CONFERENCE BOOK

International Workshop on Astronomical X-Ray Optics

5 - 9 December 2022,
Vila Lanna, Prague, Czech Republic

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

About

International Workshop on Astronomical X-Ray Optics

AXRO is International Workshop on Astronomical X-Ray Optics focused on the 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 by leading scientists in this field, plus some presentations of relevant Czech scientists. Sessions focusing on all aspects of astronomical X-ray optics, X-ray detectors and test facilities are an essential part of the AXRO conference as well. Last but not least, recent and future X-ray space missions are also presented and discussed.

The goal of the workshop is to present and discuss recent and future technologies for X-ray astronomy missions. These missions require the development of the most innovative technologies, and we would like 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 broad 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 focused on astronomical X-ray optics, we also invite 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 13th International Workshop on Astronomical X-Ray Optics.

Organising committee

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

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William Zhang	NASA Goddard Space Flight Center
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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. The main focus of this section is on potential X-ray sources for use in X-ray astronomy using telescopes and satellites.

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 space missions and related scientific payloads with the focus for X-ray domain. Contributions from all categories of satellites and space missions are welcome (like L-class, M-class as well as S/F-class). Presentations of current, new results as well as proposals for new missions are very welcome.

DET X-ray Detectors & Test Facilities

Contributions regarding detectors and facilities suitable for use in X-ray are very welcome. New methods and principles of detection can be presented as well as existing solutions and their improvements. Facilities their testing method and measurement options, along with exciting results, can be presented in this section as well.

Icons

 **Talk**  **Poster**

Time schedule

Monday, 5 December

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

Tuesday, 6 December

08:45–09:00	**Registration**	

Session chair: Rene Hudec

09:00	**Opening workshop and Welcome notes**	
09:00–09:05	**Rene Hudec**	Welcome note
09:05–09:15	**Michal Bursa**	Director of Astronomical Institute
09:15–09:25	**Zbyněk Škvor**	Vice-Rector of the Czech Technical University in Prague
09:25–09:45	**Václav Kobera**	Ministry of Transport: Space Activities in the Czech Republic
09:45–10:00	**Rene Hudec**	AXRO 2022 introduction and historical background
10:00–10:20	**Coffee break**	

Session chair: Peter Friedrich

10:20–10:40	**OPT**	**Andrzej Bartnik**	EUV optical systems for laboratory, plasma – based radiation sources: investigation of EUV induced plasmas
10:40–11:05	**OPT**	**Fabien Grisé**	Electron-beam enabled optics
11:05–11:35	**OPT**	**Dan Schwartz**	Using a Gravitational Lens as the Ultimate X-ray Telescope.
11:35–11:55	**OPT**	**Richard Willingale**	How can we achieve diffraction limited imaging of the X-ray sky?
11:55–12:15	**OPT**	**Vadim Burwitz**	Testing X-ray optics at PANTER in the AHEAD2020 context
12:15–13:30	**Lunch**		

Session chair: Richard Willingale

13:30–13:55	**OPT**	**Vincenzo Cotroneo**	Advances in novel overcoatings for soft X-ray reflectivity enhancement
13:55–14:20	**OPT**	**Thorsten Döhring**	Testing of lobster-eye type telescopes with X-rays and visible light
14:20–14:40	**OPT**	**Veronika Stieglitz**	Characterisation of lobster eye optics and investigation of alternative PSF bases
14:40–15:00	**OPT**	**Carsten Stock**	Holographic soft X-ray and EUV gratings – recent progress
15:00	**End of Day**		

16:30–18:30	**Guided tour to astronomical Prague (see Conf. Book p. 38)**
18:30–22:00	**Conference dinner in Restaurant U Špirků (see Conf. Book p. 38)**

Wednesday, 7 December

09:45–10:00	**Registration**		
	Session chair: Andrzej Bartnik		
10:00–10:20	**OPT**	**Vojtěch Šimon**	The LOBSTER-EYE monitor - Perspectives of the soft X-ray observing the Galactic center region
10:20–10:40	**OPT**	**Vladimír Tichý**	LOPSIMUL - quick numerical simulator of multi-foil reflective optical systems
10:40–11:00	**OPT**	**Rene Hudec**	Novel Lobster Eye and Kirkpatrick Baez modules based on Multi Foil Technology: design, assembly and tests
11:00–11:20	**OPT**	**Nicolas Barrière**	Silicon Pore Optics X-ray mirror development for the Athena telescope
11:20	**End of X-ray Optics Session**		
11:20–11:40	**Coffee break**		
	Session chair: Randall McEntaffer		
11:40–12:10	**DET**	**Carlos Granja**	X ray imaging with spectral and photon counting response with Timepix3 and Timepix2 radiation cameras
12:10–12:30	**DET**	**James Tutt**	The tREXS focal plane camera
12:30–12:50	**DET**	**Charly Feldman**	The VTF - 4 years of experimental physics
12:50–13:10	**DET**	**Bianca Salmaso**	BEaTriX, the new facility to test the ATHENA Mirror Modules
13:10–14:15	**Lunch**		
	Session chair: Charly Feldman		
14:15–14:35	**DET**	**Henryk Fiedorowicz**	Laser plasma radiation source as a tool for testing X-ray and EUV optics
14:35–15:05	**DET**	**Jaroslav Nejdl**	Laser-driven X-ray sources at ELI Beamlines for science and metrology
15:05	**End of X-ray Detectors and Test Facilities Session**		
15:05–16:05	**Coffee break + Poster Session**		
	Session chair: Vadim Burwitz		
16:05–17:05	**Round table (Optics/Detectors/Facilities)**		
17:05–17:20	**Coffee break**		
	Session chair: Drew Miles		
17:20–17:40	**MIS**	**Jakub Řípa**	GRBAlpha and VZLUSAT-2 CubeSats Observing the Gamma-Ray Sky
17:40–18:00	**MIS**	**Vladimír Dániel**	CubeSat microsatellite demonstrator with X-ray optical payload
18:00	**End of Day**		

Thursday, 8 December

Session chair: Lorenzo Amati

09:00–09:40	**MIS**	**Randall McEntaffer**	The Off-plane Grating Rocket Experiment (OGRE)
09:40–10:00	**MIS**	**Alan Garner**	Status of the Rocket Experiment Demonstration of a Soft X-ray Polarimeter (REDSoX)
10:00–10:20	**Coffee break**		

Session chair: Thorsten Döhring

10:20–10:40	**MIS**	**Daniel Ryan**	New Demands of X-ray Imaging Systems in High-Energy Solar Physics
10:40–11:00	**MIS**	**Drew Miles**	An extended-source grating spectrograph for suborbital rockets and small satellites
11:00–11:25	**MIS**	**Lorenzo Amati**	The X/Gamma-ray Imaging Spectrometer (XGIS) for THESEUS and other opportunities
11:25–11:40	**Coffee break**		

Session chair: Alan Garner

11:40–12:05	**MIS**	**Lorenzo Amati**	The Transient High-Energy Sky and Early Universe Surveyor (THESEUS)
12:05–12:30	**MIS**	**Peter Friedrich**	X-ray test and calibration of the Einstein Probe Follow-up telescope
12:30–13:45	**Lunch**		

