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"NEW TRENDS IN ASTROPHYSICS, COSMOLOGY AND HEP
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"ASTRONOMY AND BEYOND: ASTROPHYSICS, COSMOLOGY,
RADIOASTRONOMY AND ASTROBIOLOGY"
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PLENARY SPEAKERS

GALACTIC COSMIC RAY FACTORIES

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Over recent years, impressive progress has been achieved in the identification of major contributors to Cosmic Rays (CRs). I will argue that Galactic CRs consist of two populations. Supernova Remnants remain the prime candidates as principal contributors to the first population of Galactic CRs, however, with a reduced role at highest energies around 1 PeV ($=10^{15}$ eV). I will discuss the Clusters of Young Massive Stars and the Supermassive Black Hole in the Galactic Center as alternative suppliers of PeV particles, thus the particle accelerators responsible for the second component of CRs.

UNUSUAL SUB-LOW AND SUPER-LOW STATES OF THE MAGNETIC DWARF NOVA DO DRA

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The expert system for time series analysis of irregularly spaced signals is reviewed. It consists of a number of complementary algorithms and programs, which may be effective for different types of variability. Obviously, for a pure sine signal, all the methods should produce the same results. However, for irregularly spaced signals with a complicated structure, e.g. a sum of different components, different methods may produce significantly different results.

The basic approach is based on classical method of the least squares (1994OAP.....7...49A). However, contrary to common "step-by-step" methods of removal important components (e.g. mean, trend ("detrending"), sine wave ("pre-whitening"), where covariations between different components are ignored, i.e. erroneously assumed to be zero, we use complete mathematical models. The oversimplification of the expressions was called the "matrix-phoebia" by Prof. Z.

Mikulášek (2007OAP....20..138M). It may change the estimates of the parameters by few dozen percent, and, in worst cases, by a factor of few times or even dozens times.

Our algorithms are pointed to the period search using trigonometric polynomials of different order with a possible trend, which is approximated by a polynomial of arbitrary order. Such approximations are effective for multi-periodic multi-harmonic signals superimposed on a slow trend. In the software MCV (2004AstSR...5..264A), the approximations may be done for multi-harmonic models for (up to) 3 basic periods with a polynomial trend. A comparison between the "non-parametric" methods for the periodogram analysis is presented in 1997KFNT...13f..67A. The wavelet analysis was improved for irregularly spaced data (1998KFNT...14..490A) as a particular case of the scalegram analysis (1997A&AS..125..207A). The statistically correct expressions for the auto-correlation functions of detrended signals were presented in 1994AN....315..353A. The Principal Component Analysis (PCA) is discussed in 2003whdw.conf..325A.

The methods have been applied to 2000+ variable stars of different types using own monitoring, as well as the photometrical surveys from ground-based and space observatories. A wide range of types of variability initiated the elaboration of additional methods. To increase the accuracy for the studies of period (and other parameters) variations, the "running sine" (2013CKA....10..171A) method was proposed, which is for the signals with high coherence (studied by global approximations) and low coherence (suitable for the wavelet analysis). This method is effective for either "nearly-periodic", or "modulated periodic" variations in intermediate polars, pulsating variables etc. For quasi-periodic oscillations or fractal-type variability, the "sigma-" scalegram analysis (1997A&AS..125..207A) is proposed, with more recent improvement to "Lambda-" scalegram.

For the signals with abrupt changes, a set of approximations using "special shapes" was proposed. Particularly, the software NAV ("New Algol Variables") is effective not only for the EA-type eclipsing variables (2012Ap....55..536A), but also for EA and EB and allows distinguishing these types from non-eclipsing elliptic binaries (2016JPhSt..20.4902T) while classifying. Spline-based approximations are used for pulsating variables with asymmetric phase curves.

For studies of “near extremum” parts of the light curve, including the determination of ToM (Time of Minimum/Maximum), 19 functions (9 types of functions) were realized in the software MAVKA (2019OEJV..197...65A).

This work is a part of the “Inter-Longitude Astronomy” (2017ASPC..511...43A) international project, as well as of the “AstroInformatics” (2017IAUS..325..361V).

BLACK HOLE SHADOWS FROM NEARBY AND COSMOLOGICAL OBJECTS

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The size of the shadow of a black hole (BH) with Schwarzschild metrics was first found by J. Synge in the year 1966. For the observer on the distance much larger than the BH gravitational radius R_g , the angular size of a shadow corresponds to the radius $3\sqrt{3}R_g$. Cosmic expansion is expected to influence the size of a black hole shadow observed by a commoving observer. Except for the simplest case of the Schwarzschild black hole in the de Sitter universe, an analytical approach for the calculation of shadow size in an expanding universe is still not developed. In the paper [1], the approximate method was developed, based on using the angular size redshift relation. This approach is appropriate for the general case of any multi-component universe (with matter, radiation, and dark energy). In particular, it was shown, that supermassive black holes at large cosmological distances in the Universe with matter may give a shadow size approaching the shadow size of the black hole in the center of our Galaxy, and present sensitivity limits.

1. G.S. Bisnovaty-Kogan and O.Yu. Tsupko, "Shadow of a black hole at cosmological distances" Physical Review D 98, 084020 (2018).

EINSTEIN'S UNIVERSAL ANTI-GRAVITY

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Basing on his General Relativity, Einstein predicted the existence of an invisible cosmic essence that is now known as "dark energy". According to the interpretation suggested by E. Gliner in 1965 (and almost commonly adopted at present), this is a kind of physical vacuum that fillies the entire cosmic space and produces repulsion, or anti-gravity, everywhere in the Universe. Dark energy does not vary in space and time, and its only physical measure is Einstein's cosmological constant that is notated by the Greek letter Lambda. Einstein did not try to say anything about the physical nature of the new constant. He introduced the universal anti-gravity, but he did not elaborate any hypothesis about its nature, -- just like Newton did long ago with the universal gravity he discovered. Today, many years after Newton's “Principia” of 1687 and Einstein's idea of 1917, fundamental physics of particles and fields does not give any indications on the very existence of dark energy. But it is know now that dark energy does exist in the Universe and it is studied now both theoretically with General Relativity and observationally with the largest astronomical instruments. The major result of these studies is the extension of the dark energy concept of anti-gravity to the wide range of cosmic scales from about one Mpc to a few Gpc.

BALDONE OBSERVATORY IN THE CIRCLES OF TIME

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1957 – The first laboratory building, known as the White House, was built at Baldone on Riekstu Hill in the territory of the next Observatory. 01.01.1958 – The Astronomy Sector was separated from the Institute of Physics and commences independent activity as the Laboratory of Astrophysics at the Latvian Academy of Sciences. In 1967, with the decision of the Presidium of the Latvian SSR AS the Laboratory of Astrophysics at ZA was transformed into the Radioastrophysics Observatory. Under the leadership of the first director, Janis Ikaunieks, an observation instrumental base develops – a 1.2m Shmidt telescope was installed in 1966 for optical observations. The project of the variable base radio interferometer after the death of J. Ikaunieks was unrealized. In 1972 10m radio telescope RT-10 was purchased. Research areas in optics are spectrophotometry and non-stationary processes of carbon stars. In radio astronomy it is the study of solar activity at 755,610 and 326 MHz and its magnetic field variations. After the establishment of the UL Institute of Astronomy in 1997, the field of research in the optical range is supplemented by the research direction of small objects of the solar system, but the area of radio astronomy is stopped due to lack of funding.

The scientific potential of the Baldone Observatory remains significant. Should be mentioned the 22,000 Schmidt telescope astroplate archive obtained in 1967-2005, whole will be digitized this year. After digital image processing, coordinates and brightness for about of 330,000,000 objects will be obtained. The database will contain details of star movement, bright variability (both long-term and short-term) and details of known, unknown asteroids and comets.

In 2008, monitoring of asteroids in the solar system is started. To now 77 new asteroids has revealed in the Solar System and 11 of them have been named.

Research on carbon stars is continuing successfully. The number of carbon stars currently discovered has reached 450. A methodology has been created for estimating the temperature and distance to the carbon stars. Work is underway to improve this method.

The Observatory is continuing its work on popularizing astronomy. The number of visitors per year has risen from 1000 in 90th to almost four thousand in 2018.

THE FORM OF THE GRAVITATIONAL POTENTIAL IN FLAT, OPEN AND CLOSED UNIVERSES

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Within the cosmic screening approach, we obtain the exact formulas for the velocity-independent gravitational potentials produced by matter in the form of discrete sources distributed in the flat, open and closed Universes.

These formulas demonstrate that spatial curvature of the Universe considerably affect the form of the potentials and forces. While in the flat and open Universes the gravitational force undergoes exponential suppression at cosmological distances, in the closed Universe the force induced by an individual mass is equal to zero at the antipodal point with respect to this mass.

GLUEBALL SPECTROSCOPY IN CENTRAL EXCLUSIVE DIFFRACTIVE PRODUCTION

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The study of central production in hadron-hadron collisions is interesting for a variety of reasons. Such events are characterized by a hadronic system formed at mid-rapidity, and by the two very forward scattered protons, or remnants thereof. The rapidity gap between the mid-rapidity system and the forward scattered proton is a distinctive feature of such events. Central production events can hence be tagged by measuring the forward scattered protons and/or by identifying the existence of rapidity gaps. Central production is dominated at high energies by pomeron-pomeron exchange. The hadronization of this gluon-dominated environment is expected to produce with increased probability gluon-rich states, glueballs and hybrids. Of particular interest are states of exotic nature, such as tetra-quark ($qq\bar{q}\bar{q}$ + $\bar{q}q$) configurations, or gluonic hybrids ($qq\bar{q}$ + gluon).

We isolate the pomeron-pomeron-meson vertex and calculate the PP total cross section as a function of the centrally produced system of mass M_x . The emphasis here is the behaviour in the low mass resonance region where perturbative QCD approaches are not applicable. Instead, we use the pole decomposition of a dual amplitude with relevant direct-channel trajectories $\alpha(M^2)$ for fixed values of pomeron virtualities, $t_1 = t_2 = const$. Due to Regge factorization, the calculated pomeron-pomeron cross section is part of the measurable proton-proton cross section.

1. Fiore R., Jenkovszky L., Schicker R. Exclusive diffractive resonance production in proton-proton collisions at high energies. *Eur. Phys. J. C*, 2018, 78: 468-475.

SUN-EARTH PROBLEM: MODERN CONCEPTS AND PHYSICAL MECHANISMS

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We present a brief review of modern concepts of the Sun-Earth problem and proposed physical mechanisms of solar-terrestrial relations (STR). In fact, this field covers a wide range of fundamental and actual applied problems of paramount importance (Space Weather, radiation hazard in space, functioning of space-borne and ground-based technological systems, heliobiology etc.). It is also closely tied

with some general gnosiological problems (Weltanschauung). State-of-the-art information about existing problems is given and different channels for extraterrestrial influences are discussed at the up-to-date level: electromagnetic waves and fields, total solar irradiance, solar wind, energetic solar particles, galactic cosmic rays, cosmic dust, etc. Some of well-known and suggested STR effects and corresponding physical mechanisms are illustrated by several examples. In particular, a number of different external “signals” in observed changes of terrestrial climate and weather are considered. Especially, we analyze an expected impact of geophysical disturbances on the accuracy of some precise physical measurements and experiments. Due attention is paid to the heliobiological aspects of STR. In particular, it is emphasized the multifactor nature of magneto-biological effect (MBE), its non-stationary and non-linear behaviour. We discuss also main features of different physical mechanisms (electromagnetic fields, ionising radiation, triggers, rhythmic and resonances in solar-terrestrial systems) and their applicability to the Sun-Earth problem. The most of them are still needed in more sophisticated theoretical development and experimental confirmation. The main goals of interdisciplinary studies in this field are to determine partial impacts of solar-geomagnetic variability on the terrestrial environments and estimate (separate) relative contributions of different factors into various STR phenomena.

DARK AGES: FORMATION OF HALOS AND POSSIBILITY OF THEIR OBSERVATION

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The formation of galaxy scale halos ($M_h \sim 10^6 - 10^{10} M_\odot$) and their emissivity in the hyperfine structure line 21 cm of atomic hydrogen during Dark Ages ($z \sim 10-50$) are analyzed. It is supposed that halos are formed from the Gaussian density peaks of cosmological curvature perturbations at $10 < z < 50$. The semi-analytical modeling of formation of individual spherical halos in multi-component models shows that gas in them has the kinetic temperature in the range 60–800 K due to adiabatic compression during the collapse and the temperature of each halo depends on the time of virialization. It is also shown that inelastic collisions between neutral atoms of hydrogen are dominant excitation of hyperfine structure levels, which pull the spin temperature to the kinetic one. The brightness temperature of individual halos is in the range 1-10 K and depends on the mass of halo and redshift of its virialization, increases with increasing of both. Assuming the 1 MHz frequency band under observations the surface number density of halos at different redshifts is estimated as well as the antenna temperatures which are due to the halos of different masses. The results are compared with the measurements of the power spectrum of the 21-cm signal of neutral hydrogen given by MWA and the LOFAR.

DISCOVERY OF THE NEW CHANGING LOOK CASES IN NGC 1566

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We summarize a study of optical, UV and X-ray light curves of the nearby changing look active galactic nucleus in the galaxy NGC 1566 obtained with the Neil Gehrels Swift Observatory and the MASTER Global Robotic Network over the period 2007-2019. We also report on optical spectroscopy using the South African Astronomical Observatory 1.9m telescope between Aug 2018 and Mar 2019. A substantial increase in X-ray flux by 1.5 orders of magnitude was observed following the brightening in the UV and optical bands during the last year. After a maximum was reached at the beginning of July 2018, the fluxes in all bands decreased with some fluctuations. The most remarkable re-brightening in the light curve following the decline from the bright phase was observed at MJD range 58440-58490. The amplitude of the flux variability is strongest in the X-ray band and decreases with increasing wavelength. Low-resolution spectra (Aug 2018) reveal a dramatic strengthening of the broad emission as well as high-ionization [FeX]6374 lines. These lines were not detected so strongly in the past published spectra. The change in the type of the optical spectrum was accompanied by a significant change in the X-ray spectrum. For the last 4 spectra (Dec 2018-Mar 2019) we see dramatic changes compared to Aug 2018, accompanied by the fading of broad emission lines. Effectively, two changing look (CL) cases were observed for this object: changing to Sy1.2 type and then returning to the low state as Sy 1.8-Sy1.9 type. Some possible explanations of the observed dramatic changes are discussed.

LONG-TERM MONITORING OF SPECTRAL LINE VARIATIONS WITH THE 11-YEAR CYCLE. QUIET SUN

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The monitoring program of long-term variation of selected solar spectral lines is described. The aim of the program is to study how the physical parameters of the quiet solar atmosphere change over the last solar cycle No. 24. The research is based on high spectral resolution observations of the quiet Sun using the Ernest Gurtovenko's horizontal solar telescope of the Main Astronomical Observatory of the National Academy of Sciences of Ukraine. Since 2012 the observations are performed daily, when the weather conditions allow. We found that the line core depths and full widths at half maximum of the solar spectral lines, as well as their bisector curvature correlate with the cycle modulation of the total unsigned magnetic field of the

Sun. The behavior of these line parameters can be explained by variations of the temperature and convective motions of the quiet photosphere during the 11-year cycle.

IMPROVED CONSTRAINTS ON THE MIXING AND MASS OF EXTRA GAUGE BOSONS FROM RESONANT DIBOSON SEARCHES AT THE LHC AT $\sqrt{s}=13$ TeV USING THE RUN-2 ATLAS DATASET

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New neutral vector bosons Z' decaying to charged gauge boson pairs W^+W^- are predicted in many scenarios of new physics, including models with an extended gauge sector such as E_6 , left-right symmetric and the sequential standard model. For these benchmark models we calculate and present theoretical expectations for different values of the Z' mass and mixing parameter. Our results are based on the narrow width approximation which allows to make a convenient comparison of experiment to theoretical benchmark models. The diboson production allows to place stringent constraints on the Z - Z' mixing angle and the Z' mass, which we determine by using data from pp collisions at 13 TeV recorded by the ATLAS detector at the CERN LHC, with integrated luminosity of 36 fb^{-1} . By comparing the experimental limits to the theoretical predictions for the total cross section of Z' resonant production and its subsequent decay into W^+W^- pairs, we show that the derived constraints on the mixing angle for the benchmark models are greatly improved with respect to those derived from the global analysis of electroweak data. We combine the limits derived from diboson production data with those obtained from the Drell-Yan process in order to significantly extend the exclusion region in the Z' parameter space. Also, we demonstrate that further improvement on the constraining of this mixing can be achieved through analysis of the full Run II data set.

INFLUENCE OF A PLASMA ON GRAVITATIONAL LENSING

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Usually theoretical work on gravitational lensing is based on the assumption that the propagation of light can be modelled in terms of vacuum light rays (i.e., in terms of lightlike geodesics of the spacetime metric). In some cases, however, the influence of a medium might be non-negligible. This is true, e.g., for the time delay and the deflection of radio rays passing through the Solar corona and for the travel time of pulsar signals. In both cases the medium can be modelled as a pressure-less ("cold") plasma and as a first approximation one may assume that it is non-magnetised.

In this talk I give an overview of the theory of ray optics in a cold non-magnetised plasma on a general-relativistic spacetime. In this case the rays are timelike geodesics of a conformally rescaled metric and bundles of light rays can

be described in terms of modified Sachs equations. As specific examples, I will consider the influence of a plasma on the bending angle, the multiple imaging properties and the shadows of Schwarzschild and Kerr black holes, and on the distance measures in Robertson-Walker spacetimes.

The talk is partly based on the following publications.

- [1] V. Perlick: "Ray optics, Fermat's principle, and applications to general relativity", Springer Lecture Notes in Physics m61, Springer, Heidelberg (2000)
- [2] V. Perlick, O. Yu. Tsupko, G. S. Bisnovatyi-Kogan: "Influence of a plasma on the shadow of a spherically symmetric black hole" Phys. Rev. D 92, 104031 (2015)
- [3] K. Schulze-Koops, V. Perlick, D. Schwarz: "Sachs equations for light bundles in a cold plasma" Class. Quantum Grav. 34, 215006 (2017)
- [4] V. Perlick and O. Yu. Tsupko: "Light propagation in a plasma on Kerr spacetime: Separation of the Hamilton-Jacobi equation and calculation of the shadow" Phys. Rev. D 95, 104003 (2017)

GROUND-BASED STUDIES OF THE SUN IN THE NEXT 10 YEARS: FROM ULTRAVIOLET TO INFRARED

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The scientific goal of the talk is to review the future advances in solar physics due to the development of new ground-based telescopes with large aperture and with new optical tools. They are: the 4-m Daniel K. Inouye Solar Telescope (DKIST), the 4-m European Solar Telescope (EST) and the 1.5-m GREGOR solar telescope. At the end, we discuss what we can expect from solar studies in Ukraine.

TEST BODY ORBITS IN SPACE-TIMES AROUND RELATIVISTIC ASTROPHYSICAL CONFIGURATIONS WITH SCALAR FIELDS AND THE EVENT HORIZON TELESCOPE IMAGE OF THE BLACK HOLE SHADOW

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After the announcement of the first Event Horizon Telescope results concerning the shadow of the supermassive black hole in the center of the M87 galaxy, the question arose: is a similar picture of an accretion disk possible in the case of an astrophysical object other than a black hole. We consider this question in connection with static spherically symmetric compact objects with minimally-coupled static scalar fields (SF). The focus is on the general relativistic SF Lagrangians with the canonical kinetic term and different SF potentials. After obtaining of numerical and/or analytic solutions of the joint system of Einstein – SF equations under conditions of asymptotic flatness, we study test body trajectories and distributions of the stable circular orbits (SCO). We present examples showing that in the case of a naked singularity in the center of an astrophysical object, the Schwarzschild-like SCO distribution is possible as well. On the other hand, the models considered show that disconnected annular SCO distribution is possible both in the case of a black hole

and in the case of a naked singularity. On the basis of a number of examples we conclude that the disconnected ring-like SCO distributions NS are quite common. Possible observational signals of such distributions are discussed.

ENERGETICS OF PHOTOSPHERE JETS IN THE QUIET ATMOSPHERE OF THE SUN

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Based on high resolution observations of the quiet area of the solar disk centre, 3D hydrodynamic models of photospheric jets were constructed (by solving the inverse nonequilibrium radiative transfer problem). The obtained models include thermodynamic parameters and velocity field.

The study of influence of non-LTE effects on the model of jets and the environment was carried out.

It is shown that the regions of the greatest velocity of jets are shifted relatively to V-signal peaks, ie jets tend to appear at the edge of magnetic concentrations.

Obtained data on the reproduction of physical conditions, in particular: stratifications of temperature, line of sight velocity and excess pressure, indicate the presence of energy sources in the layers of the middle photosphere. The latter is due to the interaction of magnetic fields (which have the same polarity) of the tube and the horizontal flows of the surroundings.

DECAMETER PULSAR/TRANSIENT SURVEY OF NORTHERN SKY. RESULTS OF TRANSIENT SEARCHING

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The survey of pulsars and sources of transient radiation of the northern sky was conducted at the largest radio telescope in the decameter range UTR-2. Individual pulse data processing has led to the obtaining of a significant number of signals. A wide set of tests for the presence of artificial or natural radiation was used to distinguish of radio interference and space origin impulses, as well as new effective criteria and verification procedures were developed. A repeat partial survey of 10% of the sky was conducted to confirm the characteristics of transient signals, such as the frequency of occurrence, distribution in coordinates and in intensity.

The result of one "frame" of the survey was the discovery of 380 sources, which differ in the dispersion delay in the interstellar medium and coordinates.

COSMOLOGY, GRAVITATION, HIGH ENERGY PHYSICS, ASTROPARTICLE PHYSICS

THE EXTENDED SCATTERING ENVELOPE IN THE QSO 2237 + 0305 QUASAR

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Measuring the time delays between the brightness fluctuations in different parts of the spectra of quasars makes it possible to investigate their spatial structure with a very high spatial resolution. The method called reverberation mapping allows obtaining direct estimates of distances between the quasar regions responsible for radiation in different spectral bands.

The method of reverberation mapping has been applied to the light curves of the Q2237+0305 system in filters V, I and R of Johnson-Cousins photometric system. The data were obtained in 2004 – 2005 as a part of the long-term campaign of monitoring gravitational lenses with the 1.5-m telescope of the Maidanak Observatory. From the light curves of the Q2237+0305 system, we determined the time delays between combinations of all three filters. The time delays turned out to be an order of magnitude larger than those predicted by the standard thin accretion disc model by Shakura-Sunyaev (1973). Such large time delays mean that reverberation responses may arise in extended structures located outside the disk or on the disc periphery and thus, the classical thin disc model is, perhaps, not quite adequate in describing the Q2237+0305 spatial structure.

Explanation of the discrepancy between the model and observed inter-band time delays can be found in the classical work by Shakura & Sunyaev (1973), where a super-critical regime of disk accretion is considered. They have shown that the super-critical accretion regime results in formation of an optically thick scattering envelope that efficiently re-emits the hard and UV radiation from the disc thus making its apparent size in UV and optical ranges larger. Comparison of our measurements of delays with the results that follow from the theoretical predictions of Shakura and Sunyaev suggests the existence of a supercritical accretion mode in the quasar QSO 2237 + 0305. Having used the analytical expressions obtained by Shakura-Sunyaev for the radius of the scattering envelope, we have made calculations for a quasar QSO 2237+0305 with the black hole mass $M_{BH} = 9 \cdot 10^8 M_{\odot}$ and shown that for some parameters of the supercritical regime our results are consistent with the existence of such envelope.

NUMERICAL SIMULATIONS OF THE STOKES PARAMETERS OF SN 1006

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Supernova remnants are believed to be the best candidates for acceleration of cosmic rays up to energy $\sim 10^{15}$ eV.

They are observed in all electromagnetic spectrum from radio to very-high energy gamma-rays. At present, mostly the spectra or surface brightness distribution are used for analysis of accelerated particles on shock waves of supernova remnants. Other important observational data, namely, the radio polarization maps are almost out of use.

We use our theoretical model and numerical three-dimensional magneto-hydrodynamic simulations in order to produce the radio polarization maps of SN 1006. The Faraday rotation and ambient medium with non-uniform distribution of magnetic field are taken into account in our model.

ADDITIONAL MEANINGS OF THE TERM OF "UNIFORMITY" IN COSMOLOGICAL MODELS

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For such an example of a cosmological system like the Solar System, the most obvious expression of the connectivity of its elements is Kepler's third law, usually applied according to the rule of the "excluded third" – the organizing power center itself. This narrows the generality of the present development of the initial area of homogeneity (gas-dusty disk) under the influence of extremity (singularity) of its center. For the corresponding expansion of the geometry of the law to the universal three-node interval, according to the experimental data for planets and belts, the persistence of the relative position of the intermediate point is established (it is, as an average value, according to Fisher's criterion, preferable to regression). With this in mind, the rule of connectedness of homogeneity states as a translation of the initial extremality of the center, equivalent to Kepler's law in degree of homogeneity to the Newtonian potential, is proposed. The system of equations expressing it as generating a mathematical structure combines a similarity approach when considering a one-sided view of their comparability through nesting (similar to extrapolation, one-sided extremum) with a study of the comparison of states with a congruence approach – two-sided representation (similar to interpolation, two-sided extremum). That is, the degree of homogeneity forms such a coordinate of the development of the system, with the use of which, as in the case of its linear representation, we can proceed to a static picture. In particular, the resulting picture of the state of the Solar System is consistent with the classical Titius-Bode rule and corresponds, in a geometrical aspect, to the degeneracy of the logarithmic spiral. It is stated that signs of development along a logarithmic spiral are observed in spiral galaxies, and take place in a theoretical consideration of the Hubble-Lemaitre law. Moreover, if the degeneration of a logarithmic spiral into a circle corresponds to the form of the proposed rule as a comparison operation, a congruence, then its development corresponds to the representation of this rule as a similarity relation. In this form, it is considered its expansion to the comparison of "dark energy", "dark matter", "observable (visible) matter" as a

manifestation of the states of matter in development between extremity (singularity) and homogeneity. The obtained numerical values, respectively, 0.544; 0.295; 0.161, in comparison with accepted ones, can be interpreted as confirmation of the development of the Universe in the phase of accelerating expansion.

CONSTRUCTION OF N-POINT GRAVITATIONAL LENSES BY THE METHOD COVER PROFILES

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Let S_N be a flat N -point gravitational lens, R_X^2 – planes of the lens, R_Y^2 – plane of the source, A is the set of coordinates of point masses included in the lens, and $L: (R_X^2 \setminus A) \rightarrow R_Y^2$ is the lens map. It is known that the L map is single-valued, and the inverse $L^{-1}: R_Y^2 \rightarrow (R_X^2 \setminus A)$ map is multivalued [1]. Therefore, we will consider the S_N lens as a combinatorial topological object that covers many planes of the source.

The triple $\Omega = ((R_X^2 \setminus A), L, R_Y^2)$ is a bundle over a two-dimensional plane [2]: the total space of the bundle $tl\Omega = (R_X^2 \setminus A)$, the base of the bundle $bs\Omega = R_Y^2$, which projects the map $pr\Omega = L$. For a constructive description of Ω , we studied an important one-dimensional bundle.

Let $J = J(L)$ be the Jacobian of the map L , Θ is the set of solutions of the equation of a $J = 0$ (critical set), $K = L(\Theta)$ is the caustic, and $Q = L^{-1}(K) = L^{-1}(L(\Theta))$ is the image of the caustic under the inverse mapping. Suppose hereditary topologies are given on the sets K and Q , and the F is the restriction of the map L to Q , then the $\zeta = (Q, F, K)$ triplet is a one-dimensional bundle [2]. In the ζ triplet, the total space of the $tl\zeta = Q$ bundle, the base of the $bs\zeta = K$ bundle, and the projection map of $pr\zeta = F$. It is known that for any non-regular $p \in K$ point the power of the $n = Card(pr\zeta^{-1}(p))$ layer: has the parity of the number N , satisfies the $N+1 < n < N^2+1$ inequality and can take different values of n_s . Let K_s be a set of regular points of caustics with a power of n_s layer and $k_s \subseteq K_s$ one of its connected components. Let $cl k_s$ be the closure of the k_s connected components in the topology of the K curve.

In the terms above, it was formulated and proved.

Theorem. Let f_s be the restriction of the F_s map to $cl(pr\zeta^{-1}(k_s))$. Then a set of four elements of

$\xi = (cl(pr\zeta^{-1}(k_s)), f_s, cl k_s, n_s)$ is a branched covering in the narrow sense of the term.

$tl\xi = cl(pr\zeta^{-1}(k_s))$ is the covering space, $bs\xi = cl k_s$ is the base of the covering, $hr\xi = f_s$ is the projection mapping, n_s is the number of sheets, and $bs\xi = cl k_s \setminus int k_s$ is the set of ramifications.

The set of four elements $\Xi_{n_s} = (cl(pr\zeta^{-1}(K_s)), f_s, cl K_s, n_s)$ is n_s -sheet branched covering in the broad sense of the term.

Comment. The path of the (Ξ, K) pair, where $\Xi = \{\Xi_{n_s}\}$ is the family of all multi-sheeted covers, can be constructively continued until the Ω stratification and uniquely determines the N -point gravitational lens S_N .

For the description of covers over the Riemannian sphere one can apply graphs: segment complexes [3], profiles [4]. For the description of coverings from the family of Ξ similar graphs can be used.

Example. A binary symmetric lens with a distance between masses from 0.8 to 2.0 is uniquely determined by a 4-leaf branched covering with six simple branch points. Such a covering can be uniquely defined by the covering profile.

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A SOLUTION TO THE DARK ENERGY PROBLEM AND THE EVOLUTION OF THE EARLY UNIVERSE

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The application of the methods of the quantum microscopic theory of superconductivity in cosmology and the theory of gravity allows us to solve the problem of dark energy and obtain its observed density equal to $6 \cdot 10^{-26} \text{ kg/m}^3$. The cosmological model of superconductivity (CMS) allows a natural way to describe the inflation and the evolution of the early universe, as well as to obtain the observed value of the Hubble parameter in accordance with the Planck Collaboration results.

CREATION OF THE UNIVERSE AND OCCURRENCE OF BARYON ASYMMETRY

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Creation of the Universe and Schwinger symmetric world in which produced baryon asymmetry are shortly discussed. Classical cosmological solution for this Universe with a Λ -term has two branches divided by a gap. The quantum process of tunneling between branches took place. A model of a slowly swelling Universe as the result

of the multiple production of cosmological cycles arises naturally. Fortunately, in Schwinger symmetric world some physical processes took place owing to which lepton asymmetry appeared. In the early Universe magnetic monopoles as electrical ones were produced abundantly. Magnetic monopoles connected immediately in atoms and annihilated. The same process took place between electrons and positrons. But the first process was in 18769 times quicker than annihilation of electrons and positrons. Symmetry was broken and transferred by other process in the quark sector producing a sharp baryon asymmetry.

IMPLEMENTATION OF GRAVITATIONAL POTENTIAL SCREENING ON LARGE SCALES IN AN N-BODY CODE

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There was considered the Universe filled with cold dark matter in the form of discrete inhomogeneities (e.g., galaxies) and dark energy in the form of arbitrary continuous perfect fluids. The background space-time geometry is defined by the Friedmann metric. It was developed the first-order scalar and vector cosmological perturbation theory in the weak gravitational field [1]. Such approach works at all cosmological scales and incorporates linear and nonlinear effects with respect to energy density fluctuations. The gravitational potentials produced by matter fluctuations are characterized by a finite time-dependent Yukawa interaction range being the same for each individual contribution and which is of the order of 3700 Mpc at the present time. Therefore, the gravitational potential of the n -th fluctuation is exponentially suppressed at such scales. This suppression is called the cosmological screening. At smaller scales the Newtonian expression for the gravitational potential was reproduced [2]. The gravitational potential screening at large scales was implemented in an N-body code by adding the cosmological screening for taking into account Yukawa suppression on a large scale by the dynamic evolution of density perturbations.

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T-SOLUTIONS OF THE 5D KALUZA-KLEIN MODEL

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We consider spherically-symmetric solution of the 5D Kaluza-Klein theory, which metric coefficients depend on time only. When we construct the appropriate 4+1 splitting of the five-dimensional space and then perform the conformal transformation we get the cosmological model with hypercylinder topology. There are scalar and electromagnetic fields with contact interaction. Besides this, these fields cor-

respond to the inner region of the black hole in the appropriate choice of integration constants. Using 2+2+1 splitting technics and reduction we get the lagrangian of the model. After that we build the canonical formalism of the theory, which admits constraints. These are Hamilton, momentum and Gauss constraints. Momentum constraint is satisfied trivially in the homogeneous case. From the Hamilton constraint we obtain the Einstein-Hamilton-Jacobi equation. Main purpose of this work is to investigate this equation and three types of models, which we get from it. It turns out that the configurations with removable and unremovable electric field are possible to exist in this case. Removable electric field can be eliminated with 5D coordinate transformation.

