ROMANIAN ACADEMY
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"BABEŞ-BOLYAI" UNIVERSITY CLUJ-NAPOCA
FACULTY OF MATHEMATICS AND COMPUTER SCIENCE
FACULTY OF PHYSICS

8th International Conference on Astronomy, Astrophysics, Space and Planetary Sciences

International Conference, 2-4 July 2025, Cluj-Napoca

Programme

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Partially support by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCDI – UEFISCDI, project number P-IV-P6-6.3-SOL-2024-2-0220, within PNCDI IV

Front cover: Aurora as seen from the Astronomical Observatory Cluj-Napoca - Feleacu Station, 2024.05.10 22:23:30 UTC, image taken with Samsung SM-G998B CMOS camera, F=7mm, F-stop: f/1.8, ISO-3200, Exposure time: 0.1 s

Back cover: Aurora as seen from the Astronomical Observatory Cluj-Napoca - Feleacu Station, 2024.05.10 22:15:31 UTC, image taken with Samsung SM-G998B CMOS camera, F=7mm, F-stop: f/1.8, ISO-3200, Exposure time: 0.1 s.

Wednesday, July 2nd 2025

Astronomical Observatory Cluj-Napoca
Str. Cireşilor nr. 19

9:00

Registration

09:45

Plenary session 1
Chair: Vlad TURCU

09:45-10:00 Conference Opening

10:00-10:30 **Tiberiu Harko**

The Adomian Decomposition Method, and its applications in astronomy and astrophysics

Department of Physics, Babes-Bolyai University, 1 Kogalniceanu Street, Cluj-Napoca, Romania

10:30-11:00 **Bence Juhász, László Árpád Gergely**

On Hamiltonian formulations of the Dirac system

Department of Theoretical Physics, University of Szeged, Hungary

Coffee & tea break

11:30

Plenary session 2
Chair: Tiberiu HARKO

11:30-12:00 **Ruxandra Toma[1], Ovidiu Vaduvescu[2], Victoria Pinter[3]**

Properties of Dwarf Galaxies

[1]Astronomical Institute, University of Craiova, Romania

[2]University of Craiova, Romania

[3]Centro Astronómico Hispano en Andalucía, Observatorio de Calar Alto, Spain

12:00-12:30 **Cristian Danescu, Mark Rushton**

Observation campaign to recurrent novae and some preliminary results

Astronomical Institute of the Romanian Academy

12:30-13:00 **Kata Karácsonyi[1], Cirok Balázs[1], Isaac Chun Fung Wong[2], László Á. Gergely[1,3]**

Investigation of gravitational wave polarizations through detector network measurement

[1]Department of Theoretical Physics, University of Szeged, Hungary

[2]Department of Physics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong

[3]Department of Theoretical Physics, HUN-REN Wigner RCP

13:00

Lunch

15:30

Plenary session 3a
Chair: Mihai BARBOSU

15:30-16:00 **Richárd Tamás Varga[1], Emma Kun[2,3], László Árpád Gergely[1,4]**

Gravitational Waves from Pulsar Timing

[1]Department of Theoretical Physics, University of Szeged, Hungary

[2]Institute for Theoretical Physics IV, Ruhr University Bochum

[3]Astronomical Institute, Ruhr University Bochum

[4]Department of Theoretical Physics, HUN-REN Wigner RCP

16:00-16:30 **László Árpád Gergely**

Exact Kerr-Schild spacetimes from linearized kinetic gravity braiding

Department of Theoretical Physics, University of Szeged, Hungary

Department of Theoretical Physics, HUN-REN Wigner RCP

16:30-17:00 **Teodora Matei[1,2], Cristian Croitoru[3], Tiberiu Harko[1,2]**

Constraining the evolution of a Warm Inflationary Universe with Boundary

[1]Department of Physics, Babes-Bolyai University, Cluj-Napoca

[2]Astronomical Observatory Cluj-Napoca, Romanian Academy

[3]Department of Computer Science and Automation,Technical University of Cluj-Napoca

17:00-17:30 **Himanshu Chaudhary**

Constraining the Cosmos: MCMC Methods in Action: A Practical Guide to Constraining Cosmological Models Using SimpleMC

Department of Physics, Babes-Bolyai University, Cluj-Napoca

17:30
Coffee and tea break

18:00
Plenary session 3b
Chair: László Árpád GERGELY

18:00-18:30 **Ghulam Mustafa**

Compact stars

Department of Physics, Zhejiang Normal University

18:30-19:00 **Faisal Javed**

Gravastar configurations with cloud of strings and quintessence

Department of Physics, Zhejiang Normal University

19:00

Poster session

20:00

Conference Dinner

Thursday, July 3rd 2025

Astronomical Observatory Cluj-Napoca
Str. Cireşilor nr. 19

09:00

Registration

09:30

Plenary session 4
Chair: Alexandru POP

09:30-10:00 **Octavian Postavaru[1], Marian Craciun[2]**

Mechanisms behind gamma-ray burst generation in supernova events

[1]CITI-UPB

[2]IFIN-HH

10:00-10:30 **Tegze Tordai[1], David Hobill[2], László Á. Gergely[1,3]**

Image formation in weak gravitational lensing by compact objects of Einstein–Maxwell and Einstein–Born–Infeld theory with electric charge and magnetic dipole

[1]Department of Theoretical Physics, University of Szeged, Hungary

[2]Department of Physics and Astronomy, University of Calgary

[3]Department of Theoretical Physics, HUN-REN Wigner RCP

10:30-11:00 **Maria Craciun[1], Tiberiu Harko[2]**

General relativistic effects in Bose-Einstein Condensate dark matter halos, and their observational testing via the galactic rotation curves

[1]'T. Popoviciu' Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca, Romania

[2]Department of Physics, Babes-Bolyai University, Cluj-Napoca

11:00
Coffee & tea break

11:30
Plenary session 5
Chair: Tamas BORKOVITS

11:30-12:00 **Adrian Sabin Popescu**

A "new" danger from space for life on Earth and humanity: Magnetic excursions and magnetic field reversals

Astronomical Institute of the Romanian Academy, Romania

12:00-12:30 **Mirel Birlan[1,2], Adrian Sonka[1], Simon Anghel[1,2], Antonella Barucci[3], Cristian Omat[1], Sonia Fornasier[3], Marcello Fulchignoni[2]**