Session chair: James Tutt

13:45–14:05	**MIS**	**Charly Feldman**	The MXT instrument on SVOM
14:05–14:50	**MIS**	**Peter Predehl**	The eROSITA X-ray All-sky Survey
14:50–15:10	**MIS**	**Charly Feldman**	LEIA - First wide field-of-view X-ray observations by a lobster eye focusing telescope in orbit
15:10	**End of X-ray Missions Session**		
15:10–15:30	**Coffee break**		

Session chair: Peter Predehl

15:30–16:30	**Round table (X-ray Missions)**		
16:30	**End of Day**		

18:00–22:00	**Mysterious Faust House with dinner (see Conf. Book p. 39)**		

Friday, 9 December

Session chair: Dan Schwartz

10:00–10:25	**AST**	**Martin Jelínek**	Gamma-ray burst of September 19, 2019: Flare and bump solution
10:25–10:50	**AST**	**Gabriel Török**	The mass, spin and rapid X-ray variability of accreting compact objects
10:50–11:15	**AST**	**Vladimir Karas**	Spectral signatures from evolving black hole accretion rings
11:15	**End of X-ray and High-Energy Astrophysics Session**		

11:15–11:30	**Dan Schwartz**	Concluding remarks
11:30–11:45	**Rene Hudec**	Concluding address
11:45–13:00	**Lunch**	

13:00	**End of workshop**

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The latest version can be found at: `https://www.axro.cz`

Silicon Pore Optics X-ray mirror development for the Athena telescope

OPT

Nicolas Barrière
cosine Measurement Systems, Netherlands

Athena has been selected in 2014 by the European Space Agency as its next flagship x-ray observatory in the Science Programme. It uses a new modular technology to realize its 2.5 m diameter lens, which is made of several hundreds co-aligned mirror modules, each consisting of up to 76 mirror pairs. The telescope follows a 12-m focal length Wolter-Schwarzschild design, with the goal to deliver 1.4 m^2 effective area in a point spread function of 5" half-energy width at 1 keV, and an energy range of 0.2 to 12 keV. This corresponds to several hundred square meters of super-polished mirrors with a roughness of about 0.3 nm and a thickness down to 110 μm. Silicon Pore Optics (SPO), using the highest-grade double-side polished 300 mm wafers commercially available, have been invented to enable such next generation x-ray telescopes. SPO allows the cost-effective production of high-resolution, large area, x-ray optics, by using all the advantages of mono-crystalline silicon and the mass production processes of the semi-conductor industry. SPO has also shown to be a versatile technology that can be further developed for gamma-ray optics, medical applications and for materials research. This paper will present the status of the technology and of the mass production capabilities, show latest performance results and discuss the next steps in the development.

OPT

EUV optical systems for laboratory, plasma – based radiation sources: investigation of EUV induced plasmas

Andrzej Bartnik
Military University of Technology, Poland

In this work investigations of EUV-induced, low temperature plasmas created in rare or molecular gases were performed. Experiments were carried out 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 $1 \div 10$ ns. The EUV ionizing radiation was focused using grazing incidence collectors optimized for specific wavelength ranges. In our experiments various gases or gaseous mixtures 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. Spatio-temporal behavior of this type of low-temperature plasmas formed in various gases was investigated using an optical streak camera. Spectral measurements in EUV and VUV ranges were performed 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. Spectra measured in the wide wavelength range 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. The spectral analysis was also supported by numerical simulations of the molecular spectra measured in the VUV/UV/VIS range using various codes like LIFBASE, Specair or PGOPHER. Spectra corresponding to various molecular species not present in an initial gaseous mixtures were identified.

Testing X-ray optics at PANTER in the AHEAD2020 context

OPT

Vadim Burwitz
Max-Planck-Institut for Extraterrestrial Physics, Germany

Within the framework of the European Union Horizon 2020 program the AHEAD2020 integrated activity for the high energy astrophysics dome has been supporting the testing and calibrating of X-ray optics at the PANTER X-ray test facility of the Max Planck Institute for Extraterrestrial Physics (MPE). This is part of the joint research activity work package (WP #10) on X-ray optics. The AHEAD202 project began in March 2020 lasting until November 2024.

The PANTER activity has in part supported many projects. Starting with the testing and calibration of two new Chinese/European X-ray missions slated for launch in the second half of 2023. These are the SVOM (Sino-French) and the Einstein Probe (CAS/ESA/MPE) missions for which lobster-eye and nickel shell optics have been characterised and tested. SPO optics for the ESA ATHENA mission have been and will continue to be tested as well as high the precision optics needed for the BEaTriX SPO test facility. Also, a large novel KB-optic demonstrator has been thoroughly tested.

I will present a short overview of the AHEAD2020 X-ray optics work package and highlight results from some of the measurements that were done in this context

Advances in novel overcoatings for soft X-ray reflectivity enhancement

OPT

Vincenzo Cotroneo
INAF - Brera Astronomical Observatory, Italy

At AXRO 2019 we presented for the first time a novel idea for the realization of cost-effective overcoatings (based on dip-coating method) for the enhancement of soft X-ray reflectivity. These coatings can be realized by immersing the optics in a liquid solution, where a thin, low-density film spontaneously assembles on the optical surface. Since then, we experimented with different compounds, identifying and tuning a promising deposition process, which has a broad compatibility with reflecting materials and offers a relevant enhancement of performances. We deposited these coatings on different mirror samples representative of future X-ray telescopes and tested them in X-rays. We present the latest results and discuss their correspondence with the model and the potential further development and applications of the technology.

OPT

Testing of lobster-eye type telescopes with X-rays and visible light

Thorsten Döhring
TH Aschaffenburg, Germany

Reflective coatings for astronomical X-ray optics were developed at the "Aschaffenburg Competence Center for Astronomical and Space Instrumentation" (ACCASI) since several years. As part of a Bavarian-Czech cooperation between the Technical University of Aschaffenburg and the Czech Technical University of Prague, now two mechanically identical telescopes were built. One telescope optic was equipped with conventional gold-coated mirrors, manufactured by the Czech project partners. The 34 X-ray mirrors of the second telescope use an innovative coating system made of chromium and iridium, which was applied at the Aschaffenburg coating laboratory. Both telescopes are designed according to the bionic principle of a reflecting lobster eye. The optics works with two consecutive reflections on mutually perpendicular mirror surfaces. This enables a large field of view with many square degrees in diameter, which, however, comes at the price of a reduced angular resolution. An extensive X-ray characterization of these telescopes was carried out at the PANTER test facility of MPE, which simulates parallel starlight incident on the telescopes. The telescopes have an angular resolution of about 4 arc minutes in X-rays and a focal length of about 2 meters. Furthermore, the used X-ray mirrors reflect and focus visible light as well and this functionality in the optical regime was checked in laboratory tests. Now another test campaign is planned to examine the telescope resolution for real objects of the visible night sky and the imaging properties for star constellations. Such functional tests by observing astronomical objects of the visible sky may simplify and accelerate the development of X-ray telescopes.

OPT

Electron-beam enabled optics

Fabien Grisé
The Pennsylvania State University, United States

Custom, large-format astronomical gratings are needed for future space observatories, as further emphasized by the 2020 NASA decadal survey priorities. Their design requires (nano-)fabrication methods that are becoming increasingly complex. Amongst the many challenges, aberration-control for future gratings requires the need to patterning non-parallel grooves on flat substrates or curved substrates. Electron-beam (e-beam) lithography is one of the better-suited techniques to create these complex patterns. Subsequent processes usually involve some form of etching that enables high efficiency and/or high spectral resolution gratings to be manufactured. This talk will discuss previous and current projects taking place at the Penn State Nanofabrication Lab encompassing a wide range of e-beam enabled optics such as (E)UV gratings, curved gratings, and Fresnel zone plates.