THE AUTOMATED BINARY MORPHOLOGICAL CLASSIFICATION OF GALAXIES FROM SDSS

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We present a study on the supervised Machine Learning to be applied for binary morphological classification of galaxies. With this aim we used the sample of 60 561 galaxies from the SDSS DR9 survey with a redshift of $0.02 < z < 0.06$ and absolute magnitudes of $-24^m < M_r < -19.4^m$. We applied the following classification methods using own code in Python to predict correctly the morphologies of spiral and elliptical galaxies: naive Bayes, Random forest, Support Vector Machines, Logistic regression, and k-Nearest neighbor algorithm. To study the classifier, we used absolute magnitudes $M_u, M_g, M_r, M_b, M_z, M_u-M_r, M_g-M_b, M_u-M_g, M_r-M_z$, and inverse concentration index to the center $R50/R90$.

We compared these new results with previous one, which were made using the KNIME Analytics program delimitation. 3.5.3. It turned out that the method of Random forest provides the highest accuracy, as in the previous study, but with help of the supervised Machine Learning we increased an accuracy from 92.9% of correctly classified (96% – E and 84% – L) to 94.6% (96,9% – E and 89,7 % – L). The accuracy of the remaining methods also grew by 88% to 93%.

Therefore, using the Random Forest classifier and the data on color indices, absolute magnitudes, inverse concentration index of galaxies with visual morphological types, we were able to classify 60 561 galaxies from the SDSS DR9 with unknown morphologies. Finally, we found 22 301 E and 38 260 L types among them.

OPTICAL LUMINOSITY OF ACTIVE GALACTIC NUCLEI AND THE INTENSITY OF ITS HARD RADIATION RECORDED FROM THEM IN THE FORM OF PARTICLES AND QUANTA

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A correlation between the optical luminosity of noticeably distant galaxies with active nuclei (AGN) and the measured energy fluxes in the γ and hard X-ray ranges of their spectra was founded. The channels of reactions generated by high-energy particles and quanta, which lead to the cascade nature of energy losses and the most efficient processing of

their kinetic and nuclear energy into optical radiation, are determined. According to our results, the role of positron spectroscopy in the description of energy transfer from the center to the peripheral regions of AGN is noted. The effect of such processes on the physical state of interstellar gas-dust conglomerates surrounding AGN is shown. Calculations were made and the distribution of dust particles was estimated depending on the distance to the center of the AGN. The contribution of high-energy particles and quanta to the formation of background radiation in various regions of optically bright galaxies is determined. For the first time, characteristic properties of diffuse formations of such galaxies in the visible range, resulting from the motion of high-energy particles, are shown. It is shown that in this case the characteristic induced radiation spectrum should be sought in the simultaneous presence of certain γ – lines and Doppler broadening of the lines of certain elements participating in such interactions. AGN galaxies produce energies significantly higher than the total energy of their own stars, and the criteria for their “visibility” on large z are shown.

ELECTROMAGNETIC CASCADE MASQUERADE: ASTROPHYSICAL BACKGROUNDS FOR GAMMA-ALP OSCILLATION SEARCHES USING EXTREME TEV BLAZAR SPECTRA

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Extreme TeV blazars are active galactic nuclei with spectral energy distribution peaked at an energy of 1 TeV or above. These sources, while still rare in currently available surveys of space and ground-based gamma-ray telescopes, nevertheless play an extraordinary important role in extragalactic gamma-ray propagation studies. Some works report the existence of the "pair-production anomaly", an apparent excess of observed gamma-rays in the highest energy bins, where the optical depth of the gamma-gamma pair production process exceeds unity. This anomaly is frequently interpreted as an evidence for gamma-axion-like particle (ALP) oscillations. We inquire whether such an anomaly may be explained by any conventional astrophysical process. We show that the development of electromagnetic (EM) cascades in the intergalactic volume may potentially provide a strong source of background for gamma-ALP searches in extreme TeV blazar spectra. We provide detailed fits for a number of extreme TeV blazar spectra that were measured by imaging atmospheric Cherenkov telescopes in the past, and make detailed predictions that would allow to verify or falsify the proposed model [T.A. Dzhatdoev et al., *A&A*, **603**, A59 (2017)].

CLASSICAL DESCRIPTIONS OF THE GEOMETRODYNAMICS OF CHARGED BLACK HOLES

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The classical aspects of geometrodynamics charged black holes (CBH) are considered. For a spherically symmetric system of electromagnetic and gravitational fields, based on the Einstein-Hilbert action in the ADM form, a Hamiltonian action is constructed, which contain the Hamiltonian ($H \sim 0$), momentum ($Hr \sim 0$) and Gaussian ($H_A \sim 0$) constraints. The lapse and shift functions (N, Nr), and the

electromagnetic potential component A_0 are included in the Hamiltonian action, as Lagrange multipliers. The configuration allows an additional dynamic conserved quantity, which correspond to the total mass of the configuration. It describes the contributions of the gravitational and electromagnetic fields to the total energy of a spherical configuration and does not depend on the radius R . In addition, the Gaussian constraint leads to the law of charge conservation Q , which is proportional to the momentum conjugate to the component of the electromagnetic potential Ar . Using these conservation laws and the Hamiltonian constraint, we find the momenta P_L and P_R , which conjugate to the metric coefficient L and the scale factor R . It turns out that the momentum constraint, which is the invariance condition of the action, relative to the transformations $r = r(\tilde{r})$, for the found values of P_L and P_R is performed identically. A system of relations that equates the functional derivatives of the hypersurface action $S_{\Sigma}[L, R, Ar, r, M, Q]$ with the corresponding momenta is integrable. This allows us to find the functional of the hypersurface action S_{Σ} , as the solution of the Einstein-Hamilton-Jacobi equation in functional derivatives. Variations of action S_{Σ} with respect to mass M and charge Q lead to motion trajectories of the configuration in a mini-superspace for an arbitrary imbedding of hypersurfaces $t = \text{const}$ in the space-time. The family of these curves correspond to the solutions of the Einstein equation for different masses M and charges Q . Further, the minisuperspace metric is constructed and its geometry is studied. It is shown that for the trivial embedding of the hypersurfaces in the dynamic T -region of space-time CBH, the minisuperspace is flat. This allows us to introduce pseudo-Cartesian $3D$ coordinates in which the mini-superspace metric takes the Lorentz form. Therefore, the mini-supermetric admits the motions group $O(1,2)$. For an arbitrary embedding, this leads to a quasi-Cartesian metric in a nonholonomic basis.

DEEP LEARNING FOR MORPHOLOGICAL CLASSIFICATION OF GALAXIES

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We present the results of experiments with a deep learning applied to morphological classification of galaxies into the two classes: elliptical and spiral galaxies. To create the training sample, we visually inspected 6000 galaxies from SDSS DR9 with a redshift $0.02 \leq z \leq 0.06$ and absolute stellar magnitude $-24^m \leq M_r \leq -19.4^m$. With a given dataset, we used the state-of-art deep neural networks, namely CapsNet, InceptionV3, InceptionResNetV2, MobileNetV2, VGG16, VGG19, and DenseNet201, to provide classification trained on 5400 g-r-i composite images with k-fold cross validation. Keeping in mind a relatively small training dataset, we provided data augmentation (horizontal and vertical flips, random shifts and rotations of images). We introduced some insights about avoiding overfitting with different regularization methods (like a mixup, test time augmentation, averaging of the trained weights of trained neural networks) and proved the reliability of trained classifiers. As a result, we reached the highest overall accuracy of correctly classified types of 93.5% (95% – E and 86% – L) on 600 testing images with InceptionV3 deep convolutional neural network. The variation of accuracy obtained by another mentioned methods is statistically insignificant (92.3% to 93.0%). We expect

that ensembling all the methods as well as including additional classifier, trained on photometrical and morphological features, we are able to improve results.

ALIGNMENT OF GALAXIES IN SUBCLUSTRES PLACED IN RICH REGIONS

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The study of galaxies orientation is one of standard tests of galaxies formation scenarios. In filaments and walls the elliptical and disc galaxies show different orientations (Joachim et al., 2015).

We present the results of study of orientations of galaxies in 43 galaxy clusters which have filamentary or another regular substructures from the sample of 19 rich (richness 5 and more) superclusters containing 112 galaxy clusters. The observational basis of the work is PF Catalogue (Panko & Flin, 2006) based on Muenster Red Sky Survey (Ungruhe et al, 2003).

We compared the orientations of galaxies in filamentary structures with the directions of these substructures. We detect the not-random distribution of the mentioned acute angles. The galaxies tend to align along to direction of the cluster regular substructure.

The results of the research are discussed.

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IMAGES DISTRIBUTION OF BINARY SYMMETRICAL GRAVITATIONAL LENS

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Images distribution of Schwarzschild lens is well studied. We offer a method of studying images distribution of N-point gravitational lenses. The paper presents an example of the distribution of images in a binary symmetric lens.

We consider the equation of a binary symmetric gravitational lens in a complex form.

Masses $m_1 = m_2 = 1/2$ are located on a real axis with coordinates $A_1 = -a$, $A_2 = a$. The equation has a form

$\zeta = z - \frac{\bar{z}}{z^2 - a^2}$ and specifies single-valued continuous mapping $L: \bar{C}_z \rightarrow \bar{C}_\zeta$, from \bar{C}_z (lens plane) into \bar{C}_ζ (source plane). Inverse mapping $L^{-1}: \bar{C}_\zeta \rightarrow \bar{C}_z$ is multivalued.

Let $J = J(L) = \frac{D(\zeta, \bar{\zeta})}{D(z, \bar{z})}$ be a Jacobean of mapping L ,

Θ be a set of solutions of equation $J = 0$ (critical set), $K = L(\Theta)$ be a caustic.

Lemma. If

- $a \in (0; 0,35)$, then caustic K consists of three connected components;
- $a \in (0,35; 1)$, then caustic K is connected set;
- $a \in (1; \infty)$, then caustic K consists of two connected components.

We augment caustic in first and third case up to K^+ in order for $\bar{C}_\zeta \setminus K^+$ to consist of a few connected components, each of them to be a region and each area boundary to be a Jordan curve. We call set K^+ as augmented caustic. Only one component of the connected set $\bar{C}_\zeta \setminus K^+$ contains point at infinity. We call this component as external region and denote it as C_ζ^∞ . We call rest regions as internal.

Let $Q = L^{-1}(K)$ and $Q^+ = L^{-1}(K^+)$ to be images of caustic and augmented caustic under inversion mapping. Connected components $\bar{C}_z \setminus Q$ and $\bar{C}_z \setminus Q^+$ are divided into external (images of external components) and internal (images of internal components).

Using this designation, we have formed theorem.

Theorem. All connected components of $\bar{C}_z \setminus Q^+$ are regions. Unification of regions closure overlay the whole plane \bar{C}_z . Unification area boundary overlay Q^+ . If point source isn't located on K^+ , then all of its images belong to regions and each region contains one image at maximum. If point source belongs to external (internal) region, then all of its images belong to external (internal) regions. If point source are located on either K or K^+ or $K^+ \setminus K$, then its images belong to either Q or Q^+ or $Q \setminus Q^+$ respectively.

Remark. For binary symmetrical lens. If

- $a \in (0; 0,35)$, then $\bar{C}_z \setminus Q^+$ consists of 3 external and three sets of 5 internal regions;
- $a \in (0,35; 1)$, then $\bar{C}_z \setminus Q^+$ consists of 3 external and 5 internal regions;
- $a \in (1; \infty)$, then $\bar{C}_z \setminus Q^+$ consists of 3 external regions and two sets of 5 internal regions.

DARK AGES HALOS BRIGHTNESS IN ROTATIONAL LINES OF HEH⁺

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The interest in the helium-hydride molecular ion, HeH⁺, caused by its stability, in contrast to the neutral version, and by its composition -- this molecule is composed of the most widespread atoms in the Universe -- hydrogen, and helium. Even though this molecule a long time had considered as one of the most promising candidates for observational searches in radio

astronomy the first reliable its observation was carried out only recently by Gusten (2019). It is presumed that HeH^+ can play a significant role in the history of the first stars emerging at the end of dark ages and/or at the beginning of cosmic dawn since it is one of the first molecules to appear in the early Universe along with H_2 , HD, LiH, and their ions (on the cosmological background: Galli & Palla (1998); Lepp et al. (2002); Dalgarno (2005); Hirata & Padmanabhan (2006); in an evolutionary proto-halo and virialized halo: Novosyadlyj et al. (2018)). Molecules are known to be the only obvious coolants for baryon matter in the early Universe at temperatures below ~ 8000 K (Galli & Palla, 1998) because then there was nothing else to do that. These molecules can emit radiation away, causing the proto-star clouds of gas to cool and keep collapsing to allow first stars creation at the end of dark ages. In particular, molecules HeH^+ should be effectively cooled (Coppola et al., 2011) by emitting of radiation due to the large value of their electric dipole moment, 1.722 D, and should be present predominantly in the ground and low-lying rotational excited states. The population of HeH^+ by its ground and excited rotational states as well as the flux of its emission and/or absorption spectrum in the epoch of dark ages is defined by collisions with photons of the cosmic microwave background (CMB), free electrons and neutral atoms of hydrogen. Calculations for rotational and vibrational excitations/de-excitations rates for electron- HeH^+ collisions were performed by Rabadan et al. (1998); Hamilton et al. (2016); Curik & Greene (2017); Khamesian et al. (2018). However, up to date, there are no estimates for HeH^+ rotational excitations/de-excitations by collisions with neutral hydrogen (Roueff & Lique (2013); VAMDC; ExoMol).

The potential energy surface (PES) for H- HeH^+ collisions in analytical and numerical approximations is obtained. The state-to-state integral cross sections for rotational transitions during H- HeH^+ collisions are obtained and corresponding rate coefficients are calculated. The role of collisional excitations of low-lying rotational levels of HeH^+ in Dark Ages is discussed as on the cosmological background and inside evolutionary proto-halos and virialized halos. The thermal and resonance dark ages halos brightnesses were obtained in rotational levels of the helium-hydride molecular ion, HeH^+ .

THE ELECTROWEAK PHASE TRANSITION AND SPONTANEOUS CREATION OF MAGNETIC FIELDS

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We investigate the electroweak phase transition (EWPT) in the Minimal (One Higgs doublet) Standard Model (SM) and in the Two Higgs Doublets Standard Model (THDSM) with accounting for the spontaneous generation of magnetic and chromomagnetic fields. As it is known, in the SM for the mass of Higgs boson greater than 75 GeV, this phase transition is of second order. But according to Sakharov's conditions for the formation of the baryon asymmetry in the early Universe, it has to be strong first order. In the THDSM, there is a parametric space where the first order phase transition is realized for the realistic Higgs boson mass $m_H = 125$ GeV.

On the other hand, in the hot Universe, the spontaneous magnetization of plasma had happened. The spontaneously generated (chromo) magnetic fields are temperature dependent. They influence the EWPT. Color chromomagnetic fields B_3 and B_8 are created spontaneously in the gluon sector of QCD at temperature $T > T_d$ higher the deconfinement temperature T_d . Usual magnetic field H have also to be spontaneously generated. For T close to the T_{EWPT} these magnetic fields could change the kind of the phase transition.

At higher temperature, the symmetry is restored and all the fields are massless. We investigate also the spontaneous generation of hypermagnetic fields for this case. They could be generated spontaneously due to the quark loops. The strengths of the hypermagnetic fields at relevant temperatures are estimated.

Keywords: THDSM, electroweak phase transition, Sakharov's conditions.

ON THE DEGREES OF FREEDOM OF GRAVITATIONAL FIELD IN GR AND VARIATION TOOLS IN TETRAD REPRESENTATION

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In standard GR, the scalar curvature is used as the Lagrangian of the gravitational field. Since the scalar curvature contains not only the first, but also the second derivatives of the metric tensor, the variation procedure should result to the equations of the gravitational field as equations of the third order. Einstein's equations can be obtained only if the divergent contribution containing the Christoffel symbols in the scalar curvature is removed.

The tetrad approach allows redefining the degrees of freedom of a gravitational field (described by Riemannian geometry) so that each of them is described by a second-order equation with taking into account of all contributions to the scalar curvature. The introduction at every point of the space-time of any four non-coplanar non-collinear vectors (the local basis) allows us to represent any tensor of rank n as an n -multilinear combination of basis vectors with scalar coefficients. In particular, the tetrad approach makes it possible to go from varying the Lagrangian by the metric tensor to varying by scalar functions describing the metric tensor on the local basis.

According to the local basis, we can construct the corresponding conjugate basis. It turns out that even in the case of a holonomic basis, each of the vectors of the conjugate basis would have a non-gradient part. Separating the non-gradient parts of the conjugate basis makes it possible to introduce four antisymmetric tensors of the second rank, similar to the electromagnetic field tensor in Maxwell's theory. The currents, which are similar to electric charge currents in electrodynamics, can be constructed using antisymmetric tensors of rank II, which are not used in standard GR.

As the result, we obtain the following degrees of freedom of a gravitational field described in the framework of Riemannian geometry: a) scalar functions of the metric tensor in the tetrad representation (10 scalar functions), b) scalar functions of the full set of antisymmetric tensors of rank II in the tetrad representation (6 scalar functions), c) non-gradient parts of conjugate basis vectors (4 vector functions).

This approach is illustrated by the example of a spherically symmetric gravitational field in a vacuum (the analogue of the Schwarzschild problem in GR).

SOME COROLLARY FACTS OF THE N-POINT GRAVITATIONAL LENS EQUATION IN A COMPLEX FORM

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The equation of N-point gravitational lens has been considered in complex form:

$$\zeta = z - \overline{w(z)}, \text{ in which}$$

$$w = \sum_{n=1}^N m_n \frac{1}{(z-A_n)}; \quad \sum_{n=1}^N m_n = 1,$$

where m_n – included in the lens normalized point masses, A_n – their complex coordinates [1]. As in [2], we have taken account of:

$$w = \frac{1}{\deg P(z)} \frac{P'(z)}{P(z)},$$

where $P(z) = \prod_{n=1}^N (z - A_n)^{m_n}$.

New proofs of previously known theorems about images of a point source in an N-point gravitational lens have been obtained by using this equation. Those theorems: about single extended image (Einstein ring), about supremum of a number of point source images in the N-point gravitational lens [1,3], about infimum of a number of point source images in the N-point gravitational lens [1,3]. A new, previously unknown, result has also been obtained by using the equation in a complex form. That are formulas that single-valued express the coordinates of images through the same parameter (problem of image coordinates parameterization). Specifically, the coordinate of one of the images can be used as a parameter.

It should be noted that we can find each image coordinate, through one of its coordinates. This is the solution to one of the inverse problems of the theory of N-point gravitational lenses.

Example. Let S_2 is binary symmetrical lens with point masses. Point masses located on the real at the points with coordinates $A_1 = a$ and $A_1 = -a$. Then S_2 given by the equation:

$$\zeta = z - \frac{\bar{z}}{\bar{z}^2 - a^2}.$$

The point source is located on the real axis. For some values of the coordinates of the point masses, the source has three images at points with z_i , $i = 1, 2, 3$ coordinates. Therefore we have:

$$z_{2,3} = \frac{z_1 \pm z_1 \sqrt{1 + 4(z_1^2 - a^2)(z_1^2 - a^2 + 1)}}{4(z_1^2 - a^2)}.$$

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INTERNATIONAL NUCLEAR DATA CENTERS NETWORK AND PROSPECTS OF ITS USE IN NUCLEAR POWER IN BELARUS

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We give a brief overview of the existing nuclear data base, and describe the structure of the International Nuclear Data Centres Network. Because the amount of experimental data in nuclear physics is extremely large, the note aims to show the way to modern methods of acquaintance with the characteristics of arrays of nuclei through the nuclear data banks accessible through the Web-technologies. In particular, the note describes the methods to extract information on the nuclei and nuclear reactions in nuclear data banks. The data include information on the masses and energies of the nuclei of the separation energy of nucleons and clusters, the spectra of states of nuclei, their spin, parity, isospin, charge and mass radii and densities, information about the shape of the nuclei, the cross sections of nuclear reactions, the decay of unstable nuclei. On the completeness and accuracy of the data depends on radiation and nuclear safety, and environmental acceptability of nuclear installations. Creating a nuclear databases in Belarus will monitor the quality of nuclear data supplied to consumers, and ensure that systems of constants, used in technical projects, the current international standards.

MASSIVE ARGON SPACE TELESCOPE (MAST): A CONCEPT OF THE NEXT-GENERATION GAMMA-RAY SPACE TELESCOPE

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We consider a new concept of gamma-ray telescope called MAST for the energy range of 100 MeV – 1 TeV [1]. An era of the next-generation heavy rockets has begun (e.g., the Falcon Heavy rocket [2]), so it becomes possible to lift a payload as heavy as 63.8 t to the low Earth orbit and about 40 t to a medium (~500 km) circular Earth orbit. Therefore we consider it reasonable to propose a concept of a liquid argon heavy time projection chamber with the total sensitive mass about 36 t as a new-generation space gamma-ray telescope for the 100 MeV – 1 TeV energy range. We estimate the basic characteristics of the MAST telescope and show that its angular resolution is 3-10 times better than the Fermi-LAT one (depending on the energy) [3], and its differential sensitivity is even more than 10 times better than the Fermi-LAT one. A simplified energy reconstruction method yields the energy resolution about 20% at 100 MeV and between 6% and 10% for the 10 GeV – 1 TeV energy range. Thus the

MAST instrument may be a promising tool in a wide range of tasks, including the search for signals of dark matter annihilation/decay, precision constraints on extragalactic gamma-ray propagation models, studies of the extragalactic background light, the search for gamma-ray counterparts of IceCube neutrinos and LIGO/VIRGO.

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THREE-DIMENSIONAL (3-D) VERSION OF THE PERIODIC SYSTEM OF CHEMICAL ELEMENTS: THE FLOWER OF MENDELEEV

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A three-dimensional version of the Periodic System (PS) of chemical elements is proposed. It is based on the early works of Russian and French scientists: Mendeleev and de Chancourtois, while preserving the idea of consistency and continuity of a number of chemical elements. The resulting system resembles a "flower" with petals, which are elements with a certain orbital quantum number. The historical sequence of development of the idea of the spatial representation of PS chemical elements and the contribution of various authors are considered. D.I. Mendeleev is the true discoverer of the Periodic Law (PL) precisely because he first saw in him the Fundamental law of nature, and not just the formal system of classification of chemical elements that were already long before him, and the very idea of the periodicity of elements was known before. In the PL, he felt the unity of the elements and forces of Nature, and therefore the PS displaying him should have been a single whole, organically linking empirically isolated elements. According to the logic of the development of science at that time, it is quite natural that the PS could graphically be represented as the Periodic Table (PT). D.I. Mendeleev did so, strictly adhering to the principle of consistency and continuity, the first PTs were built. It is safe to say that the principle of consistency and continuity at that moment was the main Heuristic principle in the work of a scientist, which can still be called the principle of integrity.

And he brought overwhelming success and worldwide recognition to D.I. Mendeleev and PL. Since the PS is a single organically connected whole, according to the scientist's belief, any omissions and voids between the elements are absolutely unacceptable. It can be argued that Dmitry Ivanovich felt that the "infinity" of the PL cannot be adequately (strictly following the principles of consistency and continuity) expressed in a flat rectangular PT. The scientist foresaw that "... the system requires a bodily form that allows for convergence

in all directions." The spatial spiral shape was first proposed by the French scientist Alexander Emile de Chancourtois, one of the predecessors of D.I. Mendeleev in the opening of the PL. It should be noted that after Shankurtu many prominent scientists spoke and wrote about the volumetric form of PS. For example, academician A. Fersman proposed to erect a monumental monument (in the form of a spatial spiral) PS and D.I. Mendeleev, and the legendary physicist George Gamow used the spatial form of PS in his popular books on science. This spatial form was patented by Roy Alexander. Our model, in principle, is similar to the models of Gamow and Alexander, but there are certain differences: the s- and p- elements form separate independent petals (the previous authors combined them into one cylinder) and in our version all the petals extend from the same axis (the lines "growth"). The volumetric model of PS can be performed in various versions and can be recommended as a student manual.

Keywords: D.I. Mendeleev, periodic law, three-dimensional version of the periodic system.

THE PROBLEM OF "ZERO" IN THE WORKS OF D.I. MENDELEEV. NEUTRON MATTER AND ITS PLACE IN THE PERIODIC TABLE OF CHEMICAL ELEMENTS.

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D.I. Mendeleev wrote about the elements in front of hydrogen: "The chosen subject long occupied my thoughts, but for various reasons I didn't want to talk about it, especially because those few clarifications that I thought could withstand criticism did not satisfy me, and I expected everything from the experiments with which I intended to continue my first attempts, answers that were more encouraging in the correctness of the born conclusions. However, the years went away, the more persistent ones were torn off, and no one touched a question that seemed burning to me, so I decided to say in relation to him what and how I can do, without pretending at all about his decision." Elements before hydrogen inevitably fall into the zero group. "This position of argon analogs in the zero group is a strictly logical consequence of understanding the periodic law," stated D.I. Mendeleev. He allowed the existence of elements – X ("newtonium") and Y ("coronium") before hydrogen in the zero group. It should be recalled that Mendeleev had not been mistaken in his predictions of new elements! "When I applied a periodic law to analogues of boron, aluminum and silicon, I was 33 years younger, I had complete confidence that sooner or later the foreseeable must certainly be justified, because everything was clearly visible to me there. Justification came sooner than I could have hoped. Then I did not risk, now I risk. It needs determination. She came when I saw radioactive phenomena ... and when I realized that it was already impossible for me to postpone and that, perhaps, my imperfect thoughts would lead someone on a path more faithful than the possible one that seems to my weakening sight."

D.I. Mendeleev did not have time to solve this problem, and his students and followers tried to forget this topic as “erroneous”. It should be noted that after D.I. Mendeleev's question about “zero” elements was repeatedly raised by many authors both in the past and in the present centuries, however, for brevity, we only mention the very first and most famous ones: for example, Ernest Rutherford in 1920 and Andreas von Antropoff in 1926 as the designation for a hypothetical element with atomic number zero, which it placed at the beginning of the periodic table. A. Antropoff was the first to suggest the term “**neutronium**”. Currently, neutron matter, like neutron stars, is a recognized reality in astro- and nuclear physics. Neutron matter from the standpoint of General chemistry can be classified as chemically simple (that is, it cannot be decomposed into simpler chemical means), then inevitably the question arises about the Element corresponding to it, and its place in the Periodic System. Based on the logic of the Periodic Law – (ordinal number – electric charge) – the ordinal number of neutron matter will correspond to zero, which makes us remember and develop the ideas of Dmitry Ivanovich Mendeleev about the zero group and period.

Keywords: D.I.Mendeleev, periodic law, newtonium, coronium, neutronium, zero group and period.

SURFACE BRIGHTNESS PROFILE OF THE 3.5 KEV LINE IN THE MILKY WAY HALO

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We report a detection of 3.5 keV line in the Milky Way in 5 regions offset from the Galactic Center by distances from 10' to 35 degrees. We build an angular profile of this line and compare it with profiles of several astrophysical lines detected in the same observations. We performed a combined fit to all 5 spatial regions with relative normalization of the line in different region fixed in accordance with a Milky Way DM density profile. We are able to find a good fit to the data with a significant (about 7σ) improvement for the quality of fit when adding the new line.

Our new detection allows us to provide the new estimate on a signal-to-noise ratio of the planned sounding rocket experiment Micro-X.

NEW MASS BOUND ON FERMIONIC DARK MATTER FROM A COMBINED ANALYSIS OF CLASSICAL DSPHS

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Dwarf spheroidal galaxies (dSphs) are the most compact dark matter-dominated objects observed so far. The Pauli exclusion principle limits the number of fermionic dark matter particles that can compose a dSph halo. This results in a well-known lower bound on their particle mass. So far, such bounds were obtained from the analysis of individual dSphs. In this paper, we model dark matter halo density profiles via the semi-analytical approach and analyse the data from eight ‘classical’ dSphs assuming the same mass of dark matter fermion in each object. First, we find out that modelling of Carina dSph results in a much worse fitting quality compared to the other seven objects. From the combined analysis of the kinematic data of

the remaining seven ‘classical’ dSphs, we obtain a new 2σ lower bound of $m \gtrsim 190$ eV on the dark matter fermion mass. In addition, by combining a sub-sample of four dSphs – Draco, Fornax, Leo I and Sculptor – we conclude that 220 eV fermionic dark matter appears to be preferred over the standard CDM at about 2σ level. However, this result becomes insignificant if all seven objects are included in the analysis. Future improvement of the obtained bound requires more detailed data, both from ‘classical’ and ultra-faint dSphs.

THE KIDS STRONGLY LENSED QUASAR DETECTION PROJECT

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Strongly lensed quasars can provide unique insights into major open issues in cosmology and extragalactic astrophysics, but they are an intrinsically rare class of objects. Number of detectable of gravitationally lensed quasars (GLQ) have a strong dependence from the image quality, the depth magnitude and search area. The Kilo Degree Survey (KiDS) DR4 is covered about 1000 square degrees in 4 ugr bands. The median quality of the r-band images is FWHM=0.7 arcsec, and the deepness 25.2 mag is the best for ground based digital surveys. Such unique quality of images as well as the big enough cover area makes it as a perfect tool for testing of novel methods of searching of gravitationally lensed quasars. We tested some different techniques for detection of already known GLQs and compared results. Also, we found a several new GLQ candidates and started spectral follow up observation with SALT in order to confirm gravitational lensing nature of selected candidates.

GRAVITATIONALLY INDUCED DECOHERENCE IN TIMED DICKE STATES

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We discuss an effect of gravitational decoherence due to time dilation on the collective radiation dynamics of atomic system in timed single-photon Dicke states. We show that a photon absorbed by a stationary system of randomly placed atoms is no more spontaneously emitted in the direction of the impinging photon. Time-dilation effect leads to broadening of the angular distribution of the emitted photon towards gravitational attraction direction. This effect is potentially measurable by the techniques used in atomic interferometry.

INDUCED COLOR CHARGES AND POTENTIALS IN MAGNETIZED QUARK-GLUON PLASMA AT A_0 BACKGROUND

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We calculate the induced color charges Q_{ind}^3, Q_{ind}^8 , produced in quark-gluon plasma (QGP) with the spontaneously generated (chromo)magnetic $H^3(T), H^8(T)$ and usual magnetic $H(T)$ fields at A_0 condensate. They are created because of the color C -parity violation at this background.

The magnetic fields are generated due to asymptotic freedom of QCD at high temperature. The A_0 condensate is the order parameter of the deconfinement phase transition. It breaks the $Z(3)$ symmetry of $SU(3)$ finite temperature gluodynamics. To analyze the case of heavy-ion collisions, we consider the model of the plasma confined in the plane in one space direction and infinite in other ones plane. For this simple configuration, we derive the classical gluon potentials $\bar{\phi}^3$, $\bar{\phi}^8$ produced by these charges. The potentials are formed out of the condensates of longitudinal gluon fields. They are inevitable consequences of the A_0 condensate, that is independent of a specific bag model investigated. Possible applications of the results are discussed.

INFRARED COUNTERPARTS OF X-RAY GALAXIES

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XMM-Newton is a leading X-ray space telescope, which was used to compile the largest catalog of X-ray sources. Current version of XMM SSC catalog contains more than half a million sources. In our previous works we selected and analyzed a sample of 5021 X-ray galaxies observed by XMM. Identification and classification of these sources is essential next step of the study. We used infrared apparent magnitudes from WISE catalog of AGN candidates. In 2010 space telescope WISE performed full sky survey in four infrared bands and detected 747 million sources. WISE catalog of AGN candidates amounts 4 million of possible extragalactic sources. We built infrared color-color diagram for our sample of X-ray galaxies and assessed their types using WISE data. In the further studies we are planning to investigate the distribution of different types of X-ray galaxies within the large-scale structures of the Universe.

MODELS OF VOIDS IN THE OBSERVABLE UNIVERSE

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In recent years there are many astronomical observations of large spherical regions in the Universe with density of luminous matter, which is noticeably less, than that of their surroundings, also known as voids. This data enhanced theoretical studies of the evolution and influence of such regions in models of the expanding Universe.

Let us consider the voids, constructed by matching of Tolman solution for nonhomogeneous dust (description of void space-time) and Friedmann solution for homogeneous dust (description of space-time in the surrounding Universe) as a special case of the Tolman one. To gain a continuity of the first and second fundamental forms of the matched metrics, we impose the Lichnerowicz – Darmour matching conditions. We consider two different spherically symmetric Tolman space-times and chose the hypersurface $R=R_b=\text{const}$ as a matching boundary.

The voids described by the Minkowski space-time cannot exist in the Friedmann Universe. But it is possible to choose the Tolman Universe with exotic parameters, and such Universe can contain the voids, which are described by empty space-time. The Friedmann Universe also cannot contain the voids described by another Friedmann space-time.

Further, we investigate the voids in parabolic, elliptic and hyperbolic Friedmann space-times. We show that voids cannot exist in the parabolic Friedmann model, because the homogeneous energy density of the Friedmann Universe is equal to the average density in the internal space-time.

The possibility of the existence of the small and large voids was also considered. One can choose the mass function of the voids, which enables to describe the voids both in the early Universe and at present. The average energy density of the void is several orders less than energy density in the Friedmann Universe in the regions limited by R_b . As well, there are also the voids, which exist only in the early Universe. Now they are filled with matter. It is revealed from the numerical calculations that the Tolman time is always “older” than the Friedman one is.