Near-Earth Asteroids colors in two European projects: NEOROCKS and NEOPOPS

[1]Astronomical Institute of the Romanian Academy

[2]LTE, Observatoire de Paris, France

[3]LIRA, Observatoire de Paris-Meudon, France

12:30-13:00 **Mihai Barbosu[1], Vlad Turcu[2], Tamas Wiandt[1], Radu Dănescu[3], Dan Moldovan[2]**

Orbit Determination of Highly Eccentric Satellites Using Ground-Based Optical Observations

[1]Rochester Institute of Technology (RIT), 1 Lomb Memorial Dr, Rochester, NY, 14623 USA

[2]Romanian Academy Cluj-Napoca Branch, Astronomical Observatory Cluj-Napoca, Astronomical Institute of the Romanian Academy, Str. Ciresilor 19, Cluj-Napoca, 400487, Romania

[3]Technical University of Cluj-Napoca, Computer Science Department Str. Memorandumului 28, Cluj-Napoca, 400114, Romania

13:00

Lunch

16:00

Plenary session 6
Chair: Mirel BIRLAN

16:00-16:30 **T. Borkovits[1,2], S.A. Rappaport[2,3], T. Mitnyan[2], I.B. Bíró[1,2]**

Study of new, TESS-discovered ultra compact hierarchical triply eclipsing triple stars

[1]Baja Observatory

[2]HUN-REN-SZTE Stellar Astrophysics Research Group

[3]M.I.T. Kavli Institute

16:30-17:00 **Alexandru Pop[1], Maria Craciun[2]**

On the importance of estimation of statistical significance of spectral features in amplitude spectra of astronomical time series

[1]Romanian Academy Cluj-Napoca Branch, Astronomical Observatory Cluj-Napoca

[2]'T. Popoviciu' Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca, Romania

17:00-17:30 **Aurelia Pascut[1], John P. Hughes[2], Rubens Machado[3], Richards P. Albuquerque[3], Gastao. B. Lima Neto[4]**

What Happens When Galaxy Clusters Collide? A Closer Look at AS0592

[1]Faculty of Electrical Engineering and Computer Science, Stephen the Great University, Suceava, Romania

[2]Department of Physics and Astronomy, Rutgers University, 136 Frelinghuysen Road, Piscataway, NJ 08854-8019, USA

[3]Departamento Academico de Fısica, Universidade Tecnologica Federal do Parana, Av. Sete de Setembro 3165, Curitiba, PR, Brazil

[4]Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, Rua do Matão 1226, São Paulo/SP, Brazil

17:30-18:00 **Cristian Croitoru[1], Teodora Matei[2]**

Odette: C++ program for orbit determination

[1]Department of Computer Science and Automation, Technical University of Cluj Napoca

[2]Department of Physics, Babes Bolyai University

18:00-18:30 **Farruh Atamurotov**

Astrophysical Processes Around Black Hole

Inha University in Tashkent

18:3-20:00

Coffee break & Poster Session

20:00

Dine Around

Friday, July 4th 2025

Astronomical Observatory Cluj-Napoca
Str. Cireşilor nr. 19

09:00

Registration

09:30

Plenary session 7
Chair: Iharka SZÜCS-CSILLIK

09:30-10:00 **Cristina Blaga, Paul Blaga**

Elvira Botez - A Life Dedicated to Astronomy and History of Sciences

Department of Mathematics, Babeş-Bolyai University, Romania

10:00-10:30 **Gheorghe Lucian Pascut**

Numerical Methods Beyond Density Functional Theory for Predicting Molecular Properties

MANSiD Research Center

Faculty of Forestry, Stefan Cel Mare University (USV), Suceava 720229, Romania

10:30-11:00 **Mirel Birlan, Diana Besliu-Ionescu**

The Romanian Astronomical Journal – Highlights

Astronomical Institute of the Romanian Academy

11:00 - 11:30
Coffee & tea break

11:30

Plenary session 8
Chair: Cristina BLAGA

11:30-12:00 **Mirel Birlan[1], Ana Naghi, Sorin Marin[1], Carmen Busu, Iharka Szucs-Csillik[3], Alain Doressoundiram[4], Gustavo Rojas[5], Mimoza Hafizi[6], Francoise Roques[4]**

Romanian partnership to Erasmus+ Exo4Edu project

[1]Astronomical Institute of the Romanian Academy

[2]

[3]Astronomical Institute, Romanian Academy Cluj-Napoca Branch

[4]

[5]

[6]

12:00-12:30 **Cristian Daniel Tudoran[1], Emanuela-Maria Smădu[2], Tania-Flavia Ciceo[2]**

Arcjet Thruster in Electrothermal Space Propulsion

[1]Department of Materials, Energy and Advanced Technologies, ITIM, Romania

[2]Department of Physics, Babeş-Bolyai University, Romania

12:30-13:00 **Ulpia-Elena Botezatu**

Dark and Quiet Skies for Science and Society

Romanian Space Agency

UN Committee on the Peaceful Uses of Outer Space

13:00

Conference concluding remarks

ABSTRACTS

ORAL PRESENTATIONS

Plenary session 1

Tiberiu Harko

The Adomian Decomposition Method, and its applications in astronomy and astrophysics

Department of Physics, Babes-Bolyai University, 1 Kogalniceanu Street, Cluj-Napoca, Romania

Abstract: The Adomian Decomposition Method (ADM) is a very effective approach for solving broad classes of nonlinear partial and ordinary differential equations, with important applications in different fields of applied mathematics, engineering, physics and biology. It is the goal of the present talk to provide a clear and pedagogical introduction to the Adomian Decomposition Method and to some of its applications. In particular, we focus our attention to a number of standard first-order ordinary differential equations (the linear, Bernoulli, Riccati, and Abel) with arbitrary coefficients, and present in detail the Adomian method for obtaining their solutions. In each case we compare the Adomian solution with the exact solution of some particular differential equations, and we show their complete equivalence. An important extension of the standard ADM, the Laplace-Adomian Decomposition Method is also introduced through the investigation of the solutions of a specific second order nonlinear differential equation. We also present the applications of the method three important applications in astronomy and astrophysics, related to the determination of the solutions of the Kepler equation, of the Lane-Emden equation, and for the study of the nonlinear oscillations of stellar objects.