Novel Lobster Eye and Kirkpatrick Baez modules based on Multi Foil Technology: design, assembly and tests

OPT

Rene Hudec
AI CAS & FEE CTU, Czech Republic

We present the design, assembly and tests of new Lobster Eye (LE) and Kirpatrick Baez (KB) modules based on Multi Foil Optics technology (MFO). The LE X- ray optics is a wide field of view (FOV) optics type Lobster Eye (LE) with short (400 mm) focal length (suitable for cubesat application) based on Schmidt design. The 2D LE optics consists of two orthogonal sub-modules of flat smooth reflective foils and each sub-modules focuses in one direction. The key parameters (the FWHM, the FOV (Field of view) and angular resolution, effective area) of the 2D LE optic were measured with different detectors . The advantage of MFO LE is that for off-axis points the angular resolution is preserved throughout the FOV, as demonstrated by measuring. There is combined detector system which include two detectors - Timepix3 Quad and spectroscope. The benefit of the combined detector system was demonstrated in the real measurement. Moreover, a new generation multiple arrays module of 2D X-ray KB optics with long f (nearly 6 meters) based on multi-foil silicon assembling technology was designed, manufactured, and tested in optical light and in X-rays at the Panter facility and the preliminary results will be also presented and discussed..

OPT

Using a Gravitational Lens as the Ultimate X-ray Telescope.

Dan Schwartz
Smithsonian Astrophysical Observatory, United States

Co-authors: Alysa Rogers, Cristiana Spingola, Anna Barnacka.

The best X-ray telescopes even for future consideration do not approach milli-arcsecond resolution. We are familiar with the fact that gravitational lenses magnify the fluxes of distant objects. The lenses also amplify the spatial scale of emitters in the source plane. Sources inside and near to the lens caustic are highly magnified, and yield four images. This over determines the reference frame relative to observations in other wavebands. The mass model that determines the properties of the lens depends sensitively on image positions measured in the optical or radio bands. Since the lensing is achromatic, the X-ray images must coincide with the optical/radio images if and only if their source is at an identical position. From an astrophysical perspective this need not be true. Binary, offset and dual supermassive black holes (SMBH) are expected in the early universe as galaxies evolve and merge. X-ray emission is an ideal method to detect SMBH via Active Galactic Nuclei (AGN). We use a double maximum likelihood ratio test to first correlate the X-ray data with the predictions derived from one putative source position, and then to choose the best of a set of possible source positions. For MG B2016+112, B0712+472 and B1608+656 we measure locations to within 2 to 11 mas (one sigma) of the corresponding radio sources. These give metric distances to an accuracy better than 100 pc, unprecedented for X-ray observations at such large redshifts. For B2016 at z 3.273 we deduced the presence of two X-ray emitting regions; either a dual AGN or an AGN plus pc-scale X-ray jet. One X-ray region is within $\pm$ 40 pc of a radio counterpart. Whatever is the best resolution X-ray telescope, gravitational lensing will enhance its performance. With the advent of the Rubin, SKA, and Roman all-sky facilities, tens of thousands of lensed quasars will be revealed. Why would you bother to point an X-ray telescope at an un-lensed quasar?

Characterisation of lobster eye optics and investigation of alternative PSF bases

OPT

Veronika Stieglitz
Max Planck institute for extraterrestrial physics, Germany

During last years, new possibilities of reflective coating layers for X-ray telescopes were studied and applied in frame of cooperation between CTU and Aschaffenburg University of Applied Science. These coatings and innovative optical designs, were not only simulated, but also prepared as functional demonstrators. For preliminary testing purposes of geometrical functionality, due to high facility and time demands of actual X-ray campaigns, images done in visible light were used. While images are not providing exact results regarding the quality of X-ray image, like angular resolution, they can be still used to check the mechanical and geometrical quality of prepared demonstrators. Evaluating such images showed that a Gaussian point spread function can represent the rough shape of the mirror mapping, and provides a FWHM estimate. However the residues show that the actual image contains much more details, which can be important for evaluating images, as well as the quality of the assembly. Alternative basis functions are investigated, resolving the contributions of individual mirrors. The split is apparent in the main focus, and even more exagerated in the side lobes. This approach can be useful for the design and assembly process, but also for deconvolution of images.

Holographic soft X-ray and EUV gratings – recent progress

OPT

Carsten Stock
Carl Zeiss Jena GmbH, Germany

Based on some recent projects in the field of beamline gratings and gratings for EUV/soft X-ray space missions, we introduce the enhanced options for the manufacturing of customized gratings. In numerous discussions with customers and project partners, we have learned that the degrees of freedom offered by holography are not generally known. Thus, we are concerned that the full technological capacity is often unused. Excellent scattered light level and flexible grating profiles are typical features of this grating type. In particular, a locally adapted blaze angle enables a uniform diffraction efficiency within the grating aperture even when the deflection angle shows a strong variation. Our technology chain offers the possibility to achieve a highly variable tuning of the spectral characteristics as well, while the resulting (multi-zone) grating still does not exhibit any phase discontinuities. Furthermore, a wide variety of achievable grating profiles offers further possibilities for spectral adaptation.

OPT

LOPSIMUL - quick numerical simulator of multi-foil reflective optical systems

Vladimír Tichý
Czech Republic

A software called LOPSIMUL is presented. The main advantage of LOPSIMUL is very high computational rate. LOPSIMUL is inteded for simulation of multi-foil optical systems, particularly Schmidt of Angel lobster eye. Plenty of systems derivated of lobster eye can be simulated by LOPSIMUL, too. Kirkpatrick-Baez system can be simulated with limitations. LOPSIMUL contains few reflectivity models. Any reflectifity model can be imported to LOPSIMUL as data table. LOPSIMUL shows resulting image and graphs of $\times$ and Y profiles. The image and profiles can be exported to be processed by other software. LOPSIMUL caluculates FWHM, gain, effective collecting area and other basic results.

OPT

How can we achieve diffraction limited imaging of the X-ray sky?

Richard Willingale
University of Leicester, United Kingdom

I will review the prospects for the design and manufacture of X-ray mirrors, lenses and interferometers which could enable diffraction limited X-ray imaging for astronomical observation in space. This would open up a completely new research area of ultra high angular resolution X-ray astronomy with imaging at angular scales of order 300 micro arc seconds operating at 1 keV. X-ray interferometry has the potential to achieve a resolution of order 100 micro arc seconds or better and currently available technology is good enough to manufacture the mirrors required.

OPT

PyXLA ray-tracing software for modelling Lobster-eye optics

Ondrej Nentvich
Czech Technical University in Prague, Czech Republic

Collimation of X-rays is challenging, especially in a wide field of view. One of the wide-field optics is the Lobster-Eye type in Schmidtś arrangement, which will be considered for simulations. Recent space missions carrying the Lobster-eye optics proved they are good wide-field optics, and it is worth researching this kind of optics. This poster discusses a newly developed simulation program, PyXLA, dedicated mainly to designing these optics. It is written in Python for multiplatform usage, focusing on accurate results and optical design LE optics and X-ray detector Timepix which can be interchanged for another type. The current state of the PyXLA software can simulate Lobster-eye optics with flat mirrors and give its parameters as reflective coefficients depending on the grazing angle of incidence. The results of the software can be an image of a point-spread function or an image containing several point sources both at a defined energy. Also, getting a physical arrangement of the setup is possible to construct the actual experiment.