EXTRAGALACTIC COSMIC RAY SOURCES WITH HARD SPECTRA AND THEIR STUDY

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We discuss possible existence of extragalactic cosmic ray sources with a particle flux on the Earth which is too low to be detected. It is shown that propagating particles from these sources can produce a noticeable flux of diffuse gamma-ray emission in space. This should be accounted for when analyzing cosmic ray sources as well as dark matter models. It is proposed that data on gamma-ray and neutrino emission can be used to study these sources.

MORPHOLOGY SUBTYPES IN RICH GALAXY CLUSTER WITH INTERMEDIATE CONCENTRATION

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The Universe consists of many galaxy clusters which we observe on the sky. Galaxy cluster is structure that consists of many galaxies (from 10 to 1000). In our work we are looking for rich clusters (100 and more galaxies) with intermediate concentration. We used Panko classification of galaxy clusters.

We analyzed structure of clusters and defined some regular structures (lines, floats, etc.) and irregular peculiarities (X-, Y-, curve-peculiarity). Also we analyzed orientation of galaxies in lines and float structures and define 3 subtypes of orientation galaxies in this structures (linear (l), normal (n) and intermediate (ln)).

Result of research are discussed.

ASTROPHYSICS

(stellar atmospheres, interacting binary systems, variable stars)

UNUSUAL SUB-LOW AND SUPER-LOW STATES OF THE MAGNETIC DWARF NOVA DO DRA

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Magnetic dwarf nova DO Dra is an enigmatic cataclysmic binary between the classes of dwarf novae and intermediate polar. Previous detailed study (2008A&A...486..855A) had shown the basic low state $V \sim 15.2$, which is occasionally interrupted by outbursts similar to that of the dwarf novae, but more short in duration due to the magnetic field. A possible $\sim 300^d$ wave was detected for the low state only. Contrary to theoretical expectation that the decay time is not dependent on the magnitude at the outburst, DO Dra had shown a significant correlation and a change of the slope of the light curve. A new type of variability – the “Transient Periodic Oscillations” was discovered. The quasi-periodic oscillations were studied in 2017JASS...34...37H.

In 2017, the system underwent a drastic decrease of brightness to a range from 15.82^m to 16.34^m with a mean of 16.095 ± 0.007^m (2017ATel10477...1B) and a double-humped wave during the orbital period. We have started an international campaign to follow the brightness variations and corresponding time-scales. Alert notes were published in 2017ATel10982...1A, 2017RNAAS...1a..20A, 2018RNAAS...2d.197A, 2019ATel12527...1A. However, this unusually long state lasts till now, more than 25 months. The brightness has not returned to its basic low state, but several times returned to a state intermediate between the “low” and “super-low”. We call this state the “sub-low” state and continue monitoring. Another “super-low state was recently detected. The cause of this change in recent years is due to cease of the accretion rate. However, if it will be long-term, e.g. due to entering the “period gap” of the system due to evolution powered by gravitational radiation and magnetic stellar wind, or is of a few year-scale duration due to a solar-type activity of the red dwarf, is under question. The monitoring is continued.

This work is a part of the “Polar” part of the “Inter-Longitude Astronomy” (2017ASPC..511...43A) international project, as well as of the “AstroInformatics” (2017IAUS..325..361V).

MAVKA: STATISTICALLY OPTIMAL PHENOMENOLOGICAL APPROXIMATION OF SIGNALS IN NEAR-EXTREMAL INTERVALS

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The software MAVKA is developed for various types of data analysis, especially, for approximations of data, when time series are close to the extremum of brightness of the object. The minimal number of the parameters of the approximation, which are typically used, is one. The common terminology was “minima/maxima timings”, whereas recently the ToM (Time of Minimum/Maximum) is used (e.g. in the AAVSO). The ToMs are used for the “O-C” analysis for studies of the photometrical period and its possible changes. There were several methods used for this purpose, which were realized by various authors. We incorporated these methods (or our improvements of them), as well as a series of own algorithms, into a single software MAVKA. The user may choose a single method, or any number from 9 types of function (totally 19 approximations). The program also allows a “batch” mode, when all of the data in the subintervals are analyzed subsequently, thus allowing splitting of the work into “filter,” “selecting subintervals” and “analysis” stages. The program applies the allowed approximations, and chooses the one corresponding to the best accuracy of moment for the extremum. An important (and slow) part of the algorithm is checking the values of approximation parameters to be in physically realistic intervals. Program MAVKA allows visualization of the approximation and its “error corridors” either in “individual”, or in the “batch” modes..

Most of approximations are symmetrical. Some of them divide data set into the subintervals, each of them approximated by its own function. These methods are effective for studies of eclipsing variables, transits of exoplanets and pulsating variables with negligible asymmetry. But we compare asymmetrical functions too: parabolic spline of defect 1, asymptotic parabola. They may be applied for the pulsating variables or eclipses of the binaries with the O’Connell effect. The reviews on the methods were published (2019OEJV..197...28A, 2003ASPC..292..391A).

We made tests of all these methods using synthetic and real data. In first case we compare the deviation between generated and determined values of moment of extremum and its magnitude. In the second one, we determined moments of extrema for some photometric CCD and visual observations from different databases. The results obtained using different methods are compared.

Previous versions of the program (2019OEJV..197...65A, 2017OAP....30...57A, 2015OAP....28..158A) were applied to

observations of eclipsing binaries, pulsating variables an exoplanet transits, which were analyzed within the “Inter-Longitude Astronomy” (2017ASPC..511...43A) and “AstroInformatics” (2017IAUS..325..361V) international projects.

INTERPRETATION OF ALMA OBSERVATION OF DUSTY TORUS IN NGC1068

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It is known that the differences among AGNs are determined by the orientation of the dusty torus with respect to the line-of-sight. Such a torus plays a key role in feeding the accretion disk and in supporting the high luminosity of the central regions of active galaxies. Recent ALMA observations have resolved the obscuring torus in the nearest Sy2 galaxy, NGC1068, in the millimeter band. These observations have confirmed the presence of a geometrically thick torus and have discovered an orbital motion of the matter with some dispersion of the velocity. In the framework of N-body simulations we consider a dynamical model of an obscuring torus which accounts for the gravitational interaction between the clouds moving in the field of the central mass. In our model, clouds are orbiting around the central mass exhibiting a spread in inclination and eccentricity. The self-gravity of the torus induces dispersion in the clouds velocity with a global orbital motion which mimics the ALMA data for NGC1068. We can also explain the VLT/MIDI observations in the IR band which have revealed two regions in the temperature distribution of the torus of NGC1068.

PHOTOMETRIC MONITORING OF THE "KING OF INTERMEDIATE POLARS" FO AQR

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We run photometric monitoring of the intermediate polar FO Aqr since 2008. CCD observations were obtained using different telescopes, most commonly the 1-meter VNT at the Vihorlat Astronomical Observatory in Kolonica and 60-cm Zeiss-Cassegrain at the Observatory and Planetarium in Hlohovec, Slovak Republic. We obtained the set of nightly light curves in V and R filters, sometimes one filter or unfiltered. From each night using trigonometric polynomial of the 1st order we obtained one spin pulse maxima timing (i.e. the time of maximum of brightness and minimum of the stellar magnitude).

We build the O-C diagram with the initial values of $P = 0.014519029$, $T_0 = 2444782.9169$ (Patterson et al., 1998). The chart consists of 130 points grouped into 11 groups from season to season. We see similar linear trends in each long season, that argues for a presence of cycle miscount

about 21 cycles per duration of observations. The statistically optimal linear fit gives us the current value of the spin period of the white dwarf 0.014517857(2) days with initial epoch 2457197.07455(16). It's similar to the value of 0.014517757(9) (Kennedy et al., 2016) obtained using K2 data, 0.014521(3) (Breus et al., 2012) and 0.01451718(19) days (Andronov et al., 2004) derived from 1 season of photometry in 2004.

Using our new ephemeris we repeated O-C analysis and it revealed the sinusoidal-like trend with an amplitude of 0.81 of the spin period. We proposed two possible fits to the O-C: periodic trigonometric polynomial fit and parabolic fit. The first one may be interpreted as a presence of the third body orbiting the inner binary system with the period about 16 years. The second one agrees with previously published data about complicated changes of the spin period in this system. We can state that the system showed a spin-up until 2013 and it changed to spin-down since 2014. The maximum of sinusoidal fit to the O-C corresponds to 2010 and minimum to the end of 2017. Patterson et al. (1998) suggests that the alternation between spin-down and spin-up means the star is near its equilibrium spin period.

The third body hypothesis was rejected as the residuals for the orbital ephemeris were absent (Bonnardeau, 2016) and two earliest timings from that paper violated the proposed periodic fit. The O-C since 2013 is well described by the cubic weighted polynomial fit, but the cubic term is about 4 of its error estimate so we used quadratic one. It gives us the rate of period change $dP/dT = 1.28 \pm 0.09E-10 \text{ s}^{-1}$ which has 2 times larger absolute value then published by Williams (2003) and close to published by Bonnardeau (2016), but opposite sign.

Using data obtained in the same photometric color system, we study correlations between spin pulse times and the mean brightness of the system and between spin phase residuals and the orbital phase of the system. We propose few most probable cycle numberings of all available spin maxima timings published since 1981 and corresponding polynomial fits.

Using the fast photometry and polarimetry, obtained since 2004 using 2.6-meter Shain Telescope of the Crimean Astrophysical Observatory (Ukraine) we are trying to find periodicity on the shorter time-scales. We noticed that few sets had low-amplitude circular polarization changes with the spin pulse period, other sets show no changes.

MAGNETIC FIELD OF PULSATING STARS

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Pulsations have been detected during various evolutionary stages of stars. Moreover, recent evidence suggests that all stars pulsate, if we measure them carefully enough. To date, magnetic field has been detected in various types of pulsating stars. For several of these stars, the variability of the magnetic field with their radial pulsation period was recently confirmed. But the physical mechanism of the pulsation variability of the magnetic field remains unknown. In this brief review, we will focus on the current state of the problem of magnetic field variability in radial pulsating stars.

SEMI-REGULAR VARIABLE STARS: LONG-TERM VARIATIONS OF THE CHARACTERISTICS OF PULSATIONS. RY UMA

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The semi-regular pulsating variable RY UMa was analyzed on 6486 visual observations from the AFOEV database. The time interval HJD 2451629 – 2458026 continues the previous interval studied in the “Catalogue of Main Characteristics of Pulsations of 173 Semi-Regular Stars” (2000OAP....13..116C), where the periodogram had shown 3 peaks at periods $P=3926^d \pm 12^d$, $303.74^d \pm 0.08^d$ and $285.29^d \pm 0.07^d$ days and corresponding semi-amplitudes $r=0.197^m$, 0.122^m and 0.122^m , respectively. Our new studies show a single peak with a period $287.00^d \pm 0.14^d$, initial epoch for the maximum brightness (minimum magnitude) $T_0=2454005.2 \pm 0.8$ and semi-amplitude $r=0.211^m \pm 0.004^m$, superimposed onto a trend (which was approximated by a parabola). These parameters were obtained by using a complete model, without any detrending or prewhitening, as realized in the software MCV (2004AstSR...5..264A). The characteristics of the individual maxima and minima were determined using the new software MAVKA (2019OEJV..197...65A). The brightness at the individual maxima varies from 6.91^m to 7.29^m , at the minima – from 7.52^m to 8.09^m . For the analysis of the smooth variations of the mean brightness (over the cycle of pulsations), semi-amplitude and phase, the “running sines” method was applied (2013CKA....10..171A).

This work is a part of the “Stellar Bell” (2014AASP...4....3A) part of the “Inter-Longitude Astronomy” (2017ASPC..511...43A) international project, as well as of the “AstroInformatics” (2017IAUS..325..361V).

FORMATION AND EVOLUTION OF DUST PARTICLES IN A FIELD OF HARD RADIATION

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In present paper has been continued definition of microscopic characteristics of the low temperature plasma (LTP), who are connected with formation and evolution of dust particles (DP) in the presence of uniformly distributed proton-excess radioactive isotopes. Separately, the structure of the field of hard radiation with given source functions – $S(E)$ and the energy distribution of Auger electrons $f(E)$ are described. It has been shown that when expanding into a vacuum medium or medium with a markedly lower density, after explosive shell (more specifically, the shell of type IIb supernovae) containing LTP with DP already moves in the adiabatic phase. Than the solution of the equations of gas motion for the formulated problem is sought the Sedov’s method. In the framework of this method, semi-empirical

dimensionless powers are used with the desired thermodynamic parameters. The beginning of the formation of DP is fixed by recording the time of the occurrence of the observed infrared (IR) excess in expanding gas. For such physical conditions, features of nucleation processes have been revealed, consisting in the fact that two-three-atom molecules based on silicon and carbon are represented as monomers participating in condensation, and ionized macromolecular complexes can be primed. Equations of equilibrium and non-equilibrium nucleation and further growth of DP are taken into account the consequences of the presence of a hard radiation field $S(E)$ taken from satellite observations and added from the author’s previous calculations. It is shown that the photo-emission from the surface of the condensation nuclei caused by the radiation field forms a positive charge and, as a result, the surface potential reaching 100V. Relationships for the probability and sticking coefficient of positively charged and neutral molecular ions involved in condensation are obtained. These results were used to determine the evolution of the particle size distribution function $N(a)$ inside an expanding explosive shell comparing it with $N(a) = N_0 a^{-3.5}$, obtained by studying a supernova interstellar space local to the explosion. The analysis of observational manifestations of scattering and absorption of X-rays by known $S(E)$, received in the previous works of the author, was continued. For hard X-ray point sources, the presence of a lower size limit for the left wing $N(a)$ in the region of small particles ($a_{\min} \sim 10 \text{ \AA}$) was revealed at which their destruction occurs due to Coulomb forces. The wing of the function $N(a)$ corresponding to large sizes is limited to values of the order of $a_{\max} \sim 10^3 \text{ \AA}$. It is proposed that in the case under consideration such a restriction is caused by the cumulative effect of depletion of the content of the corresponding monomers in the unit of volume and Coulomb repulsion between the positively charged condensation nuclei and positively charged ions of atoms and molecules.

PARAMETERS DETERMINATION OF TWO POORLY STUDIED ECLIPSING VARIABLE STARS: V1044 CAS AND V0779 CAS

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We analyzed variability of poorly studied eclipsing variable stars by using ASAS-SN database. For two of them we corrected the elements and obtain the parameters of light curve by using New Algol Variable algorithm. For V1044 Cas (period 3.57917 ± 0.00001^d) we analyzed O-C curve and estimate the rate of period increasing. For V0779 Cas we made two approximations with possible periods of 6.353548 ± 0.000004^d and 3.176438 ± 0.000005^d , for both approximation we estimate the orbit eccentricity (corresponding values are 0.27 ± 0.05 and 0.37 ± 0.06). For both variables we estimate the ratio of stellar radii in assumption of the total eclipse.

THE CHEMICAL COMPOSITION OF HIP 13962 – THE POSSIBLE FORMER MEMBER OF BINARY SYSTEM WITH SUPERNOVA

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HIP13962 can be the star ejected from the binary system where the other component was exploded as a Supernova. We investigated the spectra of HIP 13962 obtained at different 2-meter class telescopes. The spectral lines were identified using the comparison of synthetic spectra calculated for different abundances of heavy elements with observed spectra. Special attention was devoted to radioactive elements, as the atmosphere of HIP13962 can be contaminated by r-process enriched matter during the SN event.

MOLYBDENUM AND RUTHENIUM ABUNDANCES IN GALACTIC DISC GIANTS

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Mo and Ru abundances in galactic disc giants with metallicities within $-1.0 < [\text{Fe}/\text{H}] < +0.3$ are presented. The observations were conducted using the 1.93 m telescope equipped with the echelle type spectrographs ELODIE and SOPHIE at Observatoire de Haute-Provence (OHP, France). The results were obtained from the analyses of spectra of typical signal-to-noise ratio ($S/N \sim 100-300$) and resolution ($R=42,000$ for ELODIE and $R=75,000$ for SOPHIE). The molybdenum and ruthenium abundances were determined by the LTE spectral synthesis. The comparison of the Mo and Ru abundances in dwarfs and giants are provided. Behaviour of Mo and Ru abundance enrichment in the Galactic disc have been discussed.

STARS WITH EXOPLANETS AND OBSERVATIONS OF THEIR TRANSITS AT CRAO

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Observations of exoplanets with the goal of advancing our understanding of their formation and structure, and eventually their habitability has been conducted at CrAO since the mid-2000s. Our co-workers participated in the works in which exoplanets were first discovered in some stars. [1]

After concluding a cooperation agreement on joint research with the Institute of Astronomy at National Tsing Hua University (Taiwan), systematic observations of exoplanet transits are carried out with the CrAO MTM-500 telescope.

The list of objects for observations includes red dwarfs with solar activity from the GTSh-10 [2] catalogue to

search for possible flares associated with the observed transit of the exoplanet.

The obtained observations, among other things, supplement the database of photometric studies of stars at the CrAO.

The analysis of the obtained results was carried out and compared with information from the ETD [3] and NASA Exoplanet Archive databases and presented in this conference report.

This research has made use of the NASA Exoplanet Archive, which is operated by the California Institute of Technology, under contract with the National Aeronautics and Space Administration under the Exoplanet Exploration Program.

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GAIA ALERTS IN X-RAY AND RADIO RANGES

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Gaia Alerts is an all-sky photometric transient survey which is based on measurements by the Gaia satellite. The repeated scans are needed to determine precise stellar positions. In addition, they are useful to search for variations in brightness of sources. In this paper, we present the object-by-object comparison of Gaia alerts with Chandra X-ray catalog, as well as WISH, GLEAMEGCAT, VLSSR and FIRST radio catalogs. Results of this comparison could help to clarify the nature of the objects.

RV TAURI STARS

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An interesting class of the long-period variables – RV Tau – type stars is reviewed.

The variables of RV Tau type are a class of low-mass (with masses of the order of one solar) pulsating F–K – supergiants ($M_v = -3^m \div 5^m$), which are probably at the short-term evolutionary stage of the transition from the red giant to the protoplanetary nebula, which explains the small number of stars of this type of variability. Using AFOEV data, the study of stars is carried out using periodogram analysis for RVa and RVb stars. Also the stars uncertain type RVa and RVb are studied. Perhaps this class of stars contains objects of other types (Mira-type of early spectral subclasses, yellow semi-regular variables, cepheids).

The mean light curves and phase portraits obtained as a result of the periodogram analysis are studied.

DATA ACQUISITION SYSTEM IMPLEMENTED IN THE ASTRONOMICAL OBSERVATORY ON KOLONICA SADDLE

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The main observing program at the Astronomical Observatory on Kolonica Saddle are different types of variable stars. During the ordinary observing night several telescopes are collecting data simultaneously. But usually only one observer is available to manage all instruments. In this work we describe unique system developed for observing management and data reduction. The crucial point of the system is the software package CoLiTecVS which creates the light curve of investigated variable star without manual data handling between processing steps and practically online as the images are downloaded from the camera. For the observer remains other important tasks: targets selection, time slots determination, pointing the telescopes, setup autoguiding systems and imaging parameters, solving technical issues during the observing session, performing visual observations. At the end of the observing session we have all light curves ready for further analysis and stored in the local database of photometric data. The analysis itself is done by professional astronomers from several institution in the world. Fruitful collaboration was developed mainly with: Odessa National University, Odessa National Maritime University, Kyoto University – VSNET collaboration, Astronomical Institute of Slovak Academy of Sciences, Masaryk University Brno, University of P.J. Šafárik Košice. We present most interesting results published in refereed journals. Short information about other scientific experiments carried out at the observatory is presented as well.

POLARIMETRIC METHODS IN ASTROPHYSICS

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The applications of the method of aperture polarimetry to various astrophysical problems are reviewed. The method allows obtaining statistically based results both on large-diameter telescopes with high temporal resolution, and on medium-diameter telescopes. The possibility of using the polarimetric and spectro-polarimetric method of measuring the flux of space objects using the existing equipment of Astronomical Observatory of the Odessa National University is discussed. The calculated error values of the degree of linear polarization depending on the brightness of the objects are given.

SPECTROSCOPIC MONITORING OF THE B[e] OBJECTS FS CMA AND MO CAM

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Objects with the B[e] phenomenon exhibit permitted and forbidden emission lines due to the presence of circumstellar ionized gas and large infrared excesses due to processing of the stellar radiation by circumstellar dust. There are five groups of B-type stars that show this phenomenon (pre-main-sequence Herbig Ae/Be stars, symbiotic binaries, proto-planetary nebulae, some supergiant, and FS CMA type objects). The latter group is the most recently discovered and the least explored one. A leading hypothesis about the nature of the group implies that they are mostly intermediate-mass binary systems, whose circumstellar medium was created during a strong mass-transfer phase due to a Roche lobe overflow of the more massive star in the system. We are conducting a long-term program of spectroscopic and photometric observations of many objects and candidates to this group. We have revealed binarity of several group objects. The current report is devoted to the preliminary results of our ongoing study of two objects with similar underlying early B-type stars, FS CMA (the group prototype) and MO Cam. The objects show different emission-line profiles and infrared excesses, which are most likely due to different tilt angles of their non-spherical envelopes with respect to the line of sight. Variability of both emission and absorption lines has been discovered and is discussed here.

CHEMICAL IMPRINTS IN ATMOSPHERIC ABUNDANCES OF PLANET- HOSTING STARS

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Peculiarities of the stellar chemical composition serve as an important tool in studying the presence of planetary

systems around stars and formation of planets. Previous spectroscopic measurements indicated some changes in the elemental composition of such stars. Thus, the dependence of the metal abundance on the condensation temperature T_{cd} was established for a number of stars. Such parameters as metallicities, lithium abundances, C/O and Mg/Si ratios, as well as the abundances of neutron-capture elements, such as barium, thorium, etc., were considered as indicators of the presence of planets. In this work, we present an analysis of the foregoing properties of stars with detected planetary systems (and estimated masses of planets) conducted on the basis of spectra obtained with the SOPHIE echelle spectrograph (1.93 m telescope) at the Observatory of the Haute Provence.

THE ON- AND OFF-STATE GENERATIONS IN THE CASE OF THE THICK ACCRETION DISK AND UNDEFINED PRECESSION PERIOD. 3-D NUMERICAL HYDRODYNAMICAL SIMULATIONS IN ACCRETION DISK IN MICROQUASAR CYG X-1.

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In the present work we have computed the thick accretion disk (the accretion disk with radiation pressure) for the case of undefined precession over very long time (more than 25 precession periods). The calculations show that in this case the originations of the ON-states and OFF-states are strong irregular in time. The calculations also show that the jet's launches are taking place very suddenly over 5-6 minutes of the orbital time.

STARSPOT ACTIVITY OF COOL STAR 61 CYG A AND EVOLVED STAR β Aql

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Studying the large-scale and small-scale magnetic fields of Sun-like stars enlightens our understanding of the field properties and gives us observational constraints for the field generation models. We modeled spectropolarimetric observations of cool star 61 Cyg A (K5 V) and evolved star β Aql (G8 IV) in order to search for and estimate their starspot activity. We calculate surface distribution of global and local magnetic fields over the visible hemisphere of the stars corresponding to a large number of dipolar magnetic field configurations, varying the dipole intensity $B_{\{d\}}$ as well as the angle β between the rotation and dipole axes. Then we calculated the atmosphere model and weighted and integrated over the visible hemisphere synthetic spectra, taking into account the contribution of both the global and local field components. Using

these synthetic spectra, the longitudinal magnetic fields of these stars were calculated and compared with the longitudinal magnetic fields obtained from observational spectra. The presented method allows us to estimate the spot activity of stars by direct spectropolarimetric measurements of their magnetic field.

Keywords: Stellar magnetic fields, convective stars, stellar activity.

RESULTS OF MONITORING OF FIVE ACTIVE GALACTIC NUCLEI IN OPTICAL RANGE

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The results of systematical monitoring of selected objects from the CTA optical follow up list, started in January 2018 are presented. The observations are carried out with the AZT-8 ($D = 70$ cm, $F = 2.8$ m) telescope of the observation station Lisnyky of Taras Shevchenko National University of Kyiv. This telescope was included in the list of supporting instruments in the CTA consortium. The AZT-8 is equipped with the PL4710-1-BB-E2V CCD and broadband Johnson/Bessel UBVR filters.

Light curves for five objects: 1ES 1011+496, PKS 1222+216, 1ES 1426+428, PKS 1510-089, Mrk 501 were plotted. We determined the variability amplitude and tested all these objects for Intraday Variations (IDV), Short (STV) and Long term variability (LTV) where it was possible. In addition, variability of color indexes with time was investigated. The results and methods were analysed.

THE SEARCH FOR CANDIDATES FOR DOUBLE OPEN CLUSTERS IN THE GALAXY

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The use of highly accurate Gaia DR2 data allowed us to obtain new estimates of the astrometric and kinematic parameters of the open clusters, supplement them with faint members, and also discover new OCs.

Star clusters form due to the collapse of giant molecular clouds. There are double star clusters, such as Persei h and χ (Messow & Schorr 1913) and some that suggest that several star clusters can form from a single cloud. The purpose of this work is to search for such clusters and analyze their properties in the light of new data that can help to understand their origin.

We compiled a compilative list of OCs, taking data from various catalogues and papers, including new clusters. The candidates for binary clusters were selected by angular distance, and by parallax (if this parameter available for cluster), after which the analysis was performed on the kinematic parameters of clusters, as well as on age. The result is a list of candidates for double star clusters with their parameters.

USING CONSUMER-GRADE DSLR CAMERA AND SMALL TELESCOPE TO FIND NEW VARIABLE STARS

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Twenty-six new variable stars were found on DSLR images captured from October 2017 to June 2019. All images were taken using unmodified Canon EOS 600D DSLR attached to a Skywatcher 150/750 Newtonian on a motorized equatorial mount. The variables were registered in The International Variable Star Index (VSX, AAVSO) as PMAK V1 .. PMAK V26 respectively. Most of them (twelve) were classified as semi-regular variables of different subtypes; nine as eclipsing binaries (EA, EW, and EB); three rotating RS Canum Venaticorum-type stars; one rotating ellipsoidal variable (ELL) and one Delta Scuti-type pulsating variable.

The setup and methodology used by the author allowed discovering of variables having a wide range of maximum brightness (from 8.9m to 14.9m in V band) and quite different periods of variability, from hours to hundreds of days. Although all variables were detected on images taken by the author, detailed analysis and classification of stars required the involvement of additional data sources (such as automated sky surveys).

Data reduction and analysis were made using a combination of free software and software developed by the author.

SPECTROSCOPIC AND PHOTOMETRIC INVESTIGATION OF CHEMICALLY PECULIAR STARS

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We have studied chemically peculiar star HD24712 using photometric observations from the space telescope TESS and spectroscopic data from the Canadian Astronomy Data Centre. This star possesses a significant magnetic field. Our analysis of the light curve obtained by TESS for HD24712 using Period04 resulted in detection of two periods of variability: one period of stellar rotation, which equals to 12.34 ± 0.06 days and period of pulsation that is approximately 6 minutes. To get the phase curve we used our code that excludes data that show significant deviation from the main sequence. Using available spectra of HD24712 we have studied the variability of line profiles and their magnetic widening with the phase of stellar rotation assuming a model of the oblique magnetic rotator.

SPECTROSCOPIC INVESTIGATIONS OF GALACTIC CLUSTERS WITH ASSOCIATED CEPHEID VARIABLES. III. COLLINDER 394 AND BB SGR.

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We present the results of a spectroscopic and photometric investigation of 17 objects from the open cluster NGC 5662, which contains the Cepheid BB Sgr.

Besides the Cepheid, we studied three K-giants, five B-giants, and nine main sequence stars. Radial velocities (RV), $v \sin i$, T_{eff} , $\log g$, and [Fe/H] were determined using photometric and spectroscopic model fitting.

We have derived the color-excesses, reddenings, and intrinsic colors for these stars to determine their true T_{eff} , and $\log g$, from comparison to the atmosphere models, especially for hot stars, and to determine their absolute magnitudes.

POLARIS, THE NEAREST CEPHEID IN THE GALAXY: 130 YEARS OF RADIAL VELOCITY MEASUREMENTS, THE ORBITAL ELEMENTS SPECIFICATIONS AND PULSATION PERIODS SEARCH

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We present the results of our analysis of Alpha UMi spectroscopic observations from 2015 to 2019. The radial velocity estimations (158 values) were added to common Polaris RV list from 1890 to 2019 and we obtained 2551 ones in total.

These data have been analyzed to specify the known pulsational and orbital periods and to search another possible ones.

THE CHEMICAL COMPOSITION OF HV 834 – CEPHEID OF THE SMALL MAGELLANIC CLOUD

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We investigated the spectrum of HV 834 obtained at 8.2 meter telescope of ESO with spectral resolving power near $R=30,000$ and signal to noise ratio near $S/N=70$. The lines of all chemical elements up to thorium and uranium (atomic numbers $Z=90$ and 92) respectively were analyzed and chemical composition of the star was found. The overabundances of elements with atomic numbers over $Z=30$ are found. The obtained abundance pattern is compared with r- and s-processes abundance distributions.

KINEMATICS OF MAIN SEQUENCE STARS IN THE SOLAR NEIGHBORHOOD FROM THE GAIA DR2 AND PMA DATA

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For kinematic investigations, 26 million main sequence (MS) stars were selected from the sample of Gaia DR2 and PMA common stars in the heliocentric distance range 100 – 1000 pc. For this, the $M_{K_s,0} - (J-K_s)_0$ diagram, corrected for reddening and extinction, was used. To analyze behavior of kinematic parameters on color (and therefore on stellar age) the MS stellar sample was binned by $(J-K_s)_0$ into 8 subsamples with bin sized 0.1 mag.

For each subsample, we decompose the stellar velocity field onto a set of vector spherical harmonics and calculate the Ogorodnikov-Milne (O-M) model parameters from the derived decomposition coefficients. As a result, systematic differences between values of some kinematic parameters derived from the Gaia DR2 and PMA proper motions were found. For example, $\Delta\omega_3(\text{Gaia DR2-PMA}) \approx -1 \text{ km s}^{-1} \text{ kpc}^{-1}$, $\Delta M_{+12}(\text{Gaia DR2-PMA}) \approx 1.5 \text{ km s}^{-1} \text{ kpc}^{-1}$ on average. As a result, the difference between values of the galactic linear rotation velocity at the solar distance ($8.0 \pm 0.2 \text{ kpc}$) $\Delta V_{\text{rot}}(\text{Gaia DR2-PMA}) \approx 15 \text{ km s}^{-1}$. Besides, a number of beyond-the-model coefficients were detected, among them the t_{211} and s_{310} coefficients have the greatest amplitude.

To analyze kinematic parameters independently in the northern and southern galactic hemispheres, a set of zonal vector spherical harmonics was applied. It was confirmed that values of the M_{+23} and ω_1 parameters derived in the northern and southern galactic hemispheres have opposite signs. This effect occurs due to the vertical asymmetric drift $\partial V_{\text{rot}}/\partial Z$: the rotation velocity of stars around the galactic center decreases with increasing distance from the galactic plane. We have found that $|\partial V_{\text{rot}}/\partial Z|$ is zero at $0.1 < (J-K_s)_0 < 0.2$, then increases up to $\sim 20 \text{ km s}^{-1} \text{ kpc}^{-1}$ at $0.3 < (J-K_s)_0 < 0.4$, and then remains roughly constant up to $0.7 < (J-K_s)_0 < 0.8$.

To confirm the fact that the t_{211} and s_{310} coefficients arise due to the presence of the vertical asymmetric drift, modelling the stellar velocity field was carried out.

THE CHEMICAL COMPOSITION OF BARIUM STAR HD 204075

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HD204075 is one of the youngest barium star that is why it is naturally to expect for the contamination of its atmosphere by s-process enriched matter, including the unstable chemical elements. We investigated the spectrum of HD 204075 obtained at 8.2-meter telescope of ESO. The overabundances of s-process elements are confirmed. The absorption lines of technetium (atomic number $Z=43$) are identified in the spectrum of HD204075 and the abundance of this unstable chemical element is estimated.

SELECTION EFFECTS OF OBSERVATIONS IN DISCOVERIES OF EXOPLANETS WITH CIRCULAR AND ELLIPTIC ORBITS

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Results of the statistical analysis of distribution of exoplanets are presented based on the taking into account the selection effects. For each known planet from the database, the probability p of its discovery is determined for the corresponding parameters. Instead of one “point”, the “number” is set to $1/p$ to estimate the “expected number” of planets. The probability takes into account the masses of the “host star” and the planet itself, and the parameters of the orbit, including the major semi-axis, eccentricity and orientation. These parameters are dependent on the “limit velocity”, which allows discovering Doppler shifts in the spectra. Results are compared to the sample histograms. The amount of existing but undiscoverable in nowadays exoplanets was estimated. The natural regularity of widespread occurrence of low-mass planets is revealed.

SUBSECTION “ASTROINFORMATICS”

NEW ASTROMETRIC REDUCTION OF THE SUPERCOSMOS PLATES ARCHIVE. FIRST RESULTS.

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The arrivals of the new accuracy reference catalogues and also develop of a new methods and approach for reduction astrometric data give the new life for photographic plates archive. Gaia DR2 is not only a giant step in the astrometric accuracy allowing to measure new objects also provides to measure and compare archive observes in the past with modern accuracy. In this work we present the first results astrometric reduction into Gaia DR2 system some photographic plates that obtained UKST and other Schmidt telescopes and was digitized the SuperCOSMOS scanning program. The photographic plates are digitized to 15 bits (32768 grey levels) with a resolution of 10 microns producing some 2 Gbytes of pixel data. In this work we used plates from the UK Schmidt telescope is a classical Schmidt with the following parameters: mirror diameter 1.83m; focal length 3.07m; photographic plate size 356mm square, covering 6.4 x 6.4 degrees of sky; plate scale 67.12 arcsec/mm; resolution 0.67 arcsec/pixel and plate size 32256x32256 pixels. To date the UKST has taken over 17,000 plates, the plates are stored in the Plate Library at the Royal Observatory, Edinburgh. We are making new reductions of photographic plates that allowing to provide valuable data for future researches as in astrometry and astrophysics. The obtained of astrometric and photometric data from photographic plates was compared with same one from modern catalogues.

ANALYSIS OF THE STELLAR PROPER MOTIONS OF GAIA DR2 AND PMA CATALOGUES

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The PMA and Gaia DR2, the new most accurate catalogues of full-sky stellar proper motions, were created in last years. Understanding strengths and weaknesses of these proper motion systems is a crucial task, and could help for future improving the stellar reference frame in the context of systematic and random errors. In this work we

present the comparison of these catalogues by means of the decomposition of differences stellar proper motions differences on a system of vector spherical harmonics (VSH) which are orthonormal on a sphere. We selected all stars from the Gaia DR2 catalogue that agree with strong astrometric errors criteria (about 145 millions "good" stars on 5 sigma level) and carried out cross-match with data from the PMA catalogue. We obtained more than 84 millions of common objects that were used for our analysis. Results of this analysis showed the good agreement between the stellar systems of proper motions of Gaia DR2 and PMA catalogues in the range of their random errors. The same analysis of "bad" cross-matched stars from the Gaia DR2 and PMA was done and also is presented in this work.

PHOTOMETRY OF STARS FOR ASTRONEGATIVES WITH A SINGLE EXPOSURE

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The paper discusses the construction of characteristic curves for various astronegatives with one exposure. Particular attention is paid to the question of extrapolation of the characteristic curve for the region of the weakest stars in the absence of standards. A new method for constructing an individual characteristic curve for digitized films and plates in the UBRV system has been proposed and implemented.

ASTEROID SEARCH RESULTS FOR DIGITIZED ASTROPLATES OF 1.2M TELESCOPE IN BALDONE

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The work on the mass search for asteroids on astroplate images and the determination of their topocentric coordinates was begun in 2016. The basis for current search was

digitized photographic-plates and films obtained at the observatory in Baldone in 1967-1993. Observations were carried out by 1.2m Schmidt telescope in Baldone with the U (for plates) and V (for films) filters. Photometric band U was realized by combining emulsion ORWO Zu1 (Zu2 or Zu21 or Kodak 103aO or IIaO) with UG1 filter. Combined emulsion A600 with filter ZS17 realized the V photometric band, respectively. Analysis of (O-C) showed that part of the positions of asteroids obtained on V-films, are burdened with significant errors, which are a consequence of the unevenness of the film surface during scanning. As a result of processing 300 U-plates and 2000 V-films, a catalog of about 1000 positions and magnitudes of asteroids was compiled. However, asteroids were found whose positions are of particular interest. In particular, these are those asteroids that were discovered much later and have almost no provisions until the discovery. The observed positions were compared with JPL ephemeris.

INNOVATION AND VIRTUAL OBSERVATIONS: CRAVO DATABASE

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The exponential accumulation of astronomical research results, which is associated with the usage of up-to-date technologies for recording and processing observations, needs an innovative approach to the problem of data storage and analysis. This is primarily caused by the development of methods for working with large databases (BigData), which are becoming increasingly important for solving fundamental problems of modern astrophysics.

The significant observational material has been accumulated and is still being accumulated at the Crimean Astrophysical Observatory of RAS. It involves tens of thousands of photographic negatives and hundreds of thousands of images of astronomical objects obtained with electronic radiation receivers for more than a hundred-year history of observations. The authors of the report have acquired experience in digitizing the observational material of the Observatory's glass library and papers published in the journal «Izvestiya» CrAO. The first steps have been taken to organize a network access to information.

When implementing the project, it is expected to develop a technology for converting a variety of observational material into the interoperable formats supported by the International Virtual Observatory. Specific examples in the presentation are demonstrating the possibility of analyzing the state of objects on time intervals from decades to days. The results of the project will allow the astronomical community to access the rich heritage of our observatory and conduct researches compared to the newly obtained data.

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PHOTOMETRY OF STARS ON DIGITIZED PLATES FROM THE COLLECTION OF THE ODESA ASTRONOMICAL OBSERVATORY

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We present the results of photometry of a series of stars on the database of digitized plates from the Odesa collection of the seven-camera astrograph (1957-1998). The goal of the work is to search for long-term brightness variations over a 30-year period, as well as testing of the measurement technique used.

INFORMATION TECHNOLOGIES AND DATABASES IN METEOR ASTRONOMY: THE 65TH ANNIVERSARY OF THE FIRST REGISTRATION OF RADIOMETEORS IN UKRAINE, WHAT'S NEXT?

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In 2019, it is 65 years since the first registration of radiometeors in Ukraine. Kharkiv scientists under the direction of BL Kashcheyev discovered unusual interferences with the ionosonde operation. These interferences was radiometeors. A group of these Kharkiv scientists was invited to participate in the program "International Geophysical Year" (IGY1957), which stimulated the development of meteor research. Among many participants in meteor studies, the results of meteor radar studies obtained in Kharkiv under the IGY1957 program were recognized as the best in the world. At the time of the beginning and in the future, BL Kashcheyev organized the highest level of meteor radar research (the centenary of birth of BL Kashcheyev will come in 2020). The introduction of highly productive radar methods in the study of meteors in those days formed the task of automating the collection, storage and processing of very large data. The science of cybernetics has been adapted for solving problems of meteor astronomy and meteor radar. We can separately distinguish meteor cybernetics and related information technology. A description of cybernetic technologies developed in the scientific school of BL Kashcheyev can be found in numerous publications of this school, some of which are publicly available in the web archive of the NURE library. By the number of radiometeor orbits (more than 200 000), the Kharkiv database for a long time occupied the first place in the world. It is currently ranked fourth. The Kharkiv meteor radar has the status of a national treasure of Ukraine since 2004. The Ukrainian meteor science represented by the Kharkiv school of meteor radar and other meteor centers of Ukraine has a powerful scientific and technical heritage and expects the interest of the Ukrainian and world community in order to receive

funding in the light of space, environmental, information and telecommunication problems.

PROBABILITIES OF PHYSICAL LINK BETWEEN THE COMPONENTS OF THE SELECTED MULTIPLE SYSTEMS FROM WDS CATALOG

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Astrometric observations of the visual components in WDS multiple systems have been performed using Axial Meridian Circle of the RI MAO with new CCD camera.

The aim of our study is to make certain conclusions concerning physical link of the components in the multiple systems considered based on both astrometric and other available information about stars that are possible gravitationally related components of the system. Positional data from Hipparcos and Gaia DR2 catalogs and photometric data from 2mass, SDSS DR12, APASS DR9 catalogs are used as sources of the additional information about the stars that are the possible member of multiple systems. The search for probable nearby invisible component in multiple systems using the method checking differences between quasi-instantaneous Gaia DR2 proper motions and accurate long-term proper motions was conducted. Detailed comments on the results for each multiple system are presented.

COMPARISON OF ASTROMETRIC REDUCTIONS RESULTS IN THE PROJECT "FON-DUSHANBE CATALOGUE"

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Since May 2018 the process of the scanning and processing of photographic plates from the archive of the Institute of Astrophysics Academy of Sciences of Tajikistan has begun. It is a matter of approximately 1560 photographic plates in the sky zones from -8 to +90 degrees that were exposed for the FON project in the Hissar observatory (HisAO) during 1985-1992. The plates are digitized by using of the Microtek ScanMaker 1000XL Plus scanner with the resolution of 1200 dpi. The size of the photographic plates is 30x30 cm or 8°x8° in the sky, the size of the digitized images is 13000 x 13000 pix. In this paper we compared results of the processing of the 71 plates of zero zone and the 152 plates of 12 and 28 zones in Tycho2 and Gaia DR2 reference catalogues. For Gaia DR2 reference catalogue we used different magnitude limit for reference stars and compare results by the accuracy of the received catalogues and by the estimation

of random accuracy of stars positions with PMA, HSOY and UCAC5 catalogues by the Wielen method.

In the realization of the "FON-Dushanbe catalogue" project five astronomical institutions are involved: Institute of Astrophysics of AS of Republic of Tajikistan; Walter Hohmann Observatory, Essen, Germany; Ulugh Beg Astronomical Institute UAS, Uzbekistan; Research Institute "Mykolaiv Astronomical Observatory", Ukraine and Main Astronomical Observatory NASU, Ukraine.

COMPARISON OF THE RESULTS OF PROCESSING OF CCD OBSERVATIONS OF SELECTED OPEN CLUSTERS

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Observations of open clusters at the RI MAO were performed using the KT-50 telescope (D=500mm, F=3000mm) in 2011- 2018. As the light receiver, a CCD camera Apogee Alta U9000 (3K x 3K, FOV 42.6'x42.6') in short drift scan mode was used. All observations were performed using R light filter. The exposure time was 20 seconds. All astrometric processing was carried out by the Astrometrica program and UCAC4 reference catalogue. Using this data we received two catalogues of positions of 4.2 million stars (J2013.6) and 3.3 million stars (J2017.3) in the vicinity of open clusters with accuracy 0.03-0.07". At this article, we compared our old results with the new one for several open clusters which carried out with the author's set of programs with primary processing in the MIDAS environment. As reference stars the Tycho2, UCAC4 and GAIA DR2 catalogues were used. The reduction of 548 frames was performed using a polynomial of the third degree. The results obtained by author programs with reference catalogues UCAC4 and GAIA, showed good convergence. Several catalogues of positions up to 17.5^m was obtained. The accuracy of the catalogues is $\sigma_{RA}=0.040''$ and $\sigma_{Dec}=0.045''$ for GAIA reference catalogue and $\sigma_{RA}=0.043''$ and $\sigma_{Dec}=0.048''$ for UCAC4 reference catalogue. At the same time, the accuracy of intraframe processing with the GAIA reference catalogue turned out to be near 1.5 times better than the analogous one with the UCAC4 catalogue. The comparison showed the possibility of receiving more good results with GAIA DR2 reference catalogue.

THE RE-PROCESSING RESULTS OF PHOTOGRAPHIC OBSERVATIONS OF ASTEROIDS WITH GAIA CATALOG AT THE MAO NASU

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At present, about 4500 asteroid positions have been determined from photographic observations made at the MAO NASU in 1949-1996. These are 2233 positions of selected minor planets obtained under the ORBIT program, and 2292 positions of faint asteroids fixed on the plates of the Northern

Sky Survey project. For processing the earliest observations of asteroids, the old reference catalogs Yale, SAO, AGK3 were used. For processing the latest observations the Tycho-2 catalog was used as a reference catalog. Most of positions of asteroids are obtained using digital astronegative processing technologies. In order to improve the accuracy of coordinates of asteroids, a new Gaia DR2 stellar catalog was used. With its use for 8 digitized observations of several faint asteroids of particular interest, a new full reduction of scans from the Joint Digital Archive of UkrVO was made. For calibrations with the Gaia catalog of 560 non-digitized observations of selected minor planets, the old published and deposited additional data were used. The results of comparison with JPL ephemeris are presented as well as with previous similar processing with other reference catalogs.

INVESTIGATION OF THE MAGNETIC ACTIVITY OF STARS OF RED DWARFS WITH THE DATABASES OF GROUND-BASED AND SPACE OBSERVATIONS

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Modern databases of rows of observations the resulting from the ground-base and space projects allow to make progress in study of magnetic activity of solar-type stars and cold dwarfs.

Digitizing of wide-filed plates in the large archives give historical data expanding the investigated time intervals up to century. Space observations allow obtaining high-precision observations with high temporal resolution over several years.

Photometric data from the ground-base and space projects for a seek and study of cycles produced by starspots and flare activity of stars are considered and results for several red dwarfs are presented.

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ON THE FON ASTROPLATE PROJECT ACCOMPLISHMENT

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The plan of the photographic survey of the northern sky (FON) was proposed in 1976 in Golosiiv observatory (now

MAO NAS of Ukraine) by I. Kolchinsky and A. Onegina. The final project of the Compiled FONAC catalog (FON Astrogaphic Catalog) is based on the digital data of photographic plates exposed at four observatories. They are MAO NAS of Ukraine (Kyiv, Ukraine), Kitab astronomical observatory (Tashkent, Uzbekistan), Hissar astronomical observatory (Dushanbe, Tajikistan), and Baldone observatory (Latvia)). The total amount of plates is 5700. The result is expected to be the catalog of positions and B-magnitudes of stars covered the declination area from -20 to 90 degrees. The estimated mean epoch of the catalog is ~1987. The limiting B-magnitude is ~17.5^m. The reference system for positions is Tycho-2. B-magnitudes are being obtained in the system of photoelectric standards. The resulted data of photometric reduction are corrected for the photometric color equation in B magnitudes. The complement for the photometric content of the catalog is U and V magnitudes of stars being obtained from the processing of 5400 plates from the glass collection of 1.2 m Schmidt telescope in Baldone. Photometric data of bright stars with V < 8.5^m U, B, V magnitudes cannot be obtained from photographic material, so those objects will gain photometric data from photoelectric catalogs. The catalog will be complemented with proper motions from GAIA.

ON THE "SOLAR SYSTEM SMALL BODIES" ASTROPLATE PROJECT OF THE UKRAINIAN VIRTUAL OBSERVATORY

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The UkrVO Joint Digital Archive of astroplates and the newest digitized data processing services allowed us to form a new approach for creation of the catalogs of astrometric and photometric characteristics of small bodies of the Solar system. As a result, more than 6,500 new astrometric positions and stellar magnitudes of asteroids, and 1,627 positions of outer planets (Pluto, Uranus, Neptune, Saturn, Jupiter) and their satellites have been determined. Most of the positions obtained from observations of large stellar surveys of the northern sky FON (Kyiv and Kitab parts) and other surveys (MEGA, Equatorial Catalog). The number of obtained new positions of asteroids is comparable to the total number of all the positions of asteroids obtained at the Main Astronomical Observatory of the NAS of Ukraine in 1949-1996. The accuracy of the new posi-

tions is higher than in traditional determinations from photographic observations, but it cannot be comparable to the accuracy of modern CCD observations. The unique fact is that we found 300 asteroids, which have the positions at that observational date only in the UkrVO astroplates. The filling of the missing data on positions in certain time intervals and their analysis can be useful not only for modern ephemeris calculations, but also for studying the evolution of asteroid orbits along time.

COLITECSAT. MATCHED FILTER FOR EXTENDED IMAGES OF OBJECTS

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Using of the optical observations of geostationary satellites (GSS) is considered a promising direction for both astrometry and celestial mechanics as well as for solving various geodynamic and geophysical problems. Another research area for application of GSS positional observations is the problem of space control in the geostationary orbit (GSO). Also the problem of littering the near-Earth outer space with artificially made bodies has become one of the most actual in modern science.

The feature of GSS observations is the positional observation without diurnal tracking, which leads to the images blurring of reference stars and, accordingly, reduces the accuracy of determining the satellite coordinates even with a slight significant exposure time. In this work we present the results of processing by matched filter of extended images of objects in CCD-frames taken without the diurnal tracking in CoLiTecSAT software.

The matched filters are designed for selection the images of objects of known shape against the background noise. Parameters of the matched filter are determined automatically by the results of frame preprocessing, and are unique for each frame. In this case, it allows improving the images segmentation of GSS and reference stars. Also, this approach allowed reducing the number of false detections, increasing the accuracy of measuring both reference stars in the frame and the investigated satellite and, accordingly, increasing the accuracy of calculation and prediction of its orbit.

THE ASTROMETRIC AND PHOTOMETRIC RESULTS OF DIGITIZED PLATES ON EPSON EXPRESSION 10000XL SCANNER WITH DIFFERENT RESOLUTIONS

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This work was done to assess the accuracy of the plate processing method and to study in detail the Epson Expression 10000XL scanner, which is used to digitize the FON-Kitab astronomical plates from the photographic archive collection of the Ulugh Beg Astronomical Institute (UBAI) of the Uzbekistan Academy of Sciences. To process the plates the specially developed software in the LINUX/MIDAS/ROMAFOT was used. From comparing the results of processing digitized files with grayscale 8 and 16 bits, an assessment of the accuracy of the developed method for determining rectangular coordinates and photometry was made. To assess the repeatability of astrometric and photometric errors of the scanner, six consecutive scans of one plate with 600, 900, 1200, 1500, 1800, 2100, 2400 and 2540 dpi spatial separations were processed.

RADIOASTRONOMY

TWO YEARS RESULTS OF METHANOL MASER MONITORING BY IRBENE RADIOTELESCOPES

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We report two-year results of 6.7 GHz methanol maser monitoring program for 45 sources, employing 32 m and 16 m radio telescopes located in Irbene, Latvia. Observations were started at March 2017 following observatory wide modernization program during it both telescopes capabilities were greatly increased. Each source was observed at least once per 5 days, with higher rate of measurements – few times per day – when a source was flaring. There was found that significant portion of maser sources are variable including: monotonic increases or decreases, un-periodical, periodic-flaring, quasi-periodic and periodic variations. For several sources (for example: Cep A, G33.641-0.0228) anticorrelation or phase lag between spectral features was found.

CALIBRATION FEATURES AT THE RADIO TELESCOPES AT IRBENE, LATVIA

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Currently, a single-dish observations is being organized at the RT-32 and RT-16 radio telescopes at Irbene. For this purpose, a spectrometer has been created to observe the maser lines of various molecules. In this paper we considered problem of calibration for spectral line observations at these telescopes. The authors estimated the main calibration parameters namely temperature of calibration diode and its on/off period. Main relations between accuracy of flux density of spectral line and noise standard deviation of receiver system is calculated. Method for determination of atmospheric opacity for RT-32 and RT-16 was discussed.

This work was supported by Latvian Council of Science (Research of Galactic Masers, Project Nr.: lzp-2018/1-0292).

GALACTIC MASER OBSERVATIONS IN VLBI MODE IN VENTSPILS

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Ventspils International Radio Astronomy Centre (VIRAC, Latvia) operates two radio telescopes RT-16 and

RT-32, accordingly with 16 and 32 m fully steerable Cassegrain type antennas. The main instruments of both telescopes are cryogenic 4.5 – 8.8 GHz receivers, additionally radio telescope RT-32 is equipped with “warm” 1.3-1.7GHz band receiver. Both telescopes equip with data registration units for interferometric observations.

VIRAC also has a high-performance computer cluster with SFXC software correlator developed by JIVE.

Since March 2018 VIRAC team have realized several successful VLBI observation sessions in the baseline Irbene – Torun at 1.67 and 6.7 GHz. These experiments show that VIRAC is capable to conduct VLBI observations starting from planning to correlation, post-correlation and data processing using astronomical software packages like AIPS or CASA.

In year 2019 VLBI experiments of Galactic maser observations are planned also for short baseline Irbene16 – Irbene32 (between the two VIRAC radio telescopes).

Results of these experiments and overview of VIRAC current level in the software developments in field of VLBI data processing will be presented in the talk.

SPECTRAL LINE REGISTRATION BACK-END BASED ON USRP X300 SOFTWARE DEFINED RADIO

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This report presents implementation of spectrometer based on off-the-shelf software defined radio (SDR) Ettus Research USRP X300 equipped with TwinRX daughterboard. Parallelized software, employing Fast Fourier Transform (FFT), is developed which allows two channel spectrum processing in real time with bandwidths up to 50 MHz per channel, sample resolution of 14 bits and FFT lengths up to 32K points. Measured Allan time of the spectrometer is at least 1000 seconds in laboratory environment. Software has network sever type interface allowing to conveniently integrate the spectrometer in radio telescope observation control and monitoring system with versatility of SDR allowing to implement various observation modes, for example total power registration functionality with high frequency selectivity, which allows to carry continuum amplitude calibration in presence of near-by radio frequency interference. Presented spectrometer has been successfully integrated and used at RT-32 and RT-16 radio telescopes of Ventspils International Radio Astronomy Center.

DUST TEMPERATURE IN HOT GAS

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Thermal regime and emission features of dust surrounded by hot gas ($T=10^6 - 10^7$ K) is described. Such gas is widespread in interstellar, circumgalactic and intracluster medium. Dust grains immersed in a hot gas experience temper-

ature fluctuations in a wide range. In this work, the temperature distribution function for grains with sizes from 30 Å to 3000 Å for different gas temperatures and densities is described along with the resulting dust emission spectra. It is demonstrated that in wide range of gas temperature and density dust emission spectra reveal a «bimodal» shape with two peaks and mimic a compound spectrum of two dust populations with different temperatures. Such a "bimodality" can severely enhance dust emissivity in a hot environment.

DEVICE FOR WORK WITH SMALL ANTENNA ARRAYS

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At present, low-frequency radio astronomy is widely developing in the world. New tools such as Lofar, LWA, GURT, NenuFAR and others are being designed, built and already was built, which cover the frequency range from 10 to 80 MHz. The basis of the antennas of such tools are small antenna arrays with highly sensitive elements. The combination of such antenna arrays, separated by large distances, makes it possible to obtain: outstanding sensitivity and angle resolution, a large field of view, versatility and the ability to map the celestial sphere.

The proposed modernization of the URAN-4 radio telescope will be based on the use of small antenna arrays with active elements that are used in the construction of the GURT radio telescope. Such a modernization will expand the frequency range of studies to 80 MHz. In addition, in the frequency range of antennas of the URAN-4 radio telescope, additional antenna arrays will allow the use of spatial signal filtering techniques. This will increase the effectiveness of radio astronomy observations. For solving a number of tasks (determining the characteristics of small antennas, measuring the galactic background with their help, the flow of radio sources, for joint measurements with antennas of the URAN-4 radio telescope), it is useful to use a set of receiving equipment which compatible with modulation radiometers that are already used on the URAN-4 radio telescope. Such equipment, with enhanced capabilities, is currently being produce at the Odessa Radio Astronomy Observatory. It includes control voltage generators for operation with amplitude and phase modulators, multichannel receiving devices, modulators, data recording systems.

ON THE NATURE OF FREQUENCY DEPENDENCE OF THE SECULAR DECREASE FLUX OF RADIO EMISSION OF CASSIOPEIA A

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For almost 60 years of continuous observations of Cas A at various frequencies of the radio band, a large amount of observational material has been accumulated.

We have considered monitoring measurements, which include a series of observations at various frequencies, as well as occasional consisting of several measurements during the year. All measurements show an inconsistent picture at various frequencies.

At millimeter and centimeter wavelengths, the prevailing rate of flux decrease is $0.48-0.53\pm 0.03\%$ per year. Observations cover the period from 2001 to 2018.

At decimeter waves, the rate of the secular flux decrease is $0.53-0.71\pm 0.07\%$ per year and demonstrates a significant scatter of data at different frequencies when observed in the interval 927-2924 MHz from 1962 to 2012.

In the meter wavelength range, the rate of secular flux decrease lies in the range from $0.69-0.78\pm 0.06\%$ per year (1960-2018) ... There are periods of growth and fall in the rate of secular flux reduction.

In the decameter range, observations on RT UTR-2, GURT and URAN-4 of the RI NASU obtained conflicting data that demonstrate the flux unchanged (1975-1988) when observed at the same time of year and its decrease over a long time interval from 1960 on 2016 (UTR-2).

According to the long-term monitoring of the flux at URAN-4, in the period from 1987 to the present, changes in the flux are observed depending on the time of day, the season of observations, the state of solar and geomagnetic activity.

A comparison was made of observational data with existing models of a secular change in the flux of Cas A. Possible causes for deviations from empirical dependencies, factors for the evolution of the residue, and the influence of a point source detected in the X-ray range are considered.

FADING OF THE CONTINUUM OF NOISE STORMS RELATED TO CME

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In this paper, the relationship between obscure phenomena in the decameter range coinciding in time with coronal mass ejections (CME) for solar proton events (SPE) is investigated. For the analysis, we used original recordings of dynamic spectra from the Solar Radio Spectrograph in the range of 25–180 MHz, as well as data on CME from the SOHO / LASCO CME CATALOG. The studied sample contains 112 proton events accompanied by a CME. It was found that during the output of a CME in the decameter range at frequencies of 25–30 MHz, there is a fading of the continuum of noise storms and continual bursts in a narrow frequency band from 0.5 to 2 MHz. Moreover, events associated with CME are distinguished by the intensity and duration of the fading of the continuum of noise storms at a given frequency, as well as the width of the fading band and the frequency of the maximum of fading.

A comparative analysis showed that there is a definite connection between the CME velocity, the velocity of coronal shock waves, the intensity of the proton flux and the intensity of X-ray bursts with the depth and duration of the fading of the continuum of noise storms during CME.

COMPARISON OF IONOSPHERIC IRREGULARITIES RADIOASTRONOMY MONITORING DATA AND IN SITU MEASUREMENTS ONBOARD SPACECRAFTS

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A special feature of decameter radio astronomy is the strong influence of cosmic plasma on the radio waves propagating. On the one hand, it allows you to study the propagation medium. For example, the scintillation of cosmic radio sources contain information about the irregularities of the interplanetary and ionospheric plasma. On the other hand, the effects of cosmic plasma create problems in the study of space objects, they introduce errors in the measurement results. In particular, this applies to radio interferometric studies on a multi-base URAN radio interferometer. In some cases, in order to correct the measurement results, it is necessary to know the characteristics of ionospheric irregularities. Simultaneous radio interferometric measurements and measurements of the irregularities characteristics are impossible in most cases. Therefore, it is relevant to study the possibility of using of ionospheric irregularities data that obtained by other methods, in particular, using orbital spacecraft. The growing interest in the creation of space weather forecasting systems for the ionosphere area has stimulated the emergence of modern projects of ionosphere research with the help of specialized satellites. The possibility of using microsatellites for ionospheric research has accelerated this process. In Ukraine, the IONOSAT space system has been developed for multi-point monitoring of ionospheric parameters using three low-orbit microsatellites. The "Potential" space project on the Sich-2 microsatellite (launch 2011, in orbit operation 2011-2012) was the first step in preparing the IONOSAT system.

In this work, the possibility of comparing data on ionospheric irregularities, which are obtained by the radio astronomy method and in situ by using Langmuir probes aboard ionospheric satellites, in particular on board the Sich-2 microsatellite, is investigated.

THE INFLUENCE OF POLARIZATION ON THE AMPLITUDE-FREQUENCY FUNCTION OF THE BREMSSTRAHLUNG OF HETEROGENEOUS PLASMA

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The previously developed statistical approach of "quasi-neutral heterogeneous plasma cells" [1-2] is summarized in a report on the case of heterogeneous plasma (HP) interacting with an external electrostatic field of thermostat sources. The anisotropy of the velocity distribution function of the gas phase (electrons and ions) in the local thermodynamic equilibrium regions of the plasma is taken

into account in the framework of the effective dipole approximation for each of the statistical cells of the quasi-neutrality of the HP, averaged over the ensemble of system realizations. In a stationary plasma, in the presence of an external electric field, the influence of the polarization of the structural elements – ions and particulates of the condensed dispersed phase (CDPh) on the parameters of the amplitude-frequency function (AFF) of the braking electromagnetic radiation generated in a self-consistent electrostatic field by the free charges of the plasma system. The level of the electrochemical potential of the electron component of the HP in the electroneutrality cells of the HP is found from the solution of the joint system of conservation equations and kinetics for the electron-ion and "partial" subsystems of the HP interacting with the stationary field of external sources. The level of the electrochemical potential of the electron component in the electroneutrality cells of the heterogeneous plasma was found from the solution of the joint system of conservation equations and kinetics for the electron – ion and "partial" subsystems of the HP interacting with the stationary electrostatic field of external sources E_0 . The spectral components of the plasma bremsstrahlung AFF were found in the wave zone. The issues of functional relationships of the determining parameters of heterogeneous plasma (temperature, countable concentration of gas electrons and ions, characteristics of the ensemble of the CDPh – particle subsystem) and relative powers of the spectral components of plasma bremsstrahlung in the radio frequency range are discussed. Model computer calculations for the plasma of combustion products of solid metallized synthetic rocket fuels were carried out.

An analysis of the field experiment to measure the intensity of radio emission from the combustion products of a suspension of micron-sized aluminum particles suspended in atmospheric air is presented. The good agreement between the theory and experiment data was noted. The applicability of the proposed approach to solving the problems of telediagnosics of the combustion products of rocket engines in a rarefied atmosphere of the Earth and near space is discussed.

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ENVIRONMENT OF SOURCES WITH GIANT RADIO STRUCTURES

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As we have estimated from the NVSS radio images, the linear sizes of sources with steep low-frequency spectra from the UTR-2 catalogue are ~ Mpc. Apart from the great jet propagation velocities of these sources (~ 10E9 cm/s) their environment may have low densities for promotion of the giant radio structures. We derive the environment density at the

assumption on equality of the jet luminosity and the corresponding kinetic luminosity of a source. For examined galaxies the environment densities are from $10E-27 \text{ g/cm}^3$ (for galaxies with linear steep spectrum) to $10E-26 \text{ g/cm}^3$ (for galaxies with break steep spectrum). The environment densities for examined quasars are, in average, $\sim 10E-28 \text{ g/cm}^3$. So, the jet environment of steep spectrum galaxies is denser than one for steep-spectrum quasars. The relation of jet environment density and redshift of examined sources displays the essential evolution of environment.

CURRENT DEVELOPMENTS FOR AUTOMATION OF RADIO ASTRONOMICAL OBSERVATIONS AT IRBENE OBSERVATORY

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Technical division of Engineering research institute "Ventspils International Radio Astronomy Centre" (ERI VIRAC) is continuously working on automation system of radio astronomical observations in order to reduce manual involvance of operators thus increasing success rate of performed observations. This system is under development and its concept and architecture will be presented in this talk. The system is capable to execute observations of different types (e.g. galactic masers, active galactic nuclei, VLBI etc.), perform hardware setup, monitor any occurring errors and respond to them. Also automatic scheduling system of observations in single station mode will be mentioned.

OPTIMIZATION OF BROADBAND RADIO INTERFEROMETR

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The possibilities of lowering the level of side lobes of the directional pattern (DP) of a broadband radio interferometer containing several antenna clusters are investigated. The frequency response is formed by summing the interferometry signals from the outputs of the frequency channels in the frequency separation range (0.1 ... 0.5) from the average frequency. Mathematical modeling of the DP radio-interferometer with 16-element gratings was carried out, corresponding to the instrument with a distance between the gratings 100 times larger than the base of one grating. It has been established that, within 0.1 of the width of the main peak of the antenna array, the side peaks practically do not decrease, and the first positive side lobe is 0.6 of the main peak. Their level can be reduced by optimizing the frequency ranges of individual interferometers and weights when summing the results of interferometry from several clusters (antenna arrays). For the case of 3 bases of interferometers, with distances of 100, 125, and 150 large bases of one lattice, the optimization of total DP was performed. Achieved a reduction in lateral peaks to the level of a single

antenna array. It should be noted that the technology in question is applicable for solving problems when a radio source can be considered a point source.

FREQUENCY DEPENDENCE OF THE IONOSPHERE SCINTILLATION PARAMETERS ON THE OBSERVATIONS OF THE COSMIC RADIO SOURCES AT THE DECAMETER WAVE RANGE

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When signal from radio source propagates through irregularity lay in the ionosphere it has fluctuations of the amplitude (scintillations) which time spectrum has power form with index $\alpha = 3$. It was shown that such form of the time spectrum of amplitude fluctuations caused by power form of the space spectrum of electron concentration irregularity in ionosphere with index $p = \alpha - 1$, i.e. $p = 4$. Based on theoretical preconditions for such form of the space spectrum the frequency dependence of scintillation index m (characteristic of scintillation intensity) was obtained in form power function: $m \sim f^n$, $n = (p + 2)/4$, thus $n = 1.5$. Similar frequency dependence of the scintillation index was observed experimentally for case of weak scintillations ($m < 0.5$). In this work the frequency dependence of scintillation parameters was analyzed on longitude observations of power cosmic radio sources on radio telescope URAN-4 at two frequencies 20 and 25 MHz. The results were compared with results of earlier carried out investigations.

DECAMETER INTERFERENCE RADIO INTERFEROMETRY, METHODS OF FIGHTING

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The report presents a brief analysis of the interference situation in the decameter range of radio waves (3 ... 30 MHz) of both natural and artificial origin, their influence on radio astronomical observations, in particular radio interferometric, conducted on the UHR decameter multi-base radio telescope. A brief review of methods of dealing with noise, including regulatory, hardware and software. A method for suppressing powerful irregular interference of artificial origin, developed and used on the URAN radio interferometer, is presented.

METHODS OF RFI MITIGATION USED AT THE URAN INTERFEROMETERS

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In this report we briefly describe radio frequency interferences (RFI) of artificial and natural origin that exist in

the decameter range of radio waves and consider their effect on radio astronomical observations using an example of the URAN interferometer network operating at decameter wavelengths. We will give a brief overview of RFI mitigation methods that include regulatory, antenna, hardware and software methods. The report dwells on features of signal processing in the URAN interferometers and describes the methods of mitigation of narrowband and impulse interferences of different origin we use in this instrument.

RESULTS OF ANTENNA SYSTEM “MARK-4B” MODERNIZATION AND PERSPECTIVES OF RADIO TELESCOPE “RT-32” CREATION

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In 2017, the Center for Space Research and Communication (CSRC) was established within the National Space Facilities Control and Test Center. The main technical facilities of the CSRC are two receiving and transmitting antenna systems: MARK-4B and KTNA-200, having a diameter of 32 and 25 meters, respectively.

In 2018, a cycle of research and development work on the gradual upgrading of the MARK-4B antenna system was started for its further use as a radio telescope RT-32 for operation in P, L, S, C, X and K – bands within the framework of the European VLBI Network. Execution of this work required involvement and consolidation of scientific, technical and production potential of the leading Ukrainian institutions in the field of fundamental and applied space research, creation of radio-astronomical observation facilities, including control systems for them.

The main results of the first stage of modernization are as follows:

1. The new antenna control system was created and installed on the site (contractor-executor – Ternopil National Ivan Pulyui Technical University).

2. The experimental radio astronomy receiving system of the C-band was developed and installed (contractor-executor – OJSC NPO “Saturn”).

3. Measurements and evaluation of main parameters of the antenna system “MARK-4B” were completed at the end of stage 1 of the modernization. Also the radio astronomical observations of the 3C9 object were carried out jointly with the radio telescope UTR-2. Testing observations were made for the following objects:

- Radio source 3C461 (Cassiopeia-A);
- The Sun;
- Pulsar from the Crab Nebula;
- Hydroxyl maser W3 (OH);
- Artificial Earth satellite “Intelsat 10-02”.

The mentioned works were performed by the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine and the Center for Space Research and Communication.

At the second stage of the modernization (2019) the following activities are planned:

- manufacturing of the radio astronomical receiving system in the C- and K-bands;

- development and manufacturing of radiometric receivers and elements of the receiving path for measuring the directional diagram in the S-, X- and K-bands;
- creation of frequency and timing synchronization system;
- study of errors during pointing and tracking of radio sources by the antenna system;
- expansion of the functional capabilities of the antenna system’s control system special software;
- development and manufacturing of the cable-laying azimuth loop;
- development and manufacturing of the mechanism for backlash compensation of mechanical elements of the control system;
- development and manufacturing of the device for adjustment and change of bands.

At the third stage it is planned to carry out preliminary and acceptance tests as well as experimental operation with the subsequent commissioning of the prototype.

Keywords: radio telescope, VLBI Network, antenna system “MARK-4B”, radio astronomy.

BROADBAND INTERFEROMETRIC OBSERVATIONS AT DECAMETER WAVELENGTHS

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Currently, ground-based radio astronomy observations are conducted in a wide range from decameter to millimeter wavelengths. Wideband digital receivers used for the observations allow to record signals in a bandwidth from a few to hundreds of megahertz depending on a working frequency. The wide band receivers make it possible to increase the sensitivity of observations, the amount of information obtained, and the quality of images of radio sources during aperture synthesis. The Ukrainian decameter radio telescopes are no exception. Now the UTR-2 and URAN radio telescopes are equipped with DSPZ wideband digital receivers operating in the entire frequency band of the radio telescopes 8 to 33 MHz. Using these receivers we have conducted the first observations of a set of compact radio sources with the URAN interferometers. The purpose of the study was:

- improvement of simultaneous utilizing of capabilities of the new hardware and signal processing techniques developed for the URAN interferometers;
- achieving a greater sensitivity of interferometric observations at decameter wavelengths;
- analysis of restrictions on the applicable frequency bandwidth at decameter wavelengths imposed by properties of a propagation medium and a geometry of source-baseline.

The results of the observations and processing will be presented in our report.

MOLECULES IN SPACE AS SEEN FROM VENTSPILS

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Despite the extreme conditions in space, molecules are widespread in it. Their main location is stellar gas dust clouds, including new star-forming regions and star gas and dust envelopes. Molecular radiation in the range from the meter to the mm waves and in the IS waves can provide important evidence of the processes that take places in these regions and their physical properties.

Research on VIRAC space molecules takes place in three main directions:

a) astrochemistry – research of chemical and molecular-related physical processes in an interstellar environment, especially chemical processes in interstellar ice;

b) molecular radiation transfer in the gas and dust envelopes of late type stars;

c) observations of cosmic masers using Irbene radio telescopes.

An introduction to these directions is given, paying special attention to (c).

EFFECTS OF LUNAR TIDAL WAVE PASSAGE IN THE TOP EARTH'S ATMOSPHERE ACCORDING TO MONITORING FLUXES OF POWERFUL RADIO SOURCES ON RT «URAN-4»

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At the radio telescope «URAN-4» of radio-astronomical institute of NAN of Ukraine since 1987 monitoring of flows of powerful space radio sources is carried out. The program of monitoring included Radio galaxies Cygnus A (3C405), Virgo A (3C274) and supernova remnants Cassiopeia A (3C461), Taurus A (3C144). Analog (1987 – 1990) and digital (1998-2004) recordings of radiation fluxes are considered. The work is based on identifying unusual recordings of radio sources, which were not related to the presence of interference in the decimeter radio band. These records were characterized by existence of saturated fibrillations of radiation sources, the strong compression or the complete disorder of record of a directional diagram of a radio telescope. Originally this effect was reflected in earlier works. All these effects can be caused by various arrangement of space radiation sources concerning a maximum of the tidal wave in an ionosphere, which works like a "plasma" lens, distorting a wave front coming from a radiation source. The angular sizes of the tidal bore reaching 60 degrees are determined by observed data. Specification of development of various tidal effects and identification of more similar structure of the tidal bore in an ionosphere depending on distance between Earth and the Moon and a possible contribution of gravitational and thermal solar tides is carried out. All these data are an element of development of space weather in which also the Moon participates. Radio-astronomical observations in the decimeter range on a radio telescope "URAN-4" are an effective research technique of the tidal phenomena in the top Earth's atmosphere.

STUDY OF VARIABILITY 3C 144 (TAURUS A) RADIO SOURCE AT FREQUENCIES 1.6, 5, 6.1 GHZ WITH PASSAGE THROUGH THE SOLAR SUPERCORONA

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The galactic radio source 3C 144 (identified with the Crab Nebula) is the most important object for studying structure of the solar wind. Being in ecliptic plane and approaching minimum distance to the Sun on June 15 every year, 3C 144 shines through the Solar supercorona, which is observed (usually at meter and decameter wavelengths) in form of radio emission scintillations on inhomogeneities of the solar wind. This paper presents preliminary results study of variability 3C 144 at frequencies 1.6, 5, 6.1 GHz at the 32-m radio telescope of the Ventspils International Radio Astronomy Center in Latvia. Possible relationship between active events on the Sun, which caused disturbances in the solar wind and observed flux density variability, is shown. Characteristic times of variability, observed at 1.6 GHz, are from several hours to 20 minutes. Also, fast variations of solar wind parameters (proton density, plasma pressure, wind speed, plasma temperature) were analyzed using satellite data from the NASA OmniWeb catalog, with hourly averaging. Using method of continuous wavelet analysis, it was shown that quasi-periods in variations of 3C 144 flux density, in band from 10 to 3 hours, are close to corresponding quasi-periods in variations of the solar wind parameters. Additionally, study was conducted of variations in 3C 144 flux density according to data of the URAN-4 phased array antenna (frequency 25 MHz, decimeter wavelength range) associated with ionosphere response to active events on the Sun. However, variability at frequencies 5 and 6.1 GHz can contain significant contribution of intrinsic fast variability of 3C 144 radio source.

INVESTIGATION FAST VARIABILITY PROPERTIES OF EXTRA-GALACTIC RADIO SOURCES OJ 287 AND 3C 273 IN RADIO AND OPTICAL BANDS

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Currently, extra-galactic radio sources OJ 287 and 3C 273 are among most intensively studied active galactic nuclei. Reason for increased interest in these objects is complex structure of variability described by double black hole model in case OJ 287, and various effects of accretion disk-

jet system in case of 3C 273. Over entire observations history of these radio sources, had accumulated huge number of observations, about 100 years in optical range and over 40 years in radio range. In this paper, fast variability of OJ 287 and 3C 273, (March – June 2019) is studied at characteristic times from several days to several hours, least studied activity appearance of these objects. Radio observations were received at 16-m and 32-m radio telescopes of the Ventspils International Radio Astronomy Center, Latvia, at frequencies 6.1 and 6.7 GHz. OJ 287 optical observation support was performed with AZT-3 telescope (Odessa Astronomical Observatory, Ukraine), 1.2-m Schmidt camera (Astronomical Observatory Baldone, Latvia), 1-m VNT telescope (Vihorlat Astronomical Observatory, Slovakia) in filters V, R, I. The comparison showed good similarity of obtained quasi-periods in radio and optical bands for OJ 287 from several days to little more than month. The characteristic times of intraday variability are 1.4 – 2, 3, 5 hours in the radio band and 0.9 – 1.1 hours in the optical band. For 3C 273, characteristic times of intra-day variability were 5.5 and 9.3 hours in radio band. In optical band (data from the AAVSO catalog) minimum significant characteristic time of variability (filter V) was about 5 days.

JOVIAN DECAMETER RADIO EMISSION: TO THE QUESTION ON THE SIZE OF SOURCES

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The question of sizes and properties of the sources responsible for the Jovian DAM radio emission is discussed. The analysis was done on the example of typical S and L storms of DAM radio emission and for a particular Io-B-storm [1] at October 30, 2008.

It is shown that the L-radiation source most likely looks like thin filaments, elongated along a magnetic field, with a thickness of 50-500 km, and a length of 500-4000 km. And the source of S-radiation looks like bundles of filament-like emissions (or plasma bunches) with a thickness of less than 1 km (10-100 threads per bundle) and with length up to 1000 km, flying at a speed of 0.05-0.1 c ($c = 3 \cdot 10^{10}$ cm/s) away from Jupiter.

The evolution of bursts in DAM Io-B-storm at October 30, 2008 consisting of a large number of S-bursts, as well as intermittent with L-bursts and N-bursts, is analyzed in detail. It is shown that S-bursts in this storm are most likely to occur at altitudes (0-0.2) R_J in the northern magnetic hemisphere of Jupiter, and at longitudes $\lambda_{iii_s} = (190..220)^\circ$ (when Jupiter is turned to an observer by longitude $\lambda_{iii} = 120..160^\circ$). The train of S-bursts are induced and modulated by the Alfvén (A) wave in the Io-Jupiter system: at the beginning of a storm, S-bursts induce the A-wave that moves out Jupiter, and at the end of a storm, S-bursts induce the A-wave that moves to Jupiter; and A-wave speed is about 0.001c (which are in 2-5 times slower than the speed of the A-wave, predicted "theoretically"). The beginning of the Io-B storm, S-bursts are associated with sources at high altitudes, and over time there sources go down to Jupiter (while the observed frequencies of S-burst storm increase with time, as typical Io-B storm).

L-bursts that observed simultaneously with S-bursts in this storm may be associated with sources from the other (southern) hemisphere of Jupiter, and be at a height of 0.3 R_J. The other case, the source of L-radiation may be located near the S-sources in the northern hemisphere of Jupiter (at a height of 0.1 R_J), but the L-source is located outside the Io-Jupiter flux tube (its passes this time at a very low altitudes of near 0 R_J, with S-sources).

All bursts of this storm have the features like modulation lanes (0.1–0.2 MHz in thickness) that drift at speeds of 10–100 kHz/s. This effect indicate us a diffraction of radiation in Jupiter's magnetosphere, and it confirms our estimates the sizes of S-sources in less than 1000 km.

The thin transverse structure of S-sources can be explained by the mechanism of electron fluctuations in low-ionized gas, with periods of $\tau \sim \tau_{ea} \sim 0.01s$, and with the features of plasma bunking mechanism that leading to electron runaway and to ejections of plasma in bundles [2]. The effects of slowing down the velocities of the A-waves in observation in compared to the "theoretical" ones can be explained by the influence of Io-Jupiter flux tube on the propagation properties of MHD waves.

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2. Boev A.G., Udaltsova N.M., Yantsevich A.A.//Radiophysic and Radioastronomy, 2001. V.6, No.3. P.252.

BROADBAND PROBING OF THE UPPER MAGNETOSPHERES OF PULSARS

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Recently, broadband low-frequency radio telescopes such as NenuFar, LWA, MWA, GURT and others are being commissioned. Along with this, radio telescopes UTR-2, URAN-1-4, LOFAR continue to operate successfully. This creates good background for continuing work on probing the upper magnetospheres of pulsars in the low-frequency range. The advantages of such probing in the low-frequency range are that the interaction of electromagnetic waves propagating in the upper magnetosphere of a pulsar occurs only with the dipole component of the magnetic field and the electron-positron plasma. Such conditions are well defined by the Goldreich-Julian model of the pulsar magnetosphere. The absence of multipole magnetic field components simplifies

the interpretation of the results obtained. Wherein, the influence of the propagation effects on the electromagnetic wave is maximum at low frequencies.

To separate the effects of the propagation in the upper magnetosphere of a pulsar and/or pulsar wind from a similar impact of the same effects occurring in the interstellar medium, interplanetary medium and the Earth's ionosphere, it is proposed to use only the giant or anomalously intense pulses of pulsars as the probes. This will allow to register the polarization parameters of the radio emission of pulsars at very short time intervals, since these pulses have a high intensity. So as the plasma parameters (concentration of charged particles, their velocity, magnetic field strength, etc.) of the interstellar medium, interplanetary medium and Earth's ionosphere on the line of sight changes much more slowly than similar parameters of the pulsar upper magnetosphere, we can be create a criterion of separation of these areas of the electromagnetic waves propagation.

The report will present the results of polarization parameters observations of the fine structure radio emission from a number of pulsars and the methods for solving the problem of sounding the upper magnetosphere of pulsars in the decameter and meter ranges.

CREATING THE RT-32 RADIO TELESCOPE ON THE BASIC OF MARK-4B ANTENNA SYSTEM. MODERNIZATION PROJECT AND FIRST RESULTS

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Creating a radio telescope based on the MARK-4B antenna system being developed for telecommunication applications, determining the possibilities of using the broadband multi range operation of a beam wave-guided antenna

system and to evaluate the antenna characteristics using the radioastronomical measurements.

A comprehensive analysis of all the MARK-4B systems allows to select the blocks and nodes to be replaced or upgraded. The analysis of the reflector and subreflector design, beam wave-guide, corrugated horn, and feeder system allows determining the possible frequency ranges of the radio telescope being created. Installing a broadband receiver with the stipulated calibration capabilities using cooled and uncooled load attenuators allows to determine the antenna system temperature. Guiding the antenna to the calibration sources and recording scans due to the Earth rotation eliminates the systematic errors or errors of the pointing system. In this way the width of the radiation pattern and the effective area of the radio telescope are determined.

An analysis of the antenna design was made and the priority stages of the reconstruction of the MARK-4B antenna system were determined. The narrow-band transmitter and the C-band receiver were dismantled and a wide-band receiver (range 4.6...5.1 GHz) with a detector and the possibility of changing the signal integration time were installed. The observed results have allowed to initially estimate the system temperature measurements which allow us to hope that the RT-32 radio telescope (Zolotchiv, Lviv region, Ukraine) together with the cooled receiver will have low self noise. A new antenna pointing system has been calculated and installed which using in the C-band has allowed astronomical tests of the radiation pattern and the level of its side lobes and effective area.

The completed measurements and calculations show that the MARK-4B antenna system allows to create a highly efficient radio astronomy instrument. The developed for now receiving and pointing systems for the RT-32 radio telescope testify to the high potential of Ukrainian science. Further cooperation between scientific research and high technologies will lead to the creation of an effective Ukrainian radio telescope of the centimeter wavelength range.

UTR-2 LOW FREQUENCY NORTHERN SKY CONTINUUM SURVEY. PART II.

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The UTR-2 radio telescope has been used to carry out a multifrequency radio survey of another part of the northern sky with coordinates $0^h < \text{R.A.} < 24^h$, $+5^\circ < \text{Dec.} < +29^\circ$ (survey in the declination range of $+29^\circ - +50^\circ$ was made earlier). The observations were performed at five frequencies from 12.6 to 25 MHz. The maps comprise emission from discrete and extended radio sources, the Galaxy background and its large-scale structures: part of the Galactic disc, the region near the Galactic pole, and the North Polar Spur.

The survey radio maps are presented and its observational parameters are briefly discussed.

SOLAR ACTIVITY, SOLAR-TERRESTRIAL RELATIONS, ASTROBIOLOGY

L'INFLUENCE DE LACTOBACILLUS PLANTARUM A L'AGENT CAUSATIF DE FUSARIOSE DU PIN

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Plus de 33,0 – 40,0% des jeunes plantes de pépinières de cultures forestières, cultivées en Ukraine et dans d'autres pays du monde chaque année, sont traitées avec des fongicides, pourtant les maladies continuent à se développer affectant la qualité du pin et générant des pertes de rendement. Cette maladie dangereuse est provoqué par les micro-mycètes des genre *Alternaria*, *Botrytis*, *Pythium*, *Rhizoctonia*, *Phytophthora*, mais le plus souvent – le représentants du genre *Fusarium*.

Les bacteries du genre *Lactobacillus* se caractérisent par une forte activité antagoniste, y compris contre les agents pathogènes de fusariose des plantes. Les lactobacilles sont absolument sans danger pour la santé humaine et animale, ce qui constitue un avantage supplémentaire de l'utilisation de tels micro-organismes.

Pour atteindre l'objectif de recherche ont été définies les taches suivantes :

1. Allouer aux plantules de pin (*Pinus sylvestris*) la culture de l'agent pathogène.

2. Etudier l'activité antagoniste de souches de lactobacilles et leur combinaisons, contre l'agent pathogène du pin *Fusarium spp.17* sur un milieu de culture artificiel.

3. Identifier la souche de lactobacillus, le plus active contre le *Fusarium spp.17* lors d'expériences sur le milieu de culture et l'assout de la plante *Pinus sylvestris*.

Isolement de l'agent pathogène du pin

Pour la détection et l'indentification la culture nous étudions les propriétés culturelles est morphologiques du mycromycète : blanc-rose, bien développé, sur certains sites – immergé dans la gélose nutritive ; le substrat est de couleur coloré en vin-rouge :

Etudier l'effet de lactobacillus sur la fusariose

On a cultivé les souches de lactobacilles *L. plantarum* ONU 12, ONU 311, ONU 355 de la collection de la chaire microbiologie, de virusologie et de biotechnologie à l'université Mechnikov et leurs consortiums *L. plantarum* ONU 12 et *L. plantarum* ONU 311 dans le milieu MRS avec la t° 37°C pendant la journée et trois jours.

L'influence de lactobacillus sur l'agent pathogène de semis du pin

A l'étape suivante nous étudions l'influence la souche *L. plantarum* ONU 311, parce que les bactéries de cette souche sont très déprimées à l'agent causal de fusariose (la zone de suppression de croissance 5 – 6 mm).

7L'introduction dans le sol le culture diurne *L. plantarum* ONU 311, permet d'augmenter la germination des graines du pin infecte *Fusarium spp17* avec 17,3% , et la survie des plantules – 7%.

L'introduction dans le sol le culture diurne *L. plantarum* ONU 311 aussi positivement influencé sur la croissance des plantules de pin, en augmentent la hauteur avec 8 %.

Donc les bactéries de genre *L. plantarum* peuvent être considérées comme les micro-organisme prometteurs pour l'améliorer la similitude de graines du pin et protéger contre les agents pathogènes *Fusarium*. Avec ça, on doit respecté certaines conditions de traitement avec des bactéries : l'introduction du fluide de culture dans le sol avec des cellules, qui ont grandi pour un jour.

MULTI-WAVELENGTH OBSERVATIONS OF A LARGE SOLAR FLARE

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We present the results of the multi-wavelength study of the two-ribbon solar flare on July 19, 2000 in the active region NOAA 9087 using combination of data from space and ground based observatories. The evolution and morphological properties of the flare productive active region have been analysed. The hard X-ray (HXR) and soft X-ray (SXR) data were obtained at the Yohkoh Telescopes (HXT and SXT) and Geostationary Operational Environmental Satellite (GOES). The full-disk magnetograms and EUV-images were provided by the Solar and Heliospheric Observatory (SOHO) Michelson Doppler Imager (MDI) and Extreme Ultraviolet Telescope (EIT). We used the H-alpha filtergrams from the Meudon spectroheliograph and white light images of Big Bear Solar Observatory (BBSO).

The active region showed a complex multipolar magnetic field configuration. It was large, evolving beta-gamma-delta region, producing many events, including the flare under consideration. According to Solar Geophysical Data (SGD) the 3N/M6.4 two-ribbon flare lasted 2.5 hours. The HXR and the type III radio bursts were observed at the flare onset. It was found that HXR coronal source was located along an S-shaped magnetic polarity inversion line of the active region. EUV loop structures indicate the observational evidence of a magnetic reconnection during the gradual phase of the flare. All the data show continuously evolving SXR, EUV and H-alpha features during the flare.

FEATURES OF THE EMERGENCE OF POWERFUL COMPLEXES OF ACTIVITY IN 12-24 SOLAR CYCLES

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The peculiarities of the distribution of groups of spots of different areas on the material of the Greenwich Catalog of Solar Activity and its expansion of NOAA-USEF for

1879-2016 were studied. The search for short-term fluctuations in changes in the total area of groups of spots has been performed. To this end, the Fourier Fast Conversion Program was used to analyze deviations from the trend of smoothed monthly values for each cycle of solar activity. It was revealed that there are two groups of oscillations of 8-10 months (which occur in 13, 16, 17, 18, 20, 22, 23 cycles) and 14-16 months (in cycles 12, 14, 15, 19, 21). The specific periods of short-term fluctuations of areas of groups of spots in separate cycles are considered. For each cycle, time periods were found during which powerful groups of sunspots appeared. These features can be used to assess sharp changes in solar activity.

EFFECT OF ALUMINUM SHIELDS IN THE METACHROMATIC REACTION (BIO-ASTRONOMICAL EFFECT OF CHIZHEVSKY-VELKHOVER)

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During many years of daily experiments, we found that metachromatic reaction of volutin granules in yeast's cell correlate with the rhythm of solar activity (the bio-astronomical effect of Chizhevsky-Velkhover) and is directly proportional to the flow of galactic cosmic rays.

We have found the absence of effects of the steel and permalloy shielding on the metachromasy reaction. The next step was to study the effect of aluminum shielding. Yeasts tubes were shielded with aluminum foil in different variations: №1 by one layer of foil; №2 by two layers; №4 by four layers. Tube №4 was shielded continuously by 4-layer wrap. In experiments we also used an aluminum cylinder with a diameter of 8.5 cm and a thickness of 1 mm. We daily stained volutin granules with Methylene Blue and fixed the presence or absence of methachromatic reaction. The experiment lasted for 44 days. It was found that aluminum shields, in contrast to all other materials, promote metachromasy phenomenon. None of the shielded variants showed the absence of reaction, compared with the control (33% of cases). The greater the number of layers of aluminum foil, the more expressed was the colour change of the volutin granules. A comparison of data with previously published results of the steel, permalloy, water, paraffin, lead screening [Gromozova E.N., Bogatina N.I. Grigoriev P.E. et al. Metachromatic reaction of *Saccharomyces cerevisiae* volutine granules under screening conditions. // The questions of bioindication and ecology. – 2011. – V.15, №2.] allows us to speculate about the ability of aluminum to shield the effects of unknown factor of a non-electromagnetic nature that greatly influences the biological processes. Only in the presence of aluminum shields 100% metachromasy occurs. The special role of aluminum shields as a stimulant of biological processes in their connection with some astrophysical and geophysical events was found earlier [Bukalov A.V. // Proc. Conf. "Space and

Biosphere". – 2011, 2013], and was taken into account by many authors. Increased metachromasy is usually caused by cell stress conditions. Therefore, we can assume that the aluminum shields violate the normal interaction of cells with the surrounding space, and probably weakens or blocks some specific field effect, which causes the response of the cells. To understand the nature of the observed effects further studies are needed.

APPROXIMATION OF THE INTEGRAL ENERGY SPECTRUM OF PROTONS OF SCR IN A RANGE OF >1-850 MEV

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This paper presents the results of approximation of the integral energy spectrum of protons of solar cosmic rays (SCR) in the range >1-850 MeV. The original records of the SCR proton flux using data from GOES were used for analysis. The sample contains 48 proton events for the period from 03-02-1986 to 12-02-2018, accompanied by protons with energies >850 MeV.

A comparative analysis showed that the previously obtained new approximation of the integral energy spectrum of protons of SCR in the range >1-100 MeV gives a good approximation for high-energy protons with energy > 850 MeV.

RELATIONSHIP OF THE PROTON FLUX INTENSITY WITH RELATIVE DISTANCE BETWEEN HARMONICS OF TYPE II RADIO BURSTS

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In this paper, arguments are given that indicate that the relative distance between harmonics of type II bursts is not a constant value, but changes over time. The studied sample contains 112 solar proton events (SPE) accompanied by type II radio bursts in the range of 25–180 MHz. For the analysis, we used the original recordings of the dynamic spectra from the Solar Radio Spectrograph in the range of 25–180 MHz, as well as the original records of the proton flux intensity of solar cosmic rays (SCR) in the range > 1–100 MeV from the GOES.

A comparative analysis showed that there is a fairly strong relationship between the intensity of the proton flux with an energy of >30 MeV and the frequency at which the minimum value of the relative distance between the harmonics of a type II burst is observed. It is shown that the lower the frequency at the main harmonic, the higher the intensity of the proton flux.

ON THE POSSIBILITY TO PREDICT THE NEXT SUNSPOT MAXIMUM

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The influence of solar activity on the Earth's magnetic field has been studied for many years. It was found that there are two main factors causing geomagnetic storms: coronal mass ejections whose probability is proportional to the number of sunspots, and high speed solar wind streams. As the times of the sunspot maximum and the high speed solar wind streams maximum do not coincide, there are two geomagnetic activity maxima in each 11-year solar cycle.

In the present work we regard the Earth as a probe immersed in the solar wind, and based on the data for the time interval between the sunspot maximum and the geomagnetic activity maximum in the declining phase of the sunspot cycle n , and the value of the minimum geomagnetic activity in the beginning of sunspot cycle $n+1$, we forecast the maximum of cycle $n+1$.

HIERARCHICAL RELATIONS BETWEEN ERUPTIVE PROMINENCE PROPERTIES, FLARE EVOLUTION AND CME KINEMATICS IN LARGE SOLAR ENERGETIC PARTICLE EVENTS

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We report a detailed study of the relationship between solar filament eruption, flare productivity and CME kinematics relevant to Solar Energetic Particle (SEP) events. We analyze kinematics and morphological behaviors of 29 filament eruptions appearing during the Solar Cycle 24, between 14 Aug 2010 and 18 April 2016. For our analysis a high resolution data in different Extreme Ultraviolet (EUV) channels from Solar Dynamic Observatory (SDO) are used. Each of the observed eruptions is associated with solar flare, observed in hard X-rays (HXR) and is followed by in situ observed proton events. The kinematics properties of the associated CME are tracked for the observed events. We perform a statistical chronological study of the observed sequence of events in order to reveal the eruption triggers and the evolved physical mechanisms.

ABOUT THE PERIODS OF ANOMALOUS DRAG OF THE SATELLITE IN CONDITIONS OF HIGH SOLAR AND GEOMAGNETIC ACTIVITY

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The data of the drag of two artificial satellites moving in elliptical and circular orbits at middle latitudes (inclina-

tion of the orbits 58° - 60°) were considered. This data includes the end of 23-rd solar cycle and the growth phase and the maximum of the 24-th solar cycle and minimum phase between them (2005-2017). Seven periods of anomalous drag of the satellites with different durations from a month to a year were analyzed.

According to the calculations of correlation coefficients, satellites drag is influenced by such manifestations of solar and geomagnetic activity as radiation in the Lyman alpha line, changes in the solar constant and electrons fluxes of the solar wind, and the DST geomagnetic storms index.

A closer look at the 30 day drag intervals of the satellites can be found reactions to individual space weather events.

The indexes of the wave radiation of the sun have a dominant influence on the deceleration of the satellite at the considered annual intervals. The presence of periods from 20 to 33 days was indicated in periodograms for these time intervals. These periods correspond to the period of rotation of the Sun at the equator and polar zones (from 25 to 35 days). These periods may reflect the prevailing influence of the northern and southern hemisphere or the equatorial zone of the Sun.

INFLUENCE OF THE ASYMMETRY OF THE SOLAR MAGNETIC FIELD POLARITY REVERSAL ON THE GEOMAGNETIC ACTIVITY

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The paper presents the results of a comparative analysis of time series of Wolf numbers, total squares of spots groups, daily characteristics of the solar large-scale magnetic field (LSMF), its two components -- photospheric and polar magnetic fields with time series of the geomagnetic planetary index A_p . The cyclic changes of solar and magnetic activity and the asymmetry of magnetic field polarity reversal in two solar hemispheres were observed. The focus of this study was to determine the level of dependence of the geomagnetic activity on the dynamics of magnetic activity during the periods of solar magnetic field polarity reversal. We used the complete homogeneous data series of the Stanford magnetographic LSMF measurements (<http://wso.stanford.edu>), the synoptic maps of photosphere magnetic fields polarities, the averaged daily squares of spots groups (<http://solarscience.msfc.nasa.gov/greenwch.shtml>), and the average daily values of A_p (<ftp.swpc.noaa.gov/pub/warehouse>; <https://www.ngdc.noaa.gov/stp/GEOMAG/kp.ap.html>). The pair of 22-23 cycles and the running 24 cycle of solar activity were investigated. We used a cumulative method of graphical representation of the studied observational data. The results are:

– The north-south asymmetry of spots formation was found during 22-24 cycles. It was received that the maxima of activity in different hemispheres are shifted by more than 1.5 years. It may indicate the independence of solar cycles development in these hemispheres.

– In the leading spots the polarities change signs at the beginning of each cycle. At the solar poles the magnetic field polarity reversal takes place during periods of solar activity

maximum and not always at the same time. It is supposed that such an evolution of solar magnetic field leads to appearance of coronal holes and geomagnetic activity.

– The evolution of distribution of both solar and geomagnetic activity in the last three cycles (1986–2019) was investigated in detail. The geomagnetic disturbances are not maximal during the period of maximal spots formation, but 1–2 years later. Thus, the geomagnetic activity reflects the north-south asymmetry of the solar cycle and the process of solar magnetic field polarity reversal connected to it as well.

EVIDENCES FOR STRONG MIXED-POLARITY MAGNETIC FIELDS IN AREA OF A SEISMIC SOURCE ASSOCIATED WITH LARGE PROTON SOLAR FLARE

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We found indications for strong mixed-polarity magnetic fields in an exceptionally powerful solar flare of 2003 October 28 of X17.2 / 4B class, which was observed with Echelle spectrograph of Astronomical Observatory of Taras Shevchenko National University of Kyiv. For time 11:14 UT, a unique observational material was obtained when the entrance slit of spectrograph was projected onto the location of a seismic source associated with the flare. Based on a detailed study of the Stokes V and $I \pm V$ profiles of several Fe I and Fe II lines with various Lande factors, excitation potentials and formation heights in atmosphere, we conclude that magnetic field in this place was multi-component, with close contact of opposite magnetic polarities and with a very wide range of field strengths. All these components were inside a $1.5 \times 1.5 \times 0.5$ Mm³ volume, corresponding to the spatial resolution of the telescope as well as to the geometric thickness of the photosphere. Apparently, such a close proximity of strong and especially strong magnetic fields of opposite magnetic polarities created the necessary conditions for intensive reconnection of lines of force with a powerful energy release in the area of the seismic flare source. A semi-empirical flare model built using the algorithm PANDORA code shows that the extremely strong magnetic fields of 10^4 G range were localized in a fairly narrow altitude range (40–50 km) of the upper photosphere.

SOLAR COSMIC RAYS: ACTUAL ASTROPHYSICAL AND APPLIED PROBLEMS

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28 February 2019 marked the 77th anniversary of the first confident registration of solar cosmic rays (SCR), the term referring to accelerated solar particles with energies from about 10^6 to $\sim 10^{10}$ – 10^{11} eV. The present paper reviews the key observational and theoretical results on SCRs that has been accumulated over this period. The history of the discovery of SCRs is briefly described together with SCR recording techniques and instruments, and some physical,

methodical and practical aspects of SCR generation are discussed in more detail. Special attention is given to charged particle acceleration mechanisms at and near the Sun. Current ideas on the interaction of solar cosmic rays with the solar atmosphere, their transport in interplanetary magnetic fields, Earth's magnetospheric movements and their impact on the Earth's atmosphere are reviewed. It is shown that this field of space physics produced many results of fundamental interest for astrophysics, solar-terrestrial physics, geophysics and practical cosmonautics (astronautics).

ANALYSIS OF THE EARTH'S SURFACE DEFORMATION ACCORDING TO THE GLOBAL NAVIGATION SATELLITE SYSTEMS DATA WITH ITS NEWEST MOVEMENTS IN THE TERRITORY OF UKRAINE

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The report considers the modern deformation of the Earth's surface according to the results of the GNSS analysis – data of the MAO NAS of Ukraine in comparison with the newest lineament zones and faults, as well as the Late Pleiocene-Quaternary vertical movements of the Earth's crust. The areas of prevailing values of compression-tension and left-right rotation of the Earth's surface, the boundaries between which can be drawn in accordance with the latest lineament zones and faults, are identified. The areas of the prevailing stretching of the Earth's surface correspond to the zones of the newest tectonic uplifts and the maximum amplitudes of the Pliocene-Quaternary movements, and to the areas of the prevailing compression to the tectonic descents and minimum amplitudes. Four large modern geoblocks have been identified: the North-West and the North-East, which rotate clockwise, and the South-West and the South-East – counterclockwise. A qualitative mechanism for interconnecting modern and newest movements of the Earth's crust is proposed.

SOLAR PLASMA DYNAMICS DURING THE FORMATION AND DEVELOPMENT OF ELLERMAN BOMB PAIR

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Ellerman bombs (EBs) are a part of solar activity. EBs are associated with a rapid local release of energy, magnetic fields, and specific plasma motions. EBs can affect the complex dynamics of the upper solar atmosphere and make a significant contribution to heating of the lower chromosphere. Observations showed that 50% of Ellerman bombs appear and disappear in pairs.

The results of the feature changes analysis of the line-of-sight plasma velocities (V_{los}) in different layers of the active region (AR) NOAA 11024 under the action appearing and developing two Ellerman bombs (EB-1 and EB-2) are presented. Spectral data with high spatial and temporal resolution were obtained with the French-Italian

THEMIS solar telescope. We used spectra were obtained in the H α -line and in the lines forming within a wide range of photospheric heights: Fe I λ 630.15, 630.25, and 630.35 nm and Ti I λ 630.38 nm. EBs evolved in the region magnetic flux that were emerging at the time. Changes in the velocity and direction of chromospheric and photospheric matter motion in the region of Ellerman bombs and in their immediate vicinity at different stages of EBs evolution were determined and analyzed.

In which layer of the solar atmosphere magnetic reconnections triggering the formation of EBs occur still remains unclear. It is assumed that the magnetic-field energy in the process of EB development is spent largely on acceleration of plasma flows. The study of specific features of motion of matter at different levels of the solar atmosphere during EBs development should help determine the height of EBs formation.

Temporal variations in the line-of-sight velocities of the chromospheric material at a level of the H α core formation showed two periods in the velocity enhancement, containing several individual peaks. The maximum V_{los} was -9 and 8 km/s toward and from the observer, respectively. Rapid upward and downward plasma streams (where V_{los} reaches -80 and 50 km/s, respectively) were sometimes observed.

It was found that upflows were predominant at all levels of the AR photosphere. At the same time, V_{los} decreased considerably in the region of EBs. Apparently, the small-scale downward flows induced by magnetic reconnections were superimposed onto the large-scale upward motion of the new magnetic flux plasma. The line-of-sight velocity in the central part of EB-1 and EB-2 varied from -1 to 0 km/s and from -1 to 0.2 km/s in the upper photospheric layer and from -1.6 to -0.2 km/s and from -1.1 to 0.25 km/s in the lower layer of the photosphere, respectively.

Based on the research, it can be concluded that the excitation caused by pulsed energy release as a result of successive magnetic reconnections propagated from the EB-1 area along the magnetic loop and initiated the formation of EB-2, then they developed as physically connected pair. The studied features of the V_{los} temporal changes indicate that during the development of EBs, multidirectional movement was observed - in the lower chromospheric layer the matter moved upward, while streams formed that moved downward, reducing the velocities of the ascending plasma at the photospheric level. Such a distribution of velocities could cause magnetic reconnections that occurred in the layer between the upper photosphere and the lower chromosphere, where the core of the H α line was formed.

The Ellerman bombs were accompanied by small chromospheric ejections (surges) lasting for 0.5-1.5 min.

PERIODS OF MAJOR INDICES OF SPACE WEATHER

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Application of wavelet analysis method allows you to obtain data not only on the availability of key periods changes of the studied indexes, but also determine the time of their existence and character of amplitude change over time. The paper presents the results of the calculations of the spectra for periods of solar activity indices (Sp, W, F 10.7, FI, LA, SI), solar wind flow (IMF, density), disturb-

ance state of the geomagnetic field (Ap, Kp, DST). For indexes that characterize the solar activity the presence of long-period component is typical (2-7 years), which move from one cycle to another. Here there are also numerous short-term variations for a period of less than one year that change with the phase of the solar cycle. Changes in indices of geomagnetic activity largely reflect trends in the range of periods of solar indices. They demonstrate the existence of a long-period component with the transition from one cycle to another. Short-periodic components exist within certain cycles of activity. Changes of the periods spectrum of solar wind indexes show numerous long-period and short-periodic components of transition from one cycle to another. Changes in solar constant (SI index) show a noticeable difference from all other solar indices showing off the most varied range of periods.

PEREGEE-SYZYGY TIDES IN ATMOSPHERE

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It is shown that in 2016/17 the smoothed anomalies of air temperature in The European Territory of Russia repeated the course of the perigee distance (that is, the distance between the Moon and the Earth at the moments of the perigee of the moon), which varies along the sinusoid with a period of 206 days. Discovered the basic pattern perigee-syzygy tides: 206 daily beating pressure anomalies for the new moons and full moons. Pressure anomalies in the full moon and new moon can be approximated by sinusoids with periods of envelope beating about 412 days and opposite phases. The range of oscillations in the antinodes reaches 40 MB, which in order of magnitude is quite comparable to the real SYNOPTIC fluctuations in atmospheric pressure.

THE CATALOG OF MAGNETIC STORMS AND OBSERVED DATAS OF VARIATIONS OF THE GEOMAGNETIC FIELD IN A ZONE OF THE ODESSA MAGNETIC ANOMALY

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At the radio telescope «URAN-4» of radio-astronomical institute of NAN of Ukraine since 1987 monitoring of fluxes of powerful space radio sources is carried out. Programs are the study of variable fluxes power cosmic radiosources and their dependencies on the state of space weather.

For identification of reaction in the nature of the geomagnetic activity observations from the Odessa magnetic station was used. The radio telescope "URAN-4" and the magnetic station "Odessa" is located near a zone of a magnetic anomaly. The version of the catalog of magnetic storms for a zone of the Odessa magnetic anomaly from 1987 for 2009 which covers 22-23 cycles of solar activity is submitted.

In the catalog include: date and time of the beginning and end of a storm, the storm duration, amplitude on three elements of a magnetic field are specified: H, Z, D, the characteristic of magnetic storms with the indication of the fissile periods. Catalogue of magnetic storms Observatory «Odessa» is comparison with catalog magnetic storms IZMIRAN.

Since November 2017 till June 2019, the variation of geomagnetic field component was monitored at the Astronomical Observatory of the I. I. Mechnikov Odessa National University with the aim of investigating geomagnetic variations in the central region of the Odessa magnetic anomaly. The measurements were made by using the precision LEMI-008 flux-gate magnetometer with a sample rate of 1 Hz. Exemplars of records of magnetic storms are presented during these measurements.

THE WATER RESOURCE OF THE MOON IS SUFFICIENT FOR ITS COLONIZATION

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To search for water on the Moon, the launch of the “Lunar Reconnaissance Orbiter” and “Lunar Crater Observation and Sensing Satellite” spacecraft was an important stage. The last, ≈4 місяця months, studied the mineral composition of the lunar surface and searched for water ice with a neutron detector. With its help, a significant amount of hydrogen was found near the south pole, because it can be a sign of the presence of water in a bound state. Moreover, in the polar latitudes of water found more. Perhaps because in cold polar craters, water and other volatile substances can remain on the surface in a stable state for several billion years (Bandfield et al., 2018). After careful analysis of the spectral characteristics of the data obtained by the probes, the presence of OH and H₂O was revealed, and it was shown that water in this state exists on the entire lunar surface, and not only limited to the circumpolar regions (Milliken & Li Sh., 2017).

Such a conclusion about widespread and relatively still water suggests that it is predominantly present as OH-hydroxyl. And its presence practically does not depend on the composition of lunar rocks, or on the time of day and slightly depends on latitude. The soil samples, delivered by the Apollo devices, showed that a large amount of water is inside the pyroclastic deposits in the form of “beads”. These rocks are formed with the active action of volcanoes, and the rock is scattered over thousands of square kilometers across the moon Vidmachenko, 2018).

But the water there is not in the form of ice, but is closed inside the minerals (Vid’Machenko & Morozhenko, 2004; 2006). Their age is estimated at 100 million years. That is, still relatively recently, the Moon was geologically active, and there were many volcanoes on its surface (Milliken & Li Sh., 2017). Water in such sediments is about 0.05% of their mass. But near the poles – the water is still more, up to 0.07%. Therefore, the total amount of water on the satellite can be estimated as quite large. It is believed that, perhaps, all of it was found from one hundred million to billion tons of water. Studies have shown that in temperate and equatorial latitudes, the maximum amount of water is in the early morning and the minimum in the lunar afternoon; the

amplitude of oscillations could be about 0.02% by weight of minerals. The mechanism of such oscillations is not yet clear, but they can say that the formation of water takes place on the Moon – even now. Its distribution on the lunar surface can help to understand where it came from. Water could get onto the lunar surface when cometary nuclei fell on it. It could also form there under the influence of the solar wind, which is a stream of electrons and protons ejected from the Sun. Protons – are the nuclei of hydrogen atoms. Combining with oxygen in lunar minerals, they can form water molecules and OH.

In (Milliken & Li Sh., 2017), a global map of Luny water resources is shown. For its construction, R. Milliken and Sh. Lee have used data from the lunar mineralogical cartographer of the Indian apparatus “Chandrayaan-1”. At its construction, no differences between water and OH hydroxyl were noted. But how to get water enclosed in minerals? If effective methods of water extraction will be found, the bases on the satellite can be placed both at the poles and at more comfortable latitudes. Water will be needed both during the construction of bases on the Moon, and during reconnaissance, and during resource extraction, when used for drinking and technical needs, as well as for extraction oxygen and hydrogen (Morozhenko & Vid’machenko, 2003; 2004; Shkuratov et al., 2003). But water is not always easily available. And for further use, hydroxyl should be extracted from minerals. In fact, the future production of water will be not much different from the traditional development of mineral deposits. Therefore, a special lunar robot should be developed to extract water from the regolith, which will have to move across the lunar surface and conduct exploratory drilling.

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WATER IN ASTEROIDS

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As the study of the Solar system, water was found in cometary nuclei, in asteroids, dwarf planets, on Mars (Vidmachenko & Morozhenko, 2014). Away from the Sun – water is mainly in the form of ice (Vidmachenko, 2018). It is believed that in the Solar System there are up to 2 million asteroids with a size of more than 1 km; 19,500 medium-sized asteroids were discovered near the Earth. Estimates of the number of near-Earth asteroids that hold water are consistent with measurements of the ratio of their C- and S-type populations. There are probably thousands of rich by H₂O, near-Earth asteroids with a diameter of more than 5 m and

their number is increasing every year. Carbon-chondritic C-type asteroids can be considered the best source of water (Vidmachenko & Vidmachenko, 2007). They have a loose, rather fragile structure. Therefore, even drilling is not required at such an object. In order to extract water, it will be enough just to scrape its surface.

In addition to water, volatile substances such as nitrogen, CO, CO₂, methane, ammonia, etc. can be detected on asteroids. In 2015, a technology was patented with the name “optical extraction” of water (Jedicke et al., 2018), which may allow extracting it from the depths of asteroids. This technology involves drilling carbonaceous chondrites and extracting water and other volatile substances from them. The collected material should be placed in the bag without the use of complex and expensive robotics. As part of a single launch of “SpaceX Falcon 9”, it is planned to collect up to 100 tons of water from the depths of a near-Earth asteroid and transfer it to the lunar orbit. For test the developed equipment, stones that imitated an asteroid were heated with using solar furnaces.

Testing methods showed that the concentrated sunlight could “drill” the hard surface of the stone and allowed to evaporate volatile substances from it, including water. It is believed that focused sunlight can “drill” solid materials and even crumble an asteroid placed in a special protective bag. This bag is made of a material that withstands high temperatures and is large enough to completely capture the target. After the asteroid is placed in this trap, concentrated sunlight will be directed at it, water will evaporate and will be redirected to the cold storage tank in the form of ice. Then this system will be able to transport these stocks to the storage space.

Thus, water in asteroid bodies is a very important resource. In addition to its hydration role, it can produce hydrogen and oxygen, it can be used to make fuel for rockets, deliver it to special storage facilities, which should be located in special strategic places of the Earth orbit and use it to carry out refueling of space systems, maintain stations in orbit, and more. This type of fuel will be able to give a tremendous impetus to the development of space flights. Apparently, it will be much cheaper to find water in space than to deliver it from the Earth (Vidmachenko, 2016). Water, in turn, will be able to provide spacecraft with inexpensive fuel, which will reduce the cost of missions. Mining specialized apparatus will be able to fly between planetoids using water extracted in asteroids, which will lead to their high payback. The success of this type of space flight should lead to a multiple reduction in the cost of rocket launches from Earth. That is, water from asteroids can significantly reduce the costs of such space missions (Vidmachenko, 2017). In addition, it can dramatically change the method of space exploration. Having access to the asteroid body, and having learned there to extract and use water resources, the extraction of various metals and other minerals on them will also become much more real.

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ON THE ORIGINAL THEORY OF THE APPEARANCE OF BIOLOGICAL MOLECULES IN ASTEROIDS

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The Main belt of asteroids is located between the orbits of Jupiter and Mars. It is located in a rather cold part of the solar system (Vidmachenko, Steklov, 2018; Vidmachenko, 2009; Vidmachenko, 2012). But it should be remembered that for the possibility of the formation of biological molecules as building blocks of some form of protein life, it is necessary that cosmic bodies be moist and warm. One of the theories about the origin of life on our planet (the so-called theory of panspermia) suggests that the simplest biomolecules were brought to Earth from space. Such vital particles could well be on Earth, along with meteoritic bodies, break-away from asteroids. But the young Sun billions of years ago was not so bright as it is now. For this reason, the asteroid belt was then even colder. However, studies show that some of the asteroids in their history were heated to a state in which water on their surfaces could be in a liquid form. That is, the asteroid bodies were then in the so-called habitat zone (Vidmachenko A., Vidmachenko H., 2007). This means that biomolecules could have formed on such surfaces, or could survive there, being brought down by panspermia.

This raises the question of how the temperature on the surface of the asteroid bodies could rise so much that the conditions necessary and sufficient for the emergence of life there were formed and then survived in a certain area inside the asteroid?

The most common theory is of the presence of radioactive processes in some space bodies. But modern models of radioactive processes causing their heating, which could predict the temperature in the asteroid belt, very rarely correspond to observational data (Morozhenko, Steklov et al., 2018; Vidmachenko, 2013).

A few years ago, an original idea was proposed, according to which asteroids, at moving in their orbits, can generate some electric field at interaction with magnetic field of the Sun (Menzel, Roberge, 2013). As a result of the interaction of a charged fluid (which may be the plasma of the solar wind) with the magnetic fields of asteroids (Vidmachenko, Morozhenko, 2014; Vidmachenko, 2016b), and in the interplanetary space, due to the proposed mechanism of multi-fluid magnetic hydrodynamics, electric currents are formed that heat the inner space of the planetoid. Such an increase in temperature could well lead to the melting of water ice near the surface of the asteroids, and to create there unique oases with conditions suitable, if not for the formation of the simplest life forms, then, in any case, for preserving biomolecules introduced from outside by panspermia (Vidmachenko, 2016a). Therefore, asteroids should also be considered as a possible source of the spread of life forms.

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TRACES OF LIFE ON MARS SHOULD BE SOUGHT IN EMISSIONS FROM CRATER HELLAS IN PLACES, WHERE WATER EXITS FROM UNDER THE SURFACE

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Now the average magnetic field near the surface of the planet is about 40 nT. But on the surface of Mars, about a dozen regions with a length of hundreds of kilometers with magnetic fields of up to 400 nT and different directions were found (Vidmachenko, 2012). Traces of possible relic life should be sought in those places on the planet where there was once water, as well as in rocks that were formed in the first hundreds of millions of years. At present, a number of areas with rocks, which are usually found in volcanic formations (Vidmachenko, 2016b; Vidmachenko & Morozhenko, 2014a; 2014b), have been discovered on the surface of Mars and that could appear there only in the presence of a fairly strong magnetic field. Detection of small amounts of methane and formaldehyde may be one of the possible proofs of life on Mars too (Krasnopolsky, et al., 2004). The only known protein life form cannot exist without water. Therefore, the search for life on Mars should also begin with the search for water. Liquid water and now periodically flows on the surface of this planet (Vidmachenko, 2009b). Hydrated perchlorate salts were detected by spectral methods in the flows of these currents on the walls of Martian craters (Hecht, et al., 2009). It is possible that it is they who do not allow the liquid to freeze at a temperature below the average daily value of about 200 K. The presence of such a brine in water bodies under the surface may well be a possible habitat for ancient life forms that could once have arisen on Mars, and then adapting survive there (Vidmachenko, 2009a; 2017a). Alternatively, the fall of fragments of asteroids and cometary nuclei to the surface of the planet could bring panspermia germs of possible life. It is believed that the huge astrobleme Hellas in the southern hemisphere of Mars was formed as a result of a catastrophic collision with

a very large asteroid. Emissions of millions of tons of soil on thousands of kilometers then closed a large part of the surface of Mars, along with possible samples of life that had begun to emerge before this time. And even if life could not survive after a global catastrophe (volcanic activity, a huge astrobleme, or their complex effect), then we believe that this simplest life could well have been mothballed there, being sprinkled with discarded astrobleme ground. That is, if life was before the catastrophe on Mars, then the cataclysms that occurred could erase its traces. Or, the life that appeared on Mars then did not disappear without a trace, but moved from the surface of the planet into its subsoil, preserved there in relic fossils, or its simplest forms were sprinkled with soil emissions (Eigenbrode, et al., 2018; Peplow, 2005; Schultz, et al., 2014). Therefore, traces of life must be sought below the surface in places where there is a lot of water and sedimentary rocks that belong to the Phyllocian geological epoch. Thousands of tons of soil thrown out over thousands of kilometers sprinkled possible samples of life that began to emerge. In this regard, on the slopes around the Hellas Plain in the newly formed impact craters, its relic tracks should be sought (Morozhenko & Vidmachenko, 2017; Vidmachenko, 2016a; 2016c; 2017b). It is at latitudes near $-(40-50)^\circ$, that there is convincing evidence of modern water exits from beneath the surface of the planet. In this regard, the main search for traces of primary life on Mars should be carried out in these places of the southern hemisphere.

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SOLAR SYSTEM AND SPACE ENVIRONMENT

ASTROMETRIC AND PHOTOMETRIC OBSERVATIONS OF COMETS AND ASTEROIDS AT THE KYIV COMET STATION (MPC 585) DURING 2006-2018

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The program of regular observation of comets on the AZT-8 telescope at the at the Kyiv comet station (Lisnyky) was launched in April 2006 at the initiative of prof. K. Churyumov. In separate periods, to observations programs were joined by: A. Simon, V. Vasilenko (Department of Astronomy and Space Physics, Kyiv National University); K. Churyumov, V. Ponomarenko, I. Lukyanyk, V. Kleszhnok (KAO), S. Borysenko, O. Ivanova (GAO), Yu. Krugly (Institute of Astronomy of the KhNU), as well as foreign scientists. For 12 years, according to the site Minor Planet Center (MPC), 39 165 positional observations of small bodies were obtained from the Lisnyky, of which 28 463 comets were observed, and 10 072 asteroids were observed. Over the past 5 years, receiving from 3 091 to 4 651 positions each year, we rank first among the nearly 500 observatories involved in collaboration with the MPC.

In order to inform the astronomical community about the results of photometric observations of comets in Lisnyky, on comet sites: "BAA / TA comet image archive", "Seiichi Yoshida's Home Page", "The German comet group", "COBS" as well as in the journals *The Astronomer and Schweifstern*, published over 2500 images of comets as well as series of photometric observations.

Among the most interesting observations of comets is worth noting: the comet 73P, which split into 60 fragments, in April-May 2006 we observed 18 fragments; comet 17P, which outburst up to 15 magnitudes in 2007; long-term observations of jets around the nucleus of the comet 29P during regular outburst of 4-5 magnitudes; observation of the morphology of the head and tail of the comet 67P in 2015 within the framework of the implementation of the comet's ground observation program in support of the Rosetta space mission; Observation of the cometary activity of the asteroid 3478 Gault, which showed cometary activity and tail structure during the first four months of 2019. According to the results of observations, together with colleagues, the important physical parameters were estimated for comets: 22P, 29P, 41P, 47P, 65P, 81P, 103P, 362P, C/2011 J1, C/2012 K5, C/2013 X1, P/2017 S5. These results are published in: *Astronomy & Astrophysics*; *Icarus*; *Monthly Notices of the Royal Astronomical Society*, *Planetary and Space Science*.

The results of long-term collective observations of three Main Belt asteroids, have revealed the YORP effect for one of them the asteroid 3103 Eger. New asteroid (2017 SV39) was discovered.

ASTROMETRIC AND PHOTOMETRIC OBSERVATIONS OF SIX TRANSNEPTUNIAN OBJECTS AT KYIV COMET STATION

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We present the results of astrometric and photometric observations of transneptunian objects (TNOs) obtained at the Kyiv comet station (Code MPC 585) of the Astronomical Observatory of Taras Shevchenko National University of Kyiv in 2017-2019. For observations, we used the 0.7 m (f/4) reflector AZT-8 with FLI PL47-10 CCD camera with filters of Johnson's photometric system.

TNOs orbit the Sun at the edge of the Solar System and are expected to play a big role in the study of our star system's evolution. Our objects are dwarf planets Pluto (134340), Eris (136199), Haumea (136108), Makemake (136472) and other TNOs: Orcus (90482), Varuna (20000) with the apparent magnitude up to 20^m.

We performed the observations of these objects and analyzed the data using astronomical software (*Astrometrica*, *MaxIM DL*). Positions and physical properties of objects (V-R color index, absolute magnitude – H, geometric albedo – p) were measured. The accuracy of the observations and calculations was analyzed.

Astrometric data for all objects were published in *Minor Planet Supplement* and *Minor Planet Center* database with residuals 0.06-0.32", which show that the observations have a high astrometric quality. V-R Color Index for Eris was measured, from the result 0.41 ± 0.1 we conclude that the object possibly has the ice rich white surface. Calculated photometric parameters for Eris: H = -1.5^m, p = 0.83; Pluto: H = -1^m, p = 0.54; Haumea: H = -0.3^m, p = 0.54. The measured physical properties were compared with the data from *Asteroids with Satellites Database Johnston's Archive* and have shown good consistency.

Results indicate that photometric system of Kyiv comet station can be successfully used for further TNOs observations and researches. Our plans are to increase the precision of calculations, perform long-term observations, observe more objects and collaborate with other observatories.

INVESTIGATION OF NEO ASTEROIDS 2006 VB14 AND 1986 DA

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In 2018, 1028 CCD images were captured, covering 200 square degrees of sky, 7 new asteroids discovered. Totally 1028 observation of positions of 826 different asteroids were obtained. 566 positions and photometric observations of NEO objects 2006 VB14 = Y5705 = 345705 and 1986 DA were obtained, to detecting rotation period and other physical

characteristics. Observations confirm the previously obtained rotation period $P = 3.04\text{h}$ for 2006 VB14. The sharp fall of brightness in phase 0.3 and the brightness peak in phase 0.1, indicate the presence of a large crater and the bright surface area (frozen gas field or water) on the asteroid surface, respectively. This research is funded by the Latvian Council of Science, project "Complex investigations of Solar System small bodies", project No. lzp-2018/1-0401.

OBSERVATIONAL COMPLEX FOR OBTAINING THE KINEMATIC AND PHYSICAL CHARACTERISTICS OF METEOR BODIES AND DETERMINATION THEIR CHEMICAL COMPOSITION

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Each meteor spectrum has its own unique set of characteristics both in the material composition and in quantitative parameters. Meteor spectra give us a data on the conditions of excitation, glow and ionization of the meteoric plasma, temperature, ablation processes (destruction of the meteor body), physical and chemical processes occurring during meteoric phenomena in the Earth's atmosphere, masses of meteoroids, causes and nature of flares, qualitative and quantitative chemical composition of the meteoric body and the concentration of elements in the meteoroid, and, hence, the refractory composition of the nuclei of comets and asteroids.

In 2018, an observational complex (automatic video and spectral meteor patrol) was created at the Institute of Astronomy of Kharkiv National University for obtaining the kinematic and physical characteristics of meteor bodies and determine their chemical composition. The meteor patrol is equipped with two CCTV cameras, one of which is equipped with a 500-lines/mm diffraction grating for spectral observations. CCTV cameras by Watec (Japan) are used as radiation detectors: WAT-902H2 ULTIMATE with a time resolution of 20 ms and a frame rate of $40\text{ ms}^{-1} \pm 0.1\text{ ms}^{-1}$. In such cameras uses a CMOS matrix with a size of $1/2''$, the physical size of one pixel is $8.6 \times 8.3\ \mu\text{m}$, the camera sensitivity is 0.0001 lx (with a relative aperture of F/1.4). The camera resolution is more than 570 television lines, the signal/noise ratio is more than 46 dB. During the observations the automatic brightness enhancement has been disabled. A television tuner with eight-bit ADC is used to convert the analog signal from the camera to the digital signal. An automatic meteor recorder is used as a software for capturing video. The time bindings of meteor patrols is carried out with GPS. All cameras are equipped with lenses Tamron 12VM1040 ASIR (F=10 mm, relative aperture F/1.4), which provides a field of view of $34.4^\circ \times 25.8^\circ$. The angle size of the single pixel is $2.65'$.

Optical devices are installed on the Sky-Watcher EQ6-R Equatorial GoTo mount and operate automatically. Image recording during observations can be performed with or without guiding of equatorial mount.

The TV image has a size of 576×768 pixels and consists of two consecutive fields: even fields and odd fields. An even and an odd fields of the image are formed every 20 ms. Since the first part of the image of the meteor stroke is received in even fields, and the second in odd fields, and the meteor is shifted during the reading time, so the image looks striped. Thus, by separating, an even and an odd fields with the help of software, it is possible to get a meteor image and after glow with a time resolution of 20 ms.

The penetrating ability (boundary magnitude) for an observation complex without a diffraction grating is $+5.4^{\text{m}}$. For the spectral camera, the penetrating ability is $+4.0^{\text{m}}$. The meteor patrol works in the spectral range of wavelengths from 350 to 800 nm. The maximum value of the spectral sensitivity is $\sim 700\text{ nm}$. The inverse linear dispersion in the first order of the spectrum is 1.60 nm/pixel and 0.76 nm/pixel in the second order of the spectrum.

The created hardware complex gives an opportunity to receive spectra of optical phenomena in the Earth atmosphere, to determine the chemical composition of objects of artificial and natural origin, which cause these optical phenomena.

The results obtained during the work of the patrol can be used for evaluation the number and masses of meteoroids that enter the atmosphere. The organization of basic observations of meteors using this complex (simultaneous observations from different points) will allow to determine the locations of the meteorites fall.

USING A SCHMIDT TELESCOPE TO OBSERVE METEORS, COMETS AND ASTEROIDS

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This paper presents the results obtained using a Schmidt telescope (with primary mirror diameter 271.25 mm; correcting plate diameter 219.2 mm; effective focal length 0.44 m and focal ratio 1/2) in different configurations to conduct television meteor patrol, as well as comet and asteroid observations.

The telescope is parallactically mounted on APT-4 at Kryzhanovka observation station. On the basis of the astrometric observations performed at Kryzhanovka station, it was registered in the Minor Planet Centre with the observatory code A85 as Odessa Astronomical Observatory, Kryzhanovka at the latitude $\varphi = 46^\circ 33' 38.6''\text{ N}$, longitude $\lambda = 30^\circ 48' 23.4''\text{ E}$ and altitude 40 m.

In the initial configuration, the telescope was equipped with camera WATEC-LCL-902 K and intended to carry out television meteor patrol with temporal resolution of 20 ms and field of view 36×48 arc minutes. The initially configured telescope was used from 2003 to 2015 in the mode of

routine observation of meteor events as part of television meteor patrol. Over that period, 2,315 meteor events were recorded with angular resolution of 1 arc second. This paper reports relevant observational data and methods employed.

The software developed on LINUX/MIDAS/ROMAFOT for processing and reducing digitized photographic plates of the Photographic Observations of Northern Sky Survey (FON) programme was used to process a portion of CCD-frames. The errors of equatorial position and magnitude determinations in the Tycho-2 Catalogue are as follows: $\sigma\alpha = 0.34''$; $\sigma\beta = 0.20''$, $\sigma m = 0.30$ m.

In 2015, the telescope was upgraded; in particular, a quartz correcting plate and camera VIDEOSCAN 415-2001 were mounted. The camera can be run both in television and accumulation modes (exposure 0.0029-40 sec). The limiting magnitude is 19.2. In this configuration of the telescope, a photometric system similar to Johnson's V system is implemented. We present observations of comets and asteroids and consider advantages and disadvantages of the telescope's current configuration.

As of today, the second set of primary mirror and correcting plate has been manufactured and is available to build a new Schmidt telescope with a filter module assembly. We plan to redeploy the VIDEOSCAN 415-2001 camera for the new telescope and having the existing telescope equipped with a new camera WATEC WAT-902H2 continue using it to conduct meteor patrol. Hence, we discuss possible programmes of future observations.

SOME FEATURES OF THE SIMULATION OF THE EVOLUTION OF SPACE DEBRIS

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Space debris are artificial objects and their fragments, as well as components and parts that are not used and cannot be saved or it is impossible to restore their original functions [1]. The mass of fragments of space debris ranges from a few grams to tons, and their diameter is from several millimeters to tens of meters. These objects move in orbits, the heights of which lie from 160 to more than 36 000 kilometers [2]. There are about 300,000 fragments in diameter from one to ten centimeters in Earth orbit. They are most dangerous for operational satellites among all the debris of space debris. These fragments are large enough to cause serious damage to a spacecraft and it is almost impossible to track them using a ground observation system for space debris objects. There are about 19,000 orbital debris larger than ten centimeters in Earth orbit. They can also disable operating satellites, but debris of this size can already be tracked and avoided collisions of spacecraft with them. Fragments of space debris smaller than one centimeter cannot be tracked, but it is possible to protect an operating spacecraft from them.

Movement in near-Earth space is of particular interest for the problems of modeling the evolution of the orbits of space debris. First of all, the created environment is a unique system

of artificial space objects in the solar system. Given the wide range of sizes of fragments of space debris, from 10^{-6} to 10 meters, it becomes possible to study the effects of disturbances of various origins and secular changes in orbital motion. A. Rossi, and al., 1998 [3] considers it possible to draw an analogy of the motion of space debris in the region of low near-earth orbits with the motion of small planets in the asteroid belt. However, the movement in near-Earth space has its own peculiarities. The spatial density of space debris objects has a dedicated direction in inclination, eccentricity and height of the orbit. In addition, some fragments of space debris form clouds – areas with a greater concentration of such objects moving in orbits, on which the satellite was before the collapse. Such features are explained by the events of the accidental or deliberate destruction of satellites that occurred in the past.

There are several approaches to modeling the evolution of space debris fragments. Depending on which near-earth orbits are simulated, fragments are treated differently. To simulate them in the low-Earth orbit region, analytical and semi-analytical methods are used. In the first variant, for example, according to Letizia Francesca, and al., 2015 [4], the motion of orbital debris is modeled in terms of their spatial density. In this case, the continuity equation is used to propagate debris. The collection of fragments of space debris is considered as a liquid. In the second variant, for example, according to Xiao-wei Wang, and al., 2018 [5], in the Space Object Long-Term Evolution Model created by them, the integration is performed with averaging short-period perturbations. In another case, according to H.G. Lewis, and al., 2008 [6], in the FADE (Fast Debris Evolution) model they created, the first order differential equations are solved by the Euler method to describe the evolution of the space debris environment. They describe the change in the number of debris over time, and collision statistics is performed by the Monte Carlo method. There are also other semi-analytical models of the evolution of space debris in the region of low near-Earth orbits. As of 2018, examples of such models are:

- model LEGEND (LEO-to-GEO Environment Debris model) from the National Aeronautics and Space Administration (NASA),
- Model DAMAGE (Debris Analysis and Monitoring Architecture for the Geosynchronous Environment) from the UK Space Agency (UKSA),
- Model MEDEE (Modeling the Evolution of the Earth in Environment) from the National Center d'Etudes Spatiales (CNES),
- model DELTA (Debris Environment Long Term Analysis) from the European Space Agency (ESA),
- Model LUCA (Long-Term Utility for Collision Analysis) from Technische Universität Braunschweig,
- Model NEODEEM (Near-Earth Orbital Debris Environment Evolutionary Model) from Kyushu University and the Japan Aerospace Exploration Agency (JAXA) [5].

The models are constructed in such a way that it is possible to take into account the perturbations from the asymmetry of the gravitational field of the Earth, the resistance of the atmosphere, the pressure of sunlight and the influence of the Moon and the Sun on the movement of space debris. The difference between them lies in considering the different number of decomposition terms in perturbing accelerations and various models of the sunlight pressure and the resistance of the Earth's atmosphere. According to

Dolado-Perez JC, 2013 [7], the difference between the LEGEND, DELTA and MEDEE models is manifested in the differences in 200-year prediction of the number of fragments, some of their orbital elements, and the density of orbital debris. Thus, the number of orbital debris larger than 10 centimeters in the area of low near-earth orbits as of 2200 according to the MEDEE model will have a value of 17,000, DELTA models – 21,000 and LEGEND models – 24,000. Such forecasts are necessary to understand the scale of the problem. As of 2018, the region of low near-earth orbits is the region with the highest concentration of space debris objects [8].

To simulate the evolution of space debris in the field of geostationary orbits, numerical methods for integrating differential equations are used. For example, the method of Everhart. In the model created by Eduard Kuznetsov, 2017 [9], the integration of the equations of motion occurs by the Everhart method of the 19th order over a period of 240 years. The perturbing accelerations from the asymmetry of the gravitational field of the Earth (harmonics up to 27 orders and degrees inclusive), the pressure of sunlight taking into account the Earth's shadow, the Poynting – Robertson effect, the resistance of the atmosphere and the influence of the Moon and the Sun are taken into account. Calculations show that large values of the ratio of the mid-section to the mass of fragments of space debris lead to the intersection of such objects of the geostationary orbit and the orbits of satellites of global navigation systems. This is due to the light pressure and the Lidov-Kozai effect [10]. This leads to long-period oscillations of the eccentricity and inclination of the orbits.

Thus, various methods of modeling the evolution of fragments of space debris allow not only to predict their future distribution to solve the global problem of orbital debris, but also to reveal new and confirm already known subtle effects.

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PHOTOMETRY OF AN UNUSUAL SMALL SOLAR SYSTEM OBJECTS 2016 ND21

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We present the first measurements of the rotational properties and surface colors of a recently discovered small object 2016 ND21 on an unusual orbit. The photometric observations of this object were performed in October and December 2017 using a 2.0m telescope at the Peak Terskol observatory when the object was close to its perihelion. Observations were carried out in the standard *BVR* filters of the Johnson-Cousins photometric system. From our data we did not detect a presence of cometary activity for this object. We found the rotational period of $P = 17.53 \pm 0.02$ hr, while another slightly longer value of $P = 17.65 \pm 0.02$ hr is also possible. Assuming an equatorial aspect of observations, a peak-to-peak amplitude of $A = 0.31 \pm 0.05$ mag (or even higher since only one maximum and one minimum were well-measured) corresponds to an elongated body with an axis ratio $a/b \sim 1.3$. The lightcurve behavior indicates a complex, possibly non-convex, shape of this object. The visible absolute magnitude is $H_V = 12.4 \pm 0.1$ mag, which was estimated by using the linear phase slope 0.04 mag/deg as the most probable value from our observations. This phase slope suggests a low-albedo surface of 2016 ND21. Assuming a surface albedo in the range of 0.04-0.10, the size of 2016 ND21 should be about 15-23 km. From our multi-color observations we determined surface colors $V-R = 0.69 \pm 0.04$ mag, $B-R = 1.79 \pm 0.08$ mag, and $B-V = 1.10 \pm 0.08$ mag. The measured colors indicate an extremely red surface of this object. A very red surface is unusual for comets, which is in agreement with the fact, that no cometary activity was detected for 2016 ND21. The $B-R$ color is higher than the typical $B-R$ colors of the red D-type asteroids, but it is consistent with colors of the red Centaurs and TNOs classified as RR type in TNOs classification. This result gives a first evidence of a possible outer belt origin of this small body.

MONITORING OF EARTH'S ATMOSPHERE BASED ON OPERATIVE PROCESSING GNSS DATA IN UA-EUPOS / ZAKPOS NETWORK OF ACTIVE REFERENCE STATIONS

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The main purpose of GNSS-meteorology is obtaining of Zenith Total Delay (ZTD) values from regional network of permanent GNSS stations for Numerical Weather Prediction (NWP). Accordingly, strategy of analysis GNSS data should provide such ZTD estimations, which meet requirements of GNSS-meteorology.

The determination process of the water vapor content from GNSS observations in the troposphere has three stages. The first one is the determination of the tropospheric delays.

At second stage the zenith wet delay (ZWD) value is calculated. At the third stage ZWD value is transformed into corresponding amount of the integrated water vapor (IWV) or precipitable water vapor (PWV) using conversion factor.

However permanent GNSS stations can be used to observe not only zenith tropospheric delays, but also slant tropospheric delays in the receiver-satellite direction. With the emerging new satellite constellations (GLONASS, Galileo, COMPASS) a large number of satellites are observed at the permanent GNSS stations and these receiver-satellite vectors intersect the atmosphere in various directions. Since the measured slant wet delays are caused by the atmospheric water vapour content along the path of the satellite signal, these observations can provide information on not only the horizontal distribution of atmospheric water vapour, but also on its vertical variability. Vertical water vapour profiles derived from GNSS data showed good agreement with radiosonde profiles at the radiosonde station.

ONGOING OPERATION AND PERSPECTIVES OF SIMPLE VLBI NETWORKS OF GEOSTATIONARY SATELLITES MONITORING

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The report is dedicated to introducing the operation and prospects of further development of simple VLBI networks which were created in Ukraine, Latvia, and China for monitoring the orbital information of geostationary satellites. The Ukrainian-Latvian network consists of five stations located in Mykolaiv, Kharkiv, Mukacheve, Ventspils, and Rivne, and it operates since 2015. The Chinese network consists of three stations located in Shanghai, Deyun, and Urumqi, and it formally carried out a network observation from June 2019.

The networks have identical hardware and software. The main principle of the operation of the networks learned from the VLBI is correlation analysis of broadband noise-like signals of satellite television DVB-S, which are emitted by satellites and synchronously received by the stations of the networks. Single-frequency GPS receivers are used for the synchronizing of network stations. Time difference of arrival (TDOA) between the signals paths from the identical TV satellite to different stations is obtained via using correlation analysis. These values of TDOA are used to determine orbital elements of the tracked satellites which are given in the report. Notably, the cost of one set of station equipment does not exceed \$2000, and the current operating costs are about \$50 per day.

The prospects of further development of the simple VLBI networks include a) the possibility of continuous independent non-invasive high-precision determination of the position of arbitrary active satellites (especially important in the case of their co-location), b) the possibility to fully automate targeting and operation, c) the possibility of using accumulated observational data to solve scientific geophysical and astronomical tasks, d) relatively few funds necessary for the modernization and operation of the networks.

OBSERVATIONS OF STAR OCCULTATIONS BY SMALL BODIES OF THE SOLAR SYSTEM IN KYIV

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Observations of star occultations by asteroids allows specifying the size, shape, and albedo of asteroids. Such observations for comets make it possible to clarify the parameters of the nucleus and the features of the internal coma of comets. The complex of observations of star occultations has been created for these tasks, which uses a camera in drift scan mode. The approachment of comet 21P / Giacobini-Zinner with the star HD 45314 was observed with this complex on September 21, 2018. According to the ephemeris, the occultation strip was at a distance of about 160 km from Kyiv. The observations were carried out using the Mirage 7 small telescope with a diameter of D = 180 mm and a focal length of F = 1800 mm. A decrease in star brightness $\ll 0.05$ mag was registered. The occultation of star UCAC4-475-051755 by the asteroid (259) Aletheia was observed with the same telescope on April 10, 2019. The maximum ephemeris occultation time was 16.7 seconds. However, the time duration of the occultation according to our data is 17.3 seconds. To explain this discrepancy, it was suggested that the asteroid (259) Aletheia has an elliptical shape with an aspect ratio greater than 1: 1.13.

GPS SYSTEM OF ACCURATE TIME FOR TV OBSERVATIONS

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This GPS time-tracking system for television observations is a continuation and development of the time system that was used in the observing system of the star occultations by the moon "Spalakh", AO of Taras Shevchenko National University of Kyiv. It consists of a GPS receiver, a microprocessor unit and a GPSwatch program for monitoring computer system time for the Windows XP, 7, 10 operating systems. The GPSwatch program receives information via a USB port with time stamps using NMEA protocol. The program operation algorithm uses the original approach, which significantly reduces the information delay and improves the accuracy of the system time reference.

In this case, the program records in the background the protocol of the system time corrections, which allows determining the time for a single event with an accuracy of 0.02 s and for a repeated periodic signal up to 0.002 s. The microprocessor unit generates time stamps from the PPS signals, which allow obtaining the timing of television observations in two ways. The first method works with analog TV systems by introducing a 1 μ s pulse synchronized by PPS directly into a television signal. The additional pulse of the same duration of 1 μ s is generated after 7 ms of the PPS signal to avoid accidental imposition of a pulse on the television sync signals. We can determine the start time of the frame with an accuracy better than 1 ms by measuring the position of the sync signals in the frame. The second method allows you to enter into the television frame the optical signal from the LEDs, the beginning of the glow which coincides with the arrival of the PPS pulse. This method allows working also with digital cameras. Combined processing of time stamps from PPS pulses and the computer time correction protocol ensures a high absolute accuracy of the time scale throughout the entire observation period.

DIFFUSE-NEBULA COMA OF SOME METEORS: OBSERVATIONAL FACTS AND POSSIBLE EXPLANATION

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An overview of meteors with strongly pronounced photometric and kinematic anomalies is given. The anomalous meteors having the diffuse view and enlarged size of their comas at the beginning part of trajectories are considered in details. The results of processing of a few such meteors detected with high-sensitive observational TV systems of super-isocon type during 2002 Leonid meteor storm are presented. A special feature of the given meteors is the enlarged size diffuse coma, but in opposite to similar phenomena described in literature not at extremely high altitudes, and below 128 km: 118 km, 123 km, and 124 km. At the beginning of their trajectories the absolute astronomical magnitude was varying in the range of +6...+4, reaching in maxima of brightness -0.5. The range of mass was 0.03-0.06 g. The possible influence of working TV system modes onto possible appearance of artifacts is considered. While the half-clear, diffuse view of boundary weak meteor image may be a result of low signal-to-noise ratio, the increase of spatial size of the coma cannot be explained by technical artifacts. The variants of natural explanation of the given phenomenon are proposed.

NEO OBSERVATIONS IN CSIRP AND NFC

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At the end of 2016, the AZT-28 telescope of the Center for Special Information Reception and Processing and Navigation Field Control (CSIRP and NFC) was upgraded. As

a result, he was able to observe the minor bodies of the Solar System, including Near Earth Objects (NEO). This possibility was confirmed by obtaining the MPC-code L-18. After occasional observations in 2017 and 2018, in 2019 regular NEO observations were organized, including follow-up of new discovered NEOs. The report presents the results of NEO observations from April 2017 to July 2019.

Keywords: NEO, optical observations.

OBSERVABILITY OF LEO OBJECTS BY OPTICAL SENSORS – A GEOGRAPHIC ASPECT

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The simulation modeling of observability by optical telescopes of low-Earth orbit (LEO) space objects was performed depending on their geographic location and time of year. As the initial data for the simulation, the LEO objects were taken from the open catalog of the space objects orbits provided by the US Combined Space Operations Center. The simulation results showed a complex dependence of the observability of LEO objects on the parameters of its orbit and on the location of the optical telescopes, especially for solar-synchronous orbits (SSO) and telescope located near the equator. Variations in the intensity of the LEO objects passages through the station view area and the time they are in the field of view for three locations of optical sensors are also considered. The obtained results and modeling techniques can be further used in planning the placement of new optical stations.

Keywords: LEO objects, simulation modeling, optical observations, observations scheduling.

FIRST RESULTS OF CLARIFYING OF ORBITAL ELEMENTS OF LOW-ORBIT SPACECRAFTS USING OBSERVATIONS OF THE RI "MAO" DOPPLER STATION

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18 artificial satellites of the Earth, which emit radio signal at a frequency of 430-440 MHz during their flight in the Mykolaiv visibility zone, were found as a result of the searching carried out in the RI "MAO". 10 of 18 satellites during not less than 7 days each were automatically tracked by the Doppler station created in the RI "MAO". Frequency of received radio signal was automatically determined as a result of spectral processing of radio signal amplitudes registered by the station during satellite tracking. Herewith 5 of 10 satellites emitted non-harmonic broadband signals.

The radial velocity of satellites is calculated using the frequency of received radio signals.

The obtained values of radial velocity changing in time were used to clarify TLE (Two-Line Element) orbital elements of satellites. Initial orbital elements were downloaded from the space-track.org site. The regular (mean) and random (standard deviation) components of the difference (O-C) of measured and model values of radial velocity were calculated. Comparison of the regular and random components of O-C was made, which showed their slight decreasing after clarifying orbital elements.

RESULTS OF POSITIONAL AND PHOTOMETRIC MEASUREMENTS OF METEOR TRAJECTORIES OBSERVED IN MYKOLAIV 2017-2018

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Regular meteor observation using TV CCD unintensified techniques was started in 2011 in Nikolaev astronomical observatory (RI NAO). New observational campaign with baselines 11.7 and 100 km was started in 2017-2018. Eight telescopes with narrow field lens ($f=50$ mm, $f/1.2$) were installed in Mykolaiv and Odessa. More than 3000 single station meteors detected, for 221 double station meteors orbital elements were calculated. Registered meteoroid masses are between 10^{-7} and 10^{-2} kg. Distribution of radiant, velocities and orbital elements for different ranges of magnitudes and masses are presented in the work.

WHAT CAN BE CALLED "TRACES" OF LIFE ON MARS

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The average temperature on the surface of Mars is about 200° K. Planet has very thin atmosphere and there is practically no magnetosphere around it (Vidmachenko, 2012). This is clearly not enough for reliable protection of possible life from the solar wind and ultraviolet. According to one definition, life can be represented as a self-sustaining chemical system capable to reproduce descendants that will be similar to parents and inherit their basic characteristics. In subsequent generations of descendants genetic changes must occur. These factors should ensure the variability of a given population and support systems of natural selection and survival in such constantly changing conditions.

Recently, microorganisms have been found on Earth living in an environment that is very similar to the environment in modern regions of Mars (Des Marais, 2008; Summons, 2011; Vidmachenko, 2017a). Also, very complex organic molecules with the so-called left-sided chirality were detected in the Martian soil. Namely this characteristic of organic matter indicates its metabolism. It is a rather convincing confirmation for the biological nature of these molecules and not only an unconvincing biological marker. Today, the only known life

form is protein. But such an amino-nucleic acid life cannot exist without water. For this reason, it is proposed to begin the search for life on the planet Mars with the search for water. For example, the discovery of craters on cliffs in the clay-rich Martian medium of such chemical elements as boron or manganese (Arvidson et al., 2016; Peplow, 2005) indicates their possible presence in the water below the surface. After all, these elements are vital for the major prebiotic processes occurring on Earth. It is possible that exactly the same processes may be related to the planet Mars (Summons et al., 2011). And they can create a certain potential for the development of independent life on Mars (Gasda et al., 2017). Carbon compounds can also be deposited under the influence of terrestrial cyanobacteria (Lanza et al., 2016; Liu et al., 2017). These organisms can survive in very arid deserts and even in an oxygen-free atmosphere. Therefore, it can be assumed that carbon deposits found in Martian soil in the regolith layer may be related to the metabolism of a possible Martian life, have a biological origin, contribute to the survival of aerobic life forms, form minerals and accumulate nitrogen.

During rover tests for future Martian missions, bacteria in a state of anabiosis were found in the soil of one of the driest places on Earth – in the Atacama desert. But when moisture got into them, they began to actively reproduce. There, at a depth of about 80 cm, it was possible to detect a previously unknown type of bacteria whose metabolism is based on methane; they are well adapted for life in dry and saline soils. Studies have shown that such bacteria can spend thousands years in anabiosis, in conditions that are very similar to those currently on Mars. To activate them, you must have a small amount of liquid water.

It also remains the possibility that if life on Mars once appeared, it could not disappear without a trace. For example, life could move from the surface of the planet into its subsoil, and be conserved there in relic fossils, and possibly remain in some simple forms. Therefore, the traces of such life forms can be searched for in the subterranean depths in those places where there was water in the Fillocian geological epoch during first 700 million years (Eigenbrode et al., 2018; Vidmachenko, 2016a; 2016b; 2016c; 2017b). Now traces of water erosion on Mars are quite numerous. A significant part of the details of the planet relief bears traces of the action of both the water itself and its flows (Vidmachenko, 2009b). Many images obtained with the help of orbiters (Vidmachenko, 2009a; Vidmachenko & Morozhenko, 2014) indicated that a large number of traces of groundwater outflow are on the slopes of valleys and in the craters (Schultz et al., 2014), at depths of 100-500 m below the surface. Apparently, ground ice in many regions of the planet melts at exactly such depths, and then water appears on the slopes. Over the entire length of these flows, the salinity of the subsurface water of Mars plays a significant role lowering its freezing point. It is important to keep in mind that these brines can have extreme conditions for any form of life. The source of liquid water can be melting ice below the planet surface or in the layers of permafrost.

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SIGNIFICANT AND FAST VARIATIONS OF DUST COLOR IN COMET 41P/TUTTLE-GIACOBINI-KRESÁK

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We observed Comet 41P from January 29, to May 25, 2017. Photometric observations of the comet were conducted with the V and R broadband filters centred at 5450 Å and 6460 Å, respectively. The reduction of the raw data included bias subtraction, dark and flat field corrections, and cleaning cosmic-ray tracks in the standard manner, using the IDL routines. The morning sky was exposed to provide a flat field correction for the non-uniform sensitivity of the CCD chip. The images were obtained during several observing runs at different sites: the 61-cm Telescope at the Skalnaté Pleso (AI SAS, Slovakia) and the 70 cm AZT8 (observation station Lisnyky of the Astronomical Observatory of Taras Shevchenko National University, Ukraine). We attribute the comet photocenter to the central isophote that encloses the maximum of brightness of the comet. To perform an absolute flux calibration of the comet images, the field stars were used. The stellar magnitudes of the standard stars were taken from the catalogue UCAC4. All of the nights were photometric, the seeing value measured as the average FWHM of several sample stars was from 2 to 3 arcsec during our observations. The residual sky background was estimated with the use of an annular aperture.

We monitor inner the coma in the comet 41P/Tuttle-Giacobini-Kresák searching for variations of its color because fast changes in color provide important clues for better understanding microphysical properties of its dust. Our photometric survey of comet 41P/T-G-K shows fast and dramatic variations of color in its inner coma. During only

one day, between March 3 and 4 of 2017, the color changed from blue to red. Having found such variations in a second comet suggests that such variations of color might not be an uncommon feature. Our modelling with the agglomerated debris particles suggests that the 41P/T-G-K coma consists of a mixture of at least two end-members, Mg-rich silicates and organics/Mg-Fe silicates.

We modelled the motion of Mg-rich silicate particles having radius $r = 1 \mu\text{m}$ with $\beta = 0.5$. The β parameter is a ratio of the solar-gravity force over the radiation-pressure force $\beta = F_{\text{Sun}}/F_{\text{rad}}$. The model is based on a time-domain approach of computation of dust-particle motion.

As the result, the Mg-rich silicate particles observed on March 3 should have left the inner coma (projected diameter of about 2000 km) within only 1 day if their ejection velocity either is smaller than 20 m/s or exceeds 120 m/s. It also is worth noting that in March of 2017, the 41P/T-G-K nucleus had a 25-h rotational period; whereas, the time difference between observations on March 3 and 4 was ~22.6 h. In other words, the time difference was shorter than the full-turn period of the nucleus. This could explain the absence of the Mg-rich silicate particles in the innermost coma on March 4.

GRAVITATIONAL EFFECTS IN SATURN'S RINGS: POSSIBLE PHYSICAL MODEL

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In this work we consider different interaction in gravitational systems consisting of Saturn, its satellites and rings. Availability of such processes leads to several sculpting of rings and changing its structure. In consequence of not trivial gravitational interaction, various perturbations are observed on the edge of rings. We use methods of celestial mechanics to describe a system containing the planet, two satellites and the ring placed between them. In such system, gravitational forces lead to running waves that deform the ring. These effects are peculiar to Saturn's F ring. The description of this perturbation needs more difficult physical model because of these effects aren't weak. Therefore, we employ methods of nonlinear physics to build the model.

SIMULATION OF THE ORBITING SPACECRAFT TO UNDERSTAND THEIR ROTATION BASED ON PHOTOMETRY

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Analysis of the photometric information allows to determine the parameters of rotation of the spacecraft. By analyzing the observed light curves of the inactive satellites

Topex/Poseidon and Sich-2, it is demonstrated how the orientation of these objects in space is determined. To interpret the information contained in the light curves, we created optical-geometrical models of these satellites and simulated optical-geometrical conditions for its passage in orbit. Further comparison of the model and observed light curves allows us to confirm the correctness of the satellite attitude determination. For the simulation, we used the MaxScript programming language, which allows us to create a satellite model, and simulate the optical-geometric conditions of its passage in orbit, including the complex rotation parameters of the spacecraft.

USING OF ULTRAVIOLET POLARIMETRY IN THE STUDY OF EARTH'S UPPER ATMOSPHERE

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Ultraviolet (UV) radiation has a significant effect on the Earth's biosphere. Therefore, it is important to assess and predict its effect on changes in atmospheric factors near the earth's surface. The passage of UV radiation to the Earth is regulated by aerosol and gas components of the atmosphere (Nevodovskiy et al., 2018a). Some gas-aerosol components have absorption bands in the UV spectrum. And their concentrations vary considerably. For example, in the stratosphere, the ozone layer is predominantly destroyed. And in the troposphere its content increases due to pollution with nitrogen oxides, etc. (Morozhenko et al., 2000). Pollutants are present mainly near sources of anthropogenic pollution or are formed during natural disasters (large-scale forest fires, volcanic eruptions, etc.) (Lacis et al., 1992).

The complex refractive index is one of the most important parameters determining the scattering and absorbing properties of atmospheric aerosol, and the value of its seasonal variations provides additional information about the qualitative transformation of particle properties and their quantitative change over time. To evaluate it, use polarization measurement data. Examples of such works are the space missions PARASOL with a polarimeter POLDER (Deschamps et al., 1994) and GLORI with a polarimeter APS (Mishchenko et al., 2004). When conducting such studies, problems arise related to the optical inhomogeneity of the dynamical system "stratosphere + troposphere + surface". In addition, the mission equipment is designed for observations in visible and infrared spectral wavelength ranges. Therefore, the degree of polarization of light gives a summary of the entire system, from which it is difficult to obtain reliable data only about the atmosphere (Morozhenko et al., 2013).

But at satellite observations of the Earth's upper atmosphere at UV wavelengths ($\lambda < 300$ nm), the strongly absorbing ozone layer completely cuts off the influence of the surface and troposphere. With this method of measurement, the properties of the reflected radiation are formed only in an optically

thin stratospheric medium. Therefore, the values of the second Stokes parameter $Q(\alpha)$, the analysis of which is based on the study of the physical properties of an aerosol, can be obtained from the expression $Q(\alpha) = P(\alpha) \cdot A(\alpha)$, where $P(\alpha)$ is the phase dependence of the degree of polarization, $A(\alpha)$ is the albedo phase dependence (Morozhenko et al., 2014; Nevodovskiy et al., 2019b). But even in this case, when setting up space experiments to obtain information on the phase dependence of $P(\alpha)$ and $A(\alpha)$ for stratospheric aerosol, it is necessary to use satellite clusters and perform polarization scanning in the plane parallel to the equator in the UV range at $\lambda < 300$ nm. This makes it possible, as mentioned above, to correctly determine the physical characteristics of the stratospheric aerosol (Morozhenko et al., 2013; 2014), and judge the causes of possible changes at different parts of the globe.

Using the existing prototype of a small-sized UV polarimeter created by us, we have shown the possibility of using ground-based observations to determine the physical parameters of stratospheric aerosols and their effect on the Earth's climate (Nevodovskiy et al., 2016; Nevodovskiy et al., 2015; 2018a; 2018b; 2019a).

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SPECTROPHOTOMETRIC RESEARCH OF COMET 46P/WIRTANEN IN OPTICAL RANGE

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We obtained the optical spectra of comet 46P/Wirtanen in 2008 and 2019 years. The spectra with an average resolution $\lambda/\Delta\lambda \approx 1300$ were obtained on the mountain observatory «Peak Terskol» (MPC code B18) with the help of the reflecting telescope Zeiss-2000 ($D = 2.0$ m; $F_2 = 16$ m). The identification of the spectral emission lines and bands of molecules CN, C₂, C₃, NH₂ and other has been carried out. Some physical parameters of neutral gaseous and dust cometary atmospheres were calculated with the help of Haser model. The distributions of general and reflected energy in spectra

have been built. The spectrophotometric gradient on the basis of the reflected energy is found. The results that were obtained in 2008 and 2019 have been analysed and compared.

ACCELERATION OF HIERARCHICAL DUST AGGLOMERATES NEAR COMET 67P/CHURYUMOV-GERASIMENKO

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Cometary dust grains are usually extremely porous particles as recent observation from the Rosetta mission revealed. In our work we present a model of the hierarchical porous cometary dust particles. The particles are constructed with small spherical monomers with size 100 nm. The main strengths of our approach are that we can simulate very large (mm-scale) agglomerates and can determine their effective cross-section and light scattering properties. The hierarchical method of creation of the dust particles also seems very probable in the early Solar system. We apply our model to the dynamics of dust in the vicinity of the nucleus of comet 67P/Churyumov-Gerasimenko. We consider a non-constant gas velocity, solar radiation pressure, comet gravity in the motion simulation. A solar radiation pressure calculated based on the Mie theory but electric permittivity of the porous agglomerates were found with the effective medium theory approximation. Our numerical simulations can reproduce the GIADA measurements of dust speeds. The calculated trajectory of the porous particles can help us to simulate photometric picture of the coma.

ANALYSIS OF NEAR-EARTH RESIDENT SPACE OBJECTS VISIBILITY CONDITIONS FROM OPTICAL GROUND STATIONS

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The continuous monitoring of space object positions in near-Earth space is necessary for tasks of:

- the collision prevention of an active satellite with other satellites or space debris objects;
- the cleaning Near-Earth space from inactive satellites and space debris;
- the planning of new satellite launches.

The optical ground stations are used to solve the problems of space situational awareness in Ukraine now due to their versatility and moderate cost compared to the radar systems. The new optical ground stations deployment outside Ukrainian territory are discussed at the same time. The telescopes can perform observation of the resident space object

only if the object is in direct view of the observation equipment, it is illuminated by Sun and observation station isn't illuminated by Sun. These demands make the observation of all objects in near-Earth space from one optical ground station impossible. In this work, the satellite visibility characteristics from ground station depending on its latitude are analyzed. And the optimal location of optical ground stations to solve problem continuous observation all near-Earth resident space objects are discussed.

SEASONAL CHANGES IN JUPITER'S ATMOSPHERE RESTORED THEIR PERIODICITY

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In (Vidmachenko, 1985), we showed that the reflective properties of clouds and of cloudless haze of Jupiter are more strongly influenced by variations of the jovimagnetic φ_m latitude. The sunflower point on its magnetosphere during the Jovian year, changes by more than 26° , showing seasonal changes (Vidmachenko, 1997; Vidmachenko et al., 1984). The presence of an eccentricity of the orbit ($e \approx 0.048$) leads to the fact that the influx of energy to the atmosphere in the northern hemisphere is 21% greater due to the fact that at the time of the summer solstice the planet is in perihelion. This causes asymmetry in the meridional distribution of the reflective characteristics of clouds [Klimenko et al., 1980; Vidmachenko et al., 1980]. The reason for this may be variations in albedo, the composition of aerosols in clouds and haze, temperature, etc. over different time scales. In (Focas & Banos, 1964; Sorokina, 1973) indicated the existence of cycles in the change in the brightness of the planet with periods of 3-25 years. To search for possible periodicities in (Vidmachenko, 1999), we used the estimates of the magnitude of Jupiter's entire M_J , obtained in 1835-1997. For about 300 individual estimates of the brightness of Jupiter in the "V" filter, we obtained that their changes have maxima for even and minima for odd cycles of solar activity (SA). We applied our program for spectral analysis using the entropy maximum method (Vidmachenko, 1994) to the $M_J(T)$ data series. This made it possible to detect in their change the manifestation of the orbital period with a value of ≈ 11.87 years, a double orbital period with a value of ≈ 23.9 years, SA periods of 22.1 and 11.1 years.

To search for seasonal changes on Jupiter, we used observational data from (Focas, 1971; Prinz, 1971; Sanchez-Lavega & Rodrigo, 1985; Vidmachenko, 2016b), supplemented them with observational data obtained in 1979-2019, and observations of astronomy enthusiasts with small telescopes (<http://kardasis.weebly.com/> – Manos Kardasis). We digitized ≈ 390 images of the planet taken in 1960-2019 in visible light, constructed photometric distributions along the central meridian, normalized them to the brightness of the lightest area (I/I_{max}), and then calculated the ratios of the brightness of the northern and southern temperate and tropical regions of $A_J = B_N/B_S$, which is a peculiar factor in the activity of different atmospheric processes on Jupiter. Our calculations using the least squares method made it possible to determine the sinusoid period with a value of $\sim 11.87 \pm 0.05$ Earth years, and this value is equal to the period of Jupiter's advancement around the Sun. It turned out that the minimal values of the brightness ratio $A_J(T)$ were in 1961.0, 1972.9, 1984.8, 1996.6 and 2008.4, the maximal – in

1967.1, 1979.0, 1990.9, 2002.7 and 2014.6. Motions in the planetary atmosphere can be synchronized under the influence of energetically small but regular external processes (Focas, 1971). For example, variations in solar irradiation affect the dynamics, kinematics and structure of visible clouds (Vidmachenko, 2016a), and this leads to the appearance and destruction of periodic components with different values in the change in the brightness of the planet, of the albedo of individual parts and areas on the disk. It turned out that the values of the atmospheric activity factor of Jupiter A_J do not always change symmetrically with respect to the value $A_J = 1$. The course of change A_J in 1960-1995. agrees well with the periodic curve with a period of 11.87 years. In 1995-2012. symmetry was broken, and from 2012 the periodicity in the change in $A_J(T)$ began to recover. That is, in 1960-1995 and 2012-2019. between the course of the $A_J(T)$ change, variations of the SA and the moments of passage of the planet perihelion and aphelion of the orbit (taking into account the shift between these dependencies), the correlation was better than 80%, and the above changes were synchronized. From 1995 to 2012 there was an "imbalance" in the frequency of changes of these parameters. But after 2012, changes in the magnitude of the energy inflow from the Sun to different hemispheres of Jupiter due to variations of the SA and the elongation of the orbit became synchronized again.

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FAMILIES WITHIN JUPITER TROJANS AND THEIR CONTRIBUTION TO THE OVERALL CHARACTERISTICS OF THE SWARMS

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In our previous works we searched for the asymmetries between the L4 and L5 swarms of Jupiter Trojans in physical and dynamical properties (periods, lightcurve amplitudes, albedos, diameters, orbital elements). We made an assumption that the most obvious asymmetry – the asymmetry within the distributions of inclinations – may be caused by the presence of the large number of asteroids smaller than 20 km. Such small bodies are products of the collisional processes. Together with the fact that they have narrow range of orbital inclinations values, it indicates that these asteroids could be the part of some family.

Calculation of the proper orbital elements of Trojans was complicated due to the resonant nature of this population. It was one of the main reasons why number of distinguished families differed from paper to paper (from several to tens). We aimed to check with the V-shape criterion some of the families and to evaluate their contribution to the asymmetry.

