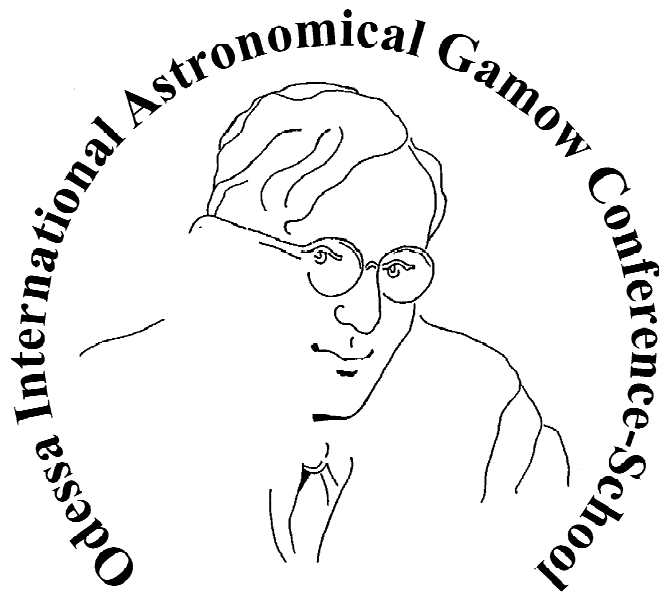# 21-th Gamow International Astronomical Conference-School
"ASTRONOMY AND BEYOND: ASTROPHYSICS, COSMOLOGY AND GRAVITATION, HIGH ENERGY PHYSICS, ASTROPARTICLE PHYSICS, RADIOASTRONOMY AND ASTROBIOLOGY"

Odessa International Astronomical Gamow Conference-School

ABSTRACTS

August 15-21, 2021
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21-th Gamow International Astronomical Conference-School
"ASTRONOMY AND BEYOND: ASTROPHYSICS, COSMOLOGY AND GRAVITATION, HIGH ENERGY PHYSICS, ASTROPARTICLE PHYSICS, RADIOASTRONOMY AND ASTROBIOLOGY"

(Ukraine, Odessa, August 15-21, 2021)

MEMORIAL SESSIONS AND PLENARY SPEAKERS

ODESSA ASTRONOMICAL OBSERVATORY: 150 YEARS!

Andrievsky S.M.
Odessa National University

The current state of scientific work at the Astronomical Observatory of the Odessa National University is presented. In particular, the main directions of scientific researches are listed, and the own park of scientific instruments is described.

MATEMATICAL MODELING OF PHYSICAL VARIABILITY OF STARS

I.L.Andronov[1], K.D.Andrych[1], V.V.Breus[1], L.L.Chinarova[1], S.V.Kolesnikov[1], L.S.Kudashkina[1], V.I.Marsakova[2], D.E.Tvardovskyi[1]
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We review results of the analysis of variability of stars and stellar systems based on the own photometric and (partially) polarimetric observations, as well as the photometric surveys obtained at ground-based and space observatories. We call this campaign the "Inter-Longitude Astronomy" project, as there are international studies based on temporarily groups from different countries. This is strongly related to the projects "Virtual Observatory" and AstroInformatics.

The main targets are pulsating stars of different types (M, SR, RV, C, RR, DSct), as well as cataclysmic (UG, NL, AM, BY Cam, DQ, WZ), symbiotic (pulsating and eclipsing) and eclipsing (EA, EB, EW). Special attention is paid to multi-component variability, e.g. periodic or aperiodic modulation of the phase curves of "nearly periodic" stars (circumbinary bodies, multiperiodicity, Blazhko effect, spin-down and spin-up of magnetic white dwarfs, period changes due to a mass transfer etc.).

For the analysis, we have elaborated a complex of programs for analysis of different types of signals – (mono-, multi-, quasi- and a-) periodic, multi- (harmonic, shift) and their combinations. Totally, 2000+ stars have been studied, and 400+ publications are indexed in the ADS.

COSMOLOGICAL SIMULATION CODE COMPETITION: SCREENING VS. GEVOLUTION

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We compare two competing relativistic approaches to the N-body simulation of the Universe large-scale structure. To this end, employing the corresponding alternative computer codes ("gevolution" and "screening"), we conduct a series of cosmological simulations in boxes of different sizes and calculate the power spectra of the scalar perturbation Φ, the frame-dragging vector potential **B** and the difference between scalar modes $\chi = \Phi - \Psi$. We demonstrate that the corresponding power spectra are in very good agreement between the compared schemes. For example, the relative difference of the power spectra for Φ is 0.04% maximum. Since the perturbed Einstein equations have much simpler form in the "screening" approach, the simulation with this code consumes less computational time, saving almost 40% of CPU (central processing unit) hours.