The VTF - 4 years of experimental physics

DET

Charly Feldman
University of Leicester, United Kingdom

The VTF is a novel test bench for individual Micro Pore Optics (MPOs), allowing the Full Width Half Maximum (FWHM), focal length, efficiency and pore alignment in a single image. Whilst it is similar to a test bench created at Goddard Space Flight Centre (GSFC), it is upside down in comparison and enables testing of MPOs at all stages of production, which will be described and discussed. The VTF has suffered many delays and technical issues which has prevented full calibration of the facility, however, initial results and modelling are promising and will be presented. It is hoped that the flight SMILE optics will be tested and some results can be shown.

Laser plasma radiation source as a tool for testing X-ray and EUV optics

DET

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

The paper presents laser plasma sources of soft X-rays and extreme ultraviolet (EUV) that can be very useful for testing optical elements for the soft X-ray and extreme ultraviolet (EUV) spectral ranges, such as mirrors, detectors or filters. The sources are based on laser plasmas produced by irradiating a gas puff target with nanosecond laser pulses at an intensity in the interaction region of about 1011-1013 Wcm-2. The laser pulses are generated using commercially available Nd:YAG lasers (EKSPLA) generating 4 ns pulses with an energy of about 0.8 J or pulses with a time duration of 1 ns or 10 ns and an energy of 10 J at a repetition rate of 10 Hz. The targets are formed by pulsed injection of working gas (Xe, Kr, Ar or mixtures thereof) in an additional annular stream of He gas under high-pressure using a double-nozzle set up (double-stream gas puff target approach). Spectral, spatial and temporal characteristics of the radiation emitted from the source are presented. The sources were used to test various elements of soft X-ray and EUV optics, including grazing incidence and multilayer mirrors, semiconductor and scintillation detectors, and absorption filters. Results of these studies are presented. The possibility of using laser plasma radiation sources for testing X-ray astronomy optics is briefly discussed.

DET

X ray imaging with spectral and photon counting response with Timepix3 and Timepix2 radiation cameras

Carlos Granja
Advacam, Czech Republic

An overview will be presented of high-resolution spectral-sensitive X-ray imaging with the hybrid semiconductor pixel detector Timepix3 and Timepix2 detectors. The imaging response, energy/spectral range and energy resolution will be described for the various semiconductor sensor material (Si, CdTe) and sensor thickness used. Results of high-contrast radiographies of a wide range of samples will be shown including soft and also high-density objects. The pixel detectors are operated with highly integrated readout electronics in the form of integrated portable radiation cameras AdvaPIX-TPX3 (high performance, fast readout) and MiniPIX-TPX3 and MiniPIX-TPX2 (miniaturized, low power consumption). Data are acquired and visualized online with modular software PIXET.

DET

Laser-driven X-ray sources at ELI Beamlines for science and metrology

Jaroslav Nejdl
ELI Beamlines Centre, FZU AV CR, Czech Republic

ELI Beamlines Centre is a high-power laser facility dedicated to the development and applications of laser-driven sources of X-rays and accelerated particles. In this contribution, we summarize the current status of research and implementation of three types of X-ray sources: the HHG Beamline, the plasma X-ray source, and the Gammatron beamline. The HHG Beamline, which is a source of coherent femtosecond XUV pulses, and the incoherent sub-picosecond hard X-ray plasma source are driven by a 1 kHz laser system. In contrast, the Gammatron beamline, employing an ultrafast hard X-ray source based on radiation of relativistic electrons, is driven by a PW-class 10 Hz laser system. The source parameters and their suitability for metrology and characterization of X-ray optics will be discussed.

BEaTriX, the new facility to test the ATHENA Mirror Modules

DET

Bianca Salmaso
INAF - Osservatorio Astronomico Brera, Italy

BEaTriX (Beam Expander Testing X-ray) is a unique facility developed at the INAF-Osservatorio Astronomico Brera (Merate, Italy) to perform the X-ray acceptance tests (PSF and Aeff) of the ATHENA Silicon Pore Optics Mirror Modules (MM) at their production rate (2 MM/day). The X-ray beam approximate the one created by an astronomical source (collimated and large), recreated in a small lab (about 9m $\times$ 18m) thanks to an innovative design. The first beam line, at the energy of 4.51 keV, is completed. It has a large monochromatic beam collimated to < 3 arcsec, with a flux of 60 photons/s/cm^2. The beam size (170 mm $\times$ 60 mm) is sufficiently large to cover the entrance pupil of the MMs. The PSF and Aeff of the first optically representative MM were performed. The presentation will describe the facility, the results obtained so far and the ongoing study for the 1.49 keV and 6.4 keV beam lines, to be possibly replicated at the cosine premises.

The tREXS focal plane camera

DET

James Tutt
Penn State University, United States

The Rocket for Extended-source X-ray Spectroscopy (tREXS) was designed to produce a line-spread-function that was tightly focused in the dispersion direction, but that extended over 300 mm in the cross-dispersion direction. To make sure that all of the dispersed light would be collected by the focal plane camera, 11 CIS113 Vega sensors had to be tiled onto the focal plane. These detectors had to be under vacuum, cooled, and the entire focal plane had to be read out every 15 seconds. The challenges of using a large, custom focal plane were further increased due to the nature of a sub-orbital rocket launch vehicle.

This presentation will discuss the tREXS focal plane camera, including design requirements, challenges in the focal plane assembly and integration into the rocket payload, and detector performance pre, during, and post flight. The sub-systems that had to be developed to allow for a large, liquid nitrogen cooled focal plane to be used on a sub-orbital rocket will also be described.

Timepix3 semiconductor radiation detector and its usage in the wide temperature range

Martin Urban
Czech Technical University in Prague, Czech Republic

The Timepix3 is a hybrid pixel-particle-counting radiation detector based on an ASIC chip designed at CERN, which contains a 256 px × 256 px matrix. This version of the detector allows simultaneous measurement of energy and time of arrival or a combination of integral energy with a count of particles. This poster presents the usage of a detector for sensing radiation in the energy range of up to 100 keV and in a wide temperature range. The effect on the distortion of the measured energy spectra with the proposed possibility of compensating for the resulting deviation is also included in this contribution.

The X/Gamma-ray Imaging Spectrometer (XGIS) for THESEUS and other opportunities

MIS

Lorenzo Amati
INAF - OAS Bologna, Italy, Italy

I describe the science case, design and expected performances of the X/Gamma-ray Imaging Spectrometer (XGIS), a GRB and transients monitor developed and studied for the THESEUS mission project, capable of covering an exceptionally wide energy band (2 keV – 10 MeV), with imaging capabilities and location accuracy <15 arcmin up to 150 keV over a Field of View of 2sr, a few hundreds energy resolution in the X-ray band (<30 keV) and few microseconds time resolution over the whole energy band. Thanks to a design based on a modularity approach, the XGIS can be easily re-scaled and adapted for fitting the available resources and specific scientific objectvies of future high-energy astrophysics missions, and especially those aimed at fully exploiting GRBs and high-energy transients for multi-messenger astorphysics and fundamental physics.

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

MIS

Lorenzo Amati
INAF - OAS Bologna, Italy, Italy

The Transient High-Energy Sky and Early Universe Surveyor (THESEUS) is a space mission concept selected by ESA for a Phase A study (2018-2021) as candidate M5 mission, and currently being reproposed for the recently opened ESA/M7 opportunity for a launch in 2037. THESEUS aims at exploiting Gamma-Ray Bursts for investigating the early Universe and at providing a substantial advancement of multi-messenger and time-domain astrophysics. Through an unprecedented combination of X-/gamma-rays monitors, an on-board IR telescope and automated fast slewing capabilities, THESEUS will be a wonderful machine for the detection, characterization and redshift measurement of any kind of GRBs and many classes of X-ray transients. In addition to the full exploitaiton of high-redshift GRBs for cosmology (pop-III stars, cosmic re-ionization, SFR and metallicity evolution up to the "cosmic dawn"), THESEUS will allow the identification and study of the electromagnetic counterparts to sources of gravitational waves which will be routinely detected in the second half of the 30s by next generation facilities like aLIGO/aVirgo, LISA, KAGRA, and Einstein Telescope (ET), as well as of most classes of transient sources, thus providing an ideal sinergy with the large e.m. facilities of the near future like LSST, ELT, TMT, SKA, CTA, ATHENA.

MIS

CubeSat microsatellite demonstrator with X-ray optical payload

Vladimír Dániel
Výzkumný a zkušební letecký ústav, Czech Republic

The presentation describes the CubeSat microsatellite spacecraft with X-ray optical payload for prompt observation of transient astrophysical objects in X-ray energy range. By combining telescope concepts and miniaturized detectors, the small spacecraft will be able to probe the X-ray temporal emissions of bright events and also short and long term observations of other types of variable X-ray sources. The spacecraft is based on the CubeSat nanosatellite platform with a volume of 8U. The spacecraft carries two X-ray telescopes combined in one demonstrator. The first is intended for X-ray transient monitoring and localization, and the second for detailed spectroscopic observation. The design, assembly and testing of demonstrator will be presented.

MIS

The MXT instrument on SVOM

Charly Feldman
University of Leicester, United Kingdom

I present the current status of the MXT instrument for SVOM, a Chinese French mission due for launch towards the end of next year. The MXT is a French instrument and the goal is to effectively localise GRBs which have been detected in a companion instrument, ECLAIRS. The Full calibration of both the lobster eye optic, the MOP, and the complete instrument have been completed at PANTER, MPE, and some of the results will be presented. Much effort has gone in to the modelling of the optic and the comparison between the model and calibrated effective area will be discussed.

MIS

LEIA - First wide field-of-view X-ray observations by a lobster eye focusing telescope in orbit

Charly Feldman
University of Leicester, United Kingdom

As a novel X-ray focusing technology, lobster eye telescopes formed by tessellated Micro Pore Optics (MPOs), feature both a wide observing field of view and true imaging capability, promising sky monitoring with significantly improved sensitivity in soft X-rays. I will present the first-light results of the Galactic centre region, Sco X-1and the diffuse Cygnus Loop nebular (0.5 - 4 keV range) from a flight experiment of the Lobster Eye Imager for Astronomy (LEIA), a pathfinder of the wide-field X-ray telescope of the Einstein Probe mission. Launched in July 2022, LEIA has a mostly un-vignetted field of view of 18.6 deg $\times$ 18.6 deg, a spatial resolution in the range of 4–7 arcmin in FWHM and the focal spot effective area is 2–3 cm^2. The results provide a solid basis for the development of the present and proposed wide-field X-ray missions using lobster eye telescopes.

X-ray test and calibration of the Einstein Probe Follow-up telescope

MIS

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

The Follow-up telescope (FXT) is one of the instruments on board of the Einstein Probe (EP) satellite of the Chinese Academy of Sciences (CAS) due for launch in late 2023. The EP mission is dedicated to the study of the time-domain high-energy astrophysics, using a Lobster-eye based wide field telescope, complemented by an eROSITA-like optics for follow-up observations. MPE has provided hardware and its test facilities as part of a European contribution to Einstein Probe by ESA, and in addition the eROSITA Flight Spare Mirror Assembly as the second FXT module. Three FXT Mirror Modules - STM, QM and FM - have been built. All were acceptance tested with X-rays and then equipped with X-ray baffles for stray-light rejection, followed by environmental tests and subsequent X-ray performance tests. The final tests of QM, serving as a Flight Spare, and FM included an X-ray calibration at various photon energies ranging from about 0.3 to 8 keV. All tests were performed at MPEś X-ray Panter test facility and the test laboratory with its facilities for vibration and thermal-vacuum test. Reported are the setups and the results of this test sequence, focusing on the QM and FM Mirror Assemblies.

Status of the Rocket Experiment Demonstration of a Soft X-ray Polarimeter (REDSoX)

MIS

Alan Garner
Massachusetts Institute of Technology, United States

The Rocket Experiment Demonstration of a Soft X-ray Polarimeter (REDSoX) is a sounding rocket instrument recently selected for funding through NASAś APRA program. While scientifically it aims to measure the soft X-ray polarization of compact objects such as blazars, quasars, and neutron stars, it also serves as an important opportunity for technology development. Specifically, the REDSoX design utilizes a novel combination of focusing optics, critical-angle transmission (CAT) gratings, laterally-graded multilayer mirrors, and sensors to create an instrument that simultaneously measures the polarization and energy of low energy X-Rays (<1 keV). I will provide a summary of the early design decisions being made for REDSoX, as well as our long-term goal of adapting the design into a future orbital mission.

MIS

The Off-plane Grating Rocket Experiment (OGRE)

Randall McEntaffer
the Pennsylvania State University, United States

An overview of the Off-plane Grating Rocket Experiment, OGRE, will be given. This is a NASA suborbital rocket mission, the smallest programs funded by NASA for spaceflight. This high-resolution spectrograph combines lightweight X-ray optics, state-of-the-art reflection gratings, and an electron-multiplying CCD array. The talk will detail the novel X-ray grating fabrication process performed at Penn State. Furthermore, the polished Si X-ray optic from Will Zhangś group in NASAś Goddard Space Flight Center will be discussed as will the EM-CCD camera, which was built at XCAM with guidance from collaborators at the Open University. Additional options for this suborbital rocket will also be presented.

MIS

An extended-source grating spectrograph for suborbital rockets and small satellites

Drew Miles
California Institute of Technology, United States

The rise of high-throughput X-ray reflection gratings has enabled new instrument concepts in soft-X-ray spectroscopy. Coupling modern, highly efficient gratings with an optical design that enables a large field of view (FOV) allows for spectrographs that can achieve higher-resolution observations of extended sources and the X-ray background. The Rockets for Extended-source X-ray Spectroscopy (tREXS) are a series of suborbital rocket payloads that apply this concept, utilizing modern reflection gratings fabricated with electron-beam lithography, passive, mechanical beam-shaping modules to achieve a large FOV, and an extended focal-plane array of X-ray CMOS detectors. We present here the design of the tREXS instrument, and discuss ways that the instrument concept can be adapted to other formats, including SmallSats, that can enable longer observations and more complete sky coverage.