APPLICATION OF THE PHASE RATIO METHOD FOR THE IDENTIFICATION OF AREAS ON THE CERES SURFACE WITH ANOMALOUS ROUGHNESS USING DAWN FRAMING CAMERA IMAGES

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Since 2015 the NASA Dawn spacecraft has been exploring geology of Ceres, the largest body in the Main asteroid belt [1]. The onboard Framing Camera was equipped with a clear filter and seven color filters in the wavelength range from 0.4 to 1.0 μm [2]. During the mission to Ceres a large volume of data at different illumination/observation geometries have been obtained with high spatial resolution. In total more than 100 000 images were obtained and about 50% of them were acquired on the High-Altitude Mapping Orbit (HAMO) and Low-Altitude Mapping Orbit (LAMO). The amount of obtained space data allows us to start a detailed investigation of the Ceres' regolith properties and to use methods that were successfully applied for the lunar surface. The slope of the phase function $f(a)$ of a regolith-like surface strongly depends on its albedo and texture. The contribution of albedo variations over the surface can be significantly suppressed when the phase ratio $f(a1)/f(a2)$, i.e. the ratio of two images of the same region acquired at different phase angles is considered. The resulting phase-ratio image contains information mainly on the structural properties of the regolith. Reliability of this method has been proved by the detections of photometric anomalies related to changes in structure of lunar surface layer in the spacecraft landing sites [5]. In order to obtain the distribution of the color- and phase-ratio images we used already calibrated, spatially combined, absolutized, photometrically normalized albedo images. Only after all this conversions it is possible to consider that the received images of color-ratio and steepness of the phase function distribution reflect real characteristics of the surface. For our purposes we used a set of calibrated Dawn FC2 images acquired during the HAMO and LAMO phases of the mission from the Planetary Data System (PDS) archive [3]. The main selection criteria of image pairs were the following: (1) difference between the phase angles should be more than 20 deg; (2) close values of the solar azimuth; (3) the same spatial resolution of the images. Analysis of phase-ratio distribution reveal lower values (i.e. steeper phase curve) for several small craters in the floor of Occator but higher values (more flat phase curve) for the Cerealia Facula in the center of Occator. Following to studies of lunar regolith [4,5] we interpret features with steep phase curves as produced by material with microstructure of higher optical roughness. Vice versa flat phase curve correspond to smooth microstructure of upper regolith layer. We note bluish color (lower C(749/438 nm) values) for the small craters with steep phase curve and higher red slope for the Cerealia Facula of flat phase curve. We consider the regolith with higher optical roughness in the small crater of bluish color as less mature material which has been not subjected to space weathering. The phase ratio method, which is well-known in studies of the lunar surface has been tested on the Dawn FC images of Ceres. Applying the phase-ratio method for two regions on Ceres (Ahuna Mons and Occator crater) we found out that bright spots in Occator

and Ahuna flanks differ from their surroundings not only in spectra, but also in the steepness of the phase function.

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WAYS OF HUMAN SURVIVAL ON THE MOON

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The temperature of the lunar surface varies from -173°C to $+117^{\circ}\text{C}$ at the equator, and in the shaded depressions of the Polar Regions, its value decreases to -223°C (Morozhenko & Vid'machenko, 2002; Vidmachenko, 2009; 2012; 2014). Therefore, on the Moon man needs to protect himself from radiation and such an extreme temperature. To this end, arriving on the Moon, after a very short stay on the surface, astronauts must go to shelters with powerful walls, or hide under the surface (Burlak et al., 2010; Choliy et al., 2017; Morozhenko & Vidmachenko, 2004; Steklov et al., 2017). To this end, special technologies should be developed for the rapid construction of premises under the surface and their heating systems. Solving the task of Steklov V.A. for the thermal conductivity of a semi-infinite rod with the above temperature difference in the equatorial part of the lunar surface, we found that the temperature below the surface at depths of 1.5-20 m is guaranteed to be constant. Consequently, it is there that space settlements must be built; and necessary to provide them with water, air, and special spacesuits for astronauts for habitations and for extracting resources (Morozhenko & Vidmachenko, 2017; Shkuratov et al., 2003; 2017; Vidmachenko, 2016; 2018; Vid'Machenko & Morozhenko, 2004; 2005; 2014). Therefore, it is first necessary to send special construction robots to the Moon, and/or specialized construction 3-D printers. On the surface of the satellite at the disposal of the builders will be solar energy and sufficient supplies of necessary materials. However, acceptable conditions for work can be there only in the morning and in the evening. And on a hot day and a cold night – performers should be buried in the ground, or install special protective systems, or install special protective systems. It is also necessary to develop a method of accumulating solar heat during the lunar day (up to 14 Earth days), a method of its transfer to the subsurface space and save there. In a simplified version, the specialists of the European Space Agency suggest using reflectors to focus the sun's rays on a small area of the surface. During the night period, the devices are proposed to be located at such a “hot spot” and, receiving heat from the heated soil, to maintain their operability. A more complex option for habitable modules should consist, for example, of a system of mirrors, prisms, heat pipes filled with coolant and underground systems that accumulate heat. Such a complex should collect heat during the lunar day, use it to operate the mechanisms and to maintain a comfortable temperature in the living quarters and to heat

the colonies. For the collection and transfer of solar energy to the subsurface premises, we suggest using periscope prism – mirror installations specially raised in the morning (Steklov et al. 2019; Steklov & Vidmachenko, 2019). Such installations will be able to work the entire lunar day, tracking the movement of the Sun across the sky and transferring heat flux to special storage systems located under the surface of the Moon. With the onset of the evening retractable parts should be hidden in the subsurface mines and close them “at night” with powerful flaps. After 15 Earth days – the periscope can again be brought to the working position.

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METHODS OF HEATING AREAS WHERE A PERSON LIVES BELOW THE SURFACE OF THE MOON

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On 1 m^2 of the surface of the Moon from the Sun enters over 1.3 kW. In the daytime, energy must be taken (Morozhenko & Vidmachenko, 2004; Shkuratov et al., 2003; 2017; Vidmachenko & Morozhenko, 2014), transformed, transported under the surface, accumulated there (Steklov & Vidmachenko, 2019; Vid'Machenko & Morozhenko, 2014) and used for everyday needs and heating of housing (Steklov et al., 2019). The thermal energy brought by the visible and near infrared radiation from the sun is collected by solar collectors (solar power plants), producing heating of the coolant material. For the transfer of thermal energy is used placed in the “pipe” coolants. They may be solid, liquid or gaseous. In practice, glycerin, petroleum oils, metal melts (Sn, Pb, Na, K), freons, nitrogen, etc. are used. The outer part of the solar heat pipe in the form of a thermos is transparent, and a highly selective coating that absorbs solar energy is applied to its interior (absorber). To increase the efficiency, the absorber is coated with black paint or with a special selective coating (black nickel, titanium oxide spraying) and it combined with a heat-conducting system.

Between the outer and inner parts of the transparent tube is a vacuum layer, making it possible to save up to 95% of thermal energy. In closed heat pipes, when the vacuum collectors are irradiated by sunlight, the heat carrier is heated at the hot end, turns into steam and moves under surface to the

opposite end. There, the heat is given to the collector, the steam is condensed, and in liquid form it is returned back to the absorber located on the lunar surface. The heated coolant, circulating through the collector, transfers thermal energy to the storage tank, where hot coolant accumulates.

In the absence of heat intake, flat collectors are able to heat the fluid to 190-210°C. Using special multilayer optical coatings that do not emit heat in the infrared spectrum under absorbing elements and introducing concentrators in the form of parabolic-cylindrical reflectors into solar collectors, it is possible to increase the temperature of the coolant to 250-300 °C. Getting higher operating temperatures – up to 500°C – is achieved by controlling the heliostats in two coordinates, or using parabolic-cylindrical mirror concentrators with a heat carrier disposed in the pipe at the focus of the parabola. Such systems can be composite with a length of up to several tens of meters and a height of up to 2-3 m. Mirrors should be oriented along the meridian of our satellite, and be arranged in rows after a few meters.

On a special bracket, in the focus of the reflector, it is also possible to fix the Stirling engine, which has an efficiency better than 30%. It is a heat engine based on periodic heating and cooling of the working fluid, with the ability to extract energy from the pressure change that occurs during this time. As a working fluid in a Stirling engine, hydrogen is usually used, or helium. Solar collectors only work during daytime. Therefore, in order to preserve heat in heat supply systems, it is necessary to have special devices that are able to accumulate and then deliver it as needed. Such systems are called *heat accumulators*. Heat can accumulate in a material with high heat capacity (magnesite, cast iron, high-strength brick, eutectic mixtures of alkali metal salts, crystalline hydrates of inorganic salts, etc.) In addition, heat accumulators can be storage tanks under the surface of hot liquids, which covered with material with high thermal insulation properties of the type of thermos. Inside of them must be non-freezing antifreeze and various heating elements for heating this fluid (boiler, electric heating element, energy from the Sun). For efficient operation, the volume of the heat accumulator must be large enough to accumulate the necessary amount of thermal energy. In general, the buffer tank increases the inertia of the heating system.

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MATHEMATICAL MODEL AND METHOD OF OPTIMAL PLACEMENT OF OPTICAL-ELECTRONIC SYSTEMS FOR TRAJECTORY MEASUREMENTS OF AIR OBJECTS AT TEST SITES

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To study the dynamic properties of the new generation of airplanes, helicopters, unmanned aerial vehicles, rocket and artillery weapons and ammunition at test sites (polygons) use mobile laser optical-electronic stations of the trajectory of

measurement (LOETMS). Each LOETMS provides the detection of test air objects in the visible and infrared spectral ranges, their high-precision tracking, measurement and delivery of the parameters of the coordinates of the movement of air objects in real time. In order to eliminate systematic and suppress random errors of trajectory measurements, LOETMSs are integrated into a unified polygon information-measuring system (UPIMS). Since the cost of each LOETMS is high enough, when constructing the UPIMS, the problem arises of choosing the minimum number of LOETMSs and their location along the test tracks of the polygon so that the dispersion of estimates of the parameters of the coordinates of the movement of air objects is minimal or at least less than or equal to a given threshold. The report provides a mathematical formulation and solution of the two-criterion problem of optimal placement of LOETMS on the territory of the polygon. The main attention is paid to the mathematical formulation and the method of solving the problem of metrological certification of the UPIMS for a fixed number and location of LOETMSs along the test tracks of the polygon. It is shown that the solution of the UPIMS metrological certification problem is reduced to linearizing the non-linear function of random arguments (model of the trajectory of air objects) and calculating the dispersions of dependent variables (parameters of motion coordinates) from known dispersions of independent variables. The results of solving the problems of optimal placement of LOETMSs on the territory of the polygon and metrological certification of UPIMS are given. The studies are relevant not only for field testing of aircraft, but also of scientific and practical interest in the construction of monitoring systems for airspace in the visible and infrared spectral ranges and the study of the trajectories of objects of artificial and natural origin in the Earth's atmosphere.

A STRUVE GEODETIC POINT FROM MOLDOVA – ON THE UNESCO WORLD HERITAGE LIST

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In antiquity, it was believed that the Earth had a spherical shape. This opinion was shared by Eudoxus of Cnidus (408–355 b.Cr.). The earliest known measurements of the Earth's size were made by Eratosthenes of Cyrene (276–194 b.Cr.). Newton (1643–1727) demonstrated for the first time that the Earth has the form of an ellipsoid. In the first half of the 19th century several attempts were taken to measure the terrestrial meridian to determine the exact shape and size of the Earth. The most precise measurements of the meridian were carried out by the Russian astronomer of German origin Friedrich Georg Wilhelm Struve (1793-1864), the first director of the Pulkovo Observatory (St. Petersburg, Russia), who built a meridian arch between the Arctic Ocean and the Black Sea on a distance of 2820 km. This Meridian Arch, completed in 1855, consisted of 258 adjacent geodetic triangles (polygons), located along the 25°Est meridian and 265 triangulation (geodetic) points of reference, between Hammerfest in Norway and Staro-Nekrassowka in Ukraine. The arch, later called the Struve Geodetic Arch, crosses 10 countries (Norway, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Belarus, Ukraine and Moldova). The Struve Geodetic Arch allowed the first exact measurement of a long segment of meridian, which contributed to the precise determination of the circumference and

the the shape of the Earth. Currently, the Arch includes only 34 of the initial geodetic points, established by Struve, including a geodetic point in Moldova – the Rudi geodetic point with the coordinates: 48°19′05" N and 27°52′35" E. By decision of the UNESCO World Heritage Committee of 15 July 2005, the 34 geodetic points of the Struve Geodetic Arch, including the Rudi station point in Moldova, were included in the UNESCO World Heritage List.

ROTATION PERIODS OF V-TYPE ASTEROIDS OUTSIDE THE VESTA FAMILY

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Recent studies have considered the presence of V-type asteroids other than those related to asteroid (4) Vesta in the inner Main Belt. To identify these bodies, both physical and dynamical characteristics of V-types in the inner Main Belt have to be determined.

Our main goal is to determine the rotational periods of a large sample of V-type asteroids outside the dynamical Vesta family. We focus on different sub-populations of V-types and compare distributions of their rotational frequencies with that of the Vesta family.

We perform photometric observations and use the standard Fourier analysis to determine rotational periods of selected asteroids. We supplement these with periods from the literature and produce frequency distributions. We compare the periods with the Vesta family rotational frequency distribution and fit a Maxwellian distribution.

We estimated rotational periods for 19 asteroids outside the Vesta family. We supplement these with periods from literature, leading to a total of 606 asteroids in our sample, with 114 outside the Vesta family. All the distributions vary substantially from a Maxwellian shape. Fugitives and low-inclination V-types show a significant surplus of fast rotators as compared to the Vesta family.

The V-types outside the Vesta family have been influenced by the YORP effect. This is not surprising, given that most of these objects are smaller than 40 km in diameter, thus, in the size range for which YORP is expected to have a large effect.

REMOVAL OF TOPOGRAPHY EFFECT FROM PHOTOMETRIC LROC NAC DATA USING METHODS OF SPACE CARTOGRAPHY

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Introduction: The phase-ratio technique is an effective tool for characterization of lunar surface structure unresolved in images [1-3]. A phase-ratio image shows a distribution of slopes

of phase curves over the studied area and can be used, e.g., for studying lunar surface evolution [2,4] or for searching for areas on the Moon with anomalous photometric characteristics [5]. False variations of phase ratio caused by local slopes of a surface relief can exceed the variations caused by the surface structure. For high resolution data (0.5 m/pixel) of the LRO Narrow Angle Camera (NAC), the problem of accounting for the topography effects is forced by the absence of a Digital Elevation Map (DEM) with a resolution of LRO NAC data sufficient to resolve features such as small craters, scarps, hills, etc. We propose a novel technique for removal of the relief effect on phase-ratio distributions using LROC NAC images.

The algorithm: *Step #1. Transformation of initial NAC images to the cylindrical equirectangular projection.* We use our Library of Planetary Cartography (LPC) [6] and SLDEM2015 [7] as an initial (base) elevation map for this.

Step #2. Calculation of local parallax shifts is performed using the robust correlation algorithm developed by us.

Step #3. Calculation of the DEM is carried out from an analysis of the parallax-shift maps. For each point of the surface, using the LPC [7], we fit the altitude (declination from mean altitude from Step #1), which provides the parallax shifts coinciding with the ones obtained in the Step #2. Obtained DEM is used for orthorectification of NAC images and is an additional independent source of information about topography of studied area.

Step #4. Compensation of influence of local slopes on photometric data is performed by using the equigonal albedo A_{eq} instead of the apparent albedo A . A_{eq} is calculated using the semi-empirical Akimov's disk function [2], photometric coordinates [2] in which are calculated with taking into account local topography slopes using the LPC [6]. Note, that map of longitudinal components of slopes is calculated not from our DEM (Step #3), but from a ratio of 2 NAC images obtained at opposite direction of illumination and close phase angles. This provides better compensation of high-frequency details of relief.

Results: We applied this technique to phase-ratio images of fresh lunar crater formed on September 11, 2013 [8] and another new crater formed on March 17, 2013 [8]. Our processing allowed to almost completely remove false variations of phase ratio caused by local slopes. The symmetric pattern of ejecta blanket of these fresh craters could be interpreted as the absence of optical roughness changes in the neighborhood of the old craters due to possible accumulation of near-ejecta material. The result pattern is free of artifacts and largely corresponds to real optical roughness [8].

Conclusion: We propose a method of removal of the topographic influence on LROC NAC photometric images. The method also provides additional high-quality information about topography of studied areas. This technique can be very useful for improvement of the quality of remote-sensing methods for surfaces with complex topography.

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POSSIBLE LIFE FORMS ON THE “YOUNG” EARTH AND MARS

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At the end of 2016, in Canada, traces of vital activity of the most ancient bacteria on Earth were found. They testified that life on our planet was present in rocks, having an age of about 4.3 billion years. Based on the age of our planet we can conclude that the primary life could be present on Earth during first 200 million years of its existence (Vidmachenko, 2016b; 2017b). Also now there are numerous proofs that the water on Mars was in the first Phyllocian Era (Vidmachenko, 2016a; 2016c). Exactly then Mars was similar to the ancient Earth, had a dense atmosphere with a pressure of up to 0.4 bar, an ocean of liquid water on the surface, and there was much warmer than it is now (Vidmachenko, 2017c). Therefore, in the young age of Mars and Earth their climatic conditions could be very similar. Based on these facts, we can conclude that if the simplest life existed on Earth in those years, then it is quite possible to assume that a similar simplest life forms on Mars could originate in its water basin or be brought from outside. Therefore, studying Mars considerable attention should be paid to those places where such simplest life forms could survive or be preserved at least (Morozhenko & Vidmachenko, 2017; Vidmachenko, 2009a).

At present it is clear that among Solar System planets only on Mars there are physical conditions (Vidmachenko, 2012; Vidmachenko & Morozhenko, 2014a) at least minimally suitable for the possible existence of some terrestrial life forms. Therefore, we can make assumptions about the nature of Martian life considering rather strange biological environments on planet Earth. Water is necessary for occurrence and maintenance of life there. The only known form of protein life cannot exist without presence of water (Vidmachenko, 2009b). But life on Earth has repeatedly demonstrated the ability to adapt to a very toxic environment. For example, there are microbes that develop in acid mines and lakes with arsenic. Also were registered arctic microbes that have been able to adapt to high levels of mercury contamination, and even some bacterial enzymes that can destroy perchlorates. But perchlorates are highly corrosive compounds (Hecht et al., 2009). They are toxic to most terrestrial organisms. A wide spectrum of salt-loving (so-called halophilic) and cold-loving (psychrophilic) microbes has also been discovered on Earth. And at the beginning of the 21st century hybrids of the above mentioned species were found (psychrohalophilic). They survive and develop in saline Antarctic lakes at temperatures below -10°C and salt concentration of about 20%. Most of the water on nearby Mars now also exists in the form of ice (Vidmachenko & Morozhenko, 2014b). Such a similarity between Antarctica and Mars fully suggests that water ice can be a satisfactory place to hide the microbial life that exists now or once existed on Mars. After all, on our planet we managed to find such microorganisms that live in an environment very similar to the environment in some regions of Mars. Such an adaptation of microorganisms that exist on Earth indicates a possible strategy for the development of Martian life forms.

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ABOUT SEVERAL WAYS TO RECOGNIZE BIOSIGNATURES OF METABOLIC ACTIVITY OF MARS

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Some object, a certain structure of a substance or a process, the origin of which requires the obligatory presence of a biological agent, is called biosignature (Des Marais, 2008). And some function that can only potentially have a biological origin and, thus, forces researchers to collect as much actual data as possible before determining the presence or absence of a possible life there, was called a potential biosignature. Therefore, those bio-signatures that may indicate possible life in the past should also be identified among the problems associated with the search for once-existing life (Vidmachenko, 2016a; 2016b; 2016c; 2017b). And if, over time, it is possible to confirm that the origin of a certain biosignature is geologically new, this fact may well indicate that some forms of life may exist somewhere even now. Or to the fact that this biosignature could be created additionally at the site of some sample in a geologically newly formed environment, in which some time ago conditions were more suitable for life forms than its current state. We also point out that it is biological activity that significantly expanded the set of terrestrial minerals known until recently (Hazen et al., 2008). This situation indicates the need to look for possible mineral deposits in places that are particularly conducive to the preservation of possible biological signals (Vidmachenko & Morozhenko, 2005). The minerals of this type include, for example, phyllosilicates, phosphates, sulfates and carbonates (Summons et al., 2011), as well as methane gas (Krasnopolsky et al., 2004). To search for physical evidence of possible metabolic activity, both the surface of the indicated minerals and their interior must be accessible. You should also not forget that the cells of microbes have a unique shape and relatively small size.

For the protein life form known to us, a kind of chemical framework consists of carbon organic compounds. They are relatively easy to identify when measuring the molecular structure and determining the appropriate molecular weight composition. However, such measurements should be able to register fairly small amounts of them, as well as allow for confidently registering the differences between possible terrestrial “pollutants” and various components that are unique to Martian soil (Vidmachenko & Morozhenko, 2014b). Such instrumental measurements should allow you to confidently find rocks and mineral structures that are similar to the fossils of biological objects, and confidently distinguish them. But at the same time, the results should be incompatible with chemical and other non-biological processes.

For example, the presence of manganese in Martian soil may indicate that this planet once had the conditions for significant oxidation in the aquatic environment (Vidmachenko,

2009b). Note that under terrestrial conditions, such a medium is almost always populated by microbes (Crerar, 1981). Therefore, the close connection between manganese, boron and life on Earth makes the rocks with the presence of these elements in them – the high priority goal of future space missions that will search for such materials [Vidmachenko, 2009a; 2017a; Vidmachenko & Morozhenko, 2014a), which will contain potential biosignatures. For the preservation of possible biological signals, the most preferred are such samples that will be susceptible to oxidation, heat and radiation.

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LONG-PERIOD CHANGES IN THE PROPER ROTATION OF NEAR-POLE SPACE OBJECTS, THEIR CAUSES

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The free rotation of a space object, natural or artificial, constantly seeks to resonate with all the disturbances affecting its rotation. And if in the case of bodies of natural origin there is lot of experimental evidence of such behavior, then for artificial space objects such data are practically absent. But the tendency to synchronize the rotation of artificial celestial bodies should exist, as is the case with natural space objects according to the objective law of nature.

The first results, revealing the nature of the own rotation of uncontrolled artificial satellites, appeared with the beginning of their photometric observations. But the rotation of the satellites, depending on the height of their flight, is simultaneously affected by a number of disturbing moments. This significantly distorts the holistic picture of the interaction and the influence of such disturbances on the rotation of each individual object.

The Laboratory of space researches of the Uzhgorod National University has been analyzing the rotation of destabilized satellites for a long time. This paper presents the results of studies of long-period (timescale more than a year) changes in the rotation of the objects of the "Midas" series located at altitudes of 3600-3750 km. with different inclination of the orbit (*i*). Such a height excludes the influence of the aerodynamic disturbing moment from the side of the Earth's atmosphere on the rotation of the satellite. The shape of the objects is a cylinder-cone with a length of 9.14 meters and a diameter of 1.52 meters. Each of them has two solar panels (SP) of a ribbed

form with an average length of about 4 meters and a different mass. Some differences in the flight altitude of the satellites, their mass (*m*) and the effective area of the SP (*S*) led to different periods of their orbital (P_{orb}) and own (P_o) rotation after destabilization. But all objects for almost 44 years maintain a constant value of long-period changes in their own rotation (P_L) and amplitudes (ΔA), namely: "Midas-3" – 477 days, "Midas-4" – 466 days, "Midas-7" – 346 days. Accordingly, the amplitudes of changes in Midas-3 – 8 sec., Midas-4 – 4 sec. Midas-7 – 22 sec.

As a result of conducted comprehensive studies, it was established that the cause of such long-period changes in the own rotation of these satellites is the mutual influence on them of the gravitational fields of the Earth, Moon and Sun. The experimental results are confirmed by theoretical calculations in the framework of the 3-body problem.

A model of mutual influence on the rotation of these satellites of the gravitational fields of the Earth, Moon and Sun was constructed. The magnitude of such an effect on their rotation is of the order of 10^{-6} N · m.

Keywords: satellites, photometrical observations, period, disturbances

BASICS OF IDENTIFICATION PROCESS IN CASE OF SPACECRAFT WITHOUT CONNECTION

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In the conditions of a sharp increase of spacecraft number, which have been launched into near-Earth orbits, their observation is becoming more and more relevant. The task of spacecraft identification is solved on the basis of an integrated approach, using data of positional, photometric, colorimetric and, if possible, polarization observations. The latest technical specifications are still being developed.

On the basis of the analysis of photometric observations of spacecraft it is possible to solve a wide range of problems: to study their orbital behavior and change of spatial orientation, signs of accidents, and to establish optical characteristics of their surfaces, to evaluate the probable geometric shape, identify spacecrafts.

Positional observations allow us to determine the spatial position of the spacecraft at the moments of their photometric observations, which are carried out in order to identify their intended purpose, probable configurations, current orientation and stabilization, optical characteristics of the surface details. On the basis of such complex data identification of the investigated spacecraft is conducted.

The accumulated experience shows that based on the laws of the Lambertian scattering and the well-chosen set of simple stereometric forms, it is possible to identify unknown space objects in up to 85% of cases and achieve acceptable results, even in the case of a spacecraft with complex form.

The authors at the current time have developed nine criteria for successfully identifying of space objects. The completion of these criteria continues. The results obtained suggest that the way we have chosen for the solution of this problem has a prospect.

Hence, the number of tried-and-tested criteria for spacecraft identification, and the sequence of their definition, can be represented as follows:

1. Form and orientation in the space of the spacecraft orbit.
2. The value of the periods of own and the precessional rotation of spacecraft and the relation between them.
3. Orientation of spacecraft and its change over time.
4. Shape of the spacecraft.
5. Existence in reflected from object light of mirror and diffuse components, and their interrelation.
6. Character of the light scattering by the surface of the spacecraft indicatrix.
7. Color-index values of satellite surface fragments.
8. Dependence of the degree of light polarization from the angle of its fall on the surface of the spacecraft.
9. Light curve modeling. This is the main criterion, which confirms the degree of probability of identification of the investigated spacecraft.

Determining any of the specified identification criteria is a solution of a particular complex task. In the case of determining the maximum number of criteria, the reliability of the results greatly increases. Therefore, the solution of the problem of spacecraft identification on the basis of its complex observations is possible only with the maximum use of the above criteria.

Keywords: satellites, photometrical observations, identification, methods.

OBSERVATIONS OF BOLIDES IN THE SKY OVER KIEV

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After a relatively short-term bright flash, dust particles and remnants of high-temperature plasma are mainly found in the bolide wake. Therefore, during the day and at dusk, the trail is illuminated by the rays of the Sun, and is clearly visible against the sky (Churyumov et al, 2014: 2015a; 2015b, 2016a; 2016b). We recorded similar traces over a period of time from seconds to more than two hours, until they were destroyed by air currents (<http://www.astronet.ru/db/msg/1198013/04.html>). Finding the path of the bolide is a Cauchy task. To solve it, it is necessary to determine in space the integral surface pass-ing through the observed trace. Its contour image can be approximated by a spatial curve, which is described by a point moving along a cone-forming element, which rotates uniformly around the axis of the screw contour. The horizontal projection of such a helix on the cylinder is a circle, and the frontal projection is a sinusoid. Therefore, the horizontal projection of the conical helix is an Archi-medes spiral, and the frontal projection is a sinusoid with a damped amplitude (https://studwood.ru/1635363/matematika_himiya_fizika/sinusoida). When moving in the atmosphere of a non-spherical object of irregular shape, a lifting force perpendicular to the velocity of movement appears. It arises as a result of the asym-metric flow of such a body with gas flows. The lift vector will be perpendicular to the velocity vector. And it is one of the main reasons for the movement of a meteoroid body along a helical trajectory.

Therefore, if it is possible to construct a sinusoidal curve on the frontal projection of the image of the bolide track, it can be said that the trajectory of such an invasion is a helix. Consideration of the motion of a meteoroid body within the framework of the dynamics of a compressible gas allows us to conclude that the movement of gas in the wake is accompanied by an unsteady rarefaction wave. Our estimates show

that almost all cosmic ones are accompanied in the troposphere by the appearance of an inversion trace (Spurny & Porubčan, 2002; Steklov et al., 2018). Under the same conditions, it can form during thousandths of a second; and in the case of saturated steam, the trace can persist for a long time (Steklov et al., 2017a; 2017b; Vidmachenko, 2015; Vidmachenko & Morozhenko, 2014; Vidmachenko & Steklov, 2013; Vidmachenko A. & Vidmachenko H., 2007). The colorimetry of tracks of Lyrid meteor shower (Kruchynenko et al., 2017) obtained in spring of 2018 in modes of continuous shooting and video recording (30 frames per 1 sec) showed that along the flight path of meteor its color changes significantly. This reflects the fact of warming up in 0.3 sec of meteoroid from 6 to 11 thousand degrees (Zhilyaev & Totochava, 1996). Also, high-frequency oscillations (in hundreds of Hertz) and “wobbling” with deviations up to 6% of meteor track width were detected in the light curves of meteor tracks.

CHANDLER WOBBLE VARIABILITY

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The works that we carried out during the last ten years lead to significant progress in the knowledge of the Chandler wobble (CW) of the Earth polar motion. In paper [1] we reconstructed the excitation of this resonant mode by using Panteleev corrective filtering. Now we are sure, that this filtering is a regularizing algorithm as far as its parameters are consistently selected with the uncertainty affecting the resonance parameters and the observations. The excitation demonstrated a quasi 20-year amplitude modulation. In the framework of the first order differential linear equation describing the polar motion, it is easy to show that this modulation accounts for the 40-year change of the CW amplitude as well as the splitting of the CW spectra. A simple model of the CW, composed of 80 and 40-year harmonics, accounts for the present minimum in Chandler wobble amplitude, like in 1930s, and also predicts that its amplitude will start to increase in the nearest future with a phase shift of 180 degree. On the other hand, geodetic excitation of the CW well matches the ocean-atmospheric excitation [2,3,4] over recent 50 years with a dominant role of the ocean, producing the 20-year modulation. Thus, the physical cause of it could stem from climatic or tidal process influencing the oceanic circulation.

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OTHER SECTIONS

THE POPULAR ASTRONOMICAL JOURNAL "NASHE NEBO"

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Znannya Society of Ukraine, Kyiv Planetarium

"Nashe Nebo" is a popular astronomical magazine. Founded in 1998 in Kyiv as a publication of the Znannya Society of Ukraine. Publisher – Kyiv. Planetarium, since 2017 – "University of Modern Knowledge". The magazine is published in Ukrainian every three months, a circulation of 1000 copies. Prints materials related to astronomical subjects. Designed for anyone who deepens their knowledge of the universe. Slogan: "Starry Sky – For All!"

The purpose of the publication is to provide information on current achievements of astrophysics, popularization of astronomical and other natural sciences, the development of amateur astronomy in Ukraine, the involvement of talented young people in astronomical observations and studies of the starry sky, the establishment of cooperation between amateur astronomers and specialists, the integration of amateur astronomy of Ukraine into international astronomical organization.

Main Titles: Cosmology, Astrophysics, Non-Galactic Astronomy, Star Astronomy, Exoplanets, Solar System, Our Planet Earth, Astronomy, Amateur Astronomy, Outstanding Figures, History of Astronomy, Astronomical Observations, Astrocalendar, Astrophotography.

The sections of the magazine contain stories about the origin and development of the universe, vision, galaxies, planetary systems, interesting to the astronomer. events related to the study of unique astrophysical objects and phenomena: quasars, black holes, neutron stars, gravitational waves; interesting information about the search for life outside the Earth, about the scientific and philosophical problems of comprehension of being in the universe. The magazine also publishes star-sky maps, detailed color images of the astronomer. objects Chief editors: I. Kryachko (1998-2001), K. Churyumov (2002-2008), V. Kusherets and O. Baransky (since 2017).

COSMOLOGICAL SINGULARITY AS AN INFORMATIONAL SEED FOR EVERYTHING

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G. Gamov is always interested in informational aspects of biological systems and their connection with cosmology.

It is considered, how to place some amount of matter into the cosmological singularity and to encode its state. Two different approaches are suggested, which give the same result. The expression for the spectral energy density of the scalar particles, which is initially encoded at the singularity, is deduced. An informational aspect of the problem is discussed.

Keywords: Cosmological singularity; Initial conditions; Quantum evolution of Universe; Informational content of singularity.

ANALYSIS OF THE SMALL RNA-SEQ DATA OF THE BREAD WHEAT LINES WITH INTROGRESSIONS FROM AMBLYOPYRUM MUTICUM

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Modern high-throughput methods of the transcriptomes analyses are tend to generate large data sets, which are impossible to interpret without bioinformatics methods. The small RNA-seq method is used to study miRNAs – short regulatory sequences widely distributed in plants. The results of small RNA-seq are stored in the FASTQ files which record millions of sequences each representing individual molecule. Data analysis workflow vary depending on the aims of the study, but the main steps are common: identification of known small RNAs, identification of novel small RNAs, looking for sequences differentially expressed among groups of genotypes, target prediction and annotation.

In this study we used bioinformatics instruments for analysis of the data obtained after sequencing of the small RNAs libraries of five genotypes: common wheat *Triticum aestivum* L. variety Aurora ($2n = 6x = 42$, AABBDD), genome substitution amphidiploid *Aurotica* ($2n=6x=42$, AABBTT) with TT genome from *Amblyopyrum muticum*, and three dark colored hairy glumed plants from the *T. aestivum* / *A. muticum* introgressive lines, the development of which is described in (1).

After trimming adapters, raw reads were filtered by length and quality score with FilterFASTQ tool. Processed reads were aligned with the Bowtie (2) against known pre-miRNA sequences of *B. distachyon* and *T. aestivum* deposited in the miRBase. Additionally, processed reads were mapped to the wheat genome with the miRPlant software to find novel miRNA sequences (3). Known miRNAs and predicted novel miRNAs were analyzed for the differential expression between libraries with limma-voom algorithm (4). The target genes for the DE predicted miRNAs were predicted with psRNATarget (5), the transcription factors were identified amongst the targets with the BLAST (6) against Gramineae sequences from Plants Transcription Factor Database.

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