SPACE OBSERVATIONS AND SUSTAINABLE DEVELOPMENT OF UKRAINE

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The report examines emerging trends in the application of Earth observation satellite technologies for sustainable development. The Global Earth Observation System of Systems (GEOSS) Programme demonstrates that the

world community has reached a qualitatively new technological level in building the foundations of the digital economy and a methodology for processing large volumes of data (Big Data) and the effectiveness of the use of satellite information. In recent years Ukrainian specialists have taken practical steps towards the widespread introduction of the GEOSS system and the European COPEERNICUS system in Ukraine.

The acquired experience makes it possible to offer the ideology of the Ukrainian segment of GEOSS - UkrGEO information system, which envisages the development and implementation of information technologies and services for measuring indicators of sustainable development in socially significant areas (food, energy, fire safety, monitoring of agricultural, forestry, water and energy resources, urban agglomerations, environmental pollution). The system is based on the concept of sharing essential variables (Essential Variables) for the assessment, prediction and monitoring of ecosystems using Earth observation data.

The satellite data systems being developed are not merely a means of improving existing methods, but an innovative approach based on the integration of ground-based and space-based data into natural and technological process models, which will provide a qualitatively new level of solving the tasks of modeling and forecasting and, in general, information support for management decisions. In recent years several projects have been initiated in which methodological approaches to the creation of practical information services have been developed, that implement the chain from observational information to the essential variables of the respective models and to the HC indicators.

UPDATED CONSTRAINTS ON HEAVY RESONANCES USING THE RUN 2 ATLAS DATA AT LHC

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The full ATLAS Run 2 data set with time-integrated luminosity of 139 fb^{-1} in the diboson and dilepton channels is used to probe benchmark models with extended gauge sectors: the E_6-motivated Grand Unification models, the left-right symmetric *LR* and the sequential standard model (*EGM*). These all predict neutral Z' vector bosons, decaying into lepton pairs or into electroweak gauge boson pairs W^+W^-, where one W in turn decays semileptonically. We present exclusion regions on the parameter space of the the Z' which are significantly extended compared to those obtained from the previous analyses performed with LHC data collected at 7 and 8 TeV in Run 1 as well as at 13 TeV in Run 2 at time-integrated luminosity of 36.1 fb^{-1} and are the most stringent bounds to date. Also presented, from a similar analysis of electrically charged W' bosons arising in the *EGM*, which can decay through W' to *WZ*, are limits on the W-W' mixing parameter and the charged W' vector boson mass.

COSMOLOGY, GRAVITATION, HIGH ENERGY PHYSICS, ASTROPARTICLE PHYSICS

NUMERICAL SIMULATIONS OF THE MORPHOLOGIES OF SUPERNOVA REMNANTS IN NON-UNIFORM MEDIUM

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There are about 300 supernova remnants (SNRs) observed in our Galaxy. Most of them evolve in the non-uniform medium. SNRs may be classified into a few morphological classes, based on their surface brightness morphologies in different photon energy ranges: shell-like (both in radio and X-rays), centrally-filled (as in radio as in X-rays), thermal X-ray composites (TXCs). The last class often called also mixed morphology SNRs and contains objects which are shell-like in radio and centrally filled in X-rays (which are of the thermal nature). We have used Pluto code in order to perform 3D MHD simulations of SNRs in a medium with non-uniform distribution of density and magnetic field. With these simulations, we have created a set of supernova remnant maps in radio, thermal and non-thermal X-rays as well as in gamma-rays. The influence of the non-uniform medium and orientation of magnetic field on the morphology of supernova remnants are shown.

X-RAY PROPERTIES OF NGC 3081 OBTAINED FROM CHANDRA OBSERVATIONAL DATA

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We present the X-ray spectral analysis of the Seyfert 2 galaxy NGC 3081 in the 0.5 - 8 keV energy range obtained by Chandra Space Observatory. The spectrum was fitted by a baseline model which includes an absorbed power-law, two emission components of hot ($kT_2 = 1.0^{+3.0}_{-0.1}$ keV) and warm ($kT_1 = 0.16^{+0.1}_{-0.02}$) diffuse gas as well as one Gaussian line for describing the Fe K_α emission line ($E_{line} = 6.39^{+0.06}_{-0.02}$ keV). The obtained power-law index is $\Gamma = 1.65^{+0.1}_{-0.9}$, column density is $N_H = 57.5^{+5.7}_{-2.8}$ cm^{-3}, line width is EW $= 50^{+0.01}_{-0.01}$ eV. It's suggested that the Fe K_α line originates in a moderate density of obscurer. We also added reflection from the cold neutral medium which is described by the pexmon model with reflection parameter R = -1.

For this case obtained power law index is $\Gamma = 1.76^{+0.25}_{-0.23}$, column density is $N_H = 71.2^{+5.8}_{-5.3}$ and two different thermal components with temperatures are $kT_1 = 0.16^{+0.06}_{-0.06}$ keV and $kT_2 = 0.86^{+0.3}_{-0.16}$ keV. Based on these results, to obtain more information about obscurer will be applied complex reflection models, such as MyTorus and XClumpy, in combination with XMM and NuSTAR observational data.