MIS

The eROSITA X-ray All-sky Survey

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

3 years after its launch from the Russian Baikonur Cosmodrome, all systems and instruments are working properly on the Spektr-RG (SRG) observatory. With eROSITA, the German contribution, half of all 8 sky surveys have been completed so far. Millions of X-ray sources, mostly of extragalactic nature, have been discovered. This confirmes what we had hoped for before the launch and had already been able to verify before the sky survey began by a sample survey of a 140 square degree field: We will easily achieve our goals of discovering 100,000 galaxy clusters, 3 million AGN, and nearly 1 million galactic sources. Already, fundamental discoveries and investigations with unprecedented sensitivity have been made with eROSITA.

New Demands of X-ray Imaging Systems in High-Energy Solar Physics

MIS

Daniel Ryan
University of Applied Sciences and Arts Northwest Switzerland, Switzerland

We discuss how scientific progress in high-energy solar physics is placing new demands on solar X-ray optics and detector systems. Understanding solar flares depends on simultaneously producing images and spectra of their X-ray emission in the range from a few to hundreds of keV. Because solar flares are among the brightest and most dynamic X-ray sources in the sky, the requirements for making these measurements are uncommon or unique in astrophysics. To date, solar spectroscopic imagers have employed indirect imaging strategies. However the next great scientific advances are likely to come from the deployment of direct X-ray focusing optics which provide greater sensitivity, imaging dynamic range and time cadence. We outline the strengths and limitations of current solar indirect spectroscopic imagers with the direct-focusing FOXSI (Focusing Optics X-ray Solar Imager) concept which is scheduled for its fourth sounding rocket flight in March 2024.

GRBAlpha and VZLUSAT-2 CubeSats Observing the Gamma-Ray Sky

MIS

Jakub Řípa
Masaryk University, Czech Republic

I will present the detector performance and science results from GRBAlpha, a 1U CubeSat mission, which is a technological pathfinder to a future constellation of nanosatellites monitoring gamma-ray bursts (GRBs). GRBAlpha was launched in March 2021 and operates on a 550km altitude sun-synchronous orbit. GRBAlpha has already detected several long and short GRBs, flashes from soft-gamma repeater SGR 1935+2154 and solar flares. Recently, it has detected extraordinarily bright GRB 221009A, which was the most intense GRB ever recorded in the 55 years history of GRB science. One and half year after launch, the detector performance is good and the degradation of the SiPM photon counters remains at an acceptable level. The same detector system, but double in size, was launched in January 2022 on VZLUSAT-2 (3U CubeSat) and it has also detected several GRBs, activity of SGR 1935+2154 and solar flares. This proves that nanosatellites can be used for routine detection of gamma-ray transients.

The LOBSTER-EYE monitor - Perspectives of the soft X-ray observing the Galactic center region

AST

René Hudec
AI CAS & FEE CTU, Czech Republic

We show the lobster-eye (LE) monitorś perspectives and observing plan based on a small LE telescope on a small (CubeSat-like) satellite platform. This instrument is important because it is able to provide wide-field X-ray imaging. We present the possibilities of monitoring the Galactic center region in the soft X-ray energy band. The reason is that many X-ray binaries, especially those with a low-mass lobe-filling secondary and mostly the neutron star accretor, concentrate in the bulge surrounding the center of our Galaxy. Several such binaries are expected to be present in our monitorś field of view (a square of about 5×5 degrees). We show the long-term activity of the examples of X-ray binaries located in this region.

Gamma-ray burst of September 19,2019: Flare and bump solution

AST

Martin Jelínek
ASÚ AVČR, Czech Republic

We studied the optical and gamma-ray behaviour of the long GRB 190919B detected by INTEGRAL and followed-up by several groud-based robotic telescopes, in particular the robotic telescope FRAM at Pierre Auger Observatory in Argentina. We present the results of our analysis, explaining the unusually steep rise as a flare of the inner-engine origin whose light gets dominated after several tens of seconds by a rising hydrodynamic afterglow emission peak. Our proposed solution is in good agreement with the relativistic fireball theory, both in spectral and temporal domain, and satisfies the closure relations for expansion into a constant density interstellar medium.

AST

Spectral signatures from evolving black hole accretion rings

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

In nuclei of galaxies strong tidal forces cause damage and disruption of stars passing within a critical distance from the central supermassive black hole (SMBH). Spectral signatures of this process depend on the environment around the SBMH horizon and the level of its accretion activity. We consider a system where the material remnant from the disrupted star forms a system of nested gaseous rings that spread in radius by action of viscous process. The evolving spectral features provide a way to reveal the parameters of the system, namely, the distance of the remnant gas from the SMBH, the radial extent of the gaseous trail, and the spin of the SMBH.

AST

The mass, spin and rapid X-ray variability of accreting compact objects

Gabriel Török
Silesian University in Opava, Czech Republic

The past three decades of observations with X-ray satellites have brought a large amount of data of rapid variability of black holes and neutron stars. We present a short review of models of quasi-periodic oscillations with the emphasis on the recent progress. Following the previous research on epicyclic oscillations of accretion disks around black holes and neutron stars, a new model of high-frequency quasi-periodic oscillations considering radial precession of accretion flow has been proposed. We discuss in detail the possibility that the quasi-periodic oscillations originate in a collective motion of matter in the innermost accretion region. Finaly, we summarize the related implications for mass estimates of neutron stars in low mass X-ray binaries.

AST

The new photometric pipeline of the D50 robotic telescope

Martin Jelínek
ASÚ AVČR, Czech Republic

The need for precise phptometric callibration obtained in real-time for images obtained with a robotic telescope is an absolute necessity in order to be able to provide automated alerts on changes of brightness of astrophysical objects. I will show the technique and results of the current version of the photometric pipeline of the robotic telescope D50 in Ondrejov. At present, the calibration is performed against magnitudes provided by the Atlas catalogue. The photometric fit includes color fitting and spatial correction, and permits usage of large number of frames in order to estimate the parameters that are not readily available by fitting a single image. By the end of October 2022, the pipeline has been used to process ∼800k images and provided photometry of ∼800M unique objects detected in these images.

Modelling polarization of black-hole accretion discs (an update)

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

X-ray polarization measurements have reached maturity. Here revisit the modelling of black-hole accretion disc with a primary illuminating source on the rotational axis. The primary X-ray power-law radiation is Compton reflected from the disc towards the observer. The gravitational field of a rotating black hole influences the photon properties on its way from the primary source to the disc and from the primary source and accretion disc to a distant observer. We study the polarization properties of the radiation how they are predicted within this scheme; namely, the degree and the angle of polarization are examined as functions of the black hole parameters.

AXRO introduction and historical background

Rene Hudec
AI CAS & FEE CTU, 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 tech- nologies for satellite projects which were either cancelled 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^2 collecting area at 2 and 8 keV, respectively. In the last few decades development of innovative technologies continued with an emphasis on glass foils and silicon wafers.