Bence Juhász, László Árpád Gergely

On Hamiltonian formulations of the Dirac system

Department of Theoretical Physics, University of Szeged, Hungary

Abstract: We extend a previously successful discussion of the constrained Schrödinger system through the Dirac–Bergmann algorithm to the case of the Dirac field. In order to follow the analogy, first we discuss the classical Dirac field as a spinorial variable, by introducing properly defined momenta and a suitably modified, factor ordered Poisson bracket. According to the Dirac–Bergmann algorithm two second class Hamiltonian constraints emerge, leading to a factor ordered Dirac bracket on the full phase space. This becomes the Poisson bracket on the reduced phase space in the canonical chart adapted to the shell. The Dirac equation is recovered both as consistency condition on the full phase space and as canonical equation on the reduced phase space. Alternatively, considering the Dirac field as odd Grassmann variable, we present the details of the Dirac–Bergmann algorithm (with either left and right derivatives acting on Grassmann valued superfunctions and involving a

different type of generalized Poisson and Dirac brackets). We propose a recipe for the canonical second quantization of all three versions of the generalized Dirac brackets, yielding the correct fundamental anticommutator.

Plenary session 2

Ruxandra Toma[1], Ovidiu Văduvescu[2], Victoria Pinter[3]

Properties of Dwarf Galaxies

[1]Astronomical Institute, University of Craiova, Romania

[2]University of Craiova, Romania

[3]Centro Astronómico Hispano en Andalucía, Observatorio de Calar Alto, Spain

Abstract: Dwarf galaxies are the most abundant in the Universe and hence researching them can help us answer key questions about galaxy formation and evolution. Our past studies (2004-2005) pinpointed a possible evolution link from early- to late-type dwarf galaxies. Further, since 2017, we have been studying dwarf elliptical galaxies using homogeneous large datasets observed in the same NIR bands (Ks and recently J, best data suitable for accurate determination of the galaxy morphology and mass). For consistency, we have also been keeping the same photometry methods aiming to study in detail the previously discovered evolutionary connection. First, we analyzed Ks band data and published the results in Pinter & Vaduvescu (2023). Further, we added a large sample of J band data to add colour information to our study. In this work, we present our methods (sample selection, data reduction, photometry etc) and previous results concluding with first results and future work.

Cristian Dănescu, Mark Rushton

Observation campaign to recurrent novae and some preliminary results

Astronomical Institute of the Romanian Academy

Abstract: T Corona Borealis is a recurrent nova with recorded outbursts in 1217, 1787, 1866, and 1946. With a recurrence interval of approximately 80 years, it has become a source of intense interest due to the expectation of an imminent eruption. This nova is unique among recurrent novae in exhibiting both a pre-outburst dip and a secondary maximum in its B-band light curve, features which defy explanation within current nova theory. In this presentation, we will outline preparations for our upcoming observational campaign, which will utilise both photometry and spectroscopy, and discuss our expectations for the results.

Kata Karácsonyi[1], Cirok Balázs[1], Isaac Chun Fung Wong[2], László Á. Gergely[1,3]

Investigation of gravitational wave polarizations through detector network measurement

[1]Department of Theoretical Physics, University of Szeged, Hungary

[2]Department of Physics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong

[3]Department of Theoretical Physics, HUN-REN Wigner RCP

Abstract: The detection of gravitational waves (GWs) in the past decade has provided an opportunity for testing General Relativity (GR) in the strong-field regime and for constraining alternative theories of gravity. While GR predicts only two tensorial polarization modes, modified gravity theories (e.g. Horndeski theories) permit additional scalar and vector modes, or combinations thereof. Given the limited number and the orientation of detectors, identifying and disentangling mixtures of polarization modes remains a significant challenge. To date, several methods have been developed to search for such non-tensorial components. Among them is the null stream approach, based upon the construction of the so-called null stream of the data. This method has been implemented in both the frequentist and Bayesian frameworks. In the frequentist case, the null stream energy serves as a test statistic to assess the null hypothesis that only tensorial modes are present, with the test statistic expected to follow a chi-squared distribution under GR. In the Bayesian framework, this distribution is interpreted as a likelihood function to compute Bayes factors comparing all viable polarization combinations to the tensor-only model predicted by GR. A key strength of the null stream method is its model independence and broad applicability to GWs from arbitrary sources, not just compact binary coalescences. In this talk, I will present the methodology of this approach, along with its implications for testing GW polarizations in a variety of modified gravity theories.

Plenary session 3a

Richárd Tamás Varga[1], Emma Kun[2,3], László Árpád Gergely[1,4]

Gravitational Waves from Pulsar Timing

[1]Department of Theoretical Physics, University of Szeged, Hungary

[2]Institute for Theoretical Physics IV, Ruhr University Bochum

[3]Astronomical Institute, Ruhr University Bochum

[4]Department of Theoretical Physics, HUN-REN Wigner RCP

Abstract: We review both the pulsar timing techniques able to detect gravitational waves in the nHz regime and the generation of such gravitational waves by compact binary sources. Their stochastic isotropic background obeys the Hellings—Downs pattern and is consistent with pulsar timing observations. Then we focus on known supermassive black hole binaries and their gravitational radiation. For either of the OJ 287, S5 1928+738 and 3C66B sources we prove that the amplitudes of the emitted gravitational waves remai below the sensitivity of the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), nevertheless they appear to be above the sensitivity of the forthcoming Square Kilometre Array (SKA) Telescope.

László Árpád Gergely

Exact Kerr-Schild spacetimes from linearized kinetic gravity braiding

Department of Theoretical Physics, University of Szeged, Hungary

Department of Theoretical Physics, HUN-REN Wigner RCP

Abstract: The Einstein equation for vacuum Kerr-Schild spacetimes is equivalent with its linearized version. The same property holds for matter sources of certain type. We impose the necessary conditions for this property to hold on the most generic minimally coupled scalar-tensor theory, which obeys all observational constraints, the kinetic gravity braiding. Among the compatible k-essence models we identify generalized pp-waves, representing either electromagnetic or gravitational waves in the high-frequency approximation.

Teodora Matei[1,2], Cristian Croitoru[3], Tiberiu Harko[1,2]

Constraining the evolution of a Warm Inflationary Universe with Boundary

[1]Department of Physics, Babes-Bolyai University, Cluj-Napoca

[2]Astronomical Observatory Cluj-Napoca, Romanian Academy

[3]Department of Computer Science and Automation,Technical University of Cluj-Napoca

Abstract: We study the impact of Weyl-type boundary terms in the late-time evolution of a warm inflationary universe on Big Bang Nucleosynthesis. Using modified Friedmann equations, we construct three cosmological models where evolution is driven by an inflationary scalar field and another scalar field associated to the Weyl vector. Constraints on these models are derived from primordial light element abundances, both analytically and through numerical simulations using the \texttt{PRyMordial} code. In particular, the helium-4 mass fraction imposes a strict upper bound on deviations from the standard radiation energy density. A numerical implementation of the constraining methods is given in the \texttt{genesys} program, which uses a Genetic Algorithm and a Markov Chain Monte Carlo analysis to constrain the model parameters and validate consistency with observational data.

Himanshu Chaudhary

Constraining the Cosmos: MCMC Methods in Action: A Practical Guide to Constraining Cosmological Models Using SimpleMC

Department of Physics, Babes-Bolyai University, Cluj-Napoc

Abstract: Measuring the Hubble constant (H_0), which tells us how fast the Universe is expanding, is one of the biggest puzzles in cosmology today. Different methods give slightly different answers, creating a “tension” that scientists are trying to understand. In this talk, I will introduce SimpleMC, an easy-to-use tool that helps researchers analyze cosmological data and estimate key parameters like H_0.
SimpleMC combines data from various sources, including galaxy ages (Cosmic Chronometers), supernova observations (like Pantheon+ and DES Y5), and measurements from the early Universe (like the Cosmic Microwave Background). I will explain how using the local measurements of H_0 from the SHOES team affects our understanding when analyzed through SimpleMC.
I will also show how SimpleMC can test different cosmological models and handle complex data relationships to get more reliable results. This presentation will give attendees a practical overview of how SimpleMC works and how it can help address the current challenges in measuring the Universe’s expansion rate.

Plenary session 3b

Ghulam Mustafa

Compact stars

Department of Physics, Zhejiang Normal University

Abstract: In this talk, we will present a new class of solutions in GR.

Faisal Javed

Gravastar configurations with cloud of strings and quintessence

Department of Physics, Zhejiang Normal University

Abstract: Gravastars, theoretical alternatives to black holes, have captured the interest of scientists in astrophysics due to their unique properties. This paper aims to further investigate the exact solution of a novel gravastar model based on the Mazur-Mottola (2004) method within the framework of general relativity, specifically by incorporating the cloud of strings and quintessence. By analyzing the gravitational field and energy density of gravastars, valuable insights into the nature of compact objects in the universe can be gained. Understanding the stability of gravastars is also crucial for our comprehension of black holes and alternative compact objects. For this purpose, we present the Einstein field equations with the modified matter source and calculate the exact solutions for the inner and intermediate regions of gravastars. The exterior region is considered as a black hole surrounded by the cloud of strings and quintessence, and the spacetimes are matched using the Darmoise-Israel formalism. The stability of gravastars is explored through linearized radial perturbation, and the proper length, energy content, and entropy of the shell are calculated. The paper concludes with a summary of the findings and their implications in the field of astrophysics and cosmology.

Plenary session 4

Octavian Postavaru[1], Marian Craciun[2]

Mechanisms behind gamma-ray burst generation in supernova events

[1]CITI-UPB

[2]IFIN-HH

Abstract: This work investigates the connection between gamma-ray bursts (GRBs) and supernovae within a temperature-dependent vacuum model. A harmonically bound particle–antiparticle system is shown to be compatible with both Hawking radiation and the Casimir effect, supporting the use of a Maxwell–Sellmeier-type relation to link the speed of light to temperature. In this framework, Lorentz invariance is violated only at temperatures exceeding 4×10^9 K, as predicted by quantum field theory. By incorporating the proposed temperature dependence of the speed of light into a 2D simulation of a Type Ia supernova, a spatial distribution of the speed of light is obtained. A theoretical snapshot of this distribution at a fixed distance aligns with the "photon photo-finish" observed in experimental data. These results suggest that a variable speed of light may provide a natural explanation for the occurrence of gamma-ray bursts accompanying supernovae.

Tegze Tordai[1], David Hobill[2], László Á. Gergely[1,3]

Image formation in weak gravitational lensing by compact objects of Einstein–Maxwell and Einstein–Born–Infeld theory with electric charge and magnetic dipole

[1]Department of Theoretical Physics, University of Szeged, Hungary

[2]Department of Physics and Astronomy, University of Calgary

[3]Department of Theoretical Physics, HUN-REN Wigner RCP

Abstract: In Einstein–Born–Infeld theory the electromagnetic waves do not propagate on metric geodesics, but rather on geodesics of an effective metric, affecting gravitational lensing. In an axially symmetric approximate solution of the Einstein–Maxwell system, generated by an object with mass, electric charge (or tidal charge) and magnetic dipole, all contributing perturbatively, the Born–Infeld modification appears as another perturbative effect. We integrate the equations of motion of light rays in the magnetic equatorial plane, deriving the deflection angle, which corrects a result from the literature. Upon substituting the deflection angle into the exact lensing equation, we obtain a lensing polynomial. Then we numerically reproduce the lensing behaviour for the known subcases of mass and tidal charge induced lensing. Finally, we analyse the other subcases of the lensing polynomial, with focus on observable quantities: the ratio of magnifications and difference of image positions. Their different interdependences could observationally set apart lensing objects of different types.

Maria Crăciun[1], Tiberiu Harko[2]

General relativistic effects in Bose-Einstein Condensate dark matter halos, and their observational testing via the galactic rotation curves

[1]'T. Popoviciu' Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca, Romania

[2]Department of Physics, Babes-Bolyai University, Cluj-Napoca

Abstract: We consider the general relativistic effects on the Bose-Einstein Condensate dark matter halos. By considering that the condensate dark matter satisfies a polytropic equation of state with polytropic index n=1, we obtain the structure equations (the mass continuity and the Tolman-Oppenheimer-Volkoff) of the condensate, as well as the mass equation describing the dark matter distribution. The mass equation of the condensate can be solved analytically in terms of a power series. The obtained solution is tested by comparing the predictions of the theoretical results for the galactic rotation curves with a selected sample of galactic rotation curves of the SPARC database. Our results show that the relativistic Bose-Einstein Condensate dark matter model can provide a good description of the observational data.

Plenary session 5

Adrian Sabin Popescu

A "new" danger from space for life on Earth and humanity: Magnetic excursions and magnetic field reversals

Astronomical Institute of the Romanian Academy, Romania

Abstract: This presentation aims to highlight the often-overlooked yet potentially severe threat posed by geomagnetic polarity reversals and excursions, natural processes that could have profound impacts on Earth's biosphere and modern technological infrastructure. While cosmic hazards such as asteroid impacts have received considerable attention, geomagnetic disturbances deserve comparable scrutiny due to their global reach and disruptive potential.

We begin with a concise overview of geomagnetic reversals and excursions, historical occurrence rates, key past events evidenced in the geological record. The discussion will also emphasize the critical role planetary magnetic fields play in shielding Earth from harmful space weather events. We will also examine the current indicators ("smoking guns") suggesting that Earth's magnetic field may be approaching a critical transition.
We explore the consequences that follow from geomagnetic reversals or excursions, including increased radiation exposure, disruptions of the electrical infrastructure, implications for species navigation and survival, etc. These potential outcomes underscore the urgent need for proactive research and preparedness.
The final part of the presentation outlines several scientific directions that could improve our understanding and forecasting of such events. We advocate for increased investment of time, funding, and interdisciplinary collaboration to refine models of magnetic field evolution and better assess the timeline and probability of a future reversal or excursion.
By framing geomagnetic instability as both planetary and space weather issue, this presentation seeks to elevate its visibility and call for a coordinated scientific response.

Mirel Birlan[1,2], Adrian Sonka[1], Simon Anghel[1,2], Antonella Barucci[3], Cristian Omat[1], Sonia Fornasier[3], Marcello Fulchignoni[2]

Near-Earth Asteroids colors in two European projects: NEOROCKS and NEOPOPS

[1]Astronomical Institute of the Romanian Academy

[2]LTE, Observatoire de Paris, France

[3]LIRA, Observatoire de Paris-Meudon, France

Abstract: Near-Earth objects (NEOs) stand out as the most readily accessible small bodies in our Solar System, easily studied by both spacecraft and telescopes on Earth. When these objects pass close to our planet, it presents valuable opportunities to determine their physical and mineral makeup. However, they also pose a continuous threat to humanity due to the potential for impact events with Earth. Recognizing this dual nature, systematic efforts are

underway worldwide to discover, track, and precisely map the orbits of these objects, alongside initiatives to characterize their physical properties and mineral composition.
This presentation will introduce two intricate programs – NEOROCKS and NEOPOPS – which employ astrometry, simultaneous ground-based observations to gather photometric and spectroscopic data for the characterization of NEOs. The focus of the presentation will be on the colors of NEOs, particularly the class of Potentially Hazardous Asteroids (PHAs). This will cover the recently concluded NEOROCKS project and the newly NEOPOPS project funded recently by the European Space Agency.

Mihai Barbosu[1], Vlad Turcu[2], Tamas Wiandt[1], Radu Dănescu[3], Dan Moldovan[2]

Orbit Determination of Highly Eccentric Satellites Using Ground-Based Optical Observations

[1]Rochester Institute of Technology (RIT), 1 Lomb Memorial Dr, Rochester, NY, 14623 USA

[2]Romanian Academy Cluj-Napoca Branch, Astronomical Observatory Cluj-Napoca, Astronomical Institute of the Romanian Academy, Str. Ciresilor 19, Cluj-Napoca, 400487, Romania

[3]Technical University of Cluj-Napoca, Computer Science Department Str. Memorandumului 28, Cluj-Napoca, 400114, Romania

Abstract: This study addresses the specific challenges associated with determining the orbital elements for highly eccentric Earth-orbiting satellites using multiple high-precision optical observations. It proposes a comprehensive methodology that integrates initial orbit determination (IOD) via least-squares differential correction algorithms with a dynamical model accounting for central gravitational forces and perturbative effects.
The methodology is applied to ESA's RUMBA satellite (COSPAR ID: 2000-045A), part of the Cluster II mission, utilizing ground-based observations from the Romanian Academy's Astronomical Observatory Cluj-Napoca, Feleacu Station.
This approach bridges observational astronomy techniques with orbital mechanics principles, providing a framework for satellite tracking and space situational awareness applications.

Plenary session 6

T. Borkovits[1,2], S.A. Rappaport[2,3], T. Mitnyan[2], I.B. Bíró[1,2]

Study of new, TESS-discovered ultra compact hierarchical triply eclipsing triple stars

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[3]M.I.T. Kavli Institute

Abstract: We report the discovery and first comprehensive photodynamical analysis of several new, ultra compact (P_out<100 days) triply eclipsing triple star systems.

Alexandru Pop[1], Maria Crăciun[2]

On the importance of estimation of statistical significance of spectral features in amplitude spectra of astronomical time series

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[2]'T. Popoviciu' Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca, Romania

Abstract: We present the use of the recently proposed SINGLE FREQUENCY STATISTICAL SIGNIFICANCE and SINGLE RANK STATISTICAL SIGNIFICANCE (Pop, A. & Craciun, M., 2025, ExA, 59:24) in the analysis of the amplitude spectra of multiperiodic and/or quasiperiodic variability phenomena in astronomical time series. The analysis methodology is illustrated by considering the recently published HARPS radial velocity and differential line width data on the systems TOI-733 and TOI-763. The benefits of estimating the two types of statistical significances are emphasized in the frame of disentagling Keplerian and stellar activity signals.

Aurelia Pascut[1], John P. Hughes[2], Rubens Machado[3], Richards P. Albuquerque[3], Gastao. B. Lima Neto[4]

What Happens When Galaxy Clusters Collide? A Closer Look at AS0592

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Abstract: Collisions between galaxy clusters are highly energetic events that can significantly change the observed properties of the merging systems. Features such as shock fronts, cold fronts, and substantial variations in gas temperature and luminosity are commonly associated with these mergers. However, the exact relationship between these signatures and the merger configuration remains an active area of research.
In this talk, I will present results from our study of AS0592, a low-redshift (z = 0.22) binary merging cluster. Our analysis of Chandra X-ray observations reveals a hot (9.7±0.3 keV) binary system exhibiting clear indicators of a merger: a bullet-like morphology in one of the subclusters, as well as the presence of shock fronts and cold fronts.
To interpret these features and reconstruct the merger history of AS0592, we conducted a series of tailored hydrodynamical simulations. I will discuss the results of these simulations and present our proposed merger scenario that best explains the observed properties of the cluster.

Cristian Croitoru[1], Teodora Matei[2,3]

Odette: C++ program for orbit determination

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Abstract: Accurate orbit determination plays an important role in the space surveillance domain, especially as the number of launched satellites is increasing exponentially. For the case of LEO satellites which orbit more closely to Earth, the prediction of the track of the orbit has low accuracy as they are subject to various perturbations. Moreover, getting position and velocity vectors with high precision from angle measurements is a long-standing problem in astrodynamics. In this regard, we developed a C++ library that supports processing astronomical observations and TLE data to obtain LEO satellite orbits. This modular framework aims to numerically integrate perturbations and to provide functionality for real time tracking of multiple satellites through efficient algorithms.

Farruh Atamurotov

Astrophysical Processes Around Black Hole

Inha University in Tashkent

Abstract: Recent VLBI observations by the EHT, including the first images of Sgr A* and M87*, have provided important insights into black hole spin. However, other key parameters—such as charge, deviations from Kerr geometry, or effects from modified gravity—remain beyond direct observational reach. These aspects are currently explored through theoretical models and indirect observables. Our work focuses on constraining black hole parameters using shadow radius and distortion features derived from modified gravity frameworks. We also highlight the role of weak gravitational lensing as a complementary tool: its subtle deflection patterns at larger distances can offer additional constraints on spacetime geometry and deviations from general relativity. Together, these approaches pave the way for a deeper understanding of black hole physics beyond current observational limits.

Plenary session 7

Cristina Blaga, Paul Blaga

Elvira Botez - A Life Dedicated to Astronomy and History of Sciences

Department of Mathematics, Babeș-Bolyai University, Romania

Abstract: We have prepared this presentation to commemorate the life and legacy of Dr. Elvira Botez (1932–2021), who dedicated her life to astronomy and education.

Gheorghe Lucian Pascut

Numerical Methods Beyond Density Functional Theory for Predicting Molecular Properties

MANSiD Research Center

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Abstract: In this talk, I will present a brief review of the Dynamical Mean Field Theory (DMFT) combined with the Local Density Approximation (LDA), a method widely used in solid-state physics to predict the properties of strongly correlated systems. Notably, the LDA+DMFT approach has also been successfully applied to the H_2 molecule, demonstrating its ability to accurately predict both the total energy and the excitation spectrum. Thanks to its explicit treatment of local electron-electron interactions, the LDA+DMFT method shows great potential for future applications in quantum chemistry. Although it is primarily used for studying solids, this method could also be extended to model and estimate potential energy barriers in chemical reactions occurring in astronomical environments—particularly when transition metal ions are involved.

Mirel Birlan, Diana Besliu-Ionescu

The Romanian Astronomical Journal – Highlights

Astronomical Institute of the Romanian Academy

Abstract: The Romanian Astronomical Journal (RoAJ) has recently undergone significant advancements, reflecting its growing recognition in the international scientific community. Since 2022 Web of Science has listed an impact factor that is slowly rising, marking the rise in the quality and influence of published research papers. Starting with 2024, RoAJ has also been included in the UEFISCDI list of journals with relative influence score.
This progress of the journal highlights the commitment to promoting high-standard, peer-reviewed research.

Plenary session 8

Mirel Birlan[1], Ana Naghi, Sorin Marin[1], Carmen Busu, Iharka Szucs-Csillik[3], Alain Doressoundiram[4], Gustavo Rojas[5], Mimoza Hafizi[6], Francoise Roques[4]

Romanian partnership to Erasmus+ Exo4Edu project

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Abstract: Exo4Edu is the European Union ERASMUS+ project which targets secondary school teachers and their students to enhance their skills in the STEAM system and the development of other competencies.
The project will include a comprehensive set of tools containing an up-to-date database on exoplanets and scientific resources aligned with this set. Exo4Edu will develop activities and train teachers on how to use the toolkit with their students. Trained teachers will be better prepared to address STEAM subjects, leading to improved student learning. Teachers and students will be able to access and analyze current data on exoplanets. They will adopt a scientific inquiry approach using analysis tools to extract original results related to a current scientific field: the search for habitable planets.
Exo4Edu will be developed from September 2024 for 36 months. Its development will follow five working packages. The Astronomical Institute of the Romanian Academy is responsible, together with the University of Tirana, for the activities related to establishing the pedagogical framework for the good implementation of the project. The presentation will highlight the progress of the project, focusing on activities developed in Romania.

Cristian Daniel Tudoran[1], Emanuela-Maria Smădu , Tania-Flavia Ciceo[2]

Arcjet Thruster in Electrothermal Space Propulsion

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Abstract: Arcjet thrusters are a class of electrothermal propulsion systems for spacecraft that allow operation at significantly higher propellant temperatures compared to conventional plasma propulsion devices. This work presents an arcjet system designed to operate at gas temperatures between 10,000 and 20,000 K, exceeding the thermal limits typically encountered in ion or Hall thrusters. By applying a high voltage between a centrally

positioned cathode and a surrounding anode, which also acts as the nozzle, the system achieves specific impulses from 280 to 2,300 seconds and thrust levels up to 5,000 mN. Although the energy conversion efficiency is somewhat lower (30%–50%) compared to resistojet or other plasma-based thrusters, the elevated operational temperatures represent a key innovation that can enable higher performance in space missions. The main technical challenges remain electrode erosion and substantial power demands. Nevertheless, operating at higher temperatures than other plasma propulsion systems may provide new avenues for spacecraft propulsion development.

Ulpia-Elena Botezatu

Dark and Quiet Skies for Science and Society

Romanian Space Agency

UN Committee on the Peaceful Uses of Outer Space

Abstract: Many companies and space agencies are building and launching space objects in low Earth orbits (LEO). Their purpose varies from providing communications services, remote sensing services, or low-latency broadband internet access, all beneficial applications of space technology and in line with the United Nations Sustainable Development Goals (SDGs), such as bridging the digital divide. However, the rapid growth of large satellite constellations poses challenges for astronomical research from streaks of reflected sunlight for optical telescopes to increased power potentially swamping faint astronomical signals for radio telescopes. The growth in number of satellites also impacts amateur astronomers, and the general connection between humanity and the night sky, including for Indigenous communities.
Given the unique nature of this topic, no single nation or entity can drive meaningful change without the coordinated action and cooperation of governments, satellite owner-operators or manufacturers, and astronomers from around the world. The United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) is well suited to address the challenge to optical and infrared astronomy and has the appropriate mandate, technical expertise, and processes necessary to achieve results under the five-year Agenda Item.

POSTER PRESENTATIONS

The regularization of a particular four-body problem

Iharka Szücs-Csillik

Romanian Academy, Astronomical Institute, Astronomical Observatory Cluj-Napoca

Abstract: Recent investigations show that the four-star system, especially two binaries (i.e. two pairs of twin stars that revolve around each other at great distances), is more common in the universe than previously thought. By studying the orbits of stars, we can obtain information about the formation processes and evolution of multiple star systems. The orbits of stars preserve information about formation processes. Therefore, investigating analytically and numerically a particular four-body problem, we can better understand the dynamic behavior of such quadruple-star systems. A particular four-body problem, namely the symmetric collinear four-body, was investigated using the geometrical restriction method, and our goal was to find stable regions and then analyze their stability. Phase portraits were used to explore the existence and stability of periodic and quasi-periodic solutions, which contain the information necessary to characterize the dynamics of a system. The regularization in this case is required because the equations of motion show singularities. We applied the McGehee local choice regularization, which blows up the collision singularity and regularizes the equations of motion. The results appear very sensitive to initial conditions and provide a deeper understanding of dynamical behaviors, which are notable for further studies in multi-body problems.

Archaeoastronomical investigations at Gura Haitii

Iharka Szücs-Csillik

Romanian Academy, Astronomical Institute, Astronomical Observatory Cluj-Napoca

Abstract: At Gura Haitii, a megalith made of andesite features incised symbols in the form of circles of various sizes. This captivating artwork appears to imitate prehistoric motifs and rituals. Since the discovery of the engraved megalith in 1987, both scientists and enthusiasts have speculated about its meaning and design. Some researchers believe that the pictograms may have astronomical or mathematical significance, possibly related to calendar systems. Others suggest that the more intricate circles might represent an anthropomorphic figure in an abstract manner or symbolize an idol within a cosmogonical context. Some interpretations propose that the symbols could serve as markers for directions, routes, or locations. The engraved elements on the Gura Haitii megalith can be seen as a form of geometric construction, including circles, semicircles, centered points, and rotated rays. The aim of investigations from an astronomical perspective is to ascertain whether the symbols hold astronomical meaning and, if so, what they might represent. Preliminary astronomical analysis indicates that the engraved megalith is a symbolic object from the Bronze Age, likely associated with basic astronomical readings, such as calendars and cosmological views. In my view, the celestial scene depicts the position of our Sun near bright stars during the vernal equinox in Bronze Age. This alignment, rich in mystery, suggests that the equinox may hold the key to unraveling the enigmatic relationships depicted on the Gura Haitii megalith.

Terrella: A New Sundial Project at the Astronomical Observatory Cluj-Napoca

Iharka Szücs-Csillik[1], Tamás Schefler[2]

[1]Romanian Academy, Astronomical Institute, Astronomical Observatory Cluj-Napoca

[2]Babes-Bolyai University, Faculty of Mathematics and Computer Science, Department of Mathematics

Abstract: The Terrella sundial project originated as an idea for a diploma thesis at Babeș-Bolyai University, focusing on spherical coordinates in astronomy. This initiative reflects the powerful collaboration between a professor and a student. Our Terrella, designed as a spherical sundial, beautifully replicates the Earth, featuring a pole and hourly meridians marked every 15 degrees on its surface. Time telling becomes a fascinating experience with pins placed along the equator. The sun reveals its position by casting the shortest shadow from these pins, allowing us to identify the moment through the pin with the shortest shadow. If the sun is not directly above the equator during the equinox, the meridian shadow points north or south. When the sun lies between two pins, we can estimate the time by comparing the lengths of the shadows, making it a captivating exploration of timekeeping. Notably, the Tropics of the Căprioarei Valley, represented as large rock balls, provide evidence of an ancient sea. Sand, cemented by calcareous waters around a core, has been shaped over time through continuous rolling to achieve its current size. Our Terrella project passionately supports STEM education both in the classroom and beyond, inspiring an enthusiasm for astronomy and inviting all to connect with the extraordinary natural rock formations of Valea Căprioarei, near the Astronomical Observatory at Feleacu and Cluj-Napoca.

How can we effectively evaluate a reentry forecast to ensure its accuracy and reliability?

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Abstract: The predictability of artificial satellite reentries has significantly improved in recent years. A notable example occurred on May 10, 2025, at 6:40 UTC (with a margin of ± 1.5 hours): the uncontrolled reentry of the Kosmos 482 Descent Craft (1972-023E). This object dates back to 1972 and was a lander module that failed during the Soviet Venera mission to Venus. Due to a malfunction of the rocket's upper stage, it became trapped in a highly elliptical orbit around Earth instead of heading toward Venus. According to literature, the object was approximately 1 meter in size and had a semi-spherical shape, with a mass of 495 kg. It was designed to withstand the intense conditions of the Venusian atmosphere, which makes the potential risk of impact significant. Using the reentry model developed by Szücs-Csillik (2017), we analyzed the orbital evolution and behavior of Kosmos 482 leading up to its reentry and compared our predictions with other estimates. After the reentry of Kosmos 482, we assessed the existing forecasts and refined our model. With each reentry, we enhance our understanding and improve our predictive capabilities.

The magnetic topology and velocity fields of solar active region NOAA 13590

Liliana Dumitru, Cristian Adrian Dănescu, Octavian Blagoi

Astronomical Institute of Romanian Academy

Abstract: In this paper, we present a study of the solar active region NOAA 13590, observed between February 19 and March 3, 2024. Although it appeared in the ascending phase of solar cycle 25, it developed numerous solar flares, three of which were of class X. A detailed analysis was made of the X6.3 class solar flare, produced on February 22, 2024 with a maximum at 22:34 UT. Using a nonlinear force-free field (NLFFF) method, we obtained the coronal magnetic field. The data used were Spaceweather HMI Active Region Patch (SHARP) vector magnetograms from the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO), for two hours before and after the solar flare.

The new solar observatory at General Berthelot

Octavian Blagoi, Cristian Adrian Dănescu, Liliana Dumitru

Astronomical Institute of Romanian Academy

Abstract: We present the new Solar Observatory of the Astronomical Institute of the Romanian Academy, installed at an altitude of 400 meters, in a more isolated area but close to the village of General Berthelot in Hunedoara county. Due to the much better climate and the less polluted area, the solar data acquired with the new instruments of the Berthelot Solar Observatory will continue and complete the solar data catalog of the Bucharest Solar Observatory.

Study of the velocity field in solar active region, using data acquired by the Berthelot Solar Observatory

Liliana Dumitru, Diana Beşliu-Ionescu, Octavian Blagoi, Cristian Adrian Dănescu

Astronomical Institute of Romanian Academy

Abstract: We study evolution of a solar active region that appeared in the ascending phase of solar cycle 25, which produced multiple solar flares. Using the Local Correlation Tracking (LCT) algorithm, we determined the photospheric velocities to compare them before, during and after a flare. We used data acquired by the Berthelot Solar Observatory. The Berthelot Solar Observatory was built to complete the range of solar observations performed at the Astronomical Institute of the Romanian Academy in Bucharest.

How far do Earth's manifolds stretch?

Nataša Todorović

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Abstract: Every planet, including Earth, has its collection of initial conditions that enable close encounters with the planet. The assumption is that all those initial positions lie on surfaces that could be identified with the so called encounter manifolds. The shape and size of these manifolds in six-dimensional phase space are not known. In this work, we will try to locate traces of some of those manifolds that are related to Earth. The method we use is purely numerical and is based on short-term mapping of a predefined orbital plane. Preliminary results indicate that Earth's manifolds extend to the far reaches of the Solar system.

Star formation from the perspective of the X-ray binary population in Nearby Galaxies

Dana Ficuț-Vicaș

Romanian Academy, Astronomical Institute, Astronomical Observatory Cluj-Napoca

Abstract: Star formation correlates with molecular gas distribution and even with stellar mass distribution. In this study we pursue further the attempt to better understand the actual role existent stars play in star formation. We concentrate on a certain population of existing stars, the X-ray binaries and analyse the insight they provide for a complete picture of the star formation sites in Nearby Galaxies. Our study is in an incipient form, yet nonetheless is promising to shed new light upon the star formation process dynamics.

Adaptive supervised learning pipeline for maneuver detection in GEO using TLE time series

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[2]Romanian Academy Cluj-Napoca Branch, Astronomical Observatory Cluj-Napoca, Astronomical Institute of the Romanian Academy

Abstract: Routine monitoring of satellite maneuvers in the geostationary belt is essential for effective space traffic management and collision risk assessment. However, for most GEO satellites, especially those without published maneuver logs, analysts are limited to using TLE data which may contain significant noise and lack explicit maneuver indicators. Detecting genuine maneuver events under these conditions remains a challenging task.
This paper introduced an automated supervised machine learning pipeline is introduced for maneuver detection using only TLE data. The method first identifies candidate maneuver events by analyzing successive TLE entries for abnormal changes in orbital inclination (Δi). For each satellite, an optimal Δi threshold is determined via grid search on historical data to maximize detection performance (F1-score), effectively tuning sensitivity to actual maneuvers while minimizing false alarms. Using these labeled candidates, the pipeline then trains and evaluates two classification algorithms: random forest and logistic regression on stratified training sets to address the significant class imbalance and to distinguish true maneuvers from routine orbital variations.

Validation experiments conducted on multi-year TLE datasets from six operational GEO satellite yielded a mean F1-score of 98.8%. Notably, the classifier produced no false positives across any of the test satellites and only a few missed detections (false negatives) for maneuvers with Δi near the threshold, demonstrating near-perfect precision and recall. The supervised approach significantly outperformed unsupervised baseline methods (e.g., static threshold detectors) in identifying these rare maneuver events under realistic noise conditions. The results confirm that combining per-satellite threshold optimization with machine learning classification yields robust performance even when maneuver events are extremely scarce in the dataset. This fully automated method operates exclusively on public TLE information and requires no external sensor data or manual intervention. It is also highly scalable, making it feasible to monitor many satellites concurrently. This capability addresses a key challenge in SSA by enabling routine, reliable detection of GEO satellite maneuvers and thereby enhancing the monitoring of satellite behavior in the geostationary orbital environment.

Some results and experiences of the Hungarian participation in the 2022-2025 years period of "EON" satellite and space debris optical tracking project

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[1]Baja Observatory of the University of Szeged

[2]

[3]

Abstract: Baja Observatory attended to the EON (European Optical Network) project in July 2021, under support by ESA and coordination by Sybilla Technologies Spólka z.o.o. The optical sensor complex has been arrived in July 2022. The first test period was done in 2023. All parameters were confirmed as excellent ones, and since June 2024 we started the first real observing campaigne. We present some statistical data and some concrete results of this campaign period on the poster. Our equipment is coded as PAN-8 within the EON system. EON system consists of 12 stations all around the World. In an typical entirely clear night PAN-8 produced ab. 10k individual exposures, partially clear nights of course less. The original indicator was an obligatory 500 hours "net" observing time - Baja Observatory fulfilled 50% more (750 hours) until May 2025. The observations are completely remote-controlled, using some excellent softwares, like the scheduler (WebPlan), and the complete observatory control (ABOT), as well as the calibrating and measuring data pipeline, all of them are made by Sybilla Technologies, supported by important local subsystems, like an allsky camera and a webcam. The first project period will be ended this year, but at the present time a new extension of it is already started, using a more innovative sensor complex, making available simultaneous multicolour photometry of the tracked space object.

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