast rotators — can display the same precession frequencies. Therefore, the lack of observational evidence for a correlation between QPO frequencies and NS spin does not contradict their precession origin.



**AST** 





### MUNI contribution to the study of galaxy clusters with XRISM

### Norbert Werner

Masaryk University, Czech Republic



Members of the High Energy Astrophysics group at Masaryk University (MUNI) participated in the scientific activities related to the Performance Verification phase of the XRISM satellite as ESA Guest Scientists. They were active members of the target team for the Centaurus Cluster of galaxies and analysed complementary Chandra data, contributing particularly to the studies of the chemical abundances in the cluster core. Members of the HEA group are also currently active in the studies and interpretation of XRISM data from the Perseus Cluster and other systems. In my talk, I will summarise these activities and the exciting new XRISM results on galaxy clusters.



## A Review of Machine Learning in Astronomical Plate Digitization and Survey Data

#### **Tauseef Ahmad Zafar**

Czech Technical University Prague, Czech Republic



Background: Historical photographic plate archives capture century-scale sky variability and objective-prism spectroscopy, but heterogeneous emulsions, optics, and digitization pipelines complicate quantitative reuse. Gap: Prior surveys cover either plate history or generic ML in astronomy; few synthesize plate-specific calibration challenges with modern ML practice and reproducibility guidance. What this review adds: (i) a unified taxonomy from plate scanning to ML evaluation; (ii) best-practice checklists for calibration and leakage-safe validation; (iii) a practical pipeline and a benchmark wish-list to enable comparable results across archives. Approach: We map digitization and metadata workflows to ML-ready representations (images, catalogs, 1D spectra), summarize modeling options (classical ML, CNNs, self-supervised learning, domain adaptation), and highlight evaluation protocols that respect plate-level correlations and time leakage. Key recommendations: Standardize density→intensity linearization and WCS/zeropoint quality control; adopt plate-held-out cross-validation; release machine-readable provenance; and explore self-supervised pretraining with light fine-tuning per observatory. Outlook: With robust calibration and open benchmarks, century-long plate data can power discoveries of rare transients, illuminate long-term stellar evolution, and recover historical AGN variability while serving as a testbed for domain adaptation across instruments and epochs

## Simulated observations of high-frequency variability in X-ray binaries: Spots

### Tomáš Stanovský

Slezská Univerzita v Opavě, Czech Republic

We develop an end-to-end simulation pipeline to evaluate the detectability of high-frequency quasi-periodic oscillations (HFQPOs) in signals from black hole X-ray binaries with various space observatories. Light curves (LC) from analytic (Karas, 1996) and ray-traced (Bakala et al., 2007, 2015) hotspot models are combined with the global flux of microquasar GRS 1915+105; and photon events with SIXTE (Dauser et al., 2019), using SIMPUT (Schmid et al., 2013), for XRISM (Tashiro, 2022) and the planned new ATHENA (Cruise et al., 2024) are generated. We analyze power density spectra (PDS) of observed LC to recover the fundamental and harmonic frequency peaks across models and signal-to-background ratios. The study benchmarks simulated performance against RXTE and LOFT to validate the capabilities of new missions to observe HFQPOs. We found that WFI detector onboard new ATHENA robustly recovers the HFQPO fundamental and harmonics for the tested setups.

## AST



# Quasi-periodic modulation of neutron star boundary layer radiation I: Synthetic data

### Gabriel Török

Silesian University in Opava, Czech Republic

Relativistic accreting stars in low-mass X-ray binaries often exhibit strong quasi-periodic oscillations in their radiation. In our study, we examined the modulation of X-ray radiation from the neutron star boundary layer through the obscuration of an oscillating, thick inner accretion flow (Torok et al., ApJ, 2025). To do this, we adopted the full relativistic ray-tracing code LSD of Bakala et al. (2015, A&A). We found that the investigated mechanism adequately explains the high amplitudes of the observed rapid NS variability. Additionally, it reproduces the differences observed in this variability between neutron star and black hole cases. Here, we briefly discuss these results and present several extensions. These include synthetic data that could be verified or falsified by the newAthena X-ray observatory in the future.







# Quasi-periodic modulation of neutron star boundary layer radiation II: The importance of relativistic effects

### Gabriel Török

Silesian University in Opava, Czech Republic



We analysed the impact of individual relativistic effects on the X-ray flux of a neutron starś boundary layer, which is modulated by obscuration from an oscillating, thick inner accretion flow. We compared the results of our fully relativistic ray-tracing simulations with their Newtonian counterparts. To achieve this, we adopted the full relativistic ray-tracing code LSD (Bakala et al., 2015, A&A). We found that for a neutron star with a radius smaller than that of the innermost stable circular orbit (ISCO), the Newtonian limit is insufficient and relativistic ray tracing must be used. However, for less compact stars, the Newtonian approach provides reliable estimates of light curve modulation.



## Complex modelling of relativistic iron line profiles from accreting neutron stars

#### Gabriel Török

Silesian University in Opava, Czech Republic



Most models used to fit Fe-Ka lines in neutron star systems assume that X-ray emission comes from the accretion disk alone and neglect the stellar surface. This simplification omits obscuration effects and possible iron line emission from the surface, where shear-heated material cools and spreads. Here, we present a relativistic model that incorporates both components consistently. Using full relativistic ray tracing, we compute photon trajectories from the disk and the neutron star surface. The resulting spectra demonstrate that even a modest surface contribution can significantly alter the observed line shape. Finally, we present synthetic spectra as they would appear when observed using the XRISM and newATHENA observatories.

### **Others**

### **AXRO** Introduction and historical background

#### Rene Hudec

Czech Technical University in Prague, Czech Republic

The AXRO history is related to the history of X-ray astronomy in general and to the history of X-ray optics developments in the Czech Republic (and formerly in Czechoslovakia) in particular. The first Czech X-ray mirror was built already in the years 1969/1970, for a solar telescope within the Eastern Europe/Soviet INTERKOSMOS program, There were also essential efforts devoted to the development of novel technologies for satellite projects which were either canceled or interrupted. The two wasted years of development on the technology of high-quality Ni foils for the Danish SODART telescope (Schnopper, 1990), 1986-1988, can serve as an example. The SOviet-DAnish Roentgen Telescope (SODART) was planned for on board the Spectrum Roentgen Gamma (SRG) satellite equipped with three different instruments devoted to X-ray spectroscopy. Each of the two thin foil telescopes had an 8m focal length, a 60 cm diameter, a 1 deg field-of-view (FOV), a half-power width better than 2 arcmin and ca. 1 700 and 1 200 cm<sup>2</sup> collecting area at 2 and 8 keV, respectively. In the last three decades developments of innovative technologies for X-ray optics continued with an emphasis on glass foils and silicon wafers mostly in Multi Foil Optics arrangements and Schmidt Lobster Eye and Kirkpatrick Baez geometries. The late achievements are then related to the AHEAD2020 PROJECT recently finished.

### **AXRO 2025 concluding address**

### Rene Hudec

Czech Technical University in Prague, Czech Republic

I will give the concluding address for the AXRO conference. The goal of the workshop was 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 discussee 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 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.











## List of Participants

Vadim Burwitz Germany Barbora Bílá Czech Republic Riccardo Campana Italy Can Chen China Yong Chen China Weiwei Cui China Marianna Dafčíková Czech Republic Konrad Dennerl Germany Kirtankumar Pravin Dixit United States Thorsten Döhring Germany Peter Friedrich Germany Susanne Friedrich Germany David Girou Netherlands Fabien Grisé United States Rene Hudec Czech Republic Vadimir Karas Czech Republic Wei Li China Zhixing Ling China Niels Lund Denmark Veronika Maršíková Czech Republic Randall McEntaffer United States Lenka Mikuličková Czech Republic Lorenzo Natalucci Italy Ondrej Nentvich Czech Republic Richard Pavlica Czech Republic Richard Pavlica Czech Republic	Christoph Braig	Germany
Riccardo Campana Italy Can Chen China Yong Chen China Weiwei Cui China Marianna Dafčíková Czech Republic Konrad Dennerl Germany Kirtankumar Pravin Dixit United States Thorsten Döhring Germany Peter Friedrich Germany Susanne Friedrich Germany David Girou Netherlands Fabien Grisé United States Rene Hudec Czech Republic Adolf Inneman Czech Republic Vladimir Karas Czech Republic Wei Li China Niels Lund Denmark Veronika Maršíková Czech Republic Randall McEntaffer United States Lenka Mikuličková Czech Republic Lorenzo Natalucci Italy Ondrej Nentvich Czech Republic	Vadim Burwitz	Germany
Can Chen Yong Chen China Weiwei Cui China Marianna Dafčíková Czech Republic Konrad Dennerl Germany Kirtankumar Pravin Dixit United States Thorsten Döhring Germany Peter Friedrich Germany Susanne Friedrich Germany David Girou Netherlands Fabien Grisé United States Rene Hudec Czech Republic Adolf Inneman Czech Republic Vladimir Karas Czech Republic Wei Li China Zhixing Ling Niels Lund Denmark Veronika Maršíková Czech Republic Lorenzo Natalucci Italy Ondrej Nentvich Czech Republic	Barbora Bílá	Czech Republic
Yong Chen China Weiwei Cui China Marianna Dafčíková Czech Republic Konrad Dennerl Germany Kirtankumar Pravin Dixit United States Thorsten Döhring Germany Peter Friedrich Germany Susanne Friedrich Germany David Girou Netherlands Fabien Grisé United States Rene Hudec Czech Republic Adolf Inneman Czech Republic Vladimir Karas Czech Republic Wei Li China Zhixing Ling China Niels Lund Denmark Veronika Maršíková Czech Republic Lorenzo Natalucci Italy Ondrej Nentvich Czech Republic	Riccardo Campana	Italy
Weiwei Cui China  Marianna Dafčíková Czech Republic  Konrad Dennerl Germany  Kirtankumar Pravin Dixit United States  Thorsten Döhring Germany  Peter Friedrich Germany  Susanne Friedrich Germany  David Girou Netherlands  Fabien Grisé United States  Rene Hudec Czech Republic  Adolf Inneman Czech Republic  Vladimir Karas Czech Republic  Wei Li China  Zhixing Ling China  Niels Lund Denmark  Veronika Maršíková Czech Republic  Randall McEntaffer United States  Lenka Mikuličková Czech Republic  Lorenzo Natalucci Italy  Ondrej Nentvich Czech Republic	Can Chen	China
Marianna Dafčíková Czech Republic  Konrad Dennerl Germany  Kirtankumar Pravin Dixit United States  Thorsten Döhring Germany  Peter Friedrich Germany  Susanne Friedrich Germany  David Girou Netherlands  Fabien Grisé United States  Rene Hudec Czech Republic  Adolf Inneman Czech Republic  Vladimir Karas Czech Republic  Wei Li China  Zhixing Ling China  Niels Lund Denmark  Veronika Maršíková Czech Republic  Randall McEntaffer United States  Lenka Mikuličková Czech Republic  Lorenzo Natalucci Italy  Ondrej Nentvich Czech Republic	Yong Chen	China
Konrad Dennerl  Kirtankumar Pravin Dixit  United States  Thorsten Döhring  Germany  Peter Friedrich  Germany  Susanne Friedrich  David Girou  Netherlands  Fabien Grisé  United States  Rene Hudec  Czech Republic  Adolf Inneman  Czech Republic  Vladimir Karas  Czech Republic  Wei Li  China  Zhixing Ling  China  Niels Lund  Denmark  Veronika Maršíková  Czech Republic  United States  Lenka Mikuličková  Czech Republic  Lorenzo Natalucci  United States	Weiwei Cui	China
Kirtankumar Pravin Dixit  United States  Thorsten Döhring  Germany  Peter Friedrich  Germany  Susanne Friedrich  David Girou  Netherlands  Fabien Grisé  United States  Rene Hudec  Czech Republic  Adolf Inneman  Czech Republic  Vladimir Karas  Czech Republic  Wei Li  China  Zhixing Ling  China  Niels Lund  Denmark  Veronika Maršíková  Czech Republic  United States  Czech Republic  China  Niels Lund  Denmark  Veronika Maršíková  Czech Republic  United States  Lenka Mikuličková  Czech Republic  Lorenzo Natalucci  Italy  Ondrej Nentvich  Czech Republic	Marianna Dafčíková	Czech Republic
Thorsten Döhring Peter Friedrich Germany Susanne Friedrich Germany David Girou Netherlands Fabien Grisé United States Rene Hudec Czech Republic Adolf Inneman Czech Republic Vladimir Karas Czech Republic Wei Li China Zhixing Ling China Niels Lund Denmark Veronika Maršíková Czech Republic United States Czech Republic China Czech Republic United States Czech Republic	Konrad Dennerl	Germany
Peter Friedrich  Susanne Friedrich  David Girou  Netherlands  Fabien Grisé  United States  Rene Hudec  Adolf Inneman  Czech Republic  Vladimir Karas  Czech Republic  Wei Li  China  Zhixing Ling  Niels Lund  Denmark  Veronika Maršíková  Czech Republic  United States  Czech Republic  Lorenzo Natalucci  Italy  Ondrej Nentvich	Kirtankumar Pravin Dixit	United States
Susanne Friedrich  David Girou  Netherlands  Fabien Grisé  United States  Rene Hudec  Czech Republic  Adolf Inneman  Czech Republic  Vladimir Karas  Czech Republic  Wei Li  China  Zhixing Ling  China  Niels Lund  Denmark  Veronika Maršíková  Czech Republic  United States  Lenka Mikuličková  Czech Republic  Lorenzo Natalucci  Italy  Ondrej Nentvich  Cremany  Sermany  Ser	Thorsten Döhring	Germany
David Girou Netherlands Fabien Grisé United States Rene Hudec Czech Republic Adolf Inneman Czech Republic Vladimir Karas Czech Republic Wei Li China Zhixing Ling China Niels Lund Denmark Veronika Maršíková Czech Republic Randall McEntaffer United States Lenka Mikuličková Czech Republic Lorenzo Natalucci Italy Ondrej Nentvich Czech Republic	Peter Friedrich	Germany
Fabien Grisé  Rene Hudec  Czech Republic  Adolf Inneman  Czech Republic  Vladimir Karas  Czech Republic  Wei Li  China  Zhixing Ling  China  Niels Lund  Denmark  Veronika Maršíková  Czech Republic  United States  Lenka Mikuličková  Czech Republic  Italy  Ondrej Nentvich  Czech Republic	Susanne Friedrich	Germany
Rene Hudec Czech Republic  Adolf Inneman Czech Republic  Vladimir Karas Czech Republic  Wei Li China  Zhixing Ling China  Niels Lund Denmark  Veronika Maršíková Czech Republic  Randall McEntaffer United States  Lenka Mikuličková Czech Republic  Lorenzo Natalucci Italy  Ondrej Nentvich Czech Republic	David Girou	Netherlands
Adolf Inneman Czech Republic Vladimir Karas Czech Republic Wei Li China Zhixing Ling China Niels Lund Denmark Veronika Maršíková Czech Republic Randall McEntaffer United States Lenka Mikuličková Czech Republic Lorenzo Natalucci Italy Ondrej Nentvich Czech Republic	Fabien Grisé	United States
Vladimir Karas Czech Republic  Wei Li China  Zhixing Ling China  Niels Lund Denmark  Veronika Maršíková Czech Republic  Randall McEntaffer United States  Lenka Mikuličková Czech Republic  Lorenzo Natalucci Italy  Ondrej Nentvich Czech Republic	Rene Hudec	Czech Republic
Wei Li  Zhixing Ling  China  China  Niels Lund  Denmark  Veronika Maršíková  Czech Republic  Randall McEntaffer  United States  Lenka Mikuličková  Czech Republic  Lorenzo Natalucci  Italy  Ondrej Nentvich  China  China  China  China  Czech Republic	Adolf Inneman	Czech Republic
Zhixing Ling China  Niels Lund Denmark  Veronika Maršíková Czech Republic  Randall McEntaffer United States  Lenka Mikuličková Czech Republic  Lorenzo Natalucci Italy Ondrej Nentvich Czech Republic	Vladimir Karas	Czech Republic
Niels Lund Denmark  Veronika Maršíková Czech Republic  Randall McEntaffer United States  Lenka Mikuličková Czech Republic  Lorenzo Natalucci Italy  Ondrej Nentvich Czech Republic	Wei Li	China
Veronika Maršíková Czech Republic  Randall McEntaffer United States  Lenka Mikuličková Czech Republic  Lorenzo Natalucci Italy  Ondrej Nentvich Czech Republic	Zhixing Ling	China
Randall McEntaffer United States Lenka Mikuličková Czech Republic Lorenzo Natalucci Italy Ondrej Nentvich Czech Republic	Niels Lund	Denmark
Lenka Mikuličková Czech Republic  Lorenzo Natalucci Italy  Ondrej Nentvich Czech Republic	Veronika Maršíková	Czech Republic
Lorenzo Natalucci Italy Ondrej Nentvich Czech Republic	Randall McEntaffer	United States
Ondrej Nentvich Czech Republic	Lenka Mikuličková	Czech Republic
	Lorenzo Natalucci	Italy
Richard Pavlica Czech Republic	Ondrej Nentvich	Czech Republic
	Richard Pavlica	Czech Republic

Germany
Czech Republic
United Kingdom
Italy
Czech Republic
Italy
Czech Republic
Czech Republic
China
Spain
United States
Czech Republic
Czech Republic
Czech Republic
China
China
Islamic Republic of Iran
Czech Republic
Czech Republic
Czech Republic

## **Emergencies**

There are several important numbers:

- The Single European Emergency Call Number
- **158** Police of the Czech Republic
- **155** Emergency medical services
- **150** Fire and rescue service of the Czech Republic

In case you are in an emergency situation or witness such a situation and do not know where exactly you are, report your **location** using the **six-digit number** on the nearest street **lighting pole** to the emergency services.

### Internet connection

Wi-Fi will be available during the conference.

SSID: Lanna\_AV PASS: Lanna123

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).

Bus/metro/tram rides do not need to be booked in advance. The passengers must buy a ticket before on-boarding and validate it immediately after boarding the bus/tram or before the entrance to the metro station by a small yellow stamping machine. Validity is limited only by time, number of transfers is not limited.

**Participants aged over 65** can verify their right to receive the free age-based fare/tariff through the use of any form of ID card or a passport.

Tickets can also be purchased via SMS (only czech mobile numbers) or the **Lítačka mobile app (highly recommended)**, which can also be used to search for the ideal public transport connection. The application is available for Android or iOS.

More information about transportation, prices and connections can be found at http://www.dpp.cz/en/

Time	Price
30 minutes	30 CZK
90 minutes	40 CZK
24 hours	120 CZK
72 hours	330 CZK





## **Smoking**

Please note that all interior spaces in Villa Lanna are strictly non-smoking. This applies without exception to the conference hall, dining rooms, guest rooms, hallways, and all other interior areas. Smoking is permitted only in designated outdoor spaces, such as the terrace and specific areas in the garden. We kindly ask all participants to respect this policy to help preserve the villa's historic interiors and ensure a pleasant environment for everyone.



### Social event

Thursday, 4 December

**14:50 Meeting place:** Entrance hall of Vila Lanna

**15:45 - 17:15** Prague Loreto and its Carillon

**17:30 - 21:00** Conference dinner

(Capuchin Monastery)

For this year's social event, we warmly invite you to explore one of Prague's most remarkable Baroque landmarks: **the Prague Loreto**. Situated on Loretánské Square in the historic Hradčany district, just a short walk from Prague Castle, the Loreto is an architectural and spiritual treasure with a history spanning nearly four centuries.

The complex of Baroque buildings with an iconic tower, a spacious courtyard framed by arcaded cloisters, the Church of the Nativity, and Chapel of the Virgin Mary. One of its most celebrated features is **the Carillon** housed in the main tower, considered the largest historical church carillon in Europe. Crafted in 1694 by clockmaker Petr Neumann, it contains **thirty bells** cast in Amsterdam, of which twenty-seven are playable.

During our visit, you will have the opportunity to enjoy the unique atmosphere of this Baroque gem and to hear the famous carillon performance live.

After the guided tour of the Loreto, we will continue to the adjacent **Capuchin Monastery** (the oldest Czech monastery of the Order of Friars Minor Capuchin), connected to the Loreto grounds by a historical covered passage. Here, in a tranquil monastic setting rarely accessible to the public, we will gather for a buffet-style evening dinner prepared specially for AXRO participants. This part of the event offers a relaxed space to enjoy conversation, good food, and the company of colleagues in one of Prague's most historically rich districts.

## **Social Prague Trip**

Friday, 5 December

**09:15 Meeting place:** Entrance hall of Vila Lanna

On Friday during the late morning and around noon, we warmly invite you to join us for a special Social Trip—an opportunity to explore yet another corner of Prague's rich cultural landscape. Unlike our previous excursions, this year's outing takes place in full daylight, allowing us to uncover details and stories that usually escape the evening eye. We will visit a place AXRO has not explored before, offering a fresh experience even for long-time visitors of the city. The exact destination will be revealed in due course, but bring your curiosity (and perhaps a camera): Prague has many secrets, and we look forward to discovering a new one together.

Dear AXRO participants,

As this year's AXRO book draws to a close, we—Veronika, Ondrej and Martin—would like to share a few personal words on behalf of the organising team.

Over the years, AXRO has grown into far more than just a scientific conference. It has become a warm, vibrant and genuinely friendly community of colleagues and friends, built on curiosity, openness and mutual respect. This community is open to collaboration, the exchange of ideas and mutual support. We have always greatly appreciated the unique atmosphere that emerges when people from different institutes and countries come together with genuine curiosity and goodwill. Seeing how naturally participants connect, collaborate and support one another has always been one of the most rewarding aspects of our work. In this sense, AXRO truly fulfils its mission—not only by presenting new scientific and technological plans, possibilities and results, but also by creating a place where professional partnerships and personal friendships can flourish.

After careful consideration, we have decided to step back from the role of organisers and return our focus primarily to our own work and research activities. The growing administrative burden, the decrease in institutional support and the difficulty in communication have made the process more complex, inefficient and less enjoyable. In several situations, this has led to considerable confusion, rework or avoidable complications.

As we have always organised AXRO in our free time—outside of our regular employment and often at the expense of family, friends, hobbies, and other responsibilities—these ongoing difficulties have gradually become unsustainable. As a result, it has become increasingly challenging to deliver the high-quality conference experience that we believe AXRO and its participants truly deserve.

For these reasons, we believe it is time to pass the honour of organising this wonderful conference to someone else in the coming years. We trust that AXRO will continue to thrive in the hands of new organisers who bring fresh energy, ideas and perspectives.

We would like to sincerely thank all of you—current and past participants— for the opportunity to work with all of you, and for your support, kindness, and enthusiasm over the years. It has been a pleasure to meet you, talk with you, share ideas, and even initiate joint scientific and technical projects. We look forward to staying in touch and hope to see you again at other events —or perhaps at a future AXRO, this time as regular participants.

Thank you once again for your kindness and cooperation, and for the many wonderful moments we shared.

With warm regards,

### **Notes**

### For all those who made it this far — congratulations!

You have officially reached the end of the conference book.

This space is reserved for your reflections, annotations, sudden insights, or that promising idea sparked during a discussion over the coffee break but you haven't told anyone about yet.

Whatever you write here — whether it's a new hypothesis, a note about an unexpected collaboration or simply a way of keeping track of what intrigued you most — it may one day become part of your next great paper or project, or at least help you remember someone's name.

We hope these pages prove useful.

Who knows - perhaps what you jot down here will evolve into something that makes its way into a future abstract ... or even a keynote.

1.	
2.	
3.	
4.	
5.	
6.	
7.	
9.	
10.	
1 1	

12.	
13.	
14.	
15.	
16.	
17.	
18.	
24.	
25.	
26.	
27.	
28.	
29.	
30.	