HOW THE PRIMORDIAL MAGNETIC FIELD AFFECTS THE PRIMORDIAL CHEMISTRY AND FIRST MOLECULES EMISSIVITY

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The results of recent probes of the intergalactic magnetic field (IGMF) with high-energy (~TeV) gamma rays emitted by distant blazars suggest that the strength of the IGMF at cosmological scales (> 1 Mpc) is larger than ~ 10^{-18} G. Since there is no generally accepted mechanism for generating magnetic fields in voids that fill most of the volume of the Universe during the formation of large-scale structures, it is natural to assume that IGMF originates from the primordial magnetic field (PMF), which arose in the early Universe as a result of some kind of magnetogenesis process.

The creation/destruction of the first molecules H2, HD, and HeH+ in the early Universe, as well as the population of their levels, are studied in the presence of PMF, which heated the baryonic matter due to ambipolar diffusion and decaying turbulence after the epoch of cosmological recombination. This leads to an increasing of the number density of H2 and HD, and a decreasing of the number density of HeH+ in the Dark ages.It is shown that emission from the first molecules lies in the same frequency range as the CMB and its spectral distortions. The intensity of this emission strongly depends on the primordial magnetic field strength, which has the maximum allowed value at the present epoch of ~3 nG. In this case, the flux coming from primordial molecules is comparable to the known CMB spectral distortions that are targets of such planned research missions as FIRAS, PIXIE, PRISM, PRISTINE, Super-PIXIE, and Voyage 2050.

ABSENCE OF LORENTZ CONTRACTION AS A RESULT OF LORENTZ TRANSFORM

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In a classical problem on the Lorentz contraction of a rod, the essential condition is the possibility to measure the coordinates of its ends at different times in the rest

frame. We change the problem specification to make such frame non-existent. Consider two identical particles which move towards each other in certain reference frame, along e.g. the OX axis according to the laws $x(t)$ and $(-x(t))$. Such reference frame is the center of mass of the particles. Suppose the condition $x(t) > 0$ holds for any $t \in (-\infty, +\infty)$. The dependence of the distance between the particles on time is then $l(t) = 2x(t)$. Let us now consider a similar frame with certain boost along the OX axis. We want to calculate the dependence of the distance l' between the particles on time t' in the boosted frame. Within such formulation, the coordinates of the particles must be measured simultaneously in each of the frames. However, the simultaneous measurements in one reference frame are non-simultaneous in another. In such case the observers in these two frames have to use different pairs of events, in contrast to the traditional problem about the length of a rod, where both observers can use the same pair of events. This situation is similar to the one considered in [1,2]. As a result, there is now way to relate the arguments and the values of the functions $l(t)$ and $l'(t')$, because they are associated to different events. And the only way to state such problem is to find a relation between the *forms* of the dependences $l(t)$ and $l'(t')$. Formally, it can be explained as follows. One has two different dependences between t' and t:

$$t' = \frac{t - \frac{v}{c^2}x(t)}{\sqrt{1 - \frac{v^2}{c^2}}}, t' = \frac{t + \frac{v}{c^2}x(t)}{\sqrt{1 - \frac{v^2}{c^2}}}. \quad (1)$$

where v is the relative velocity of the frames, c is the upper limit of the physical quantities propagation. Finding the inverse dependences to (1), one obtains two values t corresponding to each t'. Let us denote them $t_1(t')$ and $t_2(t')$. So apparently, t and t' cannot be definitely related. We can still calculate the coordinates of both particles at the time t' in the corresponding frame:

$$x_1'(t') = \frac{x(t_1(t')) - vt_1(t')}{\sqrt{1 - \frac{v^2}{c^2}}}, x_2'(t') = \frac{-x(t_2(t')) - vt_2(t')}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (2)$$

Having the coordinates of the particles measured simultaneously in the second frame, it is possible to derive the distance between them at any time t': $l'(t') = |x_1'(t') - x_2'(t')|$.

We show that it is possible to find such law of particle motion $x(t)$ that the dependences $l(t)$ and $l'(t')$ will be identical in all inertial frames. No Lorentz contraction in this case. And the absence of the contraction here is the direct result of the Lorentz transform itself.