Insights into the history of X-rays: the Deutsches Röntgen-Museum in Remscheid

Thorsten Döhring
TH Aschaffenburg, Germany

In the year 1895, Professor Wilhelm Conrad Röntgen detected a new type of radiation that was able to penetrate solid materials. He himself called them X-rays. To honour this ground-braking discovery, in 1901 Röntgen was appointed as the first Nobel Prize laureate in physics. The Deutsches Röntgen Museum (DRM) in Remscheid (Germany) is the unique institution that comprehensively explores, documents, and mediates life, work, and impact of W. C. Röntgen. The location of the Deutsches Röntgen Museum in the city of Remscheid is of course no coincidence. Röntgeńs birthplace is only a short walk away from the museum. Every visit of this famous museum is an expedition through the worlds of medicine, science, and technology. The museum focus on the diversity of Röntgeńs invention by a multi-media and multilingual approach to ensure that every visitor can make his own individual discoveries. The Deutsches Röntgen Museum in Remscheid should be a place of pilgrimage for all X-ray scientists around the world. This contribution presents an insight to the history of X-rays and gives a guided tour to the Deutsches Röntgen Museum and its exhibits.

X-ray honour gallery – award winners of the Röntgen Medal

Thorsten Döhring
TH Aschaffenburg, Germany

Starting in 1951, celebrating the 50th anniversary of the award of the first Nobel Prize for physics to Wilhelm Conrad Röntgen, the Lord Mayor of the German City of Remscheid has given out Röntgen Medals. The Röntgen Medal annually honours scientists who "in the broadest sense have made a special contribution to the progress and dissemination of X-ray discoveries in the theoretical and applied sciences". The Röntgen Medal has become highly recognized in the scientific world. To date, more than one hundred excellent scientist have received this honour. Through their chronology, this contribution presents a "Whoś Who" of X-ray science and provides selected insights into their scientific work; with special focus to the fields of X-ray optics and X-ray astronomy.

List of Participants

Lorenzo Amati	Italy
Nicolas Barrière	Netherlands
Andrzej Bartnik	Poland
Vadim Burwitz	Germany
Vincenzo Cotroneo	Italy
Vladimír Dániel	Czech Republic
Thorsten Döhring	Germany
Charly Feldman	United Kingdom
Henryk Fiedorowicz	Poland
Peter Friedrich	Germany
Alan Garner	United States
Tomas Gotthans	Czech Republic
Carlos Granja	Czech Republic
Fabien Grisé	United States
David Hladík	Czech Republic
Rene Hudec	Czech Republic
Adolf Inneman	Czech Republic
Martin Jelínek	Czech Republic
Zuzana Kapounová	Czech Republic
Vladimir Karas	Czech Republic
Kateřina Klimovičová	Czech Republic
Veronika Maršíková	Czech Republic
Randall McEntaffer	United States
Lenka Mikuličková	Czech Republic
Drew Miles	United States
Jaroslav Nejdl	Czech Republic
Ondrej Nentvich	Czech Republic

Richard Pavlica	Czech Republic
Vít Pomahač	Czech Republic
Peter Predehl	Germany
Ladislav Pína	Czech Republic
Daniel Ryan	Switzerland
Bianca Salmaso	Italy
Dan Schwartz	United States
Eva Sramkova	Czech Republic
Veronika Stieglitz	Germany
Carsten Stock	Germany
Vladimír Tichý	Czech Republic
James Tutt	United States
Gabriel Török	Czech Republic
Martin Urban	Czech Republic
Richard Willingale	United Kingdom
Jakub Řípa	Czech Republic
Vratislav Šálený	Czech Republic

Useful Information

Emergencies

There are several important numbers:

112	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:
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, 25, 26, and Bus 131).

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.

Tickets can also be purchased via SMS (only czech mobile numbers) or the **Lítačka mobile app**, 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[1]	30 CZK
90 minutes	40 CZK
24 hours	120 CZK
72 hours	330 CZK

[1] Recommended ticket type for both events

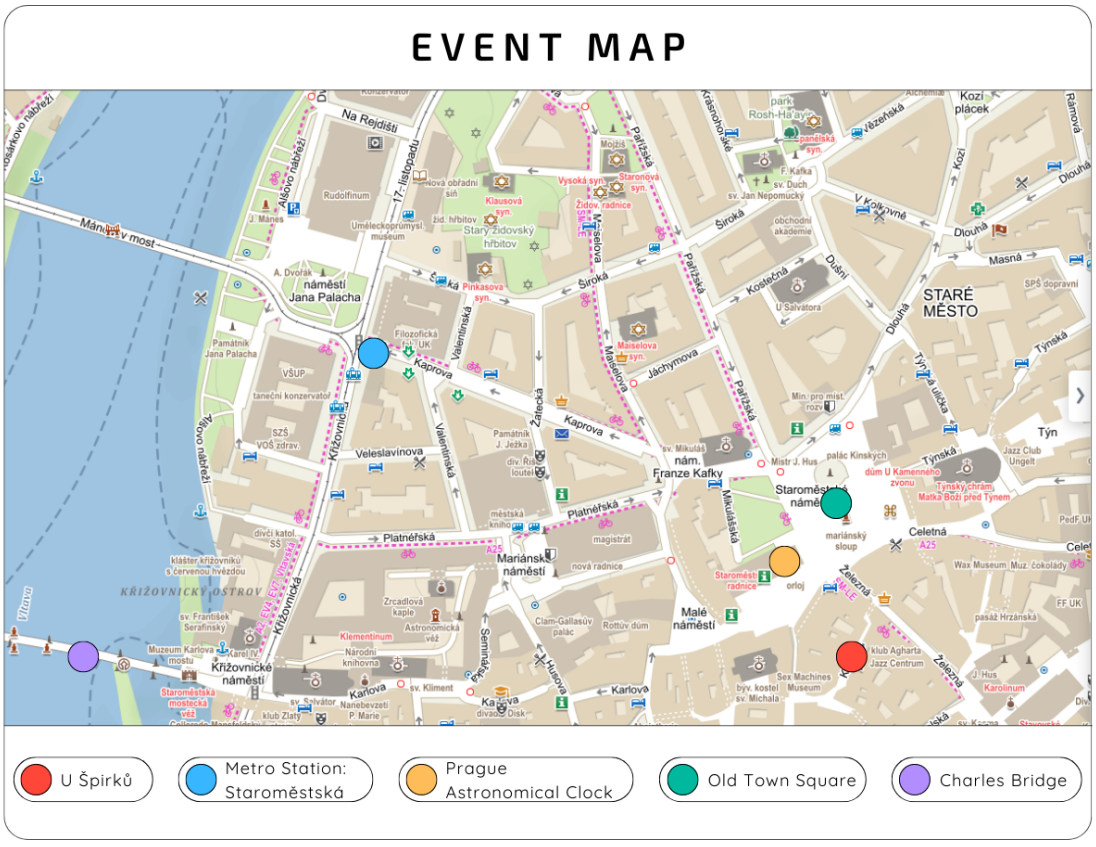
Guided tour to astronomical Prague

Tuesday, 6 December

16:30	**Meeting place:** The vestibule of **Staroměstská** metro station (in front of the turnstiles)
16:30 - 18:30	Guided tour of astronomical Prague (A. Šolcová and J. Šolc)
18:30 - 21:00	Conference dinner in Restaurant U Špirků (Kožná 12, Prague 1)

Welcome to Prague — the capital of the Czech Republic, called the "City of a Hundred Spires ", located in central Europe and designated as a World Heritage site by UNESCO. Many famous mathematicians, physicists and astronomers have spent very fruitful and creative years here and left unforgettable traces in Prague. In particular, Giordano Bruno, Tycho Brahe, Johannes Kepler, Bernard Bolzano, August Cauchy, Niels Henrik Abel, Christian Doppler, Ernst Mach, Albert Einstein and his mathematical colleague Georg Pick who was the one who inspired Einstein to study tensor calculus. During their stays in Prague, scientists developed fundamental mathematical and physical theories and engaged in related activities. For instance, at the beginning of the 17th century, Kepler formulated the first two of his three laws of planetary motion based on Tycho Brahe's observations. In the first half of the 19th century, Bolzano constructed a nondifferentiable continuous function (of a fractal character) and wrote a book on infinite sets entitled Paradoxes of infinity (1851). In 1842 Doppler, professor of mathematics at the Prague Technical University, first lectured about his Doppler effect in the Patriot's Hall of Carolinum. Einstein, while a professor of theoretical physics at the Prague German University, worked on his theory of general relativity in 1911–1912. In this guided tour, we will visit several sites in Prague's old town related to the history mentioned above.

doc. RNDr. Alena Šolcová, Ph.D.



Mysterious Faust House

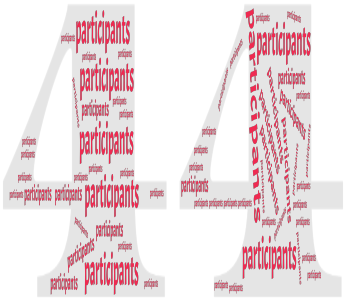
Thursday, 8 December

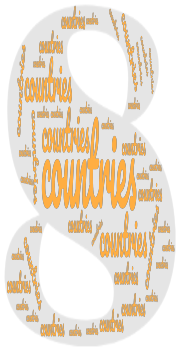
17:55	**Meeting place**: **Faust House** (Karlovo nám. 502/40, Prague) (Tram station Moráň: 2, 18 from Hradčanská, Metro B: Karlovo náměstí)
18:00 - 18:30	Welcome at Faust House
18:30 - 19:15	Presentation Astronomical Prague and History of Faust house (Alena Šolcová)
19:15 - 22:00	Conference dinner (buffet)

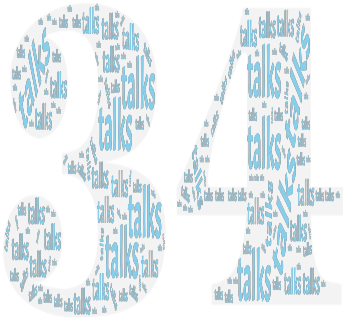
We will spend one evening in the baroque palace with a long tradition. One legend is associated with Goethe's Faust but is probably based on the historical figure of English alchemist Edward Kelley, a colleague and friend of John Dee and Elisabeth I of England, who stayed on the court of Emperor Rudolph II. Legendary Dr Faust is known for his pact with the devil and black magic. Even though the real Dr Faust probably never visited Prague, this house got its name for its mystical history and especially its eccentric inhabitants. In the 14th century, this baroque mansion was owned by Prince Vaclav of Opava, who was very keen on natural sciences and alchemy. He was the first one who gave rise to the association with Faust's legend because of his special profession. During the evening, we will explain more stories connected with this mystical house and some details of Prague's old astronomical history. Nowadays, this building houses the student club of the First Faculty of Medicine of Charles University, whose representatives kindly agreed to host our event.

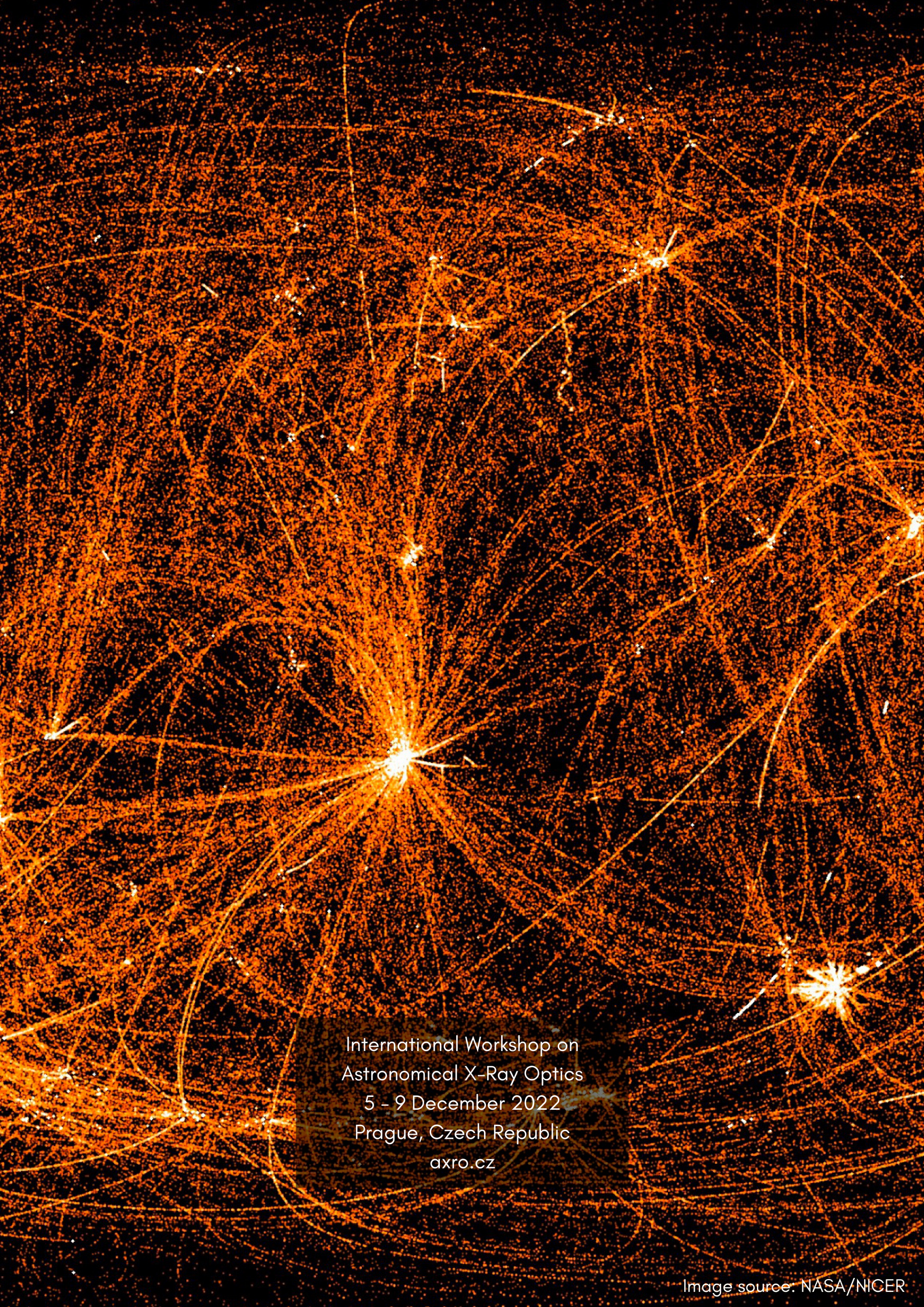
doc. RNDr. Alena Šolcová, Ph.D.

Event in numbers









International Workshop on
Astronomical X-Ray Optics
5 - 9 December 2022
Prague, Czech Republic
axro.cz

Image source: NASA/NICER