XXV Gamow International Astronomical Conference

"ASTRONOMY AND BEYOND: ASTROPHYSICS, COSMOLOGY AND GRAVITATION, ASTROPARTICLE PHYSICS, RADIO ASTRONOMY, ASTROBIOLOGY AND GENETICS"

(August 18-22, 2025, Odesa, Ukraine)

MEMORIAL SESSIONS

THE CONTRIBUTIONS OF EDWIN HUBBLE TO THE XX CENTURY REVOLUTIONS IN ASTROPHYSICS AND COSMOLOGY

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The body of scientific knowledge grows slowly through the repeated actions of researchers in anonymous laboratories, but it is those who dare to look beyond that changes its direction. This was the case with the discovery of the nature of spiral nebulae. Ever since William Herschel raised the question in 1789, astronomers had wondered whether some nebulae could be islands of matter in the universe, comparable in nature and rank to the Milky Way. However, no one had been able to find a convincing answer either way, partly due to some misinterpreted observations that had clouded the issue. This uncertainty, arising from an inability to accurately measure the distances of the nebulae, led to the formation of two opposing camps that clashed in the so-called Great Debate of 1920 (which organizer George Hale saw as a means of securing funding for his new 100-inch telescope). While the verbal clash between the representatives of the two camps ended in a draw, it was in fact the champion of the 'deniers', Harlow Shapley, who provided the tool that marked the victory of the 'island universe' partisans. In previous years, Shapley had calibrated Cepheid, the properties of which had been discovered by Henrietta Leavitt in 1912. He used these variable stars to make the epoch-making discovery of the Sun's peripheral location in the Milky Way. However, it was a young colleague who had recently returned from the First World War to work at Mount Wilson who exploited them, discovering that the Andromeda galaxy (M31) and a few other spirals appeared to be significantly further away than the outer limits of the Milky Way set by Shapley. Edwin Hubble was far from certain about his findings; yet he was compelled to present them at a meeting of the American Astronomical Society in Washington, D.C. on 1 January 1925. His doubts were such that he decided to remain in California and entrust the reading of his paper to Henry Norris Russell. He was particularly intimidated by Adriaan van Maanen's study, which seemed to indicate an astrometric rotation of the spirals on the plane of the sky; if true, Hubble's distances would imply speeds greater than that of light. It took Hubble 10 years to calm down. Nevertheless, after the standing ovation in Washington, most astronomers considered his work to be proof of the extragalactic nature of nebulae. This is why 1925 is considered the birth year of both extragalactic astronomy. A conventional birthday that is nevertheless important to promote, especially in the imagination of young people, a spirit of emulation. A few years later, Hubble would claim another epoch-making discovery, the expansion of the universe. But in this case too, as in that of the discovery of galaxies, he would have to rely heavily on the shoulders of giants to see further.

FROM GAMOW'S PREDICTION OF CMB UP TO NOW AND BEYOND (TO THE 60th ANNIVERSARY OF DISCOVERY)

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Analysis of the physical conditions during the period of cosmological nucleosynthesis led George Gamow and his students in 1948 to predict the cosmic microwave background, unexpectedly discovered by Arno Penzias and Robert Wilson in 1965, sixteen years ago. In addition to being a key confirmation of the non-stationary model of the Universe – the Big Bang theory – it also laid the foundation for physical cosmology and the physics of the early Universe. Since then, several dozen advanced experiments have been conducted to measure its temperature, polarization, and anisotropy, and tens of thousands of articles have been written in different

languages of the world. Cosmic microwave background has become a cornerstone of the scientific picture of the world, and has made it possible to establish the values of the main parameters of cosmological models of the Universe. Little-known pages of history, landmark discoveries, and expectations from future experiments will be discussed in the report.

ODESSA PERIOD OF LIFE OF THE OUTSTANDING ASTRONOMER A. YA. ORLOV: RESEARCHER, MANAGER, TEACHER

I.E.Rikun
Odesa House of Scientists

Aleksandr Yakovlevich Orlov (6 April 1880, Smolensk – 28 January 1954, Kyiv) came to Odessa in the fall of 1912. He was appointed extraordinary professor of the Department of Astronomy and Geodesy at the Novorossiysk (Odessa) University and director of the university observatory. Orlov had to make great efforts to reorganize the work of the observatory. He managed to allocate funds for the construction of new buildings and expansion of the staff, and created an exemplary library at the observatory. The scientist involved the talented mechanic Y. A. Tymchenko in cleaning and restoring the instruments. Orlov taught a number of astronomical courses at the university and at the Higher Women's Courses, in 1915 he defended his doctoral dissertation at Petrograd University, in 1916 and 1917 he carried out gravimetric expeditions to Altai, and all this intense and fruitful scientific, pedagogical and organizational activity took place in far from calm times. But, despite this, Orlov managed to educate a wonderful galaxy of astronomers. N. V. Tsimmerman (1912), D. V. Pyaskovskii (1916), I. I. Vitkovskyi (1916), V. S. Zhardetskyi (1917), and N. M. Stoyko-Radylenko (1918) were left at the university to train for the title of professor at the Department of Astronomy and Geodesy. The fates of Orlov's students, who scattered around the world, are different; what unites them is that they remained faithful to the astronomical path chosen under the influence of their teacher throughout their lives.

Stoyko-Radylenko worked at the International Time Bureau in Paris (1924–1944), and was its director for twenty years (1944–1964). Zhardetskyi was a freelance researcher at the Lamont Geological Observatory of Columbia University in New York, and since 1951 also a professor of mechanics in the Mechanical Engineering College of that university. Vitkovskyi headed the Astronomical Observatory of the University of Poznań and created a latitude station in the town of Borovets. Pyaskovskii headed the astrometric department of the Astronomical Observatory of Kyiv University. Tsimmerman worked at the Pulkovo Observatory, led the work on creating a catalog of geodetic stars. The youngest Odessa student of Orlov was Z. N. Aksentieva, she devoted almost her entire life to the Poltava Gravimetric Observatory.

Scientific Odesa does not forget the outstanding scientist: the 3rd Orlov Conference was held here (September 7–12, 1992), a memorial plaque to him was installed on the main building of the Odessa National University named after I. I. Mechnikov, and in March 2025 a street was named in honor of A. Ya. Orlov.

THE ROLE OF GEORGII ANTONOVICH GAMOW GUIDING ENRICO FERMI IN REVEALING THE PHYSICS OF THE VERY EARLY UNIVERSE, TODAY FURTHER VERIFIED BY THE "RED-DOTS" OBSERVED BY THE JAMES WEBB TELESCOPE

Remo Ruffini
Director of ICRANet, Italy

Born in Odesa, George Gamow significantly advanced the field of cosmology, pioneered by Alexander Friedmann in Saint Petersburg. While invited to the Solvay conference in Denmark, he famously managed to fool Vyacheslav Molotov, then a high-ranking Soviet official, into granting him and his future wife two passports, allegedly so they could visit the Folies Bergère.

He revolutionized nuclear physics and, together with Enrico Fermi, jointly introduced the cosmological model of the 'Hot Universe', thereby superseding the 'Cold Universe' model developed in Russia by Yakov Zeldovich. Beyond this, he also made fundamental contributions to the understanding of DNA, thus addressing crucial issues across Physics, Astrophysics, and Biology.

Gamow was truly one of the greatest scientists born in Odesa, whose profound work benefited the entire planet.

25 YEARS OF ANNUAL GAMOW CONFERENCES AND "GAMOW" SCIENTIFIC ODESSA STYLE

M.I.Ryabov
SOC and LOC Gamow Conference

25 years ago the annual International Gamov Conferences began to be held in Odessa.

Gamow made an important and decisive contribution to modern physics, cosmology and biology. His three most significant contributions to these fields are: 1) He discovered the quantum nature of alpha-decay in nuclear physics (1928). 2) He proposed the theory of the Hot Universe (1946-1953). 3) He found the clue to the genetic code in biology (1954). George Gamow was born in Odessa on March 4th 1904. Here he graduated the secondary school and studied for two years in the Odessa (Novorossiisk) University of Odessa (from 1921 to 1922). During his studies in University Gamow worked as an evaluator in astronomical observatory. In his book "My World Line" Gamow outlined his path in science, starting from Odessa.

Gamow created a special and unique "Odessa style" in science. It was based on improvisation and Odessa humor. It can be said that humor was for him among the fundamental physical constants as the basis of everything. Gamow, like no other outstanding physicist of the 20th century, was able to organize intellectual "brainstorming" on the most pressing problems from the energy sources of stars to the theory of the hot Universe and deciphering the genetic code. For the latter problem, he even organized a club of physicists and biologists! Gamow believed that when solving the most complex problems, it is necessary to improvise ideas in an informal setting. Science does not tolerate boring conversations, the solution of problems takes place in a stormy emotional discussion.

The Odessa family tradition of Gamow was the assignment of short names which accompanied them later all their lives. So during his studies at Leningrad University his team of musketeers (jazz band) included Lev Landau (Dau), Lev Bronstein (Abbot) and Dmitry Ivanenko (Dimus). Gamow himself acquired the name Johnny. Another "Gamow principle" was the idea of "non-accidental coincidences of circumstances." So together with Landau, they signed a joint work for publication on fundamental physical constants by climbing one of the peaks in the Alps.

It can be said that the "principle of non-random coincidences" also worked in the case of the Gamow conferences in Odessa. The idea of holding them appeared in 1994 in the year of Gamow's 90th birthday. By the same time, a translation of Gamow's autobiographical book "MY WORLD LINE" published in New York was prepared. It was printed in Odessa and presented to the participants of the First Gamow Conference. Gamow's biographer, Professor A.D. Chernin, took part in the organization of the First Gamow Conference. There were many other moments. All these circumstances coincided within one year.

The Second Gamow Conference was held in Odessa five years later in 1999. It was attended by Gamov's son, Professor of the University of Colorado Igor Rustem Gamov.

Due to the great interest in it, it was decided to hold annual Gamow conferences in 2000. These conferences have been going on continuously for 25 years!

A certain standard of the Gamow conferences was: up to 200 participants, over 20 plenary and memorial reports, more than 100 sectional reports in 7 scientific sections.

Covid epidemics, political upheavals and the war in Ukraine did not stop the Gamow Conferences. Only now we have to conduct them online.

The organizers of the Gamow conferences for all years was the Odessa National University named after I.I. Mechnikov (Department of Astronomy and the Research Institute "Astronomical Observatory") which celebrates its 160th anniversary this year (Rector of the University, Professor V.I. Truba).

Among the organizers of the Gamow conferences all these years were the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine and the Odessa Astronomical Society. Gamow conferences are invariably held with the support of the Ukrainian Astronomical Association (President Academician of the National Academy of Sciences of Ukraine Y.S. Yatskiv). To a large extent, the result of the Gamow conferences in Odessa was the assignment of his name to one of the squares in Odessa, the installation of a memorial plaque on the wall of the main building of the university and the establishment of the Gamow University Medal.

Of course, such a long and fruitful work of the Gamow conferences, through which more than one generation of young scientists passed, would not have been possible without the work of the scientific and local organizing committee. (The Co-Chairs of the Scientific Organizing Committee (SOC) of GMIC-25 are Professor A.I.Zhuk (Ukraine) and Professor Massimo Cappaciolli (Italy), Vice-Chairman of SOC, Dr. M.I.Ryabov (Ukraine).

Information about Gamow and all materials of the Odessa Gamow Conferences are available on the website of the Scientific Library of the I.I. Mechnikov ONU: *https://lib.onu.edu.ua/gamov-g-a/*

PLENARY SPEAKERS

VARIANLE STARS: THE DIVERSITY, CLASSIFICATION AND STATISTICALLY OPTIMAL PHENOMENOLOGICAL MATHEMATICAL MODELLING

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The stars are called "variable", if at least one of it's characteristic (typically, brightness) vary with time at an amplitude, which is statistically significant for a level appropriate for an accuracy of the measurements during the observations.

This definition suggests that all stars are variable during their evolution, but may be practically stable for much shorter time scales. The mechanisms of variability show a wide diversity of observational appearance, i.e. "types" of variability. There are ~70 main types of variability, many stars show few of them, so there are 200+ "mixed" classes.

Phenomenological mathematical modelling is the most popular type of the data analysis, as the stars are mainly discovered photometrically, and only for most interesting ones, the spectral observations are carried out. For example, hundreds thousands eclipsing variables have been discovered photometrically, and only 324 had physical modelling and are currently listed in (caleb.eastern.edu). An example of a phenomenological parameter is a visual magnitude, which is dependent on two physical parameters - absolute magnitude and distance (or parallax). Similarly, the phases of the inner and outer contacts (phenomenological) are dependent on radii of both stars and an orbital inclination, etc. So This is some kind of mathematical decrease of the dimension of the parameter space.

For the statistically optimal mathematical modelling of different types of variability, we have developed an expert system consisting of dozens of algorithms and computer programs (ADS code: 1994OAP.....7...49A, 2003ASPC..292..391A, 2020kdbd.book..191A). Particularly important are determinations of ToMs = Times of Maxima/Minimuma (2005ASPC..335...37A, 2020JPhSt..24.1902A). Our software also includes periodogram analysis, wavelet analysis, auto-correlation analysis, principal component analysis. These algorithms work for the signals with (generally) irregular arguments with/without trends. Obviously, these methods may be applied not only to variable stars and exoplanets, but also to asteroids, AGN and signals of any nature. More links are at uavso.org.ua/mavka.

These programs have been applied to 2500+ stars within the scientific direction "Astroinformatics" (2017IAUS..325..361V) and "Inter-Longitude Astronomy" Campaign (2017ASPC..511...43A) and continues the scientific school researches of stellar variablility founded by V.P.Tsesevich (1907-1983) (2017OAP....30..252A).

The most recent papers of this summer are 2025MNRAS.541.1064B and 2025KFNT...41d..20M.

NUCLEAR STAR CLUSTER FORMATION BY THE FIRST GENERATION GLOBULAR CLUSTERS DISRUPTION

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The Nuclear Star Cluster (NSC) is situated at the center of the Milky Way galaxy, which is an extremely dense star system. Several mechanisms have been proposed for the formation of NSCs, with two main ones being prominent: (i) the migration of gas to the galaxy's center, followed by the formation of NSC stars from this accreted gas, and (ii) the migration of globular clusters (GCs) to the galaxy's center, leading to their subsequent destruction/merger into a common NSC.

We will present the processes involved in the complete decay of GCs during their interaction with the NSC of our galaxy based on the second idea. We have generated "theoretical" GCs in a time-varying Milky Way-like potential, as they likely formed 10 billion years ago. For this task, we selected several time-evolving Milky Way-like potentials (TNG-TVP) from the Illustris TNG-100 cosmological simulation. We randomly generated initial positions for GCs in the total angular momentum energy phase space, considering various parameters: semi-major axis, eccentricity, apocenter, and pericenter for their orbits.

In the end, we generated 50 "theoretical" models with favorable orbital parameters for accretion. Each GC model has the same mass and King concentration parameter but three different half-mass radii: 1, 2, and 4 parsecs. For the GC N-body simulations, we used a high-order parallel dynamical N-body code, phi-GPU, based on the fourth-order Hermite integration scheme with hierarchical single-block time steps and state-of-the-art stellar evolution code. In total, we integrated these 150 GC orbits for up to 5 billion years. As a result, we will present the total mass and stellar number accretion to the NSC from our GC models. We will also analyze the parameters of the cluster orbits where the accretion of stars from clusters is more preferable.

BEYOND THE STANDARD MODEL: DARK ENERGY AND MODIFIED GRAVITY THEORIES

Mariam Bouhmadi-López
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We are currently living through a remarkable era in cosmology and gravitational physics, marked by an unprecedented influx of observational data. One of the most compelling challenges facing cosmologists today is understanding the mysterious cause behind the Universe's

recent accelerated expansion. The leading explanations for this phenomenon invoke either a dark energy component or modifications to general relativity. In this talk, we will present a range of dark energy models, including axion-like scalar fields and 3-form fields. We will also explore modified theories of gravity, with a particular focus on *f(Q)* gravity, as viable alternatives to explain late-time cosmic acceleration. Additionally, we will discuss the observational constraints on these scenarios and examine their potential to shed light on the ongoing H_0 and S_8 tensions.

INVESTIGATIONS OF GALAXY ALIGNMENT – SIGNIFICANCE AND RESULTS

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One of the most crucial problems of modern extragalactic astronomy and cosmology is problem to explain the structure formation. We have many different models which can be taken into consideration for explaining various aspects of the galaxy formation process on different scales and for various observational features of structures as well. Correct models of the large-scale structure formation must explain various observational characteristics of these structures. The final test of a given scenario is to compare its predictions with observations. Important aspect of this problem is the fact that different model of galaxies and their structures formation make provide in particular various predictions concerning orientation of galaxies in structures, distribution of their angular momenta, collinearity of the brightest galaxy and structure's major axis. It is the reason that the observed variations in angular momentum represent simple but fundamental constraints for any model of galaxy formation. In this talk we present idea and result of such investigations, and particularly we discuss the two main methods of the investigation of the galaxy alignment. They are the analysis of the distribution of position angles of the galaxy major axes and of two angles describing the spatial orientation of galaxy plane. The new version of the method enables analysis not only of alignment of individual galaxies but also of alignment in the structures as the whole. Moreover, it also allows analysis in the case of the absence of information on their morphological types. We compare results of such investigations with predictions of different models and discuss it in the context of their implications for the theory of galaxy formation.

A POSSIBLE ROLE OF PRIMORDIAL BLACK HOLES IN THE EARLY UNIVERSE?

Günther Hasinger
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The cosmic X-ray background radiation has been almost completely resolved into discrete objects, mainly from the growth of massive black holes in the universe. However, a few years ago, evidence for a new population of black holes from the early universe emerged from the correlation of fluctuations in the X-ray and infrared backgrounds. Similarly, quasars have been discovered with astonishingly massive black holes already formed shortly after the Big Bang. The detection of gravitational waves from the merger of pairs of very heavy, apparently non-rotating stellar black holes presents another puzzle. Recently, using the micro-lensing effect and distance determination with the ESA satellite GAIA, about 20 black holes in our galaxy have been discovered with masses that cannot be generated by stellar processes. In the past few months, the discovery of several galaxies that formed very early in the universe with the James Webb Space Telescope has been surprising, seeming to contradict the classical expectations of cosmology. These phenomena might be explained by a contribution of primordial black holes that formed immediately after the Big Bang to the dark matter.

SINGULARITIES AND THEIR CROSSING IN GRAVITY AND COSMOLOGY

Alexander Kamenshchik
University of Bologna and Section of INFN Bologna, Italy

We discuss the problem of singularity crossing in isotropic and anisotropic universes. We study at which conditions singularities can disappear in quantum cosmology and how quantum particles behave in the vicinity of singularities. Some attempts to develop general approach to the connection between the field reparametrization and the elimination of singularities is presented as well.

FROM A QUANTUM WORLD TO OUR CLASSICAL UNIVERSE

Claus Kiefer
University of Cologne

Modern cosmological theories invoke the idea that all structure in the Universe originates from quantum fluctuations.

Understanding the quantum-to-classical transition for these fluctuations is of central importance not only for the foundations of quantum theory, but also for observational astronomy. In my talk, I shall review the essential features of this transition, with particular emphasis on conceptual issues.

Reference: arXiv:2503.18499 [gr-qc] and references therein.

GEOSPACE AND SPACE WEATHER: A VIEW FROM UKRAINE, ANTARCTIC AND ARCTIC

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Space weather refers to the variable conditions in the near-Earth space environment, which are driven by solar

activity. The Solar-Earth connection, mediated by the solar wind and solar flares, dictates the state of our planet\'s magnetosphere and upper atmosphere. Our increasing reliance on technological infrastructure makes society highly vulnerable to the adverse effects of space weather, such as geomagnetic storms and radio blackouts. Monitoring space weather is crucial for mitigating economic and safety risks; however, modern theoretical models struggle to predict events due to the complex dynamics and multiscale interactions between the Sun and Earth.

The polar regions (Antarctic and Arctic) are ideal for space weather studies. Due to configuration of Earth's magnetic field, which funnels solar particles directly into the high-latitude atmosphere, the Arctic and Antarctic serve as primary windows into solar–magnetosphere–ionosphere interactions. Ground-based observatories and magnetometers in these regions provide critical data.

In 1996, Ukraine gained access to one of the most advanced Antarctic observatories for studying cosmic and terrestrial weather systems – the Faraday-Vernadsky Station – and a unique suite of diagnostic instruments. Over nearly 30 years of operation, the station has been fully upgraded, with modernized and expanded equipment, accumulating a unique dataset spanning more than two solar cycles. The station's remote sensing systems allow continuous monitoring of the gas-plasma characteristics of the atmosphere – from the surface and troposphere to the ionosphere and magnetosphere – enabling the study of processes throughout the entire geospace. Using the data obtained at Vernadsky station it was shown that the space weather over the Antarctic Peninsula highly depends on the processes in the lower atmosphere.

Since 2013, Ukrainian diagnostic systems, similar to those used in Antarctica, have been operating in the Arctic on Svalbard Island. This presentation discusses key results obtained from Ukrainian polar observatories, including studies of geospace and the response of space weather to disturbances in the neutral atmosphere.

MULTICOMPONENT MODELING OF NEBULAR ENVIRONMENTS SURROUNDING ACTIVE STAR-FORMING REGIONS

Bohdan Melekh
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Dwarf galaxies (DGs) are critically important for modern astrophysics due to their decisive role in the epoch of reionization, the determination of primordial helium, and chemodynamical processes in the Universe. Active star-forming regions in these objects are surrounded by nebular environments that can be divided into two main parts: the internal super-wind region (SWR) and the outer, hydrodynamically undisturbed photoionized zone. The nebular environment affects the shape of the stellar spectral energy distribution (SED). Consequently, the SED of the radiation entering the intergalactic medium differs from the stellar one.

Frequently, when investigating the chemical composition of these galaxies, researchers use grids of photoionization models that do not account for the presence and evolution of the SWR. This approach is incorrect, because SWR components modify the stellar SED and, correspondingly, the ionization structure of the outer photoionized region, where most diagnostic emission lines are formed.

We propose two approaches to multicomponent photoionization modeling of the nebular environments in DGs, using different methods for describing SWR evolution. The first is based on the semi-analytical theories of Castor, McCray & Weaver (1975–1977) and Chevalier & Clegg (1985). The equations of these theories are represented in an auto-similar form, and I will describe their application for modeling the first DGs in the epoch of reionization.

The second approach is based on the photoionization analysis of chemodynamical evolution models of DGs. It will be demonstrated how this method is used by the Lviv Nebular Team (LNT) for detailed investigations of the ionization structure of nearby DGs. LNT has also developed a method for detailed calculating diffuse ionizing radiation (DCDIR) in nebular environments and implemented it into multicomponent photoionization modeling based on the second approach. The necessity of including DCDIR for accurate modeling of DGs is demonstrated.

A PERSPECTIVE ON ECLIPSING BINARY STAR STUDIES IN THE POST-GAIA ERA

E. F. Milone
University of Calgary

Eclipsing binary stars provide a journey through discovery and innovation. They have intrigued astronomers for centuries. One of the earliest significant insights came in 1783 when 18-year old John Goodricke boldly proposed that the periodic dimming of the star Algol, which he and his friend Edward Pigott had carefully studied, was due to an eclipse by a dark companion. The communication so impressed the Royal Society of London that Goodricke was awarded the prestigious Copley medal that same year.

By the early 20th century, the fundamental gravitational physics had matured sufficiently to enable Henry Norris Russell and Harlow Shapley to develop quantitative procedures for finding the properties of stars in eclipsing systems.

Over the following decades, deeper understanding of the physics governing systems of interacting binary stars led to more sophisticated treatments. Zdenêc Kopal and other researchers expanded the analytical framework and thereby ushered in more rigorous studies of the internal and orbital dynamics of these systems.

The advent of high-speed computing in the 1970s revolutionized the field by enabling simulations of increasing complexity. Continued computational and analytical improvements, coupled with the explosive growth in observational data from wide-field surveys culminating in the Gaia mission, are propelling eclipsing binary research into a

new era. We have both the computational power and the observational depth to probe stellar structure and evolution with unprecedented precision.

This presentation will highlight key milestones in the study of eclipsing binaries, innovative capabilities in data acquisition and modeling, and the promising role of high-precision infrared photometry. Particular attention will be paid to the enhanced precision attainable through the use of improved passbands for ground-based infrared photometry at local observatories, and to the extended functionalities of the Wilson-Devinney modeling framework, and complementary analytical tools and programs.

SEARCH FOR EXOPLANETS: TOWARDS EARTH ANALOGOUS AND BIOSIGNATURES

Giampaolo Piotto
Director CISAS, Centro di Ateneo di Studi e Attivita' Spaziali "Giuseppe Colombo", University of Padova

After more than 30 years since the announcement of the discovery of 51 Pegb, we know more than 5000 exoplanets. The main lesson we learned so far is that exoplanets are extremely diverse from each other, and from the Solar System objects. Among discovered planets there also are “terrestrial” planets, some orbiting in the so called habitable zone. We are getting close to the identification of Earth analogous. Instruments, ground based and in space, have been developed for the study of their atmospheres, with concrete perspectives of finding biosignatures, as George Gamow was dreming in some of his popular science books. In this talk I will brefly summarize the status of exoplanet search, and the fantastic developments we expect for next 10 years.

PUSHING THE OBSERVATIONAL NICHES: NEW TOOLS FOR NEW FRONTIERS

Roberto Ragozzoni
President of INAF, Italy

In at least two of the emerging astrophysical topics, namely exoplanets and structure of the Universe on large scales, there is mounting evidence that previous forecasts failed to date. New kinds of exoplanetary systems that we were sure could not possibly exist, are now routinely observable and in spite of various speculations still no direct evidence of dark matter or dark energy depicting the geometry of the Universe on a large scale has been found so far. This means that we have little idea of what can be discovered expanding our observational capabilities and that ideally any push in one space in the multiparameter region of astronomical observable is likely to be a carrier of new information. This is a sort of new situation in contrast with an era in which observations were carried out to prove this or that prediction. How is this transforming the way we are conceiving new telescopes from ground and space? I will try to depict some possible answers without pretending to be exhaustive.

ULTRAVIOLET PHOTOMETRY AND REDDENING ESTIMATION OF 105 GALACTIC OPEN CLUSTERS

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This research focuses on observing unstudied Galactic open clusters in the Ultraviolet (UV) wavelength range and analyzing their photometric data. The Gaia Data Release 3 (DR3) enables us to precisely study known Galactic open clusters. We conducted observations using the 1.54-meter Danish Telescope (DK1.54) in Chile and the 2.15-meter telescope at the Complejo Astronómico El Leoncito (CASLEO) in Argentina, employing UV filters. Furthermore, we have collected available photometric and astrometric data for our observed clusters. We aim to estimate the reddening of Galactic open clusters using UV photometry. We applied isochrone fitting to determine the reddening of the clusters using well-known members. As a final result, we present the reddening values of 105 Galactic open clusters in the UV, as determined by our photometry.

JWST WEIGHS IN ON THE HUBBLE TENSION

Adam Riess
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The title fully reflects the content of the report.

TENSIONS IN COSMOLOGY: ARE WE APPROACHING NEW PHYSICS?

Emmanuel N. Saridakis
Research director National Observatory of Athens, Greece

We summarize the famous tensions between various observational datasets and theoretical predictions of the Standard Model of Cosmology, such as the H0 and S8 tensions, that could be a sign that we are approaching New Physics. Then we provide possible solutions, arising from modifications /extensions of the standard lore, focusing on (late-time) modified gravity solutions. Finally, we show how Gravitational-Wave and multi-messenger astronomy can be crucial in distinguishing various classes of gravitational theories.

THE BEST TIME INTERVAL IN THE SOLAR CYCLE FOR A FUTURE MANNED TRIP TO MARS, REGARDING THE RADIATION SAFETY

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Potential health effects to astronauts induced by space radiation is one of the most important risks for future manned missions to Mars which require a return-trip duration of about 3 years with current propulsion technology. Presented are the results for the radiation parameters of the galactic and solar cosmic rays in the interplanetary space and in Mars orbit obtained during different phases of solar cycles 24 and 25 in the period April 2016 - July 2025 aboard the ESA Trace Gas Orbiter. These results are important about the selection of the best time interval in the solar cycle for a manned trip to Mars. They confirm and specify previous studies that the expected dose for a Mars mission launched during the solar maximum is significantly less than the dose for a mission taken during other phases of the solar cycle. But a trip during the solar maximum is accompanied with a potential risk of significant, unpredictable dose contributions by sporadic solar particle events (SEP). A real time warning of SEP events and a radiation shelter aboard the spacecraft may reduce the radiation risk to the crew during the transit to the planet and back. The most effective countermeasure for the radiation risk would be reducing the transit time using new technological developments. The obtained results may be used for verification and benchmarking of the cosmic rays models in the free space and in Mars orbit.

RECENT ADVANCES IN SOLAR PHYSICS

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The aim of this talk is to review recent advances in solar physics driven by ground-based telescopes. We focus on the largest solar telescopes, which offer the highest spatial, spectral, and temporal resolutions, as well as exceptional polarimetric sensitivity achievable from the ground. These include the 4-meter Daniel K. Inouye Solar Telescope (DKIST), the 4-meter European Solar Telescope (EST), the 1.5-meter GREGOR Solar Telescope, and the 1-meter Swedish Solar Telescope (SST). We pay partial attention to the current state of coronal magnetometry, which relies on coronagraphic observations of forbidden optical and near-infrared emission lines from highly ionized atoms.

In addition, we present advancements in suborbital ultraviolet (UV) experiments designed to probe the upper chromosphere and transition region.

We also provide a brief overview of future coronal spectropolarimetry based on space-based observations of permitted extreme ultraviolet (EUV) lines.

Finally, we review the future prospects for solar research in Ukraine.

INVESTIGATING SUPERNOVA REMNANTS AT LOW FREQUENCIES

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Supernova remnants are among the most prominent sources of non-thermal radiation in the Galaxy. Observing them is crucial for several reasons. Together with their progenitor supernovae, they play a key role in stellar evolution − marking the explosive death of massive stars, redistributing the atomic elements formed within them, and triggering the birth of new stars through interactions with molecular clouds. The shock waves generated by supernova explosions profoundly influence the dynamics and evolution of the interstellar medium and contribute significantly to shaping its long-term structure.

Supernova remnants are typically powerful non-thermal emitters across a wide range of radio frequencies. Accurate radio spectra of these remnants can be used to trace their interactions with the interstellar medium and to test predictions about their temporal evolution. Historically, radio observations at low frequencies ($\nu < 80$ MHz) were constrained by poorer angular resolution and sensitivity − often an order of magnitude worse than those at higher (GHz) frequencies − largely due to technical limitations.

However, this situation has significantly improved with advances in low-frequency radio astronomy, enabled by the development of modern radio telescopes. These improvements have made it possible to study thermal absorption in and around supernova remnants, which is uniquely detectable at low frequencies. This phenomenon arises both internally, indicating the presence of thermal

material within the remnant, and externally through interactions with the surrounding medium.

Initially, intrinsic thermal absorption was observed only in the brightest remnants − such as the Crab Nebula, Cas A, and SN 1572 − due to limited observational capabilities. External thermal absorption serves as a tracer of the ionized interfaces formed by the remnant's interaction with its environment. Additionally, the distribution of ionized gas in the broader interstellar medium, unrelated to supernova remnants, can be inferred through radio emission from these remnants, which function as background sources.

Thus, low-frequency radio observations provide a promising avenue for detecting and investigating these processes. The radio telescopes GURT, URAN-2, NenuFAR, MWA, and LOFAR have ushered in a new era in the study of supernova remnants. Their observations enable the measurement of radio emission spectra from these remnants with unprecedented accuracy and sensitivity. These spectra are influenced by the properties of absorbing regions within the remnants and reveal temporal changes in absorption parameters, indicating interactions between the remnants and their immediate environment. The latest advancements in this field are presented in this report.

The authors sincerely express their gratitude to the National Research Foundation of Ukraine for financial and organizational support under the call “Excellent Science in Ukraine” (2024–2026), Grant No. 2023.03/0007.

PROBING THE SOLAR CORONA WITH LOW-FREQUENCY PULSE RADIO EMISSION OF GALACTIC SOURCES

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The study of coronal solar plasma is one of the central topics of modern astrophysics and radio astronomy. In addition to the new knowledge obtained, the study solar corona will be used to forecast space weather. Forecasting solar-terrestrial connections are of great interest for technological activities on Earth and in space. It is known that the slow and fast components of the solar wind, which consists mainly of electrons and protons, are organized into a sectoral structure, in which the electron density falls at a large distance from the Sun inversely proportional to the square of the distance. However, such a simple dependence is not applicable in the near and transit corona of the Sun. Therefore, Baumbach-Allen, Newkirk, Mann and other distributions are used here to model the electron density in the Sun corona.

These models describe satisfactorily the distribution of electrons in relatively small distances from the solar disk, but all of them, as a rule, are applicable only to conditions quiet Sun. At the same time, the solar wind is not a homogeneous structure. It contains shock waves, coronal mass ejections, and its complex plasma structure is penetrated by magnetic fields. The solar corona is very difficult to study. For such studies, in addition to special space missions (Wind, Stereo, Parker Solar Probe, Solar Orbiter), we propose to use eclipses of point broadband pulsed radio sources with a high degree of linear polarization of their radio emission. This will provide additional opportunities for obtaining information about the spatial distribution of electrons and the magnetic field in the solar corona. The corresponding radio sources include decameter storms of Jupiter and pulsar pulses. Observing these sources through the solar corona allows us to estimate, in addition to the usual Stokes parameters, two additional integral parameters of the plasma along the line of sight. One of them is the dispersion measure (DM), which is measured by the frequency delay that occurs due to the propagation of pulses in the plasma (this parameter cannot be estimated by studying continuum radiation). The other integral parameter is rotation measure (RM),

which is estimated as the rotation rate of the linear plane of polarization (Faraday effect). Although the rotation measure can be estimated for continuous radiation sources, we can obtain an estimate of the average intensity of the component magnetic field parallel to the line of sight only by combining RM and DM.

We carry out broadband polarized observations of pulsars that are located relatively close to the Earth, at different elongations from the Sun. In the spring and summer of 2025, we carry out observations of the eclipse of Jupiter by the Sun in different phases. The expected original results of these observations are: (i) the dependence of the values of DM and RM pulsar impulses on the angular distance to the Sun, (ii) the dynamic dependence of RM radio bursts from Jupiter from solar elongation up to the moment when Jupiter is visible through the solar corona and then eclipsed by it, and for a magnetic field of 10-20 Gs in the plasma crossed by radio waves (such magnetic fields exist in solar (coronal loops), it should be possible to measure the frequency dependence of DM and RM. These dependence should arise due to the significant difference in the refractive indices for ordinary and extraordinary waves in a strong magnetic field.

All observations are carried out using Ukrainian radio telescopes: URAN-2 (8-32 MHz) and GURT (8-70 MHz), the French radio telescope NenuFAR (10-85 MHz), six German LOFAR stations and one of the Latvian LOFAR station (LBA and HBA, 10-250 MHz).

PHANTOM DYNAMIC DARK ENERGY: TOWARDS A SOLUTION TO THE COSMOLOGICAL H0 TENSION

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Cosmological tensions describe significant discrepancies between different observational measurements of key cosmological parameters, such as the Hubble constant and the growth of cosmic structures. These robust inconsistencies represent one of the most serious challenges to the standard cosmological model today, potentially pointing towards new physics. In my talk, I will present a model where the Universe is filled with a phantom scalar field with a potential in the form of a hyperbolic tangent, as well as cold dark matter and radiation. This model is free from the shortcomings usually attributed to phantom models and undergoes a rapid Anti-de Sitter to de Sitter transition. At the background level, a detailed analysis of the model is performed. The numerical integration of the equations of motion is performed in such a way that both the CMB and SH0ES data are satisfied. Thus, this model points to a possible solution to the problem of cosmological tensions in theories where the cosmological constant changes its sign.

COSMOLOGY, GRAVITATION, HIGH ENERGY PHYSICS, ASTROPARTICLE PHYSICS

A NOVEL IMAGE RECONSTRUCTION APPROACH IN THE X- AND γ-RAY DOMAIN

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In present time in many applications exists the need to recreate geometric shapes of physical objects. Our work dedicated to reconstruction of a inhomogeneity's of chemical structure in space and Earth atmosphere. In contrast with classic optical method the X- and soft γ-Ray spectroscopy sensitive only to atomic composition (perfectly atomic number Z) and types of interaction mechanisms between hard radiation and atoms. This is opened new possibilities to thin geometry and physical diagnostics of these objects. Our method limited from 0.01 to 5 MeV. In this case radiation and atoms interacts by photo absorption (atomic photo effect), Compton and Rayleigh scattering and pair production mechanisms. After 20 keV of photons energies main contribution in radiation fields are from Compton mechanisms. In this case radiation field mainly consists scattering component. To this we must add the diffraction of soft X-rays on nanoparticles of dust, if environment is contained with them. We constricted and applicated the equation of transfer of such radiation for single scattering. Our approach allowed us to identify structures that differ in chemical composition at least 5%. The physical parameters of the system were not subject to change. During the solution of this problem, the task of restoring the structure from a chemical anomaly did not allow the use of existing mathematical methods without their significant modification. The structure with chemical anomaly considered in form of the distribution function μ_s (x,y) of atomic scattering agents. We have selected suitable X-ray scattering indicatrices for this purpose in the form.

THE NOVEL γ-RAY SPECTROGRAPH CONFIGURATION IN THE ENERGY RANGE 0.1–5 MEV

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The design of third-generation spectrographic gamma-ray detectors necessitates the acquisition of high signal-to-noise (SNR) spectra across a broad energy range. Halide perovskite semiconductors, such as $CsPbBr_3$, offer promising properties in this context. For gamma-ray energies up to $E_\gamma \leq 0.6\ MeV$, where the photon mean free path l remains relatively short, the detector's effective volume V can be limited to approximately 1 cm^3 without significant signal loss.

However, extending detection capabilities into the higher energy range presents technical and economic challenges, as it requires a substantial increase in crystal volume. To overcome this limitation, we examine the physical response of $CsPbBr_3$ crystals in two critical energy intervals: $0.6\ MeV \leq E_\gamma \leq 1.022\ MeV$ and $1.022\ MeV \leq E_\gamma \leq 5\ MeV$. In the first interval, we investigate the correlation between $E_\gamma$and the induced current pulse, establishing a characteristic response curve. For the second interval, a novel composite detector architecture is proposed.

The system consists of three identical $CsPbBr_3$ crystals. The central crystal is responsible for direct detection of incident gamma photons and the capture of radiation resulting from electron–positron pair production. The two lateral crystals are optimized for the detection of 0.511 MeV photons from positron annihilation, thereby enhancing the spectrograph's sensitivity in the high-energy domain. This configuration achieves improved performance while maintaining compactness and cost efficiency.

Monte Carlo simulations were conducted using the Geant4-DNA toolkit to model gamma-ray transport, calculate the angular scattering indicatrix, and evaluate the probability of 511 MeV photon escape and detection. The results indicate that pair production and subsequent annihilation substantially influence the output signal for $E_\gamma \geq 1.022\ MeV$, supporting the feasibility of compact yet highly efficient gamma-ray spectrograph designs.

The lack of cooling requirements and the availability of $CsPbBr_3$ perovskite crystals render the proposed detector design economically viable and scalable for practical deployment in various scientific and technological domains.

THE EXCESS ENTROPY IN STRUCTURED DISCRETE CONGLOMERATES AT MULTIPLE SCALES

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This study examines the spatial structure of a two-dimensional granular system (hard discs) using the concept of excess entropy, which quantifies the degree of ordering resulting from spatial correlations. The methodology is based on image analysis of particle configurations, where the pair distribution function is directly modeled with help of generalized functions and

used to compute the entropy excess (deviation from a random distribution).

Earlier the analysis was performed on a several selected configurations of two-dimensional hard discs conglomeration (which model a typical granular) formed under selected values of packing fraction (compaction). The resulting excess entropy curve shows a non-monotonic behavior which characterized by pronounced maximum at a specific scale, which corresponds to the dominant correlation length in the system. Such behavior we interpret as a formation of effective spatial long-ranged correlations which lead to the creation of range where the structure is most organized and clustering effects are strongest. This phenomenon is isomorphic to formation of long-lived clusters in slowly relaxed inhomogeneous condensed mater systems.

The proposed approach provides a convenient tool for quantifying local ordering in complex systems without the need for multiple configurations or time-resolved data. In the next stage of the study, the same technique will be applied to an astronomical dataset — an image of galaxy distribution in a cross-section (two-dimensional window) from a deep-sky survey. Comparing the entropy behavior of such vastly different (but in many sense –similar) systems may help to define the criteria's of formation of the clusters with a different internal symmetries.

STRONG GRAVITATIONAL LENSING AND MICROLENSING BY A TOROIDAL STRUCTURE WITH A CENTRAL MASS

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Gravitational lensing is widely used in cosmology and astrophysics to obtain additional information about the distribution of dark matter in galaxies and clusters. It also provides a valuable tool for studying physical processes in accretion disks around supermassive black holes (SMBHs) in active galactic nuclei (AGNs). Most commonly studied lensing systems have spherical or disk-like structures, whose lensing properties are well understood. However, some galaxies contain ring-like structures, and AGNs are often surrounded by geometrically thick tori. As gravitational lensing systems, such configurations exhibit properties that differ significantly from standard cases. This paper extends our previous investigation of lensing effects produced by a system consisting of a central point mass and a surrounding toroidal distribution. As before, the torus is modeled as a flat disk with a surface density distribution corresponding to a three-dimensional torus with either homogeneous or Gaussian density profiles. In this study, we further incorporate an analysis of microlensing effects. In particular, we compute the Jacobian determinant of the transformation between the source and lens planes using the previously derived lens equations. We calculate the critical curves and caustics for a range of parameters and simulate the resulting images. This analysis allows us to determine the number of images and magnification factors that characterize microlensing behavior in such systems. We find distinct features in image formation that can help differentiate between the homogeneous and Gaussian torus density profiles. Additionally, we compare the results to the case of a homogeneous, infinitely thin annular disk. The obtained results may serve as a basis for identifying astrophysical objects with toroidal or ring-like matter distributions through their unique gravitational lensing signatures.

TWO TIME PHYSICS, CARROLL PARTICLES AND JORDAN ALGEBRAS

Alexander Kamenshchik

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We make an attempt to describe Carroll particles with a non-vanishing value of energy (i.e. the Carroll particles which always stay in rest) in the framework of two time physics, developed in the series of papers by I. Bars and his co-authors. We also discuss the relations between two-time spacetimes and Jordan algebras.

THE IMPACT OF THE HELICITY OF THE PRIMORDIAL MAGNETIC FIELDS ON THE THERMAL AND CHEMICAL HISTORY IN THE EARLY UNIVERSE

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Primordial magnetic fields (PMFs) are weak magnetic fields that permeate the entire Universe, and are thought to have originated within a fraction of a second after the Big Bang, perhaps during phase transitions or inflation. These fields could potentially have played an important role in shaping the large-scale structure of the Universe, influencing the formation of stars and galaxies through their interactions with baryonic matter in the early Universe. PMFs are conventionally described by a power spectrum and also by a helicity, which determines how the power spectrum will evolve over time. Non-helical fields evolve under a direct cascade of magnetic energy — energy flows from large to small scales and dissipates more rapidly due to viscosity and resistivity of the primordial plasma. Helical fields undergo an inverse cascade — magnetic energy shifts from small to larger scales due to the conservation of helicity, delaying damping at small scales. We show how helical and non-helical PFMs interact with baryonic matter, determining its thermal and chemical history in the early Universe. We also show how helisity of PFMs influence the sky-averaged signal from the first molecules.

This work is done in the framework of the project "Tomography of the Dark Ages and Cosmic Dawn in the lines of hydrogen and the first molecules as a test of cosmological models" (state registration number 0124U004029) supported by the National Research Foundation of Ukraine.

QUANTUM PRODUCTION OF GRAVITATIONAL WAVES AFTER INFLATION

Alina Mierna, Gabriele Perna, Sabino Matarrese, Nicola Bartolo, Angelo Ricciardone
University of Padua

A variety of mechanisms in the early Universe lead to the generation of gravitational waves (GWs). In this talk, I will present a novel source of GWs generated by vacuum fluctuations after inflation. Being gravitons minimally coupled particles, their quantum creation takes place during inflation, but is absent in an unperturbed Universe during the radiation-dominated epoch, since they behave as conformally invariant particles. However, the presence of inhomogeneities breaks the conformal flatness of the metric, allowing scalar metric perturbations to induce the quantum production of gravitons. We computed the resulting GW spectrum from this mechanism for different models of the primordial scalar power spectrum and found that this GW signal peaks around the GHz frequency range, distinguishing it from other astrophysical and cosmological backgrounds and underscoring the need for detectors sensitive to these high frequencies.

IMPACT OF PRIMORDIAL MAGNETIC FIELDS ON THE REDSHIFTED 21 CM SIGNAL FROM DARK AGES

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The impact of primordial magnetic fields (PMFs) on the ionization and thermal history of the Dark Ages Universe ($30 \le z \le 300$), as well as its imprint on the spectral profile of the global signal in the 21 cm hydrogen line are subject of the talk. The heating functions caused by decaying magnetic fields monotonously decrease after cosmological recombination; their amplitude depends on the strength B_0 and spectral index n_B of the initial power spectrum of PMFs. We computed the ionization and thermal history from the cosmological recombination up to the end of the Dark Ages epoch for a range of PMF parameters $0.05 \le B_0 \le 0.5$ nG and $-2.9 \le n_B \le 4$, and show the essentially distinguished thermal evolution from one in the ΛCDM model. We also show that the profile of the redshifted 21 cm hydrogen line is very sensitive to the PMF parameters from this range and can be used for their constraints. The possibility of detection of the global signal in the 21 cm hydrogen line from the Dark Ages epoch will be discussed too.

This work is done in the framework of the project "Tomography of the Dark Ages and Cosmic Dawn in the lines of hydrogen and the first molecules as a test of cosmological models" (state registration number 0124U004029) supported by the National Research Foundation of Ukraine.

CAN WE CONSTRAIN A COSMOLOGICAL MAGNETIC FIELD VIA NETWORK ANALYSIS?

Anton Rudakovskyi, Maksym Tsizh, Franco Vazza
BITP&UniBo

The nature of magnetic fields detected on scales of galaxy clusters remains uncertain. Astrophysical mechanisms that generate magnetic fields often struggle to describe the observed field strengths, making scenarios involving primordial magnetic fields (PMFs) particularly appealing. In such models, the additional pressure generated by magnetic fields can influence the formation of low-mass galaxies and affect their distribution within the cosmic web.

In this work, we present a novel suite of magneto-hydrodynamical simulations, MAKITRA, designed to investigate the effects of PMFs on the structure of the cosmic web. We model the distribution of galaxies in the simulations as a network and apply innovative methods of network analysis. Our results show that various network centrality measures hold strong potential for constraining the cosmological parameter σ8, which governs the amplitude of the dark matter power spectrum. We demonstrate that these metrics can serve as sensitive probes of PMFs at the nanogauss (∼nG) level, providing constraints comparable to those derived from Cosmic Microwave Background (CMB) observations.

THE DYNAMICS OF A SUPERMASSIVE BLACK HOLE UNDER THE INFLUENCE OF A CLUMPY SELF-GRAVITATING TORUS

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Toroidal (or ring) structures, such as dusty tori in active galactic nuclei (AGNs), can be massive enough to influence the dynamics of the central supermassive black

hole (SMBH). In this work we investigate the motion of a central point-mass under the gravitational influence of a clumpy self-gravitating torus. We performed a series of N-body simulations for a wide range of torus-to-central mass ratios and different initial distributions of particle orbital elements. The simulations were carried out using a high-order Hermite integrator (ϕ-GPU). Our results show that the central mass exhibits two distinct types of oscillations: (i) short-period oscillations with frequency close to that of the torus orbital motion and (ii) long-period oscillations whose amplitude and phase depend on the torus mass and initial geometry. In particular, the final radius of the SMBH orbit is larger for more massive or geometrically extended torus. We have found that these long-term oscillations of the central mass are anti-correlated with the motion of the torus barycenter, confirming that the central mass responds to asymmetry of particle distribution in the torus. Such asymmetry can be a result of the nodal resonance in particle orbits that leads to formation of a massive clump in the torus. An interesting problem is why the clump stops growing. The mechanism is possibly a balance between pressure and self-gravity. These features may turn into observable signatures of the internal dynamics of obscuring tori in AGNs and could be used as a diagnostic for torus structure and mass.

STABILITY OF RELATIVISTIC SYSTEMS WITH FRACTIONAL POWER-LAW SCALAR FIELDS

Vahnuyk B.I., Tugay A.V.
Taras Shevchenko National University of Kyiv

We study static spherically-symmetric (SSS) asymptotically flat configurations with scalar fields featuring fractional power-law potentials, $V(\phi) \sim \phi^{2n}$. This work extends the previous analysis conducted for integer exponents. We investigate the linear stability of such systems against radial (monopole) perturbations. Our numerical investigation shows that the instabilities arising for fractional exponents are intermediate cases that smoothly interpolate between the previously identified instabilities for integer values of n. As in the previous studies, configurations with a small scalar charge Q exhibit divergent perturbation modes, which supports the Penrose conjecture regarding the instability of such naked singularities. Meanwhile, for sufficiently large values of Q, we did not detect certainly unstable modes. However, the definitive question of the stability for singularities with large charges remains open and requires further analysis involving other types of perturbations.

UNIVERSAL STRUCTURE OF STATIC SPHERIALLY SYMMETRIC SOLUTIONS OF F(R) GRAVITY

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We study static spherically symmetric (SSS) vacuum solutions of the f(R) gravity in the Einstein frame for known scalaron potentials. The focus is on solutions describing asymptotically flat configurations having astrophysically relevant configuration mass M and scalaron mass larger than several meV. Analytical and numerical analysis reveals universal properties of some elements of the SSS solutions for different masses and sufficiently large size of a scalarization region r0, where the metric differs significantly from the Schwarzshild case. In particular, the scalaron field has universal behavior regardless of M and r0 in case of each of the models considered. Asymptotic parameters of the metric near the naked singularity at the center of the SSS configuration are obtained for all the models.

ASTROPHYSICS 1
(nucleosynthesis, stellar atmospheres, kinematics, structure and chemical evolution of the galaxy)

DETERMINATION OF ELECTRON TEMPERATURE AND IONIZED MASS OF PLANETARY NEBULA OF NGC7009

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The electron temperature of NGC 7009 was determined by means of [OIII] forbidden line intensities, the ionized mass was determined by mean of Hb line flux. The emission Hb line and the forbidden [OIII] lines l 5007, l 4959 and l 4363 were identified from spectra obtained by the "ESO" planetary nebulae archives. The observed flux for Hb and observed intensities for [OIII] lines were corrected for interstellar reddening. The intensity ratio of [OIII] lines I5007+I4959/I4363 was 134,21 and flux of Hb was 5,31·10-11. Respectively the electron temperature of 11569 K and ionized mass of 0,043 M0 were found for the NGC 7009, the results obtained were compared with results of other authors.

VELOCITY ELLIPSOIDS OF THE GAIA DR3 GIANTS AND SUBGIANTS IN THE GALACTIC PLANE

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The results of determining the parameters characterizing the shape and orientation of the residual velocity ellipsoids of red giants and subgiants Gaia DR3 are presented. The distribution of velocity dispersions in the galactic plane, obtained from the three components of the spatial velocity, is shown, as well as the distribution of coordinates of the intersection points of the axes of the velocity ellipsoid with the celestial sphere, in particular, the deviations of the longitudes and latitudes of the vertices of stellar regions located in spheres with a radius of 1 kpc centered in the median plane of the Galaxy. We show that the deviations of the vertices in some regions of the Galactic midplane can reach 30° in longitude and 15° in latitude. This indicates the presence of kinematic distortions of the stellar velocity field, especially noticeable in the angular range $150° < \Theta < 210°$ at a distance of about 13 kpc. We propose to consider the deviation angles of the longitudes and latitudes of the ellipsoid axes of residual stellar velocities as kinematic signatures of various Galactic deformations, determined by the real spatial velocity fields. We present the distribution of parameters characterizing the shapes of velocity ellipsoids, as well as the distribution of their semi-axes length ratios. We indicate a local feature in this distribution and in the distribution of the ellipsoid elongations.

THE ROLE OF MOLECULAR HYDROGEN IN THE ENERGY BALANCE OF GIANT PLANETS

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It is known that giant planets emit more heat than they receive from the Sun, indicating the presence of internal heat sources. However, none of the existing mechanisms can fully explain the origin of these internal energy sources. In this study, based on some theoretical calculations, a mechanism is proposed in which the conversion of energy occurs during the transition of ortho-hydrogen (o-H_2) to para-hydrogen (p-H_2), accompanied by the release of heat (approximately −1400 J/mol), in this process does not participation of catalysts. The efficiency of the conversion from o-H_2 to p-H_2 depends on temperature, pressure, the total amount of hydrogen, the ratio of ortho- to para-hydrogen, and so on. Therefore, in regions where more favorable conditions are established for the effective conversion of ortho- to para-hydrogen, greater thermal energy is released.

Therefore, on based of spectrophotometric measurements of giant planets obtained between 2014 and 2021 using a CCD-equipped spectrometer at the Cassegrain focus of the 2-meter telescope, weak quadrupole lines of molecular hydrogen from the H_2 (4-0) band were studied in the infrared region of the spectrum. With spectral resolutions of R = 14000, 28000, and 56000, certain atmospheric parameters of giant planets were determined from the minima of the H_2 (4-0) S(0) and S(1) band lines.

Understanding the chemical composition and physical properties of molecular hydrogen under the atmospheric conditions of giant planets can provide a better insight into their energy balance and the structure of their atmospheres.

VARIATION OF THE HA LINE PROFILE IN THE SPECTRUM OF THE SUPERGIANT STAR HD 207260(A2 IAE)

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We present the results of a detailed spectroscopic investigation of the supergiant HD 207260 (A2 Iae), based on high-resolution echelle spectra obtained in 2018 with the

2-meter telescope at the Shamakhy Astrophysical Observatory. The focus is on the variability of the Hα line, which exhibits a complex and variable profile, consisting of both an absorption core and an emission component. The emission intensity and its radial velocity were found to vary significantly across different epochs. These changes were accompanied by synchronous variations in the radial velocity of the absorption core and in the equivalent width of the line. Such behavior suggests a dynamical origin for the emission component, possibly related to the upper atmospheric instabilities or episodic mass-loss events.

Fourier analysis of the radial velocity variations reveals a quasi-periodic signal with an approximate timescale of 35–40 days. This timescale is consistent with the presence of radial or non-radial pulsations, which may drive structured outflows in the upper layers of the stellar atmosphere. Our findings support the scenario where the interplay between pulsation and mass loss results in variable emission features, particularly in the Hα line.

This work contributes to the growing evidence that intermediate-temperature supergiants undergo complex atmospheric motions, and that Hα variability serves as a sensitive diagnostic of these processes.

ESTIMATING PHOTOMETRIC AND COLOR VARIABILITY OF F7V PLANET HOST WASP-1 TIC 57984377: MAGNETIC MODULATIONS AND ROTATIONAL SIGNATURES

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We present a detailed photometric and theoretical analysis of the F7V star WASP-1, host to an inflated hot Jupiter, using high-precision data from TESS and Gaia. With a consistent brightness modulation of about 3% and a precise stellar rotation period of about 0.51 days, our observations show strong magnetic surface activity, including starspots. Temperature differences on the stellar surface, caused by cooler magnetic regions than the photosphere, are confirmed by changes in the color index over time.

Our custom Python tool Tesser was used to systematically to process and filter the raw photometric data, removing transit signals and instrumental systematics while maintaining intrinsic stellar variability. The impact of magnetic fields on stellar oscillations and energy transport was then examined using this cleaned dataset in conjunction with stellar evolutionary models. Our method demonstrates that magnetic suppression of convective energy results in temperature gradients that produce the observed photometric and color variability, while magnetic fields modify the propagation of acoustic waves, leading to detectable shifts in oscillation frequencies.

Our combined observational and modeling approach demonstrates that magnetic activity in F-type planet-hosting stars significantly impacts their photometric stability and asteroseismic behavior. This variability must be accounted for when analyzing exoplanet transit data to avoid misinterpretation of signals. The case of WASP-1 highlights the complex interactions between magnetic fields, stellar oscillations, and surface features in intermediate-mass stars, offering insights relevant for exoplanet studies and stellar physics.

ENRICHMENT WITH THE FIRST- AND SECOND-PEAK S-PROCESS ELEMENTS IN GALACTIC DISC GIANTS

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We investigated the enrichment of disc stars using a sample of 150 Galactic disc giants.

Spectra of giant stars, observed with the 1.93-m telescope at Observatoire de Haute-Provence (France) using the ELODIE echelle spectrograph covering 4400–6800 Å at a resolving power of R = 42,000 with signal-to-noise ratios of 130 to 230 at 5500 Å were used.

The abundances of elements in the first (Sr, Y, Zr) and second (Ba, La, Ce) s-process peaks were derived and compared with Galactic Chemical Evolution (GCE) models.

Our results confirm that the enrichment of the 1st-peak and 2nd-peak s-process elements is due to both the s-process and the r-process, without excluding some additional contribution of other nucleosynthesis sources.

NEW APPROACHES MATHEMATICAL JUSTIFICATION STEADY OF THERMODYNAMICALLY EQUILIBRIUM OF GIANT PLANETS

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Our main objective is to stimulate some interest in studies of gas giant planets, as studies of thermodynamic equilibria using facts of hydrodynamic rotational stability (author) of Jupiter. Saturn and Jupiter, known to have cloud decks in parallel bands of latitude and below the tropopause level, alternately composed of ammonia and ammonium hydrosulfate crystals. Cloud bands are located mostly in the highest of the three major layers covering Jupiter. Including Uranus and Neptune, cloud layers are composed mainly of methane gas. The condition for convection to occur in Jupiter's atmosphere is the presence of an unstable temperature gradient, that is, the temperature in the upper atmosphere must be lower than in the lower atmosphere, and as the air rises, it must maintain a temperature different from the ambient temperature. This leads to upward air currents that cause the formation of clouds and thunderstorms and affect the dynamics of Jupiter's belts. In this case, the convective processes associated with mixing and heat

exchange in the atmosphere influence the existence and dynamics of Jupiter's belts, which are bands of clouds observed in the planet's atmosphere. In general, the convection form of the Navier-Stokes equation derived as a particular form for the motion cloud (possible cases) of giant planets. For thermodynamic equilibrium of Jupiter concerning temperature, energy, pressure, and volume, the thermodynamic law must be satisfied. For this reason, constructing the thermal wind equation, we obtain that zonal and meridional velocity satisfy conditions for thermodynamic equilibrium. By the new method established the thermodynamic law, which satisfied circulation energy and proved the thermodynamic equilibrium with agreeing equilibrium of the chemical model and hydrodynamic steadiness of Jupiter (and for giant planets).

NEW APPROACHES THEORETICAL ASTROPHYSICS FOR APPLICATION TO SOME ASTRONOMICAL OBJECTS: AN APPLICATION OF NON-CLASSICAL EQUATION MATHEMATICAL PHYSICS TO THE MAGNETO-HYDRODYNAMIC EQUILIBRIUM FOR TOROIDAL MAGNETIC STARS

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First, let us give a few words to explain the title of this work, since it contains such concepts as terms, non-classical equations of mathematical physics, hydrodynamics, and equilibrium magnetohydrodynamics. In this case, the stream function is determined for incompressible (divergence-free) flows in two dimensions, as well as in three dimensions with rotational symmetry. Therefore, the flow function can be used to construct streamlines, which represent the trajectories of particles in a steady flow. In fluid dynamics, the flow function is a scalar function that characterizes the two-dimensional state of a liquid or gas. Therefore, the equilibrium in ideal magnetohydrodynamics (MHD) for a two-dimensional plasma, such as the discovered axisymmetric toroidal (azimuthal) plasma in a tokomak. Hence, including directly that the Hicks equation from hydrodynamics belongs to the category of equations of non-classical mathematical physics. Non-classical models of mathematical physics are those whose representations in the form of equations or systems of partial differential equations do not fit within the framework of one of the classical types.

According to Hopf's theorem, from Maxwell's equation and the magnetic force balance equation, we obtain an equation of nonclassical type for the mathematical model of the toroidal magnetic field in a magnetic star. From the solution of this equation, we obtain the vector magnetic field and formulas for density and temperature for a magnetic star. By means of methods of straight lines and methods of transformation, numerical and exact solutions of the equation of nonclassical type were obtained. Finally found the condition of magnetohydrodynamical equilibrium of a magnetic star. Analogically, additionally founded conditions that satisfy the equilibrium of magnet statistics and hydrostatics.

DETERMINATION OF THE EFFECTIVE TEMPERATURES AND SURFACE GRAVITIES OF SEVERAL A-TYPE STARS BASED ON PHOTOMETRIC PARAMETERS

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The fundamental parameters – effective temperatures (Teff) and surface gravities (g) – have been determined for of A-type stars: HD 6364 (A5/7III), HD 6365 (A3III/IV), HD 6492 (A9V), HD 6723 (A8V), HD 25093 (A7II/III), HD 123798 (A8/9V), HD 129175 (A6V), HD 129433 (A0IV), HD 129660 (A7V), and HD 209124 (A0III-IV).

Effective temperature and surface gravity are fundamental input parameters in stellar atmosphere modeling. The accurate determination of the chemical composition of stellar atmospheres depends critically on the precision of these model parameters. Moreover, knowledge of Teff and g enables the derivation of stellar evolutionary characteristics such as mass, luminosity, radius, and age.

The effective temperatures and surface gravities of the investigated stars were derived using a model-based approach. This method involves comparing observed and theoretical values of the photometric indices [c1], Q, and β.

The following values of Teff and log g were obtained for the studied stars: HD 6364: Teff = 7610 K, log g = 4.25; HD 6365: Teff = 7880 K, log g = 4.35; HD 6492: Teff = 7390 K, log g = 3.70; HD 6723: Teff = 7380 K, log g = 4.00; HD 25093: Teff = 7780 K, log g = 4.10; HD 123798: Teff = 7090 K, log g = 3.65; HD 129175: Teff = 8220 K, log g = 4.35; HD 129433: Teff = 9960 K, log g = 4.00; HD 129660: Teff = 7710 K, log g = 3.65; HD 209124: Teff = 9820 K, log g = 3.80.

THE ABUNDANCE OF RADIOACTIVE ELEMENT IN THE ATMOSPHERE OF STARS. PROMETHIUM.

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We investigate absorption lines of promethium, a radioactive element with a short half-life, in the spectra of magnetic chemically peculiar (MCP) A0Vp star HD

25354 and Cepheid HIP13062 in the wavelength range of 370.0-940.0 nm.

We present the abundances of promethium in the atmosphere of HD25354 and HIP13962 which neither exceed log N(Pm) = 5.85 and log N(Pm) = -0.37 on the hydrogen scale log N(H) = 12.

The investigation interval has been limited to the spectral range of 4000–5600 Å and oscillator strengths within -0.76 < log gf < 0.4. If the promethium line identification is only performed based on the coincidence of the line wavelengths in the stellar spectra with the laboratory ones, then the number of such lines beyond the wavelength of 5600 Å would be considerably greater. When determining stellar abundances of promethium, Pm lines beyond the wavelength of 5600 Å are not observed in synthetic spectra, but they can be identified in actual spectra, which may indicate the necessity to correct the oscillator strengths used.

In result, we added the lines of PmII with correct the oscillator strengths.

ASTROPHYSICS 2
(interacting binary systems and variable stars)

PERIODIC VARIATIONS OF THE OPTICAL SPECTRUM AND BRIGHTNESS OF THE POST-AGB OBJECT LN Hya

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BS 4912 (also known as HD 112374 or LN Hya) has been considered a post-AGB F-type supergiant with a dusty disk. It is located at a high galactic latitude of b = +36.3 degrees. However, previous studies of this object have relied on small spectroscopic or photometric datasets.

In this work, we present the results of a large set of medium-resolution (R ≈ 12,000) optical spectroscopic observations — 70 spectra obtained at the Three College Observatory in North Carolina, USA, between 2021 and 2025 — along with an optical light curve covering the past 40 years.

We detected regular variations in the radial velocities (RV) of absorption lines and in brightness, with a period of 148.5 days. Both the RV and photometric variations suggest that LN Hya is a binary system, with a much fainter secondary companion compared to the F-type primary star. Several spectra taken in 2021 also show the presence of TiO molecular bands.

PROLONGED VARIABILITY IN THE PRE-MAIN-SEQUENCE STAR V1295 Aql

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Herbig (1960) was the first to conduct a systematic investigation of a specific category of stars now known as Herbig Ae/Be (HAeBe) stars. These objects are characterized by the following observational criteria:

a) Spectral type A or earlier, exhibiting emission lines;

b) Location within obscured regions of the interstellar medium;

c) Association with relatively bright nebulosity in their immediate surroundings.

Herbig defined these characteristics based on the observed properties of their lower-mass analogs—T Tauri stars—and compiled a list of 26 HAeBe stars meeting these criteria. Since this foundational study, both the catalog and the defining features of HAeBe stars have been significantly expanded. Currently, over one hundred HAeBe stars of spectral types earlier than F5 are known. Although not all exhibit every Herbig characteristic, all display infrared (IR) excess and an atypical extinction law, differing from that of classical Be stars.

These properties strongly suggest that HAeBe stars are in an early evolutionary stage, still enshrouded by dust and gas in a circumstellar envelope or disc. However, it was the spectroscopic investigation by Ström et al. (1972) that provided the first conclusive evidence of their pre-main-sequence (PMS) nature. By demonstrating that HAeBe stars have systematically lower surface gravities than main-sequence (MS) stars of similar spectral type, they established HAeBe stars as progenitors of intermediate-mass MS A/B-type stars.

Our initial publication focused on detecting rapid spectral variability in one such star, using consistent spectral data collected from the 2-meter telescope at the Shamakhy Astrophysical Observatory (Ministry of Science and Education, Azerbaijan) from 2015 to 2023 (Jarvinen et al., 2024). The current paper presents results for the 2016–2023 period, based on high-resolution spectroscopic data (R ≈ 28,000). Comprehensive information on these observational materials is provided in the first installment of our series.

This is the second in a sequence of studies dedicated to the spectral analysis of the peculiar Herbig Ae star HD 190073. Here, we investigate long-term spectral variability spanning the years 2016 to 2023. Utilizing synthetic spectra from standard stars, we extracted profiles of circumstellar structures for hydrogen and Ca II H and K lines. These spectral features consistently exhibit P Cygni profiles, where the pronounced blue-shifted absorption component shows significant variability. The complete cycle of slow, long-term variability is approximately 11 years. We have also determined the star's fundamental parameters and evolutionary status.

Persistent long-term variability has been detected in the spectrophotometric characteristics of hydrogen, helium, and various metallic lines. This variability appears to follow a general cycle lasting roughly 11–12 years. The origin of such periodic changes may be attributed to a stellar companion or massive planetary bodies.

A correlation has been identified between certain spectral parameters and the intensity of the blue-shifted absorption component. This supports the conclusion that the dominant mechanism driving the observed activity is accretion.

INVESTIGATION OF NOVA SCO 2024

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In the constellation of Scorpius, on February 9, 2024 (2024 Feb 09.8438 UT), the nova Sco 2024 (PNV J17261813−3809354, later designated as V1723 Sco) was discovered independently by observers Andrew Pearce (Australia) and Yukio Sakurai (Japan), with an apparent magnitude of approximately 7.3. The object was later spectroscopically confirmed as a classical nova. We

investigated the photometric and spectroscopic properties of the object during the early stages of its evolution. Spectra covering the period from February 11 to February 27, 2024, were obtained from the international ARAS database. An analysis of the Hα emission line dynamics revealed a rapid increase in equivalent width, indicating a strong mass ejection. Radial velocities in the emission and absorption lines reached –4000 km/s in the initial phase, pointing to significant changes in the physical conditions within the expanding envelope. Changes in He I lines and diffuse interstellar bands (DIBs) were also studied, allowing us to trace the evolution of the interstellar environment. Beginning on February 27, 2024 – 18 days after the outburst – Na I absorption lines appeared in the spectrum. At the same time, a relatively narrow absorption component was observed on the blueward wing of the Hα line. Based on the measured equivalent width of the DIB 6613.63 line (EW = 0.291 Å), the interstellar extinction was estimated as A(V) ≈ 0.86, which corresponds to a distance of approximately 1.54 kpc to the object. From the analysis of the photometric light curve, the decline parameters were determined as t_2 = 6.71 days and t_3 ≈ 10.4 days. The shape of the curve corresponds to type A (smooth decline) – a steadily fading nova without a plateau or secondary maxima, typical of fast-declining classical novae. The obtained results help refine the physical parameters of Sco 2024, its position in the Galaxy, and expand our understanding of the evolution of classical novae.

PHENOMENOLOGICAL MODELING OF TOTAL ECLIPSES AND TRANSITS

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Eclipsing binaries are the main source of the physical information on stellar components, as the 3-rd Kepler law allows to make an additional equation to scale the solution. The majority of the observations and discoveries are made photometrically and mainly are available in the international databases of the ground-based and space observatories. Modern physical modelling is based on the Wilson-Devinney (1972ApJ...171..413W, 2022Galax..10...17K, Kallrath J., Milone E.F. Eclipsing Binary Stars: Modeling and Analysis, Springer, 2009). A large part of discoveries and studies are related to pure photometry – so there are no data on the temperatures, radial velocities/ The distances/parallaxes are typically available via the GAIA catalogue.

Among approximations of the complete phase curves, the most common is the trigonometric polynomial (TP, often called the Fourier Transform= FT) (1980Ap&SS..72....3K). The statistically optimal degree *s* may be determined either using the ANOVA analysis (the Fischer criterion), or "the best accuracy" (1994OAP.....7...49A, 2003ASPC..292..391A, 2020kdbd.book..191A). However, the number of parameters for the EA-type systems may be enormously large (up to few dozen parameters (depending on the width of the eclipse). Thus the "New Algol Variable" (NAV) algorithm was proposed (2012Ap.....55..536A, 2016JPhSt..20.4902T), which combines the TP2 model + special shapes for the profiles of the eclipses. This makes the accuracy of the approximation much better – up to few times.

Similarly, for the case of total eclipses and transits of exoplanets, the near-minimum parts of the light curves are almost flat, so the "Wall-supported" approximations have been proposed (2017OAP....30...57A). These algorithms were implemented in the program MAVKA (http://uavso.org.ua/mavka).

However, much better accuracy of the TESS light curves shows a need for improvement of the function, and we test some new functions to make approximations better.

VARIABILITY OF THE PROTOTYPE POLAR AM HERCULIS FROM SECONDS TO DECADES

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AM Herculis is the prototype of magnetic cataclysmic variables (MCV). Due to their large polarization, they are called "polars". Their main difference from "non-" or "weakly-" magnetic CVs is the "phase-locked" variations of the polarization, radial velocities and photometry. This is explained by a "standard model" (1977ApJ...212L.125T, 1977ApJ...211..859B, 1977ApJ...212L.113S), according to which, the binary system consists of a red dwarf, which fills its Roche lobe, and of the white dwarf, which has magnetic field sufficient to catch (channelize) the plasma flow via vicinities of the inner Lagrangian point. No accretion disk is formed, the accretion creates a column, which emits polarized cyclotron radiation.

The photometric monitoring has started at the Mayaki station of the astronomical observatory of the Odessa Mechnikov State University in 1978. From 1989, S.V.Kolesnikov and N.I.Shakhovskoy made regular monitoring simultaneously at the 2.6m Shain telescope and with the UBVRI photometer polarimetry at the AZT-11 telescopes of the Crimean Astrophysical Observatory. Hundreds of nightly runs have been obtained, making this monitoring the most long in the history.

We report on results of this monitoring, as well as the photometric data obtained at ground-based and space observatories, including long runs at CHANDRA and TESS.

SPIN-UP OF THE WHITE DWARF IN THE INTERMEDIATE POLAR V2069 CYG

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Study of the structure and evolution of magnetic cataclysmic binary stars is an actual problem of the modern

astrophysics. Intermediate polars, often called DQ Her star, are close binary systems which consists of a compact object - a white dwarf, and a red dwarf filling its Roche Lobe. Such systems are physical laboratories that enable study of the influence of magnetic field on flows of matter.

Our analysis includes large data set of photometric observations of V2069 Cyg obtained in different locations between 2007 and 2024. The reduction, consisting of calibration of scientific images for bias, dark, flat-field, and the extraction of instrumental magnitudes, was carried out with the MUNIWIN. The final derivation of magnitudes was obtained using MCV. Barycentric corrections were applied to all geocentric Julian dates. To determine spin maxima timings we used the trigonometric polynomial approximation of the light curve implemented in MCV.

The (O-C) diagram since 2014 shows white dwarf spin period decrease and the best fits to (O-C) diagram is parabolic. Insufficient data for the previous seasons did not allow us to make a continuous unambiguous cycle counting since 2007. The data between 2014 and 2024 correspond to the current value of the spin period of P = 0.0086041266(9) days (743.39654(8) s). The white dwarf in V2069 Cyg shows a spin-up with a characteristic time of $4.7(1)\cdot10^5$ years, that was estimated for this system for the first time. Our previous research shows similar order of the characteristic time for other objects: $1.483\cdot10^5$ yr for RX J2133.7+5107 and $5.3\cdot10^5$ yr for V2306 Cyg.

Period variations are frequently observed in intermediate polars and are typically detectable at a time scale of decades. From theoretical expectations, the spin periods of the white dwarf should be equal to some equilibrium value, which is equal to the period of "Kepler" rotation of the inner accretion disk at a distance of the magnetosphere radius. Period variations may be caused by changes of the accretion rate due to modulation of the mass transfer caused by magnetic activity of the red secondary fluctuations of the orbital separation, or precession of the magnetic white dwarf (which will be present either with constant, or variable accretion rate) or precession of the magnetic white dwarf.

MULTIPLICITY OF EARLY B-TYPE SUPERGIANTS IN THE SMALL MAGELLANIC CLOUD

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The blue supergiant (BSG) domain contains a large variety of stars whose past and future evolutionary paths are still highly uncertain. Since binary interaction plays a crucial role in the fate of massive stars, investigating the multiplicity among BSGs helps shed light on the fate of such objects. Aims. We aim to estimate the binary fraction of a large sample of BSGs in the Small Magellanic Cloud (SMC) within the Binarity at LOw Metallicity (BLOeM) survey. In total, we selected 262 targets with spectral types B0-B3 and luminosity classes I-II. Methods. This work is based on spectroscopic data collected by the FLAMES instrument, mounted on the Very Large Telescope, which gathered nine epochs over three months. Our spectroscopic analysis for each target includes the individual and peak-to-peak radial velocity measurements, an investigation of the line profile variability, and a periodogram analysis to search for possible short- and long-period binaries. Results. By applying a 20 km/s threshold on the peak-to-peak radial velocities above which we would consider the star to be binary, the resulting observed spectroscopic binary fraction for our BSG sample is 23 ± 3%. An independent analysis of line profile variability reveals 11 (plus 5 candidates) double-lined spectroscopic binaries and 32 (plus 41 candidates) single-lined spectroscopic binaries. Based on these results, we estimated the overall observed binary fraction in this sample to be 34 ± 3%, which is close to the computed intrinsic binary fraction of 40 ± 4%. In addition, we derived reliable orbital periods for 41 spectroscopic binaries and potential binary candidates, among which there are 17 eclipsing binaries, including 20 SB1 and SB2 systems with periods of less than 10 days. We reported a significant drop in the binary fraction of BSGs with spectral types later than B2 and effective temperatures less than 18 kK, which could indicate the end of the main sequence phase in this temperature regime. We found no metallicity dependence in the binary fraction of BSGs, compared to existing spectroscopic surveys of the Galaxy and Large Magellanic Cloud.

IDENTIFICATIONS OF SELECTED GAIA OBJECTS AS SU UMA TYPE CATACLYSMIC VARIABLES

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We present the results of optical monitoring of selected Gaia Alerts objects, which we observed at the Lisnyky observation station of the Taras Shevchenko National University of Kyiv. As well as an analysis of open data for CV candidates Gaia17cuh, Gaia18bad and Gaia24amv. Collected data by BHTom project form ASASSN, ZTF and ATLAS as well as our own observations were analyzed.For all three objects, we detected both kinds of outbursts: short outbursts with the duration of some days (normal outbursts) and long outbursts with the duration of ten days or longer (most likely superoutbursts). For Gaia17cuh, Gaia18bad and Gaia24amv we obtained the average durations of normal and superoutbursts and magnitudes at maximum brightness for these outbursts. All these data gives us a possibility to assume that listed above Gaia objects are SU UMa type Cataclysmic Variables. All our observation data were uploaded to the BHTom service and are now available on the Objects pages. For each object, a detailed analysis of historical data was carried out using other observation tools. All these data gives us an opportunity to determine the value of period of superhumps. We are providing ongoing optical monitoring of objects on the Lisnyky observational station.

VARIATIONS OF THE FI SGE LIGHT CURVE SHAPE ACCORDING TO TESS DATA

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We studied the light curve shape variations for the FI Sge (RR Lyr type variable) during 50 consecutive cycles. Our data set contains the TESS photometry for FI Sge, covering the time from MJD 59769 to 59796. Our results confirmed the bi-cyclicity effect for FI Sge, and allowed us to suppose the presence of a complex type of bi-cyclicity.

MATHEMATICAL MODELING OF NONLINEAR DYNAMIC PROCESSES IN PULSATING VARIABLE STARS. PERMUTATION ENTROPY METHOD

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Permutation entropy is a simple tool for assessing signal complexity that takes into account the order and local structure of the time series.

The method was tested on three stars of different types. AF Cyg is a semi-regular giant (SRb) with pulsation mode switching and characteristic times of 93, 163 days and a long period of 926 days. S Per is a slow semi-regular supergiant (SRc) with a variability cycle from 700 to more than 2000 days, sometimes showing clear regularity. o Cet (Mira) is a Mira pulsating with a period of 331 days.

The method proved to be simple to implement and suitable for non-uniform data in time. However, it turned out to be excessively sensitive to changes in local structure (amplitude, phase shifts, light curve asymmetry). When smoothing the permutation entropy curve, local sensitivity is lost. It is also difficult to determine the boundary value of permutation entropy to describe chaotic and regular variability. The method was extended by calculating the first and second derivatives of the smoothed permutation entropy to identify various deviations. It is also proposed to conduct a spectral analysis of the smoothed permutation entropy.

Thus, the method provides information about the complexity of the light curve, but does not always correlate with visual regularity. Combination with other methods (derivatives, regression, spectrum) allows to obtain a more complete picture of the dynamics of the star.

SPECTRAL STUDY OF THE HERBIG AE STAR HD 31648. THE Hα AND Hβ EMISSION LINES

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We present the results of observations of the Ha and Hb lines in spectrum of Herbig Ae star HD 31648. Seven spectra from the Be Stars Spectra Database, with a spectral resolution of R ≈ 11,000, were used, along with three spectra obtained using the 2-m telescope at the Shamakhy Astrophysical Observatory with the Shamakhy Fiber Echelle Spectrograph (R ≈ 28,000). In the spectra at our disposal, the Hα line is predominantly observed as a PCygIII type profile, characterized by a line intensity ratio of Ib/Ir <<1 and in two cases it was observed as a classical PCyg type profile – a red-shifted emission peak with blue-shifted absorption. There is no correlation in the changes in the intensity of the blue (Ib) and red (Ir) components. The blue component undergoes the greatest changes, and variability is also present in the intensity of the red emission peak. The Hβ line profile in the central part shows a PCyg-type structure with wide photospheric wings. The red emission component of the Hβ line shows strong variability, which correlated with the red emission component of the Hα line. In general, variability in the profiles of the Hα and Hβ lines occur synchronously. In the work, a comparative analysis of the behavior of the Hα and Hβ lines is carried out using similar data from published data.

MULTICOLOR ANALYSIS OF VARIABILITY IN THE SYMBIOTIC STAR V407 CYG

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V407 Cyg is a rather unusual symbiotic variable star that exhibited Z And-type outbursts in 1936 and 1998, as well as a short-term but powerful (about 8^m) outburst in 2010, which most closely resembles the outbursts observed in known recurrent symbiotic novae. The red giant component of the system also shows pulsations with a period of about 750 days.

We used multicolor photometry obtained at the Astronomical Institute of the Slovak Academy of Sciences, data from previous published studies of this system, and AAVSO archival photometry to analyze its variability across different photometric bands and timescales, including the stability of its pulsation period. We also compared its long-term and pulsation variability to that of other symbiotic stars, in particular the symbiotic novae PU Vul and RT Ser.

HR 4049: A SPECTROSCOPIC ANALYSIS OF A POST-AGB OBJECT

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A new spectroscopic study of HR 4049, a post-AGB star in a binary system, based on échelle spectra taken

between 2019 and 2025 with the 0.81 m telescope of the Three College Observatory (North Carolina, USA) at a resolution of R ≈ 12 000 is reported. A cross-correlation analysis of 73 spectra of a single C I multiplet in the 4760–4780 Å range yielded the following orbital parameters: the orbital period P = 428.474 ± 0.002 days, eccentricity e = 0.29 ± 0.01, argument of periastron ω = 242.3° ± 0.3°, (epoch of periastron) T_0 = 2 458 383.2 ± 0.6, heliocentric systemic radial velocity γ = −30.12 ± 0.09 km s^{-1}, and semi-amplitude of the radial velocity curve K_1 = 15.52 ± 0.13 km s^{-1}. Phase-dependent variations of the Hα line profile indicate dynamic processes in the circumstellar environment. The luminosity of HR 4049 was refined using the Gaia EDR3 parallax (0.71 ± 0.10 mas), corresponding to a distance of 1 397 ± 170 pc, and the average visual magnitude in the brightest state (m_V = 5.35 mag). The derived luminosity, $\log(L/L_\odot)$ = 4.22 ± 0.12, suggests an initial mass of 3.0–4.0 $M_\odot$. Analysis of the mass function and most probable orbital inclinations (60°–75°) leads to current masses of ~0.75 $M_\odot$ for the primary and 0.70–0.82 $M_\odot$ for the secondary component. The results confirm the system's long-term orbital stability and provide further insights for future research into the nature of post-AGB binaries.

THE PHOTOMETRIC VARIABILITY OF HIGH-MASS X-RAY BINARY HD 226868

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This study presents the results of photometric investigations of the high-mass X-ray binary HD 226868 = Cyg X-1, a well-known system consisting of a stellar-mass black hole and a blue supergiant. The system is notable for being one of the first confirmed black hole candidates and is among the few persistent X-ray sources, in contrast to the typically transient ones. Photometric observations of this star were carried out in the V filter of the BVRI system using a CCD photometer attached to the 60-cm telescope at the Shamakhy Astrophysical Observatory named after N. Tusi, during the period from 2020 to 2022. Data processing was performed using MaxIm DL software. The star HD 226867 (V = 10.7) was used as the comparison star. The stars HD 226938 (V = 10.14) and HD 226919 (V = 9.56) were used as control stars. To complement our observations, we also analyzed high-precision (σ ≈ 0.003 mag) V-band data from the AAVSO database for the star HD 226868.

The analysis reveals both short-term and long-term photometric variability of star HD 226868. These variations may be related to the orbital motion, wind accretion instabilities, or irregularities in the mass transfer process. Our findings contribute to the understanding of the nature of physical processes occuring in massive X-Ray binary systems.

ORBITAL SPECTRAL VARIABILITIES IN SYMBIOTIC STAR AG PEGASI

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The results of the study of orbital spectral variability due to binary nature of the symbiotic star AG Peqasi are presented. Due to the interaction of a hot white dwarf and a cold giant, periodic variations in the radial velocities of the absorption lines of the cold giant and the emission lines formed around the hot component are observed. Two sets of spectroscopic observations were used in the present study. The first set 16 spectrum were carried out at the Cassegrain focus of the 2-m telescope of the Shamakhy Astrophysical Observatory named after N.Tusi, on fiber echelle spectrograph (ShAFES) with the spectral resolution of R = 28000, in 2016-2019 years, the second set 25 spectrum borrowed from the ARAS Spectral Database, obtained in 2020-2024 with spectral resolutions of 9000 - 11000. The system's orbital period is approximately 814 days, and its spectral changes are correlated with this period. In this paper we present the radial velocity curve of the cold component (M3III), as well as the emission lines Hα, Hβ, and the HeII lines λ4686 Å and λ5412 Å formed around the hot component of the AG Peg system, constructed according to our measurements. The mass function of the cold component of the symbiotic AG Pegasi system was estimated from the velocity curve of the red giant.

OPTICAL SPECTROSCOPY OF SYMBIOTIC STAR EG AND. HA ORBITAL VARIABILITIES.

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This paper includes the results of the studies of the orbital variability of the emission and absorption components of the Ha line of the eclipsing symbiotic system EG And. About 30 spectra from the ARAS Spectral Database were used in this research. These spectra were obtained between the year 2010 to 2025 have spectral resolutions of 9000 - 11000. Radial velocity curves of the cool component were derived from the mean of the measured radial velocities of selected absorption lines forming in the atmosphere of a M-type red giant. The system\'s orbital period is approximately 483.3 days. It is assumed that the emission lines, and in particular the Ha line, are formed in the vicinity of a hot white dwarf. We have established that the intensity of the emission component of the Ha line has the greatest value at an orbital phase of about 0.5 (corresponding to the eclipsing of the cold primary component by the white dwarf) and the lowest at about 0.1 (the red giant eclipses the hot secondary component and the region of formation of strong emission lines), and an average at about a phase of 0.8.

EXTRAGALACTIC ASTRONOMY AND ASTROINFORMATICS

CONSTRAINTS ON THE LOW-FREQUENCY STOCHASTIC GRAVITATIONAL-WAVE BACKGROUND FROM GAIADR3 QUASAR PROPER MOTIONS

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In the era of Gravitational Waves observations, searching signals at the very low-frequencies ($<10^{-7}$ Hz) can bring important constraints on cosmology and the early universe. With the next Gaia Data Release (DR4) approaching, astrometric data can be a powerful and complementary tool to other observational techniques, like PTA, for the detection of GWs from a Stochastic Background or Single Sources.

We investigate the two data analysis techniques used for the extraction and characterization of GW signals from quasar proper motions: Vector Spherical Harmonics (VSH) and angular correlation functions (or Hellings-Downs Curve – HDC). Using realistic simulated data, we forecast their sensitivity and accuracy to GWs, and evaluate the impact systematic errors might have on them.

Also, we test scalability, as a significantly growing number of quasars with high quality proper motions is expected in the next Gaia data release (DR4).

Compared to HDC, VSHs appear more statistically robust, less prone to cherry picking and with a significantly smaller computational cost. Besides, pixellisation techniques are available to mitigate further computational issues with acceptable loss in sensitivity.

We find that, with Gaia DR3 proper motions errors, the lower limit for a detectable GW strain is of $\sim 5 \cdot 10^{-11}$, with possible improvements for the next Data Release.

CLUSTERING OF OBSERVED COSMIC WEB

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The results of exploration the clustering of galaxies in datasets from COSMOS2020 data release is reported.

Here, I advocate somewhat different approach to characterization of clustering in observational data, based on less-parametric methods of spatial point processes statistics, namely, Ripley's K and Besag's L∗ functions, as well as Lieshout-Baddeley J function. Such approach is proved to be simple, robust and scalable method for exploring observational data on Cosmic Web.

SHORT-TERM OPTICAL VARIABILITY AND QPOS IN BLAZARS FROM TESS OBSERVATIONS

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We present a preliminary analysis of short term optical variability in 16 blazars observed by TESS full frame images, with a focus on detecting Quasi Periodic Oscillations (QPOs). These short-term variations, occurring on timescales of hours to weeks, may originate from jet dynamics or processes within the inner accretion disk. Specifically, shorter QPO periods could point to Doppler modulation, while longer ones may reflect disk instabilities or precession.

TESS offers high-cadence, near-continuous optical observations ideal for capturing such fast variability, something that's often difficult with ground based telescopes. However, its large pixel size and systematic noise present challenges for accurate light curve extraction. To address this, we tested three photometric extraction methods: Quaver (interactive aperture with background subtraction and matrix regression), TESSreduce PSF (Point Spread Function fitting with background and image shift corrections), and TESSreduce Aperture (fixed aperture).

Our comparative analysis showed that Quaver produced the most consistent metrics (e.g., excess variance, RMS, chi-square), with its flux histograms fitting Gaussian profiles well. PSF gave sharper curves but sometimes less stable results, while Aperture had the most noise. Using WWZ and LSP on the Quaver curves, we detected QPOs in the 0.7–11 day range. Several sources showed multiple periods, hinting at complex origins.

However, we suspect Quaver's strong Gaussian fits may be misleading. Real blazar variability, especially on longer timescales, often shows bimodal or log-normal flux distributions - as seen in PSF and Aperture results. Since Quaver uses matrix regression to remove systematics, it may over-smooth real variability, flattening the light curve and therefore artificially improving Gaussian fits.

To test this, we're developing a method to apply time dependent multiplicative scaling to match TESS data with ground based "truth" (ATLAS). Future work will include red noise testing for QPO validation, flare analysis, and a deeper evaluation of extraction methods for blazars.

DEEP LEARNING-DRIVEN DISCOVERY OF POLAR RING GALAXY CANDIDATES

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We used deep learning methods to search for rare polar ring galaxies in the Sloan Digital Sky Survey. First, we compiled a sample of polar ring galaxies from every available catalog and conducted a visual inspection of this sample. As there is a very limited number of discovered polar ring galaxies, training a classic CNN from scratch would be problematic. Therefore, it was decided to generate synthetic images of polar ring galaxies for pre-training. We used GALFIT software to generate synthetic images of polar ring galaxies. A CNN model was selected and trained on synthetic images and then retrained on a sample of 87 real polar ring galaxies (strong and good candidates). Despite the CNN overfitting, we conducted a search for polar ring galaxies in a Vavilova (2021) dataset of 300k galaxies in SDSS. The search returned 3,246 galaxies with a probability of more than 0.999. We then visually inspected these galaxies and found that our CNN seems to have learned the ring pattern, as most of the galaxies have similarities with a ring, although they are not polar ring galaxies. Our deep learning approach has resulted in the discovery of three PRGs (SDSS J140644.42+471602.0; SDSS J133650.48+492745.3; SDSS J095717.30+364953.5). Finally, a multiwavelength analysis of the SDSS J140644.42+471602.0 galaxy was conducted.

AUTOMATED GALAXY MORPHOLOGY WITH VISION-LANGUAGE MODELS: A FRAMEWORK FOR IDENTIFYING MILKY WAY ANALOGS

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The analysis of large-scale astronomical surveys is often constrained by the scarcity of expert-labeled training data. Addressing this challenge, our work introduces a data-efficient methodology leveraging Vision-Language Models (VLMs) for the task of identifying Milky Way Analog (MWA) galaxies. We benchmark our method by classifying spiral galaxies, utilizing a sample of approximately 170,000 galaxies at z<0.1 from the Sloan Digital Sky Survey (SDSS) with ground truth labels from Galaxy Zoo 2. The core of our technique is the generation of high-dimensional embeddings from SDSS g,r,i imagery using various VLM architectures. A subsequent logistic regression classifier trained on these embeddings demonstrates high accuracy, reaching an F1 score of approximately 90%. A significant finding is the model\'s robustness in low-resource settings, achieving high accuracy with training sets as small as several hundred samples. Beyond classification, the approach provides a versatile foundation for tasks such as anomaly detection, zero-shot classification, visual question-answering and similarity search, thereby enhancing our capacity to discover and analyze MWAs.

MULTIWAVELENGTH SED ANALYSIS OF MILKY WAY GALAXIES-ANALOGUES: THE CASE OF NGC3521

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Milky Way galaxies-analogues provide a unique laboratory for studying the structure and evolution of our Galaxy from an external perspective. In the era of multiwavelength astronomy and Big Data, we can now comprehensively explore such systems by combining observations across the electromagnetic spectrum to reconstruct their physical properties in detail.

This work presents a multiwavelength analysis of NGC~3521, a nearby spiral galaxy considered a close analogue of the Milky Way. The dataset spans from ultraviolet to radio wavelengths, including GALEX (UV), SDSS (optical), 2MASS, WISE, MIPS (Spitzer), PACS, SPIRE (Herschel) for the infrared (IR), and NRAO VLA for radio observations. To reconstruct the spectral energy distribution (SED), we used the \texttt{CIGALE} software, producing two models: one without (model A) and one with (model B) an active galactic nucleus (AGN) component.

The nuclear activity of NGC 3521 is classified as a LINER based on the BPT diagram. The model provides the best fit to the observed SED, which includes contributions from all galactic components under the assumption of an inactive nucleus. From this model, we derive a stellar mass of $M_{star} = 2.13\times10^{10}$ M_{Sun}, a dust mass of $M_{dust} = 8.45\times10^{7}$ M_{Sun}, and a star formation rate of SFR = 1.76 M_{Sun}/yr, with χ^2{d.o.f.} = 1.8$. Based on HIPASS radio data, the mass of neutral hydrogen is estimated as $M_{HI} = 1.3\times10^{10}$ M_{Sun}, which is half the stellar mass.

THE INNER STRUCTURE OF GALAXY CLUSTERS IN ISOLATED PAIRS OF GALAXY CLUSTERS

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We present the result of the study of the distribution of galaxies in 56 galaxy clusters belonging to isolated pairs. The pairs were found in the list 1711 PF galaxy clusters

with estimated redshifts z < 0.15 and richness over 50 galaxies in the cluster field. The selected 56 galaxy clusters with a richness of 100 or more galaxies allow us to study the emergence of the substructures under the only influence of their neighbor. Using the CC tool, we detected the presence of all types of regular substructures having a special alignment.

DERIVING THE LUMINOSITY FUNCTION OF GALAXY CLUSTERS USING DATA FROM THE SLOAN DIGITAL SKY SURVEY

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The luminosity function is one of the fundamental tools enabling the study of the large-scale structure of the Universe, playing a crucial role in investigating both the individual properties of astrophysical objects and their distribution. We present galaxy luminosity functions in clusters based on photometric data from the Sloan Digital Sky Survey. In parallel, we also determine the luminosity functions of galaxy clusters. We compare our results with those previously obtained by our group and interpret them in the context of theories of formation of galaxies and their structures.

USING CLUSTER CARTOGRAPHY 2D FOR DETECTING SUBSTRUCTURES IN THE SIMULATED 3D GALAXY CLUSTERS

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During the detailed study of the inner structure of PF galaxy clusters, we found different kinds of regular substructures in these objects. In addition to the classical filamentary features, we include complex cross-shaped substructures and short dense chains of galaxies as regular. The online version of the Cluster Cartography 2D tool (https://clustercartography.github.io/) allows the detection of all these features on a statistically significant level. We checked the possibility of studying the 3D distribution of galaxies in the simulated galaxy clusters. We showed that using 2D projections allows us to detect the regular substructures, and the 3D version will allow us to restore their real shapes.

CHEMODYNAMICAL PROPERTIES OF GAS-RICH GALAXIES: A COMPARISON OF OBSERVATIONS AND SIMULATIONS

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We perform a comprehensive analysis of the chemical and dynamical properties of quasar-DLA galaxies and compare these to the GEAR, as well as Illustris-TNG, EAGLE and AURIGA chemodynamical simulations. Specifically, we aim to constrain the behavior of α-element enhancements with metallicity, the dependence of [α/Fe] on the specific star formation rate (sSFR), as well as the velocity widths vs. stellar mass, velocity widths vs. metallicity, and mass–metallicity relations. For the comparison, we select five galaxies simulated with the chemodynamical Tree/SPH code GEAR with stellar masses in the range $6.1 \leq \log M_{\star}/M_{\odot} \leq 10.8$ and at six different redshifts between 0.33 and 4.12. We find that the abundance ratios [α/Fe] and [M/H] observed in the ISM of DLA galaxies overlap with the abundance trends in gas of the simulated galaxies. Our findings corroborate a picture in which DLAs with velocity widths below and above 100 $km \cdot s^{-1}$ trace galaxies with masses in the ranges $6 < \log M_{\star} < 9$ and $9 < \log M_{\star} < 11$, respectively. Comparing the simulated [α/Fe] vs. sSFR relations with observations, we suggest that the observed galaxies are experiencing a more intense star formation than is assumed by the theory and used in simulations. We find that the gas distribution within the GEAR simulated galaxies is more compact than that observed for DLAs, which could be attributed to the too weak stellar feedback used in the GEAR code. We further find that the velocity widths vs. stellar mass, and mass–metallicity relations agree well with observations, while GEAR should be calibrated more carefully to reproduce the velocity widths vs. metallicity relation.

SOLAR SYSTEM, EXOPLANETS AND NEAR-EARTH ASTRONOMY

THE DISTRIBUTION OF TEMPERATURE IN THE DETAILS OF JUPITER'S DISK BASED ON THE ABSORPTION LINES OF THE NH3 λ6450 Å BAND

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In order to understand significant meteorological processes occurring in Jupiter's atmosphere, studies were carried out on ammonia NH3 absorption lines, whose relative amount is small but whose influence could be comparable to water vapor in Earth's atmosphere. These observations were performed using a high spectral resolution échelle spectrometer installed at the Cassegrain focus of the 2-meter telescope at Shamakhy Astrophysical Observatory. Variations in the intensity of NH3 absorption lines in the NH3 λ 6475Å band were studied in different regions of Jupiter's disk and at the center of Saturn's disk. Based on the observational data obtained, Jupiter's rotational temperature was determined from different line pairs. The calculated temperatures vary between approximately 180 K and 80 K. The observed variations in temperature could be attributed to lightning events within these layers. Summarizing the obtained results, the average temperature in the details of Jupiter's disk was determined to be approximately 127 K, aligning well with findings reported by other authors.

DETERMINATION OF ROTATIONAL TEMPERATURE IN THE ATMOSPHERE OF URANUS AND NEPTUNE

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The strong absorption bands observed in the visible region spectrum of Uranus and Neptune are mainly due to methane gas. The presence of CH_4 gas absorption bands in the spectra of both planets indicates that the atmospheric temperature of these planets is T > –182.5°C (the melting point of methane gas). It is also known that the effective temperature of Uranus and Neptune, depending on the energy they receive from the Sun, ranges between 49–57 K (at 0.1 bar pressure). Determining at which depth the CH_4 absorption lines are formed in the atmospheres of these planets has been a subject of great scientific interest, and many studies have been conducted in this field.

In our study, the rotational temperature was determined based on the intensity of absorption lines in the R-branch of the CH_4 $5\nu_3$ absorption band at 6800 Å in the spectra of both planets. For this purpose, spectra obtained with the 2-meter telescope of the Shamakhy Astrophysical Observatory (ShAO) on August 30, 2017 (Uranus) and September 17, 2017 (Neptune) were used. The spectra were recorded using a spectrograph with a focal reducer and a fiber optic echelle spectrometer with a resolution of R = 28000. The obtained spectra were analyzed with the help of the DECH software package. Spectral line parameters were measured.

As a result, the rotational temperature in the atmosphere of Uranus was determined to be 78–102 K, and in Neptune 74–112 K. These values show that due to the internal energy of the planets, the methane gas does not freeze, and the presence of heat radiation in Neptune is stronger compared to Uranus.

IMPROVING THE EFFICIENCY OF METEOR OBSERVATIONS BY AUTOMATING AND INTEGRATING THE RMS PLATFORM WITH ARTIFICIAL INTELLIGENCE TOOLS INTO THE VIDEO-SPECTRAL COMPLEX OF THE ASTRONOMICAL OBSERVATORY OF TARAS SHEVCHENKO NATIONAL UNIVERSITY OF KYIV

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The effective obtaining and processing of observational data, with subsequent accurate determination of meteor bodies characteristics, requires constant improvement of both optical instruments and observation techniques, as well as methods for processing the obtained information. Currently, the research group of the Astronomical Observatory of the Taras Shevchenko National University of Kyiv is working on modernization of the video-spectral meteor complex in order to increase the efficiency of observations and the accuracy of the obtained results. Modernization of the video-spectral complex (VSC) occurs through integration with the RMS (Raspberry Pi Meteor Station) platform, which is open-source software from the Global Meteor Network. RMS is designed for automated meteor detection, analyzing their trajectories, and uploading the results to cloud servers for further scientific analysis. The advantages of the chosen approach are: the compactness of the station, which allows placing all components, including the video camera in a sealed box; cost-effectiveness, due to the use of the Raspberry Pi microcomputer; and high-resolution of HD IP cameras (1280 x 720), providing a greater sky coverage area with astrometric precision comparable to analog cameras. The autonomous operation of the station is ensured by both energy independence and the ability to upload data and update software via the Internet. RMS automatically identifies meteors based on the received data, calculates atmospheric

kinematic parameters and heliocentric orbits, which allows to quickly obtain scientifically significant results.

Special attention is paid to the use of artificial intelligence for automatic generation of software code for modeling meteoroid trajectories in order to predict the locations of meteorite impacts. The developed approach was tested on real observations of fireballs. The results demonstrate the prospects for using modern technologies and artificial intelligence in meteor astronomy.

DETERMINING THE ORBIT OF THE TEMPORARY EARTH SATELLITE OF ASTEROID 2024 PT5

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This study investigates the gravitational influence of the major planets and the Moon on the orbital dynamics and mechanical energy of near-Earth asteroid 2024 PT5 during its temporary capture by Earth. Discovered on 7 August 2024 by the ATLAS Sutherland survey, the asteroid transitioned onto an elliptical geocentric orbit in late September 2024 and returned to a heliocentric trajectory in mid-November 2024.

The primary objective is to determine which massive bodies of the Solar System specifically the Moon and the nearest planets facilitated the capture process, induced changes in the asteroid's total mechanical energy during the capture phase, and provided the key perturbations leading to its escape from Earth's gravitational field. High-precision geocentric ephemerides and osculating orbital elements were obtained from the JPL Horizons service. Numerical analyses of the time series for kinetic, potential, and total mechanical energy, as well as eccentricity, were performed to characterize both the capture and release phases.

Particular attention was given to the temporal correlations between the asteroid's close approaches to the Moon and to the major planets, and the corresponding variations in its orbital elements. This approach isolates the intervals during which 2024 PT5 experienced the most pronounced dynamical changes, thereby informing targeted numerical simulations.

The methodology includes a detailed statement of the problem and computational procedure, including the criteria used to define the start and end of the temporary satellite phase and efforts to identify the bodies exerting the strongest gravitational influence. The results lay the groundwork for developing a general algorithm to assess the probability of capture for any near-Earth object, and to evaluate its potential hazard or scientific value for future sample-return missions. Application of these techniques promises to enhance the precision of asteroid trajectory forecasts and to support ongoing planetary defense initiatives.

CHARACTERIZATION OF LUNAR IRREGULAR MARE PATCH INA WITH A SYNTHESIS OF SPACE AND TELESCOPIC MEASUREMENTS

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The Ina Irregular Mare Patch (IMP) on the Moon displays unusual morphology and anomalously young-appearing features. This study combines data from the Lunar Reconnaissance Orbiter, Earth-based telescopes, and Chandrayaan-1's M³ spectrometer to analyze the composition and maturity of Ina's summit pit crater and evaluate its formation.

Measurements of FeO, TiO_2, and optical maturity (OMAT) reveal that the Ina mounds and surrounding flanks share similar composition and maturity, while the rough floor unit is compositionally distinct, with higher TiO_2 content and larger regolith particles. M³ data show a stronger 3 μm absorption in the rough floor, indicating elevated an excess of H2O/OH– compounds and a relatively young surface. These findings are consistent across all datasets.

We assess several formation models and find that a roof-collapse scenario best explains the data. In this model, ancient basaltic eruptions formed a small shield volcano. A lava lake in the summit crater cooled and solidified from the surface downward, creating a roof. The underlying molten lava drained away, leaving a void. Over billions of years, the surface was buried by regolith. Recently—within the last tens of millions of years—a nearby impact likely triggered seismic activity, collapsing the roof.

The collapse created the rough floor from debris and formed the mounds as remnants around structural pillars. Crater density analysis confirms the young age of the collapse, and the preservation of H_2O/OH^- and lack of mature regolith textures further support this. This model accounts for the compositional and maturity similarities between mounds and flanks, the distinct nature of the rough floor terrains that are considered to be very young. The young age of the interior areas is consistent with the photometric and polarimetric data that predict undeveloped fairy-castle microstructure and the availability of large particles in the regolith.

LONG-TERM EVOLUTION OF ROTATION PARAMETERS OF ROCKET BODIES ON LEO (ON THE EXAMPLE OF OBJECT 18340)

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Knowledge of the rotation parameters of space debris objects has a great importance for planning and effective implementation of active space debris removal (ADR) missions. However, this information cannot always be obtained from observations immediately before such missions. It leads to the need to create more or less accurate models of the motion of such objects around their center of mass over long time intervals. This requires knowledge of not only individual factors influencing this type of motion of non-cooperating space objects (NSO), but also the degree of their influence. This can be achieved as a result of long-term observation of the corresponding NSO populations or at least their individual representatives.

In this report, we present the results of an almost nineteen-year (September 2006 – August 2025) study of changes in the rotation parameters of the rocket body with the USSPACECOM ID 18340. During this time, not only data on the change in the rotation period of this NSO over a long-time interval were obtained, but also attempts were made to estimate the change in the orientation of its rotation axis in space using different methods and to determine the causes of such NSO behavior.

ASSESSMENT OF THE FEASIBILITY OF USING A COLOR CMOS CAMERA FOR PHOTOMETRIC OBSERVATIONS

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MAO NASU

This study assesses the feasibility of using a color CMOS camera, the SVBONY SV405CC equipped with a Sony IMX294 sensor, for photometric observations of stars and artificial objects. A UV/IR cut filter was used to better match the R, G, and B channels of the Bayer filter (distinct from standard astronomical photometric bands).

Raw images captured with the Bayer filter were separated into individual channels (R, G1, G2, B), which were processed independently. The G1 and G2 channels were subsequently combined to improve photometric accuracy.

The image processing workflow accounts for both systematic and random noise sources. Systematic components include dark current, fixed-pattern readout noise, non-uniform background illumination, and the stellar background. Random noise sources include thermal noise and stochastic readout noise.

Subsequent processing steps mitigate these effects: B-spline interpolation for background equalization along rows or columns; subtraction of an averaged dark frame; subtraction of a background frame with masking of high-noise pixels; and frame stacking with motion compensation applied separately to stars and satellites. Outlier rejection based on z-scores is performed during interpolation, averaging, and stacking.

Astrometric image processing was performed using the Astrometry.net and SExtractor software packages.

To determine transformation coefficients between the instrumental magnitude system and the Gaia photometric system, cross-matching was performed using the Gaia EDR3, Gaia DR3 Synthetic Photometry, and Gaia DR3 Astrophysical Parameters catalogs via the CDS Upload Cross-Match service in the TOPCAT software (Taylor, 2005). Coefficients were obtained by linear regression.

Processing of test star field observations demonstrated that, with appropriate calibration and image processing, a color CMOS camera is well suited for photometric monitoring of low Earth orbit satellites, providing accuracy sufficient for such tasks.

TYPES OF VOLCANIC FORMATIONS ON THE MOON

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The Moon exhibits abundant evidence of intense volcanic activity in its distant past, which has significantly shaped its present-day appearance. Volcanism, as a fundamental geological process, plays a critical role in the formation and evolution of the surfaces of terrestrial-type planets and their satellites in the Solar System. Therefore, the study of lunar volcanism is extremely important not only for understanding the Moon's own geological history and thermal evolution, but also for drawing comparisons with volcanic processes on other celestial bodies, including Earth, Venus, Mars, and Jupiter's satellite Io.

This work presents an overview of volcanic-related surface structures on the Moon, such as lunar maria, volcanic domes and cones, lava tubes, pyroclastic deposits, and rilles. Particular attention is given to the investigation of skylights—openings that formed as a result of the collapse of lava tube ceilings, providing access to subsurface voids. Their dimensions, spatial distribution, and density are analyzed based on data from the Lunar Reconnaissance Orbiter (LRO). An attempt is made to evaluate specific characteristics of lunar lava tubes, including their lengths, orientations, and burial depths. A comparative analysis with similar terrestrial formations is also undertaken.

Studying lunar volcanoes contributes to our understanding of the formation and evolution of rocky

planets and satellites, and may offer practical implications for potential lunar exploration. The subsurface cavities formed by ceiling collapse within lava tubes are considered as prospective sites for future lunar bases, as they may provide natural shielding against cosmic and solar radiation, micrometeorite impacts, and extreme temperature fluctuations.

THE POSSIBILITY OF DETECTING MAJOR ORGANIC MOLECULES ON THE SURFACE AND IN THE ATMOSPHERES OF EXOPLANETS

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The chemical composition of exoplanet atmospheres is one of the key factors determining the potential habitability of these planets for the emergence and maintenance of life. Recent advances in observational methods, particularly transit spectroscopy, allow for the study of exoplanet atmospheres. This study focuses on the analysis of exoplanetary atmospheres based on spectral data obtained with the James Webb Space Telescope (JWST) and accessed through the NASA Exoplanet Archive.

The aim of the research is to determine the chemical composition of exoplanet atmospheres and to search for potential biosignatures that may indicate conditions favorable for life.

Five terrestrial or super-Earth exoplanets were selected for analysis, some of which are located within the habitable zone: GJ 486 b, LHS-475 b, L 98-59 c, TOI-836 b, and TOI-836 c. The primary method used was transit spectroscopy, and spectral modeling was carried out using the Planetary Spectrum Generator (PSG). The generated models were compared with observational data to identify molecules such as CH4, H2O, CO2, NH3, N2O, O3, among others.

In several cases, possible traces of biosignatures were identified; however, the data quality generally does not allow for definitive conclusions about their presence. The results highlight the importance of further refinement of atmospheric models and the expansion of spectroscopic observations in the search for biosignatures.

LIGHT CURVES OF THE SELECTED EXOPLANETS' TRANSITS

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We present the results of determining the parameters for 4 exoplanets' transits. Light curves were obtained using the Unistellar eVscope 2 telescope. We calculated their mid-transit times for future Transit Timing Variation (TTV) analyses, total transit duration, ingress/egress transit duration, and transit impact parameter (in stellar radii). The results are discussed.

COMPARATIVE ANALYSIS OF CANON EOS CAMERAS CMOS SENSORS

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The paper presents some results of Canon EOS CMOS photosensors study. Cameras with image sensor formats of 22.2 × 14.8 mm and 36.0 × 24.0 mm were studied. The analysis was conducted at ISO=100. Analysis method is based on application of a proportional factor of photosensors logarithmic sensitivity function.

Typically, the parameters of the trend lines of the experimental dependence of the sensor output signal on the predictor are determined by the corresponding simple regression equations S(x)=Kx+A for linearly scaled operands, or lgS(x)=(1+a)lgx+b for the logarithmic scaled data. In the second case, S(x) = Cx×x^a, where lgC=b. For small values of the parameter a, the multiplier Cx is a factor of proportional dependence of the operands of the logarithmic function of the sensor sensitivity, and the difference in the factor x^a characterizes the deviation of the dependence of S(x) from proportionality. The authors decided to use the functional relationships as a tool for estimating the photosensors linear response ranges.

Analysis of experimental images show a slight discrepancy in the parameters K and C for all cameras studied (K is slightly more than C, by 2-5%).

In small-format cameras, when the sensitivity function lgS(lgx) is used, the ranges of linear response of the sensors are 61 – 66 dB and 70 – 84 dB in the R, G, B channels at sensitivity levels of 80, 170, 90 DN/sec. When using the C parameter of the logarithmic sensitivity function, the sizes of these ranges take average values 63 – 57 dB. Similar changes in the calibration methodology of more modern wide-format cameras cause a narrowing of the linear response ranges from 85 dB to 70 dB at sensitivity levels of 319.2, 547.0, 323.4 DN/sec.

Taking into account the results of conducted analysis, the use of proposed metodics with C parameter can be considered acceptable.

FOCUSING SYSTEM UPGRADE OF THE AZT-8 TELESCOPE FOR ENHANCED OBSERVATIONAL PERFORMANCE

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As astronomical instrumentation evolves, the modernization of legacy telescopes has become essential to maintain their scientific relevance and operational

efficiency. In Ukraine, many telescopes remain structurally viable but require targeted technical upgrades to meet modern observational and educational standards. We present the results of a modernization project for the AZT-8 telescope (D = 70 cm, F = 280 cm), focused on enhancing its optical performance through the development and implementation of a new focusing system and coma correction. The upgrade employs a compact optical-mechanical unit designed to interface with commercially available CCD cameras and other scientific-grade detectors. This modernization is an example of how small-size observatory-class telescopes can be revitalized with cost-effective and modular enhancements. The upgraded instrument now supports imaging and photometry, positioning it for continued use in both research and student training. This project illustrates a scalable path for other institutions aiming to extend the operational life of aging optical systems.

REFLECTANCE SPECTRA OF DISTINCT SURFACE UNITS IN THE MARCIA CRATER REGION ON VESTA

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Marcia (190°E, 10°N, D = 67.60 km) is the youngest large impact crater on Vesta. Both the crater and its surroundings are notable for hosting the majority of Vesta's pitted terrains — features potentially linked to outgassing processes in volatile-rich, impact-melted material. Additionally, the region is characterized by irregularly shaped deposits known as lobate orange material patches, named for their distinctive orange-to-red tones in Clementine false-color maps. Previous studies suggest that these deposits may have formed through interaction between typical surface regolith and melt material excavated during the formation of the Rheasilvia impact basin.

Despite being relatively young and large enough to disrupt and excavate sub-surficial material, Marcia do not exhibit presence of dark mantle ejecta, unlike the neighboring mid-size crater Octavia. Absence of the wide diffuse dark mantle deposit and resemblance of pitted terrains and lobate orange material patches spectra make region around Marcia an appealing target to investigate.

We built global color-ratio mosaics of the region as well as particular areas hosting orange material patches and/or pitted terrains. For number of selected features normalized color spectra were built. As input data we used calibrated images obtained by Dawn spacecraft's onboard instrument Framing Camera during HAMO orbital phase. We claim color ratio C(438nm/749nm) as the most informative, while other color ratios served for additional validation.

As a result, we found that both pitted terrains and orange material exhibit higher albedo, redder spectral slopes, and generally deeper 0.9 μm pyroxene absorption band compared to the surrounding surface. However, these features also display markedly different morphologies and spatial distributions across Vesta's surface. Detailed analysis of the reflectance spectra behavior of both features will be presented during the presentation.

TIME SYNCHRONIZATION IN THE RADIO AND AUDIO FREQUENCY RANGES TO OBSERVE ARTIFICIAL EARTH SATELLITES AND METEOROIDS

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A feature of radio observations of artificial Earth satellites and meteoroids in the "Mykolaiv Observatory" department is the use of an SDR receiver based on a USB receiver of terrestrial digital TV and radio ("DVB-T+DAB+FM"). Payload signals, respectively, are the radiation of radio beacons from artificial Earth satellites and the reflection of the signal of the French radar GRAVES by the plasma trails of meteoroids. The required frequency measurement error is ensured by using an external reference signal of the receiver, the relative frequency error of which is 10^{-10} and is ensured by phase synchronization with the sinusoidal signal of 10 MHz of the GPS receiver. A pilot signal is used for time synchronization, namely, 1 Hz pulses on the given carrier frequency. In this case, an inexpensive generator with the ability to control the frequency from a computer is used to generate the carrier frequency. The pilot signal pulses are synchronized with the PPS (Pulse-Per-Second) signal of the GPS receiver. The error in determining the time by the pilot signal does not exceed a few ns.

To create a complex for recording infrasound waves generated by meteors, sound-metric hardware and software complexes were developed and tested using standard sound recording devices. Here too, a time synchronization error of 10 μs is ensured by using a pulse pilot signal synchronized with the PPS at a carrier frequency of 6 kHz.

CREATING A PROTOTYPE NETWORK OF TWO DOPPLER STATIONS FOR ACCURATE ORBIT DETERMINATION OF LOW-EARTH SATELLITES WITH BEACON

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The work was carried out within the framework of the scientific cooperation agreement between the Research Institute "Mykolaiv Astronomical Observatory" (RI "MAO", Ukraine) and the Shanghai Astronomical

Observatory of the Chinese Academy of Sciences (SAO, China), aimed at creating a network of Doppler stations for tracking satellites. The stations are designed to determine the Doppler frequency shift of radio beacon signals (in the range of 430-440 MHz), which some low-orbit satellites are equipped with. A network of two ground stations located in Mykolaiv (Ukraine) and Sheshan (China) was developed for observing such satellites. Each station is equipped with an omnidirectional antenna covering the upper hemisphere, consisting of eight horizontally polarized Yagi elements. Automatic switching between antenna sections is carried out on the basis of pre-calculated azimuths and elevation angles using orbital data from the NORAD catalog. Satellite signals are received by inexpensive DVB-T+DAB+FM receivers. The software provides real-time control, signal processing and orbital parameter refinement.

A prototype network of two stations was tested during synchronous observations, successfully demonstrating the possibility of refining the orbital elements of low-orbit satellites equipped with beacons. Five identification sessions were conducted for the OSCAR-19 satellite, resulting in four refined orbital solutions. The radial velocity determination error did not exceed 15 m/s, which corresponds to a Doppler shift error of 21 Hz.

To further improve the measurement accuracy, the following improvements are proposed: increasing the frequency stability of the receiver\'s reference oscillator from 10^{-6} to 10^{-9} using a frequency synthesizer and synchronizing the measurements with absolute time using a 1 PPS (pulse per second) signal. These improvements will allow more accurate tracking and refining of low-orbit satellite orbital elements using the available ground infrastructure.

DURATION OF SUNLIGHT EXPOSURE OF NEAR-EARTH SATELLITES DURING THE YEAR

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The aim of this work is to construct a refined model of the illumination of artificial satellites in Earth orbits.

In Earth orbit, satellites can be in the shadow or penumbra of the Earth for long periods of time. To model this, we used a circular cone approximation based on a circle with the mean radius of the Earth. The satellite\'s motion is modeled by a Keplerian orbit. The computer model allows us to determine with a given accuracy the duration of the satellite\'s stay in the Earth\'s shadow and penumbra.

We have modeled the duration of satellite illumination in different types of orbits throughout the year. The results of the modeling will allow us to refine the influence of solar radiation and solar wind on the movement of satellites over a long period of time.

The paper presents the obtained durations of exposure to direct sunlight, penumbra, and shadow of satellites in low, medium-altitude, and geostationary orbits. This will allow the use of additional satellite accelerations resulting from radiative effects to change the orbits of space debris and clean up near-Earth space.

To build a sophisticated model of illumination around Earth satellites, we must take into account the time the satellite spends in shadow and penumbra on the Sun. To do this, we wrote a program that calculates the time satellites spend in each of these zones at different moments. In addition, we calculate the time spent in shadow and penumbra using another program.

Shadow and penumbra are formed as a result of the Sun creating huge cones of shadow and penumbra around the Earth. We derived the equations for the cones, taking into account the movement of the Sun, and use them in our programs.

The results of the time a satellite spends in a certain zone depend on the height of its orbit above the Earth\'s surface, the time of day at any time of the year, the position of the Sun relative to the Earth, and other elements of the satellite\'s orbit.

Conclusions: We will use the results obtained to analyze the illumination of orbits in order to understand which orbits can use sunlight to combat space debris.

THE DETERMINATION OF THE EXOPLANET TYPE FROM ITS TRANSIT LIGHT CURVE

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We present the results of our classification of the exoplanet candidate OGLE-TR-1061 b. The data for its transit light curve were extracted from the OGLE (Optical Gravitational Lensing Experiment) database, which contains a large number of photometric observations of variable stars and potential exoplanet host stars.

Our analysis demonstrates that OGLE-TR-1061 b is a hot Jupiter. The results of our classification are discussed.

PHOTOMETRIC ANALYSIS OF IMP SOSIGENES BASED ON LROC NAC DATA AND ITS POSSIBLE VOLCANIC ORIGIN

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Irregular Mare Patches (IMPs), which have hypothetical origin as a result of volcanic activity, are anomalous photometric and geological formations on the Moon. Sosigenes is one of the largest IMP formations of this type after Ina and is a prominent representative. Because of the unusual and complex characteristics of

IMPs, their specific mechanism and time of formation are being discussed.

IMP Sosigenes is located at the bottom of a deep abyss and has a varying degree of manifestation, uneven distribution along the edges of the former lava lake.

New additional information for understanding the mechanisms of formation of Sosigenes and other IMPs has been provided with our photometric studies. Our method of photometric correction of LROC NAC data is based on analysis of phase dependence of albedo in wide range of phase angle.

We performed model calculations of parameter maps of the proposed Korokhin et al. two-parameter phase function for this region. All used images have been co-registered, combined and corrected for the geometric and photometric influence of lunar topography using high resolution DEM obtained by us.

On the maps of phase ratio of the equigonal albedo EA(67º)/EA(34º), photometric anomalies are clearly visible: the light spots correspond to the IMP Sosigenes formation, the dark formations are rocks and landslide structures, and the gray color highlights usual undisturbed lunar regolith. The phase dependence of the equigonal albedo of the Sosigenes demonstrates striking differences in the optical properties of the various selected areas, the inverted behavior of the dependence for the "hummocky" areas relative to the usual surrounding regolith, and a significant difference in the surface roughness of the "blocky" and rocks and to other surface groups.

THE PROBLEM OF MONITORING NEAR SPACE

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The report will present the problem of monitoring near space by observing artificial space objects. The main attention is paid to the photometric observation method as the most effective tool for diagnosing the state of artificial space objects in orbit. For demonstration, the results of space debris observations conducted using the Celestron CPC 925 telescope with the ZWO ASI174MM camera will be presented. The results obtained are of practical importance for monitoring near space and planning strategies for removing space debris from orbit.

RADIO ASTRONOMY

LOW-FREQUENCY ANTENNA FOR RADIO ASTRONOMY STUDIES OF THE UNIVERSE FROM THE FAR SIDE OF THE MOON

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Radio astronomy research at low frequencies, particularly below 30 MHz, offers a highly promising avenue for investigating the early Universe, stellar flares, galactic magnetic fields, and other cosmic phenomena. However, the Earth's ionosphere acts as a cutoff barrier to these radio waves, preventing their detection by ground-based telescopes. Consequently, modern radio astronomy is increasingly focused on the development of space- and lunar-based observatories specifically designed to operate within this unique spectral range.

In this direction, a prototype of a low-frequency active antenna was developed and studied at the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine. The prototype is designed for both autonomous operation and integration into interferometric systems or antenna arrays intended for future lunar telescopes. Although the ultimate goal is deployment on the Moon, a substantial portion of the research and testing was conducted under terrestrial conditions. This allowed for a detailed examination of the antenna's characteristics and its potential applications across a broad range of Earth-based studies, including astrophysics, atmospheric phenomena, ionospheric behavior, and radio wave propagation.

RESTORATION AND DEVELOPMENT OF THE GURT RADIO TELESCOPE NETWORK: NEW OPPORTUNITIES FOR OBSERVATIONS UNDER WARTIME CONDITIONS

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The Giant Ukrainian Radio Telescope (GURT) is a next-generation low-frequency instrument designed to study cosmic radio emissions within the 8–80 MHz frequency range. Following the full-scale invasion by the Russian Federation, a substantial portion of GURT's equipment was damaged or destroyed. Despite ongoing military activity and extensive destruction, the staff of the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine undertook significant efforts to restore and adapt the infrastructure. Last year, the restoration of two GURT sections located at the S.Ya.Braude Radio Astronomy Observatory was completed and presented, following the installation of a solar power plant at the site.

This report presents the results of the restoration and commissioning of the third section of the GURT. Due to the complexity of conducting work near a combat zone, mine contamination, and persistent power supply issues at the S. Ya. Braude Radio Astronomy Observatory, the third section was restored and installed at a new location – at the Poltava gravimetric observatory in Stepanivka, Poltava region, adjacent to the URAN-2 radio telescope. An uninterruptible power supply was established, which is critically important in conditions of frequent outages. This enabled regular monitoring of sporadic solar radio emissions. Furthermore, the section was used to identify and partially eliminate internal (local) radio interference caused by observatory equipment – an essential step toward improving the quality of acquired data. These efforts highlight the persistence and adaptability of Ukrainian radio astronomers in wartime, driven by a commitment to preserving scientific capability and continuing exploration of the Universe.

UNESCO HERITAGE PAGES IN RADIO ASTRONOMY ASSOCIATED WITH BERNARD LOVELL AND BORIS KASHCHEYEV: DISCUSSION

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In the twentieth century, radio technologies triggered a scientific revolution in astronomy akin to Galileo's telescope of 1609. Sir Bernard Lovell is honoured not only for building the first fully steerable radio telescope (the future Mark I or Lovell Telescope, operational mid-1957), but also as a pioneer of meteor-radar research. In December 1945, he brought ex-military radar equipment to Jodrell Bank; unexpectedly, the instrument returned a stream of transient radio echoes, which he later confirmed – alongside contemporaneous visual reports – to be ionisation trails from meteors, long before Mark I existed. On the peak night of the 1946 meteor storm (Draconids, then called Giacobinids), his "searchlight telescope" with Yagi antennas detected thousands of echoes on 9–10 October; rotating the antenna by 90° abruptly cut signals to background levels – convincing confirmation that the echoes came from meteors, not terrestrial sources. These early experiments directly influenced Lovell's concept and pushed for a large steerable dish, leading to the creation of the Mark I

telescope. Jodrell Bank Observatory (founded in 1945) was placed on the UK's Tentative World Heritage List on 7 July 2010, shortlisted on 22 March 2011, nominated in January 2018, and officially inscribed as a UNESCO World Heritage Site under criteria (i), (ii), (iv) and (vi) on 7 July 2019. Today, Jodrell Bank continues to sit at the forefront of radio astronomy—especially in very-long-baseline interferometry (VLBI), which traces its conceptual roots to the early era of radar-based atmospheric observations including meteor echoes. Moreover, under Lovell's influence, meteor-radar research became a highlighted branch of the 1957 International Geophysical Year (IGY); in that programme both he and later Boris L. Kashcheyev's Kharkiv team were internationally recognised among the world's foremost for meteor-radar achievement. In 2025, we commemorate the 105th anniversary of Boris L. Kashcheyev's birth (8 March 1920 – 15 January 2004).

We therefore propose formally considering UNESCO heritage designation for the Kharkiv Meteor-Radar Centre – including the MARS radar, the B. L. Kashcheyev Radio Astronomy Laboratory, and its archival collections – as a potential site now under threat due to the war in Ukraine.

ON THE ISSUE OF IMPLEMENTING APERTURE SYNTHESIS TECHNOLOGY ON THE URAN-3 RADIO TELESCOPE

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The main aspects of implementing aperture synthesis technology for a simple interferometric system with a small number of baselines have been analyzed. Results of modeling and experimental reconstruction of a radio image of a sky region are presented. It is shown that the scanning time required for image reconstruction when interferometer antennas are placed along the East-West line and Earth\'s rotation is used, fundamentally depends on the width of its synthesized beam. For the URAN-3 radio telescope, this is approximately 1 hour. Reducing the scanning time requires additional interferometric baselines oriented at an angle to the East-West line and the application of appropriate techniques, such as artificial rotation or aperture masking.

BEHAVIOR OF IONOSPHERIC SCINTILLATION CHARACTERISTICS OF COSMIC RADIO SOURCES DURING THE SOLAR ECLIPSE OF MARCH 29, 2025

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As is known, a solar eclipse initiates transient processes in the atmosphere caused by the Moon screening the flow of electromagnetic and corpuscular radiation from the Sun. The investigation of the dynamics of these transient processes is one of the area in the study of Solar-Terrestrial relations. Our work relates to the study of the influence of solar eclipses on ionospheric turbulence. One of the markers of ionospheric turbulence is scintillation of compact cosmic radio sources. In this paper, we consider the behavior of ionospheric scintillations characteristics of cosmic radio sources in the decameter wavelength range during the partial solar eclipse of March 29, 2025. We obtained observational data on the URAN-4 radio telescope located near Odessa, Ukraine. Usually, with a significant maximum phase of the eclipse at the observation site, a direct effects of a screening of the solar radiation can be detected. During the eclipse of March 29, 2025, at the location of the radio telescope, the maximum phase was 0.018. In this regard, the direct effect of the eclipse is small and the focus is on the indirect effects of the eclipse on the ionosphere in the observation area.

METHODOLOGY FOR STUDYING TRANSIENT RADIO EMISSION IN THE SOLAR SYSTEM AND THE GALAXY BASED ON THE ANALYSIS OF THE EXISTING ARCHIVAL DATABASE OF THE URAN VLBI

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The reseaech of transient cosmic radio emission is an important way to study transient cosmic processes with high energy release. Many sources of transient rradio emission are known and successfully studied. The availability of information on the coordinates of tsources and the patterns of radio emission allows planning and conducting radio astronomical observations, despite the sporadic nature of the appearance of transient signals. Everything comes down to the possibility of conducting a certain amount of observations on a specific radio telescope. The task is complicated if the source of transient radio emission is not determined. There are two known ways to solve the problem of effectively searching for sporadic transient radio emission when the coordinates of its source are unknown. The first way is to use large antenna arrays with a synthesized directivity pattern or to use a network of radio telescopes with a wide directivity pattern and VLBI technology. The second way is to use large archive databases of radio astronomical observations, from which, with special processing, it is possible to extract information on sporadic transient signals and their sources. This approach is widely used (for example, the first Fast Radio Burst was discovered during the analysis of archived data from the Parkes radio telescope in Australia). Our work examines the use of the URAN VLBI archive database for reseaeching sporadic

transient radio emission and determining the coordinates of sources. An algorithm for extracting transient signals from URAN VLBI archive records is presented. The result of processing the transient signal is shown.

KNOTS OF RADIO EMISSION OF THE NORTH POLAR SPUR AND CYCLIC ACTIVITY OF OUR GALAXY

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Since 2003 we have proposed the North Polar Spur (NPS) may be the kpc-scale jet of our Galaxy enveloped by extended cocoon. The NPS is the very intensive large scale feature of the Galaxy radio background emerging from the Galactic disk. The NPS's structure is very inhomogeneous. We have used the NPS radio maps by number authors obtained at high frequencies. Our analysis of separated knots of the NPS allows to estimate the time of possible activity of our Galaxy. For this aim we have obtained the jet propagation velocity (the magnetic field strength), the linear distance among separated knots.

VISUALIZATION AND ANALYSIS OF VECTOR NETWORK ANALYZER MEASUREMENTS FOR THE EXPERIMENTAL ACTIVE ANTENNA MODEL OF THE GURT RADIO TELESCOPE

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During the development and testing of radio engineering devices, such as the active antenna sections of the GURT radio telescope, effective processing and interpretation of measurement data is critically important. The graphics v.1.9 program was developed to significantly improve the processing of data obtained from the Obzor-103 vector network analyzer.

This program offers advanced measurement data visualization capabilities, allowing users to generate high-quality graphical reports suitable for publications and presentations. A key feature of graphics v.1.9 is the function of averaging measurements of the same type. This allows us to obtain generalized characteristics of the devices under study, identify statistical deviations, and evaluate the repeatability of results, which is especially valuable when analyzing the parameters of a series of identical components.

The use of graphics v.1.9 significantly improve the efficiency of analyzing experimental data obtained during the study of the active antenna section of the GURT radio telescope, providing tools for a deeper understanding of the system's characteristics and optimization of its operation.

MODELING OF AN ADAPTIVE INTERFERENCE SUPPRESSION SYSTEM FOR LONG-WAVELENGTH RADIO ASTRONOMY APPLICATIONS

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In long-wavelength radio astronomy, wideband signal processing is often hampered by various sources of terrestrial interference. The objective of this study is to develop an effective interference mitigation approach by modeling an adaptive system capable of compensating for both stationary and short-term interference in radiometric and radio interferometric systems.

Based on the analysis of experimental data from long-wavelength radio astronomy, a mathematical modeling framework is proposed for cosmic signals and terrestrial interference. It is shown that the problem reduces to mathematical modeling of the wideband stochastic signal processing in the presence of short-term narrowband interference with unknown spectral characteristics. The methodology enhances the conventional two-channel spatial correlation processing approach by incorporating estimated correlation properties of the interference to enable effective suppression.

An adaptive time-domain interference suppression system is developed, based on estimating the correlation parameters of interference in each spatially separated receiving channel. Requirements for the size of the training dataset during system adaptation are established for various interference models. To reduce computational complexity associated with covariance matrix inversion, a time-domain implementation using adaptive lattice filters is proposed.

The proposed adaptive systems do not require significant hardware overhead compared to conventional radiometric and interferometric configurations. They achieve near-optimal signal detection performance under short-term interference conditions.

MEASUREMENT OF TOTAL SPECTRA OF COSMIC RADIO SOURCES AT DECAMETER WAVELENGTHS IN INTERFEROMETRIC STUDIES WITH THE URAN NETWORK

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Combined with data obtained at higher frequencies, this allows the construction of spectra of radio sources that refine the flux density estimates at decameter wavelengths, reveal spectral characteristics of their low-frequency emission, and identify various absorption effects present in the studied objects.

MONITORING RFI IN INTERFEROMETRIC STUDIES WITH URAN

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The signals received by the interferometric receivers of the URAN radio telescope network contain both useful information about cosmic radio emission and interference signals of various origins. The receiver software implements an efficient algorithm for the real-time excision of narrowband interference, which is a common problem in low-frequency radio observations. Using this algorithm, spectral regions affected by interference are identified and removed “on the fly”, while the cleaned signals are recorded for further correlation processing. At the same time, information about the spectral structure and average power of the removed interference is stored in the same data files, providing data for post-processing analysis. These data were used to monitor radio frequency interference (RFI) at the network’s telescopes as a function of frequency, observation time, and other parameters. Archival data from several years of observations were processed, and average RFI levels at 20 and 25 MHz were obtained within a 250 kHz bandwidth during predominantly nighttime winter sessions. In addition, new observations were carried out using the URAN-1 radio telescope to determine diurnal variations in RFI at 20 and 25 MHz. The dependence of spectral occupancy and average interference power on frequency was evaluated. The results are compared with earlier RFI studies conducted at the URAN-1 and URAN-4 telescopes. The findings contribute to improving data quality and interference mitigation strategies in low-frequency radio astronomy.

PERSPECTIVES OF THE SOLAR RADIO EMISSION STUDIES WITH THE ADVANCED GURT ANTENNA ARRAY POWERED BY SOLAR ENERGY

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The first test results of the upgraded, small-size, broadband GURT antenna array powered by the solar power plant are presented in the report. To reduce the conductive interferences from the power plant current converter the line filter that effectively suppresses noises from 20 MHz up to 80 MHz was developed and implemented. The primary analysis of the different solar radio bursts such as Type II, IIIb, III, IV, U- bursts, spikes, drift pairs, which were registered during the summer campaign of observations in 2024, is performed. The bursts associations with the events occurred on the solar surface and in its corona observed with the SOHO, SDO, and WIND space station are also discussed.

SPECTRAL INVERSION EFFECT OF "ELECTROMAGNETIC SMOG" IN THE SHORT AND ULTRASHORT WAVE RANGES

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Physical saturation of radio airwaves with signals from multiple artificial sources has been known since the mid-20th century. By now, this phenomenon has taken the form of a poorly controlled, quasi-natural disaster. From a general ecological point of view, the phenomenon has a negative character and has received the terminological definition of "electromagnetic smog". At the end of the 20th century, there was a sharp shift in user interest from the shortwave range to the more information-intensive ultrashort wave range. The studies of the “noise” environment conducted half a century ago have lost their relevance and need to be updated.

The measurements were carried out in the band of 10…160 MHz, covering the “broadcast” ranges of short and ultrashort wavelengths. A wideband receiver with a Fourier spectrum analyzer was used: 3818 channels of 40 kHz, analyzed in parallel. The Fourier spectrum analyzer FFTS-160 was developed at the RI NASU based on an FPGA matrix. The main advantage of the FFTS-160 in application to the task at hand is a sharp, approximately 4 orders of magnitude, reduction in the time of full spectrum review. Taking into account the implemented accumulation (integration) time in a single channel of 5 sec, parallel analysis allows for a full cycle of measurements to be carried out within an hour. Studies under identical weather conditions and time of day obviously have increased reliability.

We measured the background radio environment during the day and at night, varying the size, polarization and spatial arrangement of the antennas. A large array of primary data was obtained, allowing not only to characterize the radio environment as a whole, but also to identify the most important sources: AM and FM broadcasting, television, etc. It is concluded that the density of quasi-noise energy in the VHF range, even in the evening/night time, is almost 20 dB higher than in the shortwave range. Previously, when a large number of high-power short wavelengths broadcasting stations were in operation, the situation was the opposite. It is this effect, characterized quantitatively by the authors, that is proposed to be called "spectral inversion" of the electromagnetic environment. Our observations were conducted in a highly urbanized area. The specific location is the outskirts of Kharkov. Far from large cities, the spectral inversion effect will probably be weaker. Additional studies are needed to obtain a more detailed picture.

APPLICATION OF AN AUTOREGRESSIVE NEURAL NETWORK FOR FILTERING INTERFERENCE CLUSTERS FROM THE FLUX MONITORING DATA OF POWERFUL RADIO SOURCES AT THE URAN-4 RADIO TELESCOPE

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The URAN-4 phased antenna array (Mayaky village, Odesa region), operating in the decameter radio range (10-30 MHz), is an element of the Ukrainian national low-frequency radio interferometer, URAN. Operating in a single-station mode, it has provided unique data for over 30 years on the flux variations and scintillations of powerful radio sources, which are dependent on space weather conditions. The observations cover the period of solar activity cycles 22 through 25.

However, a critical problem for monitoring observations of cosmic radio sources in the decameter range is interference of both natural and anthropogenic origin. In the URAN-4 observation data, three main types of interference can be identified: impulsive, in the form of individual high-amplitude spikes; random, appearing as a 'cloud' of points above and below the recorded scans of radio sources; and interference clusters, which are regions with a compact arrangement of numerous high-amplitude outliers. While the first two types of interference can be removed with varying degrees of effectiveness using digital filtering methods, interference clusters are practically impossible to eliminate through such means. This is because they heavily distort the moving average and median values of the signal.

In this work, the removal of this type of interference is accomplished through the application of an autoregressive neural network for adaptive filtering of interference in the radio source recordings data from the URAN-4 radio telescope (at 20 and 25 MHz frequencies). The results demonstrate that the autoregressive neural network effectively suppresses high-amplitude interference clusters in the URAN-4 data by predicting the normal signal behavior and identifying deviations. It automatically trains on clean sections of the signal and adapts to changing conditions and interference types, all while preserving the structure of the useful signal and the ionospheric scintillations. It has been experimentally shown that, in the context of the interference environment at the URAN-4 antenna location, this approach is particularly robust against both interference clusters and impulsive noise.

JUPITER'S DAM RADIO EMISSION AND SOLAR ACTIVITY: IO-DEPENDENT AND NON-IO SOURCES

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There is analyzed the activation of storms of the DAM radio emission of Jupiter that formed due to ionization in the auroral zone of the Jupiter's lower magnetosphere under influence of the dense solar wind and the coronal mass ejections (CME). Penetrating into the magnetosphere of Jupiter, the streams of solar matter can reach the polar regions of the Jupiter's ionosphere and activate the sources of non-Io DAM radiation. On the other hand, changes in the structure and current layers of the Jupiter magnetosphere under the pressure of the solar wind and CME will enhance the Io-dependent DAM radio emission.

The parameters of the activating Alfven waves and their physical characteristics for non-Io and Io-dependent sources are estimated. The corresponding structures are found and analyzed in the large-scale dynamic spectra of the DAM radio storms.

It is shown that the DAM radio emission of Io-dependent storms begins with the activation of the source at an altitude of 0.3 Rj of the magnetosphere (with a high density of neutral gas), and then, within an hour, gradually descends to the ionosphere of Jupiter. At the same time, a structure of low-frequency Alfven waves create the DAM source, in which the wave vector of the wave unfolds over time in the direction of MHD energy transfer. The storm power may be modulated by the solar wind pressure on the magnetosphere of Jupiter.

On the other hand, in non-Io radio sources associated with solar plasma injections, the ionosphere is initially heated by splashes of solar matter containing high-energy ions, and is later activated by MHD (Alfven) pulses coming from the magneto-tail with current discontinuities. As a result, the high-energy ion plasma of sun-wind matter affects the DAM radiation of these sources, which leads to the formation of a number of specific DAM bursts, for example, with a zebra structure in high-resolution dynamic spectra.

ANGULAR STRUCTURE OF RADIO GALAXY 3C20 AT DECAMETER WAVELENGTHS

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Studies of extragalactic radio sources at decameter wavelengths using the URAN interferometric network have revealed that their angular structures often differ significantly from those observed at decimeter and shorter wavelengths. As the observation frequency decreases, the flux ratio between compact hot spots and extended lobes often changes, typically due to the steeper spectra of the diffuse components and the increasing impact of absorption processes, such as synchrotron self-absorption or free-free absorption in the surrounding medium. Additionally, the apparent angular sizes of the lobes increase at lower frequencies, and their positions may shift toward the central active nucleus. In some cases, large-scale, low-surface-brightness structures with steep spectra

become visible, which are undetected at shorter wavelengths.

In this study, we investigated the angular structure of the FRII-type radio galaxy 3C20 using data from the URAN interferometers at 20 and 25 MHz. At 1400 MHz, this radio source has a maximum angular size under one arcminute and consists of two symmetric lobes with bright hot spots. Our results show that at decameter wavelengths, the structure of 3C20 undergoes substantial changes. We observe a redistribution of flux among components and an increase in the angular extent of the lobes. The presentation will report the measured parameters of the individual components at low frequencies, compare them with those at higher frequencies, and discuss the physical mechanisms responsible for the observed structural and spectral changes.

MULTI-FREQUENCY STUDIES OF DECAMETER CARBON RADIO RECOMBINATION LINES AT UKRAINIAN UTR-2 AND URAN-2 RADIO TELESCOPES

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This report will be devoted to hardware and methodological features of multi-frequency studies of carbon radio recombination lines (RRLs) at Ukrainian UTR-2 and URAN-2 decameter radio telescopes. The instruments, equipment as well as the methods of highly sensitive radio spectroscopy at decameter wavelengths will be discussed. The UTR-2 and URAN-2 radio telescopes which operate at frequencies below 32 MHz are the most advanced tools for carbon RRLs studies in this range. The using of broadband multichannel DSP-Z digital spectrum analyzers at these studies is crucial for the high measurement sensitivity achievement. In report the recent results of decameter carbon RRLs studies carried out on UTR-2 (2017 – 2021) and URAN-2 (2023 – 2025) radio telescopes will be presented. Using the examples of both pointing and transit observations, the possibilities of radio spectroscopy in RRLs will be shown using multi-channel receiving equipment and various observational methodologies. The impact of higher frequency resolution on the observation results (2 kHz instead standard 4 kHz) will be presented. Various methods for estimation the sizes of decameter RRLs forming regions will be analyzed (including through the multibeam and multisection measurements). Transit observations of RRLs in Galaxy will be highlighted separately using the example of celestial sphere surveys.

ON THE POSSIBILITY OF JOINT ANALYSIS OF OBSERVATIONAL DATA OF PULSED, CONTINUUM, AND MONOCHROMATIC RADIO EMISSION IN THE DECAMETER RANGE

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The report will address the potential for joint analysis of observational results from various types of radio emission – pulsed, continuum, and monochromatic – to refine the physical conditions in the diffuse interstellar gas. In Ukraine, extensive research has been conducted over many years on pulsars, continuum emission, and spectral lines in the decameter wavelength range. Each of these research objects is characterized by a specific set of physical parameters (electron temperature, electron density, dispersion measure, etc.) and their frequency dependence. This report will be focused on investigation and validation of method for the joint analysis of these physical conditions. Such a joint analysis, based on measurements of radio emission from pulsars and carbon radio recombination lines in the same direction, will enable more precise determination of electron density and emission measure. Additionally, a novel method for studying HII regions at low frequencies will be proposed, which involves analyzing the pulse delay of a pulsar located behind of HII region along the line of sight. Comparing the observational validation of this proposed method with classical approaches to studying HII regions in the decameter range, based on their screening of the Galactic non-thermal background, will provide insights into some questions, particularly regarding the increase in the dispersion measure values of pulsar signals as they propagate through these regions at high frequencies.

PERIODIC PROCESSES IN AGN AND THEIR JETS BASED ON MOJAVE VLBI MONITORING OBSERVATIONS

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Active galactic nuclei (AGN) demonstrate unique dynamics of matter movement in jets, which is directly related to active processes occurring in the nuclei and leading to the formation of jets up to kiloparsec scales.

For more than two decades, the MOJAVE (Monitoring Of Jets in Active Galactic Nuclei with VLBA Experiments) project is carried out – systematic observations of more than 500 AGNs have been conducted using VLBI technology, including a frequency of 15 GHz, achieving a resolution of ~0.12 mas, which allows resolving the close environment of the active nucleus, including with good time coverage. During this time, the project has managed to collect an amazing set of data, in particular, on flux (in the format of tables and radio maps) and the movement (separation jet) of bright features (components) in jets.

These data allow for the study the kinematics of their motion, its patterns and variations, as well as compare and correlate with the processes that occur in the nuclei in particular and in the jets in general according to the data on the variability of radio fluxes. Analysis of the positions of the components shows the presence of both general trends and individual variations; the presence of moving and quasi-stationary components that only slightly change their positions relative to the core over time.

Based on the moving components, the average velocities and accelerations in the jets were estimated in projection onto the picture plane. The distribution of the velocities of the components in the jets was also investigated and assumptions were made about their structure and injection conditions.

Of particular interest are the periodic movements of the components: around their average positions (for quasi-stationary) and movement trends (for moving). Which can be caused by the propagation of shock waves and recollimation shocks in the jets.

SOLAR ACTIVITY, SOLAR-TERRESTRIAL RELATIONS, ASTROBIOLOGY

RECENT ADVANCES IN SOLAR RADIO OBSERVATIONS AND IMAGING WITH THE RT-32 RADIO TELESCOPE AT IRBENE

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This work presents recent advancements in solar radio astronomy at the Ventspils International Radio Astronomy Centre (VIRAC), focusing on the modernization and automation of observational workflows using the RT-32 radio telescope. A comprehensive web-based platform has been developed to streamline solar observations at centimetre wavelengths, integrating scheduling, real-time control, data acquisition, and automated image reconstruction. The system enables operators to generate solar tracking files based on astronomical ephemerides, execute spiral scanning procedures, and produce solar brightness maps using advanced image processing methods such as bilinear interpolation and Gaussian filtering. Built entirely with open-source tools and Python-based astronomical libraries, the infrastructure significantly enhances observation reproducibility, data accessibility, and long-term scalability.

The RT-32 telescope, equipped with the multichannel Low Noise Spectral Polarimeter (LNSP4), was also employed during the partial solar eclipse on 29 March 2025, observed from Irbene, Latvia (eclipse phase: 15–16%). Spectral-polarimetric measurements of the Sun were carried out in the 4.1–14.1 GHz range (2.1–7.3 cm) across 12 frequency channels for both left and right circular polarizations. The eclipse provided a unique opportunity to probe near-limb microwave emission from the quiet Sun with enhanced spatial resolution, as the Moon's shadow acted as a natural spatial modulator. Simultaneous full-flux measurements at 4.07, 6.42, and 8.40 GHz were analyzed to derive the brightness temperature distribution in the near-polar solar region.

This combined study demonstrates how automated observing systems and celestial events such as solar eclipses can be synergistically leveraged to enhance the spatial diagnostic capabilities of single-dish radio telescopes in solar research.

METHODS FOR IDENTIFICATION OF QUASI-PERIODIC PULSATION IN SOFT AND HARD X-RAY RADIATION OF SOLAR FLARES

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The study of quasi-periodic pulsations of solar flares in the X-ray range provides opportunities for elucidating the fundamental physical processes of the plasma dynamics of the flare, plasma and magnetic field diagnostics. Analyzing flares in different energy ranges, the key question of identifying pulsations and their characteristics arise. Accordingly, the purpose of this study is to identify quasi-periodic pulsations for selected solar flares and to perform a comparative analysis of the methods used in different energy ranges according to data from the STIX Solar Orbiter instrument.

To achieve this goal, spectral analysis methods are used: fast and short-time Fourier transform. The power spectral density of the Lomb-Scargle periodogram and wavelet analysis was estimated.

As a result, the curves of the fast Fourier transform spectrum, the spectrograms of the short-time Fourier transform, the spectral density curves of the Lomb-Scargle periodogram and the spectrograms of wavelet analysis were obtained. All methods were performed for six energy ranges. These results clarify the applicability and limitations of the methods used and show the characteristics of these pulsations.

Keywords: STIX, Solar Orbiter, X-ray flare, Fast Fourier Transform, Short-Time Fourier Transform, Lomb-Scargle periodogram, Wavelet analysis.

A STUDY OF THE CHARACTERISTICS OF ASSOCIATED SOLAR FLARE-CME EVENTS

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Solar flares and coronal mass ejections (CMEs) are the most intense processes of energy release in the solar atmosphere and the most important sources of space weather. Often, these phenomena are observed simultaneously and accompany eruptive processes

occurring in the same active region on the solar surface. Such events are usually called associated flare-CME events. Previous studies of such events have shown that there is a temporal relationship between the phases of flare progression and the CME phases.

The soft X-ray (SXR) intensity pattern profiles in the range of 4-10 keV, recorded by the STIX instrument of the Solar Orbiter mission, are used as a feature of solar flares. This range of the STIX instrument describes the thermal component of the X-ray emission of a solar flare. Based on the SXR profile and its temporal parameters, all flare-CME matching events are classified into groups: impulsive, gradual, and long-duration events. Criteria for classifying events into groups are proposed.

During its development, at each phase, the CME can have observational signs in X-ray and radio ranges. The slow ascent phase is characterized by a series of weak flares in the SXR. It is followed by a rapid acceleration phase with maximum acceleration of the ejection. Usually, it is the shortest phase and, as a rule, its end corresponds to the peak of the X-ray emission, and it is accompanied by radio bursts of different types, depending on the origins of the magnetic reconnection and the dynamics of the process.

We present the analysis of several flare-CME associated events in the X-ray and radio ranges during the CME acceleration phase. These studies show the possibility of using the SXR profile signatures for the associated flare-CME events for space weather forecasting.

This work is supported by the "Long-term program of support of the Ukrainian research teams at the Polish Academy of Sciences carried out in collaboration with the U.S. National Academy of Sciences with the financial support of external partners".

APPLICATION OF CLUSTER ANALYSIS METHODS TO SPATIAL AND TEMPORAL DISTRIBUTION OF SOLAR FLARES IN DIFFERENT CYCLES. TEMPORAL AND SPATIAL DISTRIBUTION OF POWERFUL FLARES ON THE SUN IN 23-25 CYCLES OF ACTIVITY DETERMINED BY CLUSTER ANALYSIS

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The analysis is based on the catalogs of the World Network of data on powerful solar flares for 23-25 cycles of activity. These data include the time, duration and coordinates of flares, the connection between coronal mass ejections, and the presence of a proton flux.

A database and relevant software have been prepared. This made it possible to obtain samples for each cycle of activity for flares of different power points, to identify the nature of the movement of the zones of flare activity formation for the northern and southern hemispheres of the Sun.

Of particular interest is the distribution of the most powerful flares, accompanied by coronal mass ejections and proton fluxes. Each of the cycles under study shows a different temporal and spatial distribution of the most powerful X-ray flares of the X and M classes.

To determine the trends in the development of flare activity, cluster analysis of various variants of parameters that determine the state of space weather and the manifestations of geomagnetic planetary storms was used.

Cycle 25 of solar activity demonstrates the most rapid shift of the zones of flare activity to the equator and the presence of clusters mainly in the southern hemisphere.

FEATURES OF THE 25TH CYCLE OF SOLAR ACTIVITY IN THE MAXIMUM PHASE OF ITS DEVELOPMENT

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Solar activity significantly affects the environment and is closely related to geomagnetic phenomena. Reliable forecasts of solar activity help to assess these natural processes. Mathematical and statistical methods are currently used to predict solar activity. In addition to the cycle amplitude, the assessment of such cycle parameters as the duration of the growth phase of the cycle and the total duration of the solar activity cycle is of considerable interest.

To estimate the specified parameters of the 25th cycle, we used the construction of the dependence of the cycle amplitude, the duration of the growth phase and the duration of the cycle on the rate of increase in activity based on the known data of the 24 previous cycles. The determination of the coefficients of linear and polynomial dependences was performed using the OriginPro 8 software environment. In this work, we clarified the previously calculated forecast of the 25th cycle, estimated the duration of the growth phase and the total duration of the 25th cycle, taking into account the average rate of increase in activity in the growth phase of the 25th cycle.

The constructed dependencies made it possible to specify the amplitude of the 25th cycle, which is Wmax 25 = 156.3 ± 14.4 units (the previously obtained amplitude of the cycle was estimated within 150-160 units), as well as to calculate the duration of the growth phase and the full duration of the cycle. The duration of the growth phase and the full duration of the cycle were calculated using linear and polynomial dependencies. The values obtained using linear and polynomial dependencies are close to each other.

The course of the 25th cycle indicates that according to https://www.swpc.noaa.gov/ until October 2024, the increase in the average monthly smoothed Wolf numbers continued: in August 2024 – 156.7 units, in September 2024 – 159.3 units, in October 160.8, and in November there was a decrease to 157.0 units (as is known, the time of occurrence of the maximums and minimums of the cycles is set by the smoothed average monthly values of the Wolf numbers). It should be noted that the average monthly

observational values changed with significant fluctuations from 216.0 units in August 2024 to 79.2 units in May 2025.

As a result of the work performed, the forecast of the amplitude of the 25th cycle was refined, the duration of the growth phase of the cycle and the duration of the 25th cycle of solar activity were calculated. It was found that the dependence of the duration of the growth phase of the cycle on the rate of increase in activity is quite high. The best result was obtained for a polynomial dependence (polynomial of degree 2) with R-Square (COD) = 0.84. In this case, the duration of the growth phase of the 25th cycle should be 57.8 months. For linear dependence, we have the best result for Pearson's coefficient r = - 0.88. In this case, the duration of the growth phase of the 25th cycle should be 58.8 months. Based on the result obtained for the duration of the growth phase of the 25th cycle, an estimate of the duration of the 25th cycle was made based on the obtained dependence of the cycle duration on the duration of the activity increase phase. The best result for the polynomial dependence for the 25th cycle is 11.5 years. For linear dependence, we have the best result for Pearson's coefficient r = 0.56. In this case, the duration of the 25th cycle should be 11.2 years.

THE INFLUENCE OF LUNAR-SOLAR TIDES IN THE EARTH'S ATMOSPHERE ON THE VISIBILITY OF COSMIC BODIES IN UKRAINE IN THE NEXT THREE YEARS

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Lunar-solar tides in the Earth\'s atmosphere change the density of the air at different altitudes. At the tidal phase, the resultant of tidal forces from of the Moon and the Sun is directed upwards relative to the horizon, in the ebb phase – downwards relative to the horizon.

At the ebb phase at certain altitudes there will be an increase in air density due to the lowering of the higher layers. Therefore, during these periods more meteors with high appearance altitudes should be recorded. This conclusion is confirmed by the analysis of the meteor catalogues.

At the tidal phase, the upper layers of the atmosphere rise to even greater heights. This may in some way affect the movement of spacecraft in low orbits.

The values of the resultant of tidal forces of the Moon and the Sun for different periods of the year in different cities of Ukraine for 2026 - 2028 have been calculated.

At the tidal phase, the resultant values are maximum in June and December. Besides, these values are somewhat greater for lower latitudes. For Odessa, they are 10-20% greater than for Kyiv. The values of tidal forces do not depend on the geographical longitudes.

The maximum values of the resultant at the tidal phase in 2026 are 7% greater compared to 2027 and are 11% greater compared to 2028.

At the ebb phase, the values of the resultant are the same for each year and practically do not depend on either the season or geographical coordinates. Therefore, the visibility of meteors at anomalously high altitudes will always be the same for Kyiv, Odessa, Kharkiv and Lviv.

MODELING THE INTERRELATION BETWEEN DATA CHANGES IN THE GEOMAGNETIC FIELD, COSMIC RAYS AND SOLAR WIND USING DIFFERENT TYPES OF NEURAL NETWORK AND CROSS-SPECTRAL WAVELET ANALYSIS METHODS

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This study examines cross-spectral correlations between solar wind parameters (from the NASA OmniWeb catalog) and geomagnetic variations (measured at Sodankylä, Finland and Belsk, Poland stations), as well as cosmic ray intensity variations (from OULU Neutron Monitor) over the period January 1 – April 9, 2024. The research explores the possibility of short-term geomagnetic variation forecasting using different types of neural networks. The study applies cross-spectral FFT analysis method and wavelet coherence analysis to identify spectral correlations in the data. An approximating neural network was used for precise reconstruction of Forbush decreases and the detection of rapid cosmic ray intensity variations in the declining region. Several attempts have been made to predict geomagnetic field data using different approaches and types of neural networks. The experimentally observed wave activity effects, caused by solar wind flows to the geomagnetic field and cosmic ray intensity, provide some new insights into regional differences in solar activity responses between the polar and mid-latitude regions of Earth.

MORPHOLOGICAL FEATURES OF EXTREME GEOMAGNETIC STORM SOURCES

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The modern world is becoming increasingly vulnerable to geomagnetic storms due to the rapid development of new technologies and technical systems. This applies to all areas of human activity where power grids, GPS, the Internet, and digital communications are used.

Storms can cause damage to energy, aviation, navigation, satellite electronics, communication systems, industry, and the agro-industrial complex. Extreme geomagnetic storms can cause enormous economic damage and endanger to human health. Their prediction is very important, but not yet perfect enough.

Extreme geomagnetic storms are typically caused by coronal mass ejections (CMEs) during powerful flares. A detailed investigation of their sources is very important. To study the conditions that favor the occurrence of extreme storms, we selected 8 active regions (ARs) that were their sources in solar cycles 23, 24, and 25 in the period from 2000 to 2024. We have analyzed the spatial and temporal evolution, the morphological characteristics, magnetic field structure, and the flare activity of the ARs NOAA 09077,

09393, 10484, 10486, 10501, 10696, 11520, 13664. Some ARs were concentrated in large activity complexes.

The magnetograms, continuum images and EUV-images were provided by the Michelson Doppler Imager (MDI) on board the Solar and Heliospheric Observatory (SOHO), the Solar Dynamics Observatory (SDO) the Helioseismic and Magnetic Imager (HMI), and the Atmospheric Imaging Assembly (AIA). The X-ray data were obtained at Geostationary Operational Environmental Satellite (GOES).

The ARs studied developed rapidly, their area and number of spots increased, the magnetic structure became more complex, and the flare activity increased. Most of these AOs had a very large maximum area of more than 2000 millionths of a solar hemisphere. On the days when the eruptions occurred the ARs were located near the central meridian, and the Bz-component of the interplanetary magnetic field was directed to the south. Their area and number of spots were close to the maximum, the magnetic configuration in most cases was βγδ. The sources of the CMEs were M and X class flares, which were preceded by the rapid emergence of new magnetic fluxes and their reconnection with the already existing magnetic field of the region.

The most powerful geomagnetic storms in the considered period with a DST index of geomagnetic activity (Disturbance Storm Time Index) less than -400 nT were observed on November 20, 2003 and May 10, 2024. The storms were caused by CMEs from flares occurred in ARs NOAA 10501 and 13664. These ARs were characterized by complex magnetic topology and rapid magnetic flux emergence. The storm on May 10, 2024, was preceded by cannibal CMEs that enhanced its strength and duration. The most powerful storm of the period under consideration, on November 20, 2003, with a DST of -422 nT, was caused by a CME from an M3.9 flare in the AR NOAA 10501. During the peak of the storm, auroras were observed as far south as Florida, Michigan, and Wisconsin in the United States and Greece in Europe. It was found that ARs with a small area and moderate flares can cause very powerful extreme storms, while ARs with a large area and powerful flares do not cause them.

NORTH-SOUTH ASYMMETRY OF SUNSPOT ACTIVITY DURING THE MAUNDER MINIMUM

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An important clue to the study of the influence of solar activity variations on the Earth\'s climate is the Maunder Minimum (1645–1715), during which exceptionally few sunspots were observed. Applying the rare event analysis method to these observations allowed the researchers to conclude that the appearance of spots during the Maunder Minimum is characterized by a weak amplitude 22 year cycle. The concept of continuity of magnetic cycles at this time is also supported by measurements of cosmogenic radionuclides in natural terrestrial archives. Therefore, it is now generally accepted that during the Maunder minimum, the cyclic magnetic activity of the Sun did not stop, although the amplitude of the cycles was quite low. Within the framework of the αΩ dynamo model, researchers explain this by the fact that the magnitude of the magnetic induction of the toroidal field excited by the radial differential rotation in the solar convective zone (SCZ) at this time did not reach the threshold value necessary for the lifting of magnetic force tubes to the solar surface (nonlinear dynamo mode).

An important feature of the weak activity during the Maunder minimum was its strong north–south asymmetry, when sunspots were observed mainly in the southern hemisphere of the Sun. The observed asymmetry of surface magnetism may be associated with the asymmetry of the structure of the deep magnetic field of the Sun. Therefore, it is necessary to look for ways to detect this asymmetry. We proposed a dynamo scenario that takes into account the Ω effect in the deep layers of the radiant zone (below the SCZ) and the αΩ dynamo process in the SCZ. The key role in the proposed scenario is played by the special mode of the Sun's internal rotation. According to the data of helioseismological experiments, the SCC is divided into polar and near-equatorial domains with opposite signs of the radial gradient of angular velocity. In addition, the radial gradient of angular velocity penetrates into the deep layers of the stable radiant zone below the SCZ. It is shown that, taking into account these data, the αΩ dynamo excites two harmonics (dipole and quadrupole) of the toroidal field in the SCZ, which change their direction with the period of the solar cycle. At the same time, the deep Ω effect in the radiant zone creates a toroidal field of stationary orientation. The superposition of the quadrupole harmonic of the toroidal field of the SCZ and the stationary toroidal field of the radiant zone can lead to a predominance of the intensity of sunspot formation in one of the hemispheres of the Sun.

POSSIBLE SIGNATURES OF EXTREMELY STRONG MAGNETIC FIELDS OBSERVED IN A SUNSPOT USING SPECTRO-POLARIMETRY IN A SPECTRAL RANGE OF 75 ANGSTROM AROUND THE D3 LINE

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The main goal of our research was to search for super-strong magnetic fields in ‘quiet’ sunspots without flares. Our method is based on Stokes *V* spectro-polarimetry in a wide spectral range – from –50 Å to +25 Å relative to the D3 He I line. Observations were carried out with the Echelle spectrograph of the horizontal solar telescope of the Astronomical Observatory of the Taras Shevchenko National University of Kyiv (HST AO KNU). The objects of the study are two simple sunspots of 35-40 Mm in diameter, which were observed on July 17 and 24, 2023, close to the disk center, with the heliocentric angles of about 18 degrees. The novelty of our study: in the second sunspot, we found characteristic spectral features at approximately –18.8 and –8.4 angstroms from D3 He I line, which can be strongly split Zeeman sigma components of the mentioned line for the following reasons: (a) their Stokes *V* signs are opposite, and amplitudes reach 5%, significantly exceeding the

measurement errors, (b) amplitudes of 'blue' and 'red' peaks change synchronously along the entered slit of the spectrograph, (c) spectral profiles of both peaks are similar in shape and mutually anti-symmetrical. If the indicated spectral features are interpreted as a manifestation of a joint action of Zeeman and Doppler effects, then we can assume the existence of very fine-structured (spatially unresolved) jets in the sunspot, in which the magnetic field's order of magnitude is 10^5 G, and the ascending plasma velocity reaches 700 km/s. If this interpretation is confirmed, it will be possible to take a new look onto two current problems in heliophysics: anomalously fast rotation of the corona at low latitudes and arising of superstrong magnetic fields in the chromosphere and corona.

It is worth recalling that it was precisely such a hypothesis – about high-speed flows from under the photosphere, which can effectively heat the solar corona – that was proposed by the Teacher of the author of the report, Nikolai Avenirovich Yakovkin (1915-1993); this was around the 1980s. Nikolai Avenirovich repeatedly and convincingly presented his idea of a "cold" corona at seminars and scientific meetings of the observatory. This idea greatly interested another student of Nikolai Avenirovich, Prof. Peter Heinzel. He expressed his readiness to begin searching for spectral manifestations of high-speed flows from under the photosphere on the basis of a thorough study of the spectrograms that were then obtained on HST AO KNU. For certain reasons, this was not done then. Most likely, such searches would then be fruitless, since it was thought possible to detect such flows from data in unpolarized light, i.e. in the Stokes parameter *I*. But from the data obtained by the author (V.L.) it follows that the corresponding effects can be observed only in polarized light (Stokes parameter *V*), while in parameter *I* they are not visible. That is, it seems that the hypothesis of N.A. Yakokin is correct, but it was put forward before the time when it could be confirmed instrumentally.

STUDY OF THE PROPERTIES OF FAST GEOMAGNETIC VARIATIONS IN THE ODESA MAGNETIC ANOMALY, USING DIFFERENT METHODS OF FREQUENCY-TIME SPECTRAL ANALYSIS

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The Odesa Regional Magnetic Anomaly (ORMA) is one of the largest in Ukraine, covering a significant part of the Odesa region. From 2018 to 2022, measurements of rapid geomagnetic field variations were conducted at the Odesa Astronomical Observatory, located in the central part of ORMA, to study the influence of the magnetic anomaly on the spectral shape and properties of regular and noise-like variations within the 10–600 second period range. This study has used applied programming methods and numerical data analysis using different approaches to bandpass filtering of data and construction of frequency-time spectra. The main characteristics of these variations during geomagnetic storms were examined using continuous wavelet analysis and discrete wavelet decomposition. A comparison was made with the geomagnetic variations recorded on the same days at the Nurmijärvi Geomagnetic Station, Finland.

SPECTRAL FEATURES OF A SINGLE TYPE III BURST IN THE FREQUENCY RANGE OF 0.3 -19 MHZ ACCORDING TO PSP DATA

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A solar flare in AR 13234 was happened on the dark side of the Sun during 15 perihelion of Parker Solar Probe (PSP), on 13 March 2023. This flare initiated the CME, which accompanied with Type II and Type IV bursts at low frequencies. As usual a group of powerful Type III bursts preceded this radio activity. Before this group PSP registered a simple powerful Type III burst in the wide frequency band from 0.3 to 19 MHz. Maximum flux of this burst was more than 10 times of background flux. It allowed studying spectral characteristics of this Type III burst in details as for single Type III burst observed by UTR-2, URAN-2 and GURT on 4 June 2020 at higher frequencies from 8 to 70 MHz. In this report we show that the Type III burst observed by PSP has properties similar to those for Type III burst at frequencies 8-70 MHz. Electrons with higher velocities are responsible for the leading edge and the electrons with smaller velocities generate radio emission of the trailing edge. The functional dependence of Type III burst duration on frequency again is close to Elgaroy-Lingstad one. We also show that Type III radio flux increases with decreasing frequency at high frequencies with maximum at 2 MHz and after that the flux is decreased quickly.

REGARDING THE CONNECTION BETWEEN SOLAR ACTIVITY WITH THE SUN'S LARGE-SCALE MAGNETIC FIELD AND THE EARTH'S MAIN MAGNETIC FIELD

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It is known that on average the large-scale magnetic field of the Sun ((LSMF) changes its direction every 11 years (Schwabe cycle), that is, after 22 years (Hale cycle) it has the same direction. The same periodicity is characteristic of solar activity (SA). The Earth's main magnetic field (IGRF) had one direction for the last 680,000 years. Hale cycle begins at the maximum activity of an odd 11-year cycle, when the LSMF at the north pole is directed from the Sun (positive during the decline phase of the odd cycle and during the growth phase of the activity of the of the 11-year cycle). At the minimum of the solar cycle, the heliospheric current layer which causes

the LSMF (heliomagnetic equator), lies in the plane of the solar equator, while at the maximum it can be tilted up to 90°. At the minimum between the 22nd and 23rd SA cycles, the LSMF was positive in its north and negative in its south and at the maximum of the 23rd SA cycle it changed to negative in the north and positive in the south. At the 24th SA maximum, the field changed from negative in the north to positive in the south. Therefore, in the minima before odd cycles, the field in the northern hemisphere has a positive direction and, accordingly, in odd cycles of solar activity during their maximum, the polarity of the LSMF changes from positive to negative, and in even cycles – vice versa. The maximum manifestation of the dipole character of the LSMF is observed during solar minimums. During the weakening of the LSMF and the movement of the dipole axis to the equatorial plane, it acquires a quadrupole character and the superposition field of the Maunder butterflies begins to play the main role. The Maunder butterfly field has a polarity opposite to the polarity of the near pole.

The report analyzes the solar activity of the southern and northern hemispheres depending on the direction of the LSMF and the main magnetic field of the Earth. It also shows the consistency of solar activity with the rotational regime of the Sun and the Earth, which indicates, a likely, physical connection between them.

25 CYCLE OF ACTIVITY OF THE NORTHERN AND SOUTHERN HEMISPHERES OF THE SUN

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The features of the 25th cycle associated with the difference in the development of the activity of the northern and southern hemispheres of the Sun are considered. At the growth phase of cycle 25, its activity, in contrast to previous cycles, manifested itself in a simultaneous increase in the number of groups of spots of both hemispheres. Subsequently, the northern hemisphere became one of the leaders, which formed the first maximum of the cycle.

In 2024, the activity of the southern hemisphere began to prevail, which formed the second-main maximum of the cycle in August this year. It seems that the main "secret" of the increased activity of the 25th cycle, according to the Wolf numbers, for the entire disk of the Sun was the synchronization of the manifestation of the activity of the Sun's hemispheres.

The convergence of the spot-forming zones of the Northern and Southern hemispheres is currently taking place against the background of a general decline in activity. To what extent the manifestations of the active periods of the 25th cycle are possible in the case of the formation of complexes of activity uniting groups of spots of the northern and southern hemispheres will be shown in the near future.

The features of the manifestations of cycle 25 in the northern and southern hemispheres were identified using correlation, cross-spectral and wavelet analysis. At the same time, the degree of synchronicity of the manifestation of activity in the northern and southern hemispheres of the Sun and the main periodic processes of their activity was revealed.

RADIATION ENVIRONMENT IN MARS VICINITY DURING DIFFERENT PHASES OF SOLAR CYCLES 24 AND 25 ACCORDING MEASUREMENTS BY LIULIN-MO DOSIMETER ABOARD THE EXOMARS TRACE GAS ORBITER

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Presented are the results for the dose rates and particle fluxes of the galactic and solar cosmic rays in the interplanetary space and in Mars orbit obtained during different phases of solar cycles 24 and 25 in the period April 2016 – July 2025. Data are provided by Liulin-MO dosimeter aboard the ExoMars Trace Gas Orbiter. Discussed is the selection of the best time interval in the solar cycle for a future manned trip to Mars, regarding the radiation safety. The obtained results may be used for verification and benchmarking of the galactic and solar cosmic rays models in the free space and in Mars orbit.

EFFECTS OF THE MARCH 29, 2025 SOLAR ECLIPSE FROM RADIO ASTRONOMICAL AND MAGNETOMETRIC OBSERVATIONS IN THE "STRUVE GEODETIC ARC" REGION

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The penumbral solar eclipse of March 29, 2025, provided a unique opportunity to investigate the effects of ionospheric scintillations of cosmic radio sources and rapid geomagnetic variations caused by the transient weakening of solar ionizing radiation, as well as other accompanying phenomena. The eclipse was visible in Western and Northern Europe, the northern part of Eastern Europe, northeastern North America, Greenland, the North Atlantic, and the polar Arctic region, including the area of the "Struve Geodetic Arc."

An observational campaign was organized and conducted in collaboration with the Ventspils International Radio Astronomy Centre (Latvia), the Institute of Radio Astronomy of the NAS of Ukraine, the Sodankylä Geophysical Observatory (Finland), and the Institute of Geophysics of the NAS of Ukraine. The search for ionospheric effects was carried out using the phased low-frequency antenna arrays LOFAR LV614 (Latvia)

and KAIRA (Finland), located within the eclipse zone. Data from magnetometer stations situated along the "Struve Arc" were also used. Data from magnetometer stations in the United Kingdom and Canada revealed local bursts of rapid geomagnetic variations during the passage of the lunar penumbra.

Over the territory of Ukraine, the eclipse was observed at a significantly lower phase (Kyiv and Lviv – approximately 0.6%). On the day of the eclipse, a decameter-wavelength radio burst was registered on the Sun, along with quite intense ionospheric scintillations of the radio source Cas-A, observed by the LOFAR telescope in Latvia. Based on this data, a comparison was made between the scintillation patterns of Cas-A and those from March 28 (a geomagnetic storm).

In collaboration with the Institute of Geophysics of the NAS of Ukraine, an unusual burst of irregular variations in the 22–60 second period band was recorded by the magnetometer at the URAN-4 observatory (Mayaky, Ukraine) on March 29, 2025, from 11:00 to 14:00 GMT (eclipse interval: 8:51 – 12:44 UTC). Analysis of observations from geomagnetic stations in Ukraine (Odesa, Kyiv), Finland (Sodankylä, Nurmijärvi), Romania (Surlari), and Poland (Hel) showed the presence of very similar patterns of geomagnetic variations on the day of the eclipse. Furthermore, the predominant periods of longer geomagnetic variations in the data from the eight magnetometer stations were found to be very close, at approximately 74, 46, and 34 minutes. For verification, additional data from geomagnetic stations in Canada (Iqaluit) and the United Kingdom (Lerwick) were analyzed, yielding similar results.

This work presents a synthesis of the obtained results and compares them with other studies on the characteristics of ionospheric scintillations and geomagnetic variations during solar eclipses.

DIGITIZATION OF ANALOG RECORDINGS OF POWERFUL RADIO SOURCES MONITORING ON THE URAN-4 RADIO TELESCOPE IN THE 22ND CYCLE OF SOLAR ACTIVITY USING MACHINE VISION METHODS

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The report examines the process of digitizing the records of the URAN-4 radio telescope at frequencies of 20 and 25 MHz for the period 1987-1992, based on classical methods of machine vision. Monitoring observations included: supernova remnants Cassiopeia A and Taurus A (3C461, 3C 144) and radio galaxies Cygnus A and Virgo A (3C405 and 3C274).

The observations were made in the mode of passing through the directional pattern with observation intervals of 40 minutes (3C 144, 3C 405, 3C 274) and 60 minutes (3C 461) two hours before and after the culmination. Particular interest in such data is the possibility of using digital methods for processing unique analog data from the period of magnetic storms and observations of radio sources during the passage of tidal waves in the ionosphere.

For comparison with the state of the geomagnetic field, a catalog of geomagnetic storms for the period of radio astronomical observations from 1987 to 2009 was used, compiled in cooperation with the Institute of Geophysics of the National Academy of Sciences of Ukraine, based on data from the Odesa Geomagnetic Observatory. According to it, priority time intervals were selected for digitizing analog records. The results of digital processing of analog data for various types of radio source records are demonstrated.

ATMOSPHERIC OZONE RESPONSE ON SOLAR ACTIVITY BY MLS VERTICAL DISTRIBUTION DATA

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Solar ultraviolet radiation is a primary source determining ozone distribution in the Earth's atmosphere. Photochemical reactions are predominantly important in the upper stratosphere and mesosphere, at the heights above 30–35 km. There are two main phenomena of solar origin that can influence variations in ozone concentrations at least at some altitudinal levels. Firstly, 11-year solar cycle can cause long-term periodical changes. Secondly, high-energy solar flares can decrease ozone content, in particular, due to precipitation of charged particles into the polar mesosphere. In this case, the effect can appear with time delay relative to the solar flare, reaching several days.

Our goal is searching both the mentioned phenomena using vertical profiles obtained by Microwave Limb Sounder (MLS) onboard Aura platform operating since 2004 hitherto. The limb measurements are rarer in comparison with usual total ozone data calculated from backscattered ultraviolet radiation, that restricts their coverage of the Earth's surface. As a result, we have considered the grid with the step of 4° by latitude and 20° by longitude, but the ozone values for these cells are not available for some days. In addition, the observations are limited by the latitudes lower 80°.

The MLS ozone data cover the atmospheric layers from the troposphere to the upper mesosphere. We have grouped the data into five altitudinal ranges in order to decrease influence of observational errors. We have identified variations with periods close to the 11-year solar cycle despite of relatively short MLS ozone series. Lomb–Scargle periodogram method was used for this purpose. An analysis of changes in the ozone distribution after solar flares of X class was also conducted, but its preliminary results do not show clear signs of solar influence.

ASTRONOMICAL EDUCATION AND OUTREACH

DETERMINISTIC AND STOCHASTIC PROCESSES AND MODELLING OF THEM

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The "In every science, there is only as much science as there is mathematics in it."
Immanuel Kant (1724–1804)

The foundation for decision-making based on forecasts is the data analysis. Both components - the data and the analysis - must be sufficiently accurate and adequate. While the quantity and quality of data is a separate task, the choice of analysis methods requires a "grid of algorithms" (expert system) that combines phenomenological and physical models. Phenomenological models include "partially physical" ones, but they may be significantly fewer than purely physical models. For example, the Moon and a streetlamp both emit light. At a certain distance, the radiation flux (a phenomenological parameter) may appear the same, but two physical parameters (power/luminosity and distance) require additional measurements. Similarly, from the equation 4 = x + y, it is impossible to determine both parameters x and y separately, although there is an obvious functional relationship between them.

When analyzing data series, the simplest analysis is descriptive statistics (mean, standard deviation or variance, possibly median, mode, quartiles, minimum and maximum values, amplitude, range, skewness and kurtosis coefficients). In practice, this is often simplified to just the mean (e.g., salary, workload, temperature – average over a century, year, month, day, or moment). The next step is approximating the data with a straight line to check for trends and their statistical significance. A common oversimplification is the "aesthetic" division of the possible values of the absolute correlation coefficient |r|: 0, 0.3, 0.7, 1 – corresponding to none, small, large correlation. However, the statistically correct approach is to use the Student's t-distribution:

$$t = r / \sigma_r, \text{ where } \sigma_r = \sqrt{((1 - r^2) / (n - 2))}$$

and determine the false alarm probability (FAP = p-value). A simplified version is the "three-sigma rule": if |t| > 3, consider the correlation statistically significant. But the key point is that the criterion depends on the number of data points n. After all, a straight line can always be drawn through two points, giving r = 100%, but other points are unlikely to align perfectly. So, "you need enough data to make statistically significant conclusions."

Another important issue for trends, even linear ones: the simple equation of a straight line is usually written as y = a + bx. Precision to 16 decimal places (common in spreadsheets and most computer programs) is sufficient to compute the function's value. However, problems may arise if the data is significantly offset from the origin. For example, if we take our annual income from the start of receiving a scholarship or salary, say 1980–2024, and calculate the coefficients a, b, then y = a + b * 0 = a will "show" our income in 2025, which obviously makes no sense. Often, the first data point is used as the initial argument. This was convenient during the era of mechanical calculators, where negative numbers were represented, e.g., 0 - 1 = 9999...99. But in the computer age, which handles negative numbers well, this limitation is meaningless.

Figure 1 shows an example of linear regression with a "confidence corridor." The best approximation accuracy is in the middle of the interval (=mean, when weights are present, "weighted"), so it's correct to use the equation: y(x) = ym + b(x - xm), where a = ym - bxm. This "partial orthogonalization" gives a statistically correct estimate of forecast variance. In the case of a uniform distribution of arguments x, using the start of the data as the origin gives a fourfold higher variance estimate in the center and sevenfold on the right boundary. A seemingly simple transformation, but it corrects the effect of neglecting the non-orthogonality of basis functions.

There is no room in this short conference report to discuss inverse dependencies x(y), scatter ellipses, orthogonal regression (with possible extension from 2-D to higher-dimensional data – singular analysis, principal component analysis, etc.).

Obviously, besides linear regression ("sloped line"), there are many other functions with more parameters, which can be divided into "linear" and "nonlinear." A separate task is to determine the optimal number and set of parameters to avoid both underfitting and overfitting.

Clearly, this short conference presentation is not a substitute for full courses in statistically optimal data analysis (the author personally studied and later taught such courses for four semesters). I propose introducing a course titled as in this presentation into the list of elective disciplines.

USING ASTRONOMICAL PHENOMENA IN SCIENCE POPULARIZATION AND EVENT TOURISM

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There are astronomical phenomena that attract tourists who are willing to travel long distances to see these unique natural phenomena. Event tourism is a specialized sector of tourism focused on attracting visitors through planned events and creation of economic, cultural, and social value for local communities. Unlike sporting tournaments, conventions, or cultural festivals, astronomical events are not planned by humans, but this does not prevent them from being used to develop event tourism.

The use of astronomical phenomena in event tourism should be viewed not only as a business, but also as a popular science component. In particular, the science popularization, dissemination of scientific knowledge and involvement of citizens in scientific and scientific and technical activities is one of the tasks of the plan for the implementation of the principles of open science in the EU, which was approved by the Cabinet of Ministers of Ukraine on October 8, 2022, No. 892-p.

Solar eclipses tend to attract the most attention from tourists around the world. Unlike other astronomical phenomena that can be observed from anywhere on Earth over a long period of time (for example, the closest approach of a bright comet to the Earth, which is quite rare, or the maximum of one of the meteor showers that occur annually), total solar eclipses are rarely observed from one location, and their full phase is quite limited in time (2-3 minutes, under the best circumstances no more than 7.5 minutes). It is total eclipses that attract tourists to the regions where the full phase can be observed.

The solar eclipse of August 11, 1999 was visible in many countries. It became one of the most watched eclipses in history because of the high population density in the areas where it could be observed. Special events such as festivals and tours for tourists were organized in the cities through which the moon's shadow passed and, accordingly, where the full phase was observed.

The solar eclipse of 22.07.2009 was the longest total eclipse of the 21st century and attracted the attention of tourists to such countries as China and India, and to a lesser extent Bhutan, Bangladesh, and Myanmar. In China, special tours were organized to the places where the eclipse could be best observed.

The solar eclipse of August 21, 2017, attracted millions of tourists from other countries to the United States. It was called the "Great American Eclipse" because it was the first solar eclipse since the declaration of US independence in 1776, the full phase of which could be observed exclusively in the United States.

Solar eclipses cannot be unambiguously categorized using classical event tourism classification, because depending on the conditions of observation, they can be included in both mega-events and regional events. The use of solar eclipses in event tourism has an economic impact, which includes revenues from hotels, restaurants, transportation, souvenirs, temporary stimulation of small business development, and the creation of a significant number of temporary jobs. Thus, astronomical phenomena are a new promising direction of event tourism in Ukraine.

FROM EQUATIONS TO STARS: STRATEGIES FOR AVOIDING STRESS WHILE STUDYING PHYSICS, MATHEMATICS AND ASTRONOMY

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Higher education places significant demands on students, especially in the study of exact and natural sciences such as advanced mathematics, physics, astronomy, and statistics. In recent years, there has been a growing need to examine the complex set of problems and challenges students face in mastering these subjects through the lens of emotional pressure. It is no longer sufficient to analyze only the objective factors related to the nature of the material—its abstractness, the need for logical and analytical thinking—and subjective factors such as students' prior preparation, motivation, and the quality of instruction. Individual psychophysiological traits, particularly temperament, have a significant impact on academic success.

This work pays special attention to emotional pressure and its potential consequences, such as frustration, lowered self-esteem, loss of motivation, and ultimately academic failure or emotional burnout. It emphasizes that misunderstanding the material is not only a cognitive issue but also a deeply emotional one, which can lead to long-term negative effects on a student's mental well-being. The most common ways students avoid stress during learning are analyzed, along with possible strategies for overcoming difficulties that students themselves can apply. Known behavioral strategies in stressful situations, which influence academic success, are largely determined by temperament, which serves as the primary foundation for mobilizing personal resources.

Temperament traits manifest in how energetically a person acts, how quickly they engage in work, whether they can maintain a high pace for long periods, how easily they fall into various emotional states, how intensely or reservedly they express them, how quickly their mood changes, how easily they switch from one activity to another, and whether they can quickly abandon habits, among other things. These traits combine in different proportions to form a unique dynamic pattern of behavior and reactions for each person, directly influencing the choice of specific cognitive actions in response to stressful situations. In other words, the nature of strategies for overcoming difficult situations and the psychological defenses a student uses depend on life experience, psychological factors, and are strongly correlated with temperament traits.

However, in influencing creative and academic success, innate temperament traits are now unfortunately being challenged by "long COVID." Observed cognitive impairments—such as problems with concentration, memory deterioration, slower thinking, and general "brain fatigue"—can directly affect the ability to effectively absorb educational material. For prospective students, this results in difficulties preparing for entrance exams, while for current students it leads to reduced academic performance, challenges in completing assignments, poorer retention of lecture material, and increased stress from academic workload. This necessitates the development of adaptive approaches in the educational process.

Thus, there is now a need for a differentiated approach to teaching complex "difficult material." It is necessary to adapt methods of presenting material without lowering academic standards, while creating a supportive and empathetic learning environment to ensure deep and high-quality mastery of complex disciplines, minimizing the risk of emotional exhaustion for each student.

PHYSICS. TASKS WITH SOLUTIONS

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The study guide (textbook) is part of a set of materials designed to support high-quality practical training in physics. It includes a collection of tasks for organizing both in-class and independent work. The guide serves as a foundation for further study in physics-related disciplines and aligns with current educational programs. This textbook presents a curated set of 120 physics problems with detailed solutions, structured according to the first-year bachelor's curriculum. Each section addresses common student questions and emphasizes conceptual understanding. Problem-solving is essential in physics education. It not only tests knowledge but also transforms theory into practical skills. Applying physical laws to real-world scenarios enhances comprehension and fosters analytical thinking. Through solving problems, students gain deeper insight into physical phenomena and develop effective strategies for analysis, and develop solutions to tasks-making the learning process truly comprehensive. The textbook is available for free at https://doi.org/10.48550/arXiv.2507.00064 or http://rp.onmu.org.ua/handle/123456789/4683.

LIMITATIONS AND OPPORTUNITIES OF UKRAINIAN UNIVERSITY MUSEUMS

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Astronomical Museum of Taras Shevchenko National University of Kyiv, Observatorna Str., 3, Kyiv, 04053, Ukraine
Boris Paton State Polytechnic Museum at the Igor Sikorsky Kyiv Polytechnic Institute, Beresteyskyi Avenue, 37, Kyiv, 03056, Ukraine

Over the past three years, museum workers at Ukrainian universities, like no other in Europe, have felt critical limitations and threats.

In addition to the already familiar financial problems that significantly deepened during the war, there was the threat of physical loss of collections during shelling, their looting during occupation, reduction of visits during frequent alarms, and much more.

At the same time, we received new opportunities and new directions for research work, which became a request from local communities and society.

Thanks to the support of European colleagues, we received packaging materials, devices and equipment for the preservation of our museum collections, for which we are sincerely grateful.

And museum visitors, with their questions, encourage us to study and exhibit our national identity in the history of science and technology in greater depth and restore the names of scientists and designers that were forgotten and once banned in imperial times. At the same time, a society tired of constant stress needs new methods of museum work to restore mental health.

ASTROTOURISM AS AN INTERDISCIPLINARY STRATEGY FOR REGIONAL DEVELOPMENT: EDUCATION, SCIENCE AND PARTNERSHIP IN WAR AND POST-WAR CONDITIONS

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The full-scale war in Ukraine has severely affected the scientific and educational infrastructure, including astronomy-related institutions. Several observatories and planetariums have been destroyed, occupied, or rendered inoperative. Amid these challenges, astrotourism emerges as a promising interdisciplinary field that integrates science, education, environmental awareness, and regional development. It provides not only psychological relief during wartime but also a foundation for rebuilding local economies through science-based tourism.

This paper proposes a model in which universities, astronomical observatories, and private businesses collaborate to create sustainable astrotourism programs. Universities serve as educational hubs, preparing specialists with basic knowledge of astronomy, tourism management, and ecology. Observatories act as scientific and experiential platforms for guided night sky observations. The final product—an integrated astrotourism route—can include general cultural excursions led by university-trained guides and professional astronomical sessions conducted at observatories.

The paper highlights the Odesa region as a potential pilot area. The collaboration between Odesa National Maritime University and the Astronomical Observatory of Odesa I. I. Mechnikov National University is presented as a viable example of local synergy. Proposed mechanisms of public-private partnership include co-funding, infrastructure sharing, co-branded event development, and involvement of regional authorities.

The astrotourism model presented here demonstrates how scientific institutions, even during wartime, can contribute to regional resilience, youth engagement, and public science communication. The initiative also reinforces the importance of preserving dark skies as a cultural and natural resource while fostering innovation in sustainable tourism.

THE ROLE OF THE ASTROPHYSICAL COMPONENT IN UPDATING THE CONTENT OF SECONDARY SCIENCE EDUCATION IN UKRAINE

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In the context of educational reforms and global scientific advancement, the integration of astrophysical knowledge into general science education is becoming increasingly relevant. In Ukraine, the secondary education reform within the framework of the New Ukrainian School (NUS) emphasises a competency-based and interdisciplinary approach, creating favourable conditions

for modernising the content of natural science disciplines. As a field that bridges physics, mathematics, chemistry, geography, and information technology, astrophysics provides a powerful platform for developing scientific thinking and research skills, as well as fostering a holistic view of the universe.

However, astronomy and astrophysics remain poorly represented in the Ukrainian school curriculum. They are taught briefly and often lack sufficient methodological or technical support. This paper emphasises the importance of incorporating an astrophysics component into the renewal of science education content at all levels, regardless of the chosen academic path. Understanding basic astrophysical concepts, such as the structure of the Universe, stellar evolution, and the physical properties of cosmic objects, is crucial for developing scientific literacy and a worldview grounded in evidence-based reasoning.

The paper examines the potential for integrating astrophysical topics into existing science curricula and proposes strategies for promoting collaboration among schools, universities, and research institutions. The authors advocate the development of updated teaching methods and training programmes to empower educators to utilise astrophysical content as a meaningful tool in modern science education. Strengthening the astrophysical dimension of natural science education is essential not only for future scientific and technological development but also for equipping students to engage critically with contemporary challenges.

METHODICAL GUIDE "PRACTICAL ASTRONOMY ACTIVITIES"

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We have revised our old (2005) methodical guide "Practical Astronomy Activities", improving and expanding the tasks. The first part (which is expected to appear soon on the website of the Richelieu Science Lyceum) describes activities that can be performed by high school students over one or several lessons, using simple educational materials and instruments. These activities are dedicated to orientation in the night sky and constellations, planning observations using the Stellarium program, measuring the Sun's altitude, and observing phases of the Moon.

The second part of the guide (currently in preparation) will be dedicated to more advanced and creative activities that can be performed by members of astronomy clubs and extracurricular courses throughout the year. These activities focus on observing solar activity, lunar relief, variable stars, and meteors. Some of them require a telescope for observations.

THE NEW BACHELOR'S EDUCATIONAL PROGRAM 'ASTROPHYSICS AND SPACE PHYSICS' AT IVAN FRANKO NATIONAL UNIVERSITY OF LVIV

Bohdan Ya. Melekh
Ivan Franko National University of Lviv

Ivan Franko National University of Lviv has launched a new educational program "Astrophysics and Space Physics" this year. The program includes bachelor-level educational components covering spatial and temporal scales from the upper layers of Earth's atmosphere and near-Earth space, as well as solar and heliospheric physics, extending to the physics of stars, galaxies, their clusters and superclusters, and, ultimately, the foundations of cosmology. A special focus within the program is placed on the study of the basics of space situational awareness.

The presentation will discuss the prerequisites for the development of this educational program, describe its structure with an analysis of its educational components, examine the list of its key stakeholders and the University's interaction with them, and present the measures undertaken to promote the program among prospective students. The effectiveness of these measures is assessed based on the results of the 2025 admission campaign. Possible pathways for further study and/or employment of the graduates of this educational program are also analyzed.

THE OPEN EUROPEAN JOURNAL ON VARIABLE STARS, ALIAS OEJV

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The Open European Journal on Variable Stars, alias OEJV (*https://oejv.physics.muni.cz/*), is an online electronic journal open to anyone who wishes to publish their research on variable stars. Here you will find all kinds of studies dealing with the different groups of variable stars, including discoveries, conference proceedings, as well as tables with extreme ranges of brightness, times of minima of eclipsing binaries and times of maxima of pulsating stars. Since August 2006, OEJV has recruited an international editorial board. All OEJV publications are included in the Smithsonian/NASA ADS (Astrophysics Data System) and Simbad databases. The OEJV is registered as an online continuous journal: ISSN 1801-5964. It also has its DOI: 10.5817/OEJV202x-xxxx.

UNISTELLAR EVSCOPE 2: TECHNICAL SPECIFICATIONS, USER COMMUNITY, AND PROSPECTS FOR APPLICATION

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The purpose of this study is to provide a concise overview of the capabilities of the "smart" Unistellar

eVscope 2 telescope as a tool for amateur observations and citizen science. The eVscope 2 combines a compact Newtonian optical system with high-speed electronics that enable automatic pointing, as well as real-time signal stacking and enhancement (enhanced vision). Thanks to its fast focal ratio and built-in sensor, the telescope produces color images of faint objects without the need for long exposures or complex manual processing. The integrated electronic eyepiece offers comfortable visualization, while the mobile application provides intuitive control, autonomous star-based alignment, and access to a deep-sky object catalog. Its compactness, built-in battery, and wireless data exchange make it a portable setup suitable even for urban observations under light-polluted skies.

A key feature of the eVscope 2 is the Unistellar Network user community and its coordinated scientific campaigns. Through the application, telescope owners synchronize with assigned projects: recording asteroid occultations, monitoring exoplanet transits, tracking variable stars, and observing comets. This approach transforms scattered amateur observations into coherent data sets, increasing their scientific value. The community serves as an educational and methodological environment: it disseminates protocols, conducts webinars, standardizes reporting, and provides rapid feedback for newcomers, reducing the entry barrier and improving the reproducibility of results.

The platform's development prospects are linked to further improvements in image processing algorithms, expansion of catalogs, and automation of campaign planning. Closer integration with professional survey projects and educational programs is expected, which will enhance citizen science contributions to transit confirmations, refinement of small body orbits, and rapid photometry of transient events. Despite its relatively high cost compared to traditional amateur configurations, the eVscope 2 offers a unique combination of accessibility, mobility, and scientific relevance. Thus, the Unistellar eVscope 2 is not only a tool for aesthetic observations but also a platform for collective data collection, capable of supporting modern astronomical research and STEM education on a scalable level.

OBSERVATORY 'OSOKORKY': FROM STARS TO BYTES AND BACK AGAIN

Maksym Pyatnytskyy
Private observatory 'Osokorky'

Inspired by observing the supernova SN 2017eaw, I began conducting regular observations of variable stars from the Osokorky neighborhood in Kyiv. My initial equipment consisted of a modest 150mm Newtonian telescope and an equatorial mount with tracking, paired with a Canon EOS 600D DSLR camera. After several years of observations, I not only contributed to the AAVSO international database but also managed to discover 31 new variables, which were registered in the International Variable Star Index (VSX). Later, I shifted focus to sky surveys – primarily using the TESS archive – and discovered several dozen more variable stars through data mining; the total number of discovered variables to date is 137, with several more currently under review, plus 27 revisions or submissions of known objects.

With an improved setup, I continued my observations and uncovered interesting details about several binary systems, leading to publications in astronomical journals. Some of the most interesting cases will be presented in this report.

Additionally, my work involved developing software for photometry and light curve analysis, which will also be briefly discussed.

POPULARIZATION OF ASTRONOMY AND PLANETARIUM IN UKRAINE

THE ODESA ASTRONOMICAL CALENDAR IS AN ENCYCLOPEDIA OF ASTRONOMY AND COSMONAUTICS

N.I.Koshkin, M.I.Ryabov
(Co-editors Odesa)

The issue of the "Odessa Astronomical Calendar" for 2025 (OAC-2025) is the 26th issue of the publication of the same name, which was published by the Odessa State Astronomical Observatory under the editorship of O.Ya. Orlov in 1919-1924. 76 years later, in 2000, the calendar was revived by the editorial board under the leadership of Professor V.G. Karetnikov, who was the editor-in-chief until the 20th issue of the calendar. The calendar continues the traditions that made the Odessa astronomical calendar popular and known far beyond the borders of Ukraine. Currently, all its issues in electronic form are available on the website of the scientific library of ONU named after I.I.Mechnikov (http://lib.onu.edu.ua/ru/odeskyj-astronomichnyj-kalendar/).

OAC 2025 is intended for a wide range of astronomy enthusiasts and people interested in this topic. The purpose of the calendar is not only to provide the reader with information about the astronomical phenomena of the year, visible to the naked eye or with the help of small optical instruments, but also to provide a panorama of new advances in astronomy and astronautics. The calendar is approved as a textbook for teaching astronomy in schools, gymnasiums, and colleges, allowing teachers to receive information about current advances in astronomy and astronautics that cannot be quickly reflected in textbooks. It is also useful when conducting practical classes.

To facilitate the teaching of astronomy and lectures in Planetariums, the issues of the calendar provide information on memorable and significant dates in the history of astronomy and astronautics. This issue contains materials dedicated to the 145th anniversary of the birth of the outstanding scientist and organizer of science, director of the Odessa Astronomical Observatory, academician O. Ya. Orlov. An overview of the results of the 24th International Gamow Conference is presented, at the plenary sessions of which famous cosmologists and astrophysicists from different countries spoke.

We're continuing with structural changes that will make the calendar more appealing to readers. A section has appeared, which presents interesting astronomical events of each month, essays about traveling in the starry sky. Particular attention in the history of astronomy is paid to the anniversaries of its outstanding creators — N. Copernicus, G. Galileo, I. Newton, J. Kepler. The rubric reflecting events and dates related to the history of astronomy in Odessa has been revived. The story about the work of Odessa astronomy lovers continues. UAC-2025 celebrates the 180th anniversary (!) of the Astronomical Observatory of Kyiv University. In the section dedicated to the anniversaries of outstanding Ukrainian astronomers, the editorial board expresses its congratulations to the President of the Ukrainian Astronomical Society (UAA), Academician of the National Academy of Sciences of Ukraine Ya. S. Yatskiv.

ODESSA PLANETARIUM – YESTERDAY, TODAY AND TOMORROW

M.I.Ryabov
Odessa Astronomical Society

According to the Odessa press on January 12, 1952, the Planetarium was opened at the Odessa Astronomical Observatory. Thus, the Odessa Planetarium turned 73 years old in 2025. The Zeiss Planetarium apparatus was purchased on the initiative of the director of the astronomical observatory, professor V.P. Tsesevich.

The Planetarium was located in the former building of the First Odessa Observatory of astronomy lovers of the "World Studies" society. In addition to visiting the Planetarium, visitors went on a tour of the observatory and could observe the starry sky through the old Cook and Sons telescope.

In 1963, the Odessa Planetarium moved to the building of the Odessa Theological Seminary, where it was located for 30 years. At that time, it was named after K.E. Tsiolkovsky. The initiators of its creation were professors V.P. Tsesevich and N.B. Divari. Graduates of the I. I. Mechnikov ONU worked as lecturers in it, and employees of the astronomical observatory worked as freelance lecturers. Among these lecturers was the author of this report.

The Planetarium had a lecture hall and a film lecture hall: lectures on astronomy, astronautics, geography, physics and scientific atheism are held. There is a special series of lectures for children. After the return of the church premises, the Planetarium was closed and its equipment was not preserved. On the initiative of the Odessa Astronomical Society, the Planetarium-Lecture Hall was revived again on the territory of the astronomical observatory of the university in 2000. It hosted popular lectures on astronomy and guided tours of the observatory.

In 2018, it was decided to install a digital Planetarium on the territory of the observatory. The sponsors of the installation of the dome house for it were the Odessa enterprises INTERCHEM, Odessakabel and Stalkanat. The equipment for the Planetarium was purchased under the competition of the "Odessa Public Budget".

Currently, the Planetarium holds author's lectures in the "Star Hall" of the Planetarium, in the "Cosmic Lecture Hall". The planetarium has numerous expositions on the territory of the observatory (Ukraine is a space power, Odessa in the history of cosmonautics", "Parade of planets", "Telescopes of the Odessa Observatory", "Lunarium").

Among the expositions is the largest model of the «Energia-Buran» rocket in Ukraine. The implementation of the Planetarium program is provided by researchers and teachers of the Department of Astronomy and Physics, the Astronomical Observatory of ONU, the Odessa Observatory of the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine. The work of the Planetarium reflects the modern achievements of astronomy and cosmonautics. The work of the Planetarium is presented on the Internet pages: *https://www.facebook.com/planetarium.odessa*, *https://www.instagram.com/planetarium_odessa*

The number of visitors to these pages reaches more than 5 thousand people.