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CALCULATION OF MULTI-LOOP DIAGRAMS OF ELASTIC SCATTERING BY THE LAPLACE

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The work is devoted to the study of the possibility of applying the Laplace method to calculate the contributions of R.Feynman diagrams with loops to the amplitude of elastic scattering of particles. We have considered a two-loop diagram and the simplest model, when scalar particles interact and they exchange scalar particles. Using R.Feynman's identity, the analytical expression corresponding to this diagram can be reduced to a seven-dimensional integral containing the Dirac delta function, which is taken into account by moving to seven-dimensional spherical variables. After performing the described procedures, the subintegral expression is represented as

$$A = \lim_{\varepsilon \to +0} \int_0^{\pi/2} d\theta_1 \int_0^{\pi/2} d\theta_2 \int_0^{\pi/2} d\theta_3 \int_0^{\pi/2} d\theta_4 \int_0^{\pi/2} d\theta_5 \int_0^{\pi/2} d\theta_6 \frac{F(\theta)}{(Z(\theta) + i\varepsilon)^3}$$

Here θ denotes the whole set of quantities $\theta_1, \theta_2, \theta_3, \theta_4, \theta_5, \theta_6$. The function $F(\theta)$ has no features within the integration area. Instead, the function $Z(\theta)$ on some subset of the integration domain vanishes. As a result, we cannot make the boundary transition to integrating and cannot effectively apply numerical methods for calculating integrals. But the integral (1) can be written as:

$$A = \frac{1}{2}\lim_{\varepsilon \to +0} \frac{\partial^4}{\partial \varepsilon^4} \int_0^{\pi/2} d\theta_1 \int_0^{\pi/2} d\theta_2 \int_0^{\pi/2} d\theta_3 \int_0^{\pi/2} d\theta_4 \int_0^{\pi/2} d\theta_5 \int_0^{\pi/2} d\theta_6 F(\theta) \times$$
$$\times \left((Z(\theta) + i\varepsilon)\ln(Z(\theta) + i\varepsilon) - (Z(\theta) + i\varepsilon) \right).$$

As can be seen from formula (2), the region in which $Z(\theta) = 0$ now makes a zero contribution to the integral. Therefore, we can now apply the Laplace method to calculate the integral of the real and imaginary parts of the subintegral expression. The maximization of the modules of the real and imaginary parts showed that the points at which the maximum values of the modules of the real and imaginary parts are reached do not change with variable ε. In addition, for some variables the maximum is reached at the limit value $\pi/2$, and for some at values less than the limit. Then representing the integral (2) in the form

$$A = \frac{1}{2}\lim_{\varepsilon \to +0} \frac{\partial^4}{\partial \varepsilon^4} \int_0^{\pi/2} d\theta_1 \int_0^{\pi/2} d\theta_2 \int_0^{\pi/2} d\theta_3 \int_0^{\pi/2} d\theta_4 \int_0^{\pi/2} d\theta_5 \int_0^{\pi/2} d\theta_6 \times$$
$$\times \exp\left(\ln\left(\text{Re}\left(F(\theta)\left((Z(\theta) + i\varepsilon)\ln(Z(\theta) + i\varepsilon) - (Z(\theta) + i\varepsilon) \right) \right) \right) \right) +$$
$$+ \frac{1}{2}\lim_{\varepsilon \to +0} \frac{\partial^4}{\partial \varepsilon^4} \int_0^{\pi/2} d\theta_1 \int_0^{\pi/2} d\theta_2 \int_0^{\pi/2} d\theta_3 \int_0^{\pi/2} d\theta_4 \int_0^{\pi/2} d\theta_5 \int_0^{\pi/2} d\theta_6 \times$$
$$\times \exp\left(\ln\left(\text{Im}\left(F(\theta)\left((Z(\theta) + i\varepsilon)\ln(Z(\theta) + i\varepsilon) - (Z(\theta) + i\varepsilon) \right) \right) \right) \right).$$

Now we replace the exponent with its Taylor series near the point where the maximum value of the modulus of each term is reached. Thus for those variables for which

the maximum is reached at limit values it is possible to be limited by the schedule to linear members, and on the rest - to the second order. After that, the calculation of the integral is not a problem.

THE SCAN OF PARAMETRIC SPACE FOR H2HDM WITH DIFFERENT EXPERIMENTAL CONDITIONS

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We discuss theoretical and phenomenological aspects of two-Higgs-doublet extensions of the Standard Model. In modern notation the h2HDM is the model with m_h=125.26 GeV, where the lightest neutral scalar particle in 2HDM is the usual Higgs boson in Standard Model.

The parametric space of this model is very rich and admits many scenarios of phenomenology of New Physics. But the many restrictions and conditions should be satisfied.

We present the conditions for parametric space of h2HDM with taking into account the anomalous magnetic moment of muon. The experimental data is recently published by Fermilab National Accelerator Laboratory.

Another point is the Sakharov's conditions for the formation of the baryon asymmetry of the Universe in models with extra scalar fields, we try to show that we can satisfy them in h2HDM and find the region of parametric space where the phase transition is first order. The Sakharov's conditions are not satisfied in Standard Model but it is fundamental problem of modeling the Universe so the searching the New physics this way is relevant.

DISTORTION OF COSMIC MICROWAVE BACKGROUND IN THE DARK AGES AND COSMIC DAWN EPOCHS

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The creation/destruction of the first molecules H_2, HD and HeH^+ in the early Universe and the luminosity of protogalaxy halos at the cosmic microwave background (CMB) are studied. The upper limits of the energy density of the first light are estimated for four models of thermal light evolution in the Cosmic Dawn using the observational constraints on the re-ionization of the intergalactic medium. The results show that molecules H_2 and HD are destructed by photodissociation processes long before the full re-ionization in interhalo medium, in medium of both types of halos and for all models of the first light. While, the number density of HeH^+ molecules illustrate essentialy more complicated dependendences on kinetic temperature of halos and the models of the first light. The time-dependence of differential brightness temperatures of protogalaxy halos mainly follows the number densities of molecules and kinetic temperature of baryonic matter in them. In the case of hot halos, their differential brightnesses are comparable with the CMB temperature fluctuations at subsecond angular scales. Therefore, the observations of protogalaxy halos in the Dark Ages and Cosmic Dawn epochs in the lines of the first molecules may be informative probe about physical processes at the beginning of the first stars and galaxy formation as well as about the distortion of CMB on small angular scales.

ON SCHOUTEN'S GEOMETRIES IN METRIC GRAVITATION THEORIES

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For cosmology, very interesting are the methods developed in differential geometry, when a finite region of a smooth continuous manifold is equipped with a system of coordinate lines and a metric tensor. Coordinate lines allow us to find the position of any point in the considered region. The metric tensor establishes a way to determine the distance between any two infinitely close points in this area (Pythagorean theorem). The operation of translation of a vector by an infinitesimal distance leads to covariant derivatives containing connections, which compensate non-tensor contributions that arise during the usual differentiation of the vector.

As Schouten showed in 1935, in the general case, under covariant differentiation of vector fields, connections may contain, in addition to Christoffel symbols, two tensors of rank III, antisymmetric in two indices (two torsion tensors), and a tensor of III rank, symmetric in two indices, a tensor of nonmetricity. This means that linear manifolds equipped with a metric tensor, can obey the differential laws of one of the 27 Schouten geometries.

In the series of works by A.D. Chernin and his co-workers discussed possible mechanisms of the formation of polygonal structures of galactic arms. We consider the possibility of explaining this phenomenon as one of the manifestations of Schouten's geometries in astrophysics: the transition of the region of space where part of the galaxy arm is located from one Schouten geometry to another during the evolution of space-time.

NEARBY GALAXY CLUSTERS: EVOLUTIONARY CHANGES

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We discuss the role of statistically significant regular substructures the evolution of galaxy clusters. Our data set contains rich galaxy clusters with redshifts up to 0.12. We detected the regular features such as: linear substructures, intersecting stripes (type X, Y, or a more complex version), short dense stripes, curved chains. We showed the direction of the linear substructure is usually related to the location of the nearest galaxy cluster. Bright galaxies in clusters are located mainly in regular substructures and show significant alignment along the substructure, corresponding to alignment in filaments.

The discovered features correspond to the results of modern numerical simulations of the large-scale structure

of the Universe and can be considered as a result of the formation of a cluster of galaxies at the intersection of filaments or the interaction of a filament with a wall.

ON ANGULAR DISTRIBUTION OF ELECTROMAGNETIC RADIATION FROM KERR BLACK HOLE

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Based on the consideration of algebraically-special solutions of Maxwell's equations in Kerr space-time, exact expressions for the Stokes polarization parameters of electromagnetic waves emitted around a black hole are obtained. It is stated that the existence of singular points of a solution in a local orthonormal frame is a consequence of the Poincare-Brouwer theorem. The asymmetry of the dependence of the ellipticity angle on the polar angle for the fundamental mode and all harmonics of polarized radiation is revealed. This created the basis for a new method for determining the intrinsic angular momentum of a Kerr black hole.

OBTAINING NEUTRON MATTER AND HYPERHEAVY NUCLEI. POSSIBLE INSTRUMENTAL APPROACH

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The report discusses possible mechanisms for the creation of superheavy nuclei as a result of electron-nuclear collapse [1] and neutron matter by condensation of ultracold neutrons (UCN) [2]. The fundamental possibility of creating such objects was previously justified by A.B. Migdal [3]. Analysis shows that neutron matter, which, due to the Tamm interaction, as well as the Hund beta equilibrium should be sufficiently stable at the microlevel, can be stable not only at the mega-level (neutron stars) due to gravitational interaction, but also on the scale of the "usual" macromatter. The formation of such systems due to the effect of neutronization is possible not only with critical gravitational interaction, but also by fundamentally different mechanisms (supercritical increase in the atomic number of elements due to electron-nuclear collapse and condensation of ultracold neutrons), which opens the way to the fundamental possibility of obtaining both neutron matter in laboratory conditions [2] and superheavy nuclei [1]. The possibility of the existence (and obtaining in laboratory conditions) of stable neutron matter (for $Z \gg 175$, $N \gg Z$, $A \geq 10^3 -10^5$ with a size of 200-300 femtometers and more) at the microlevel, and not only at

the mega-level, as is now believed in astrophysics, based on the work of Migdal, Tamm and Hund.

The following technical approaches to the implementation of UCN condensation are considered:

1. Slow isothermal compression;
2. Refrigerator for dissolving helium-3 and helium-4;
3. Use of a conical concentrator for UCN focusing (Vysotsky cone) [4];
4. Magnetic trap;
5. Additional UCN laser cooling.

Neutron matter is also seen as a potential candidate for cosmological latent mass.

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DARK-AGE 21 CM POWER SPECTRUM IN COSMOLOGICAL MODELS WITH INTERACTING DARK MATTER AND DARK ENERGY

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The effect of non-minimally coupled dark matter and dark energy on the dark-age 21 cm angular power spectrum is studied. We take into account the linear effect coming from the perturbations of ionization fractions, matter and spin temperature during Dark Ages. The relative perturbations of Hydrogen and Helium ions number densities have been evolved using the perturbed system of equations for the effective 3-level atom model. The possibility of distinguishing between the minimal and non-minimal coupling using the dark-age 21 cm line tomography is discussed.

MODELING COSMIC VOIDS PROFILES IN MULTIDARK COSMOLOGICAL SIMULATION

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In our work we compare profiles of the void found in Multidark simulation with the ones obtained as numerical solution of cosmological perturbation evolution equations. Multidark is dark-matter-only cosmological N-body

simulation of Lambda-CDM Universe. Its authors [1] have provided free access to both particle and dark matter halo data. We have applied void finding algorithm VIDE [2] to latter ones, which find voids in halo distribution combining Voronoi tessellation and watershed algorithm. Among large population of the voids formed at modern cosmological time we select only those largest and most spherical ones. The radial density profiles obtained in this way is then compared to ones, that had evolved as initial hydrodynamic perturbations of certain form in the continuous multi-component media. The evolution of cosmological perturbations is governed by Einstein and conservation equations. We argue, that both N-body simulated and numerical voids share a number of common features, such as: the amplitude of density in the center, the presence and the radius of the overdensity shell, the radii of the voids etc. We have also compared velocity profiles of the voids and they also share some common features. This shows, that selected initial spacial profile in numerical solution suits well for modeling the evolution of cosmic voids.

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TOPOLOGY OF LARGE SCALE STRUCTURE OF THE UNIVERSE

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We revised topology studies of large scale structure (LSS). Early works in mentioned field were based on genus statistics, which is averaged curvature of isosurface of smoothed density field. Later, significant number of other methods was developed. This comprise Euler characteristics, Minkowski functionals, Voronoi clustering, alpha shapes, Delanuay tesselation, Morse theory, Hessian matrix and Soneira-Peebles models. In practice, modern topology methods are reduced to calculation of three Betti numbers which shall be interpreted as a number of galaxy clusters, filaments and voids. Such an approach was applied both to simulated and observed LSS data. Topology methods are generally verified on LSS simulations. Observational data normally includes SDSS, CFHTLS and other surveys. These data have many systematical and statistical errors and gaps. Furthermore, there is also a problem of underlying dark matter distribution. The situation is not better in relation to calculations of the power spectrum and its power law index which do not provide a clear picture as well.

We propose some tools to solve above problems. First, we are interested in topology description of simple LSS models such as cubic, graphite and random Gaussian distribution of matter. Our next idea is to set a task for LSS topology assessment using X-ray observations of the galaxies. Although, here could be a major complication due to current lack of detected high energy emitting galaxies. Nevertheless, we expecting to get sufficient results in the future encouraging comprehensive X-ray data. Finally, we consider the options of applying artificial neural networks to observed galaxies and fill the data deficiency. This shall enable to define topology at least for superimposed superclusters and other LSS elements.

LAPLACE METHOD FOR SINGLE-LOOP DIAGRAMS OF ELASTIC PROTON SCATTERING

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Elastic proton scattering has been the subject of experimental and theoretical research for decades. A large amount of experimental results has been accumulated, but there is still no dynamic theory based on fundamental physical principles [1]. In this work, we calculated the differential cross section of the elastic proton scattering by the square of the transmitted four-momentum based on dynamic model only. This model is built upon the fundamental physical principles, starting from the Lagrangian to derive the dynamic equations, quantization procedures and solving equations that determine the dynamics of the corresponding relativistic quantum system in Fock space. For this purpose we use the model of multiparticle fields [2, 3].

A model of a three-particle bispinor field which interacts with the twoparticle field of glueballs (the bound states of two gluons) was used to calculate the differential cross section. Within this model, a single-loop diagram is considered. The expression corresponding to this diagram contains a multidimensional integral over the virtual four-momentum, which was calculated using the Laplace method [4]. These multidimensional integrals were reduced to two-dimensional or onedimensional and have been calculated numerically. We calculated the dependences of the differential cross section of elastic proton scattering on the square of the transmitted four-momentum at different energies and two fitting parameters – the glueball mass and the effective glueball coupling to proton.

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ASTROPHYSICS

(stellar atmospheres, interacting binary systems, variable stars)

MATEMATICAL MODELING OF THE PHYSICAL VARIABILITY. SEMI-REGULAR PULSATING STARS

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Results of the multi-method analysis of semi-regular pulsating stars are reported. For the analysis, we have used the observations available at the international database of the AFOEV (http://cdsarc.u-strasbg.fr/afoev/).

The study includes the periodogram analysis using the complete sine fit. The SR-type stars are often characterized by a presence of few periods, which may act simultaneously, or show switches between preferred pulsation modes. Such an analysis assumes stable periods during the observations. For the signals with changing amplitude, phase and mean (over the pulsation period), the method of "Running Sine" (RS) is effectively applied. Next in the queue of methods for signals with decreasing coherence is the wavelet analysis. Our modification allows to increase the "signal/noise" contrast. Finally, for the quasi-periodic oscillations (QPO), the "sigma" and "Lambda" scalegram analysis is to be performed to determine characteristic time-scales of variability.

Different types of variability among the SR class are present and discussed. This work is in a frame of studies in the studies of AstroInformatics/Virtual Observatory/Inter-Longitude Astronomy.

SPIN PERIOD VARIABILITY IN INTERMEDIATE POLARS: RECENT RESULTS

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

We report the results of long-term time series photometry on selected intermediate polars.

Using data taken during 9 years of photometric monitoring of the magnetic cataclysmic variable V2306 Cygni, we detected the spin period variability which shows a spin-up the white dwarf with a characteristic time typical for this kind of objects. The value of the spin period was 733.33976 seconds with the formal accuracy of 0.00015 seconds. Also we derived and improved the value of the orbital period of the system to be 4.371523 +- 0.000009 hours. These results were published in 2019. Recent data shows the spin-up of the white dwarf changed to spin-down in 2019.

In our previous publication on the intermediate polar V405 Aur we suggested two models of possible O-C changes: third order polynomial fit that corresponds to the spin-up of the white dwarf and periodic model of (O-C) changes that corresponds to the presence of the third body orbiting the inner binary system. Recent data obtained in 2016-2019 shows that the spin-up changed to spin-down few years ago.

Using data taken during 13 yr, we confirmed and improved the results obtained by de Miguel et al. (2017). Due to longer time-base we obtained more accurate value of the spin-up time-scale $1.536(3)\times10^5$ yr. The observed rate of spin-up is even faster then reported by de Miguel et al. (2017) and one of the fastest of all known intermediate polars. We confirm the presence of superhumps and studied the changes of superhump period. Also we report a presence of complicated changes of (O-C) with a period of about 7 years, that may be interpreted either as fluctuations around the equilibrium period or as a presence of a third body orbiting the inner close binary system.

THE COORDINATES ESTIMATION OF THE GALACTIC VERTEX BY MEAN OF KINEMATIC ANALYSIS OF THE RED GIANTS AND SUBGIANTS VELOCITY FIELD CONTAINING IN THE GAIA EDR3 CATALOGUE

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In this work we present the results of estimation coordinates X_G and Y_G of the rotation center of the Milky Way galaxy (vertex) in a Cartesian galactic coordinate system and the Galactocentric distance to the Sun R_0. Using method determination of the deviations from vertex by stellar velocity fields of some samples in the Galaxy plane the rotation center coordinates were estimated. The kinematic analysis of the spatial velocities of more than 3.8 million red giants and subgiants contained in the Gaia EDR3 catalogue was carried out. The rays emanating from the analysed stellar

samples and have directions to the vertex are intersecting at a certain geometrical place that probably is the center of the Galaxy rotation. In the current work, we used classical distances to stars based on trigonometric parallax (as $1/\pi$) and the distances estimated by Bayesian method (photogeometric). Using the different distances leads to a difference of estimations of stellar kinematics parameters of the Galaxy, as a consequence, give a difference of the coordinates of the center of Galaxy rotation.

THE γ-RAY'S DIAGNOSTICS BY THERMONUCLEAR FLARES IN POLARS WITH MASSIVE WHITE DWARFS

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The induced γ-ray emissions in contact cataclysmic binary systems with strong magnetic fields near white dwarf and companion star components are considered. CNO atoms in white dwarf's atmosphere are collided by flows falling to magnetic poles. At the white dwarf's surface the speed of falling flows stream reaches $3 \cdot 10^6 \ m/s$ and creates conditions sufficient for nuclear γ-radiation emission. The energies of resulted γ-radiation emission are distributed in 0.1 – 150 MeV interval depending on the colliding atoms and particles. The mass loss from binary component is used can be of the order of $\dot{M} \approx (10^{-11} - 10^{-7}) M_\odot$. We considered the collisions of p – He, α – He, p – C, α – C, p – N, α – N, p – O, α – O, C – He, C – C, C – N, C – O, N – He, N – C, N – N, N – O, O – He, O – C, O – N, and O – O types. The chemical compositions, the dynamics, and the monochromatic energetic luminosities L_γ of flows falling to magnetic poles has been calculated for cataclysmic systems with different values of mass loss $\dot{M}$. The result is the dependence of L_γ from chemical composition and the calibration of the synthetic γ-spectra in the above mentioned energy intervals.

ACTINIUM ABUNDANCE IN THE ATMOSPHERES OF CEPHEID HIP13962

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The actinium abundance in the atmospheres of HIP13962 was estimated. The results of spectral observations with the BAO, South Korea) 2-m telescope with resolving power R = 80000 were used.

VARIABILITY PARAMETERS OF CEPHEIDS AND W VIRGO VARIABLES

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We analyzed the AAVSO photometric (UBVRI) observations of 87 Cepheid and W Vir variables. As a result of the analysis of observations, the mean light curves were obtained as well as their trigonometric polynomial approximations.

Using the method of periodogram analysis based on the trigonometric polynomial fit, the values of the periods of pulsations published in the "General Catalogue of Variable Stars", were corrected.

The characteristics of variability were obtained, such as: asymmetry, amplitude of the curve, values of phases and amplitudes of harmonics.

Based on the data obtained by using the MCV and FDCN programs, the dependences on the period of amplitudes, asymmetry of brightness curves and amplitudes and phases of harmonics were analyzed, and it was found that the short-period Cepheids with a period P $<10^d$ have an asymmetry in the range [0.25; 0.4]. And the stars that have a period P within [10^d; 30^d] show the decrease of asymmetry with an increasing period, and have an asymmetry within [0.2; 0.54].

Based on the B-V data, the phase curves of temperature and radius were constructed and their influence on the luminosity curves was analyzed. The phase shifts between maximum of luminosity and temperature were calculated and their dependences on other parameters of phase light curves were analyzed.

The period-luminosity dependences were obtained for both types (Cepheid and W Vir variables).

PERIOD CHANGES OF FOUR CEPHEID VARIABLES

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We analyzed the AAVSO photometric (UBVRI) observations of several dozens of Cepheid and W Vir variables. These observations allowed to found the period changes of four Cepheid variables: ζ Gem, VX Cyg, V Lac, TT Aql. Mean phase light curves were obtained for 3-5 intervals of observations by using trigonometrical polynomial approximations of data in the V-band. VX Cyg shows the period decrease in 400 days interval that is also accompanied by decrease of asymmetry. It is not

possible to found regularities of period changes of other variables within error estimates due to relatively small amount of observed cycles.

SOME FEATURES OF VARIABILITY OF THE LIGHT CURVE OF THE RR LYR-TYPE PULSATING VARIABLE FI SGE

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We present the result of tree-seasons photometrical observations of the FI Sge, scantly explored RR Lyr-type variable. The observational data were obtained using the 48-cm telescope AZT-3 of SRI "Astronomical observatory", I. I. Mechnicov Odessa National University. The telescope is equipped with a CCD camera and light filters which realize instrumental photometric system closely approximating the standard V-R-I bands. The observation data were obtained in 2013-2018.We obtained 55 full individual light curves. Using frequency analysis (Period 04 set) we estimated the period of the Blazhko effect for amplitude and phase of the fundamental period as well as we detected the variations of the fundamental period.

We obtained the characteristics of the light curve of explored star showing the Blazhko effect.

MATEMATICAL MODELING OF PHYSICAL VARIABILITY OF SEMI-REGULAR STAR RX BOO WITH MASER EMISSION

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The historical light curve of the semi-regular pulsating star with a maser emission, is analyzed based on the AAVSO database. While the star is extensively studied in the IR and radio, the optical behavior was discussed in 2006. The star was marked by the "Variable Star of the Season" for June, 2021.

Our previous study (1988AN....309..323A) was based on 349 photovisual observations obtained in the Astronomical Observatory of the Odessa National University. The periodogram showed the peaks at 352 ± 5^d, 179.1 ± 0.3^d and 162.4 ± 0.8^d. Speil (2006JAVSO..35...88S) reports on a double periodicity with 160^d and 278^d.

Current study is based on 13220 (visual+V) observations obtained in 1938-2021. The periodogram (using the trigonometric polynomial approximation of order s=1) shows few (formally) statistically significant peaks, also at 160.4d, but the strongest one is at 17970 ± 270^d (T_max=2446890±71, semi-amplitude 171±5 mmag) with apparently strong peaks at 4448^d, 2289^d, 1027^d, 568^d, 372^d, 286^d. The trigonometric polynomial of order s=16 shows a chaotic curve with a formal period $P=17110\pm27^d$. However, the presence of so many peaks shows that there are no "true" periods, but "cycle lengths". The "Lambda-scalegram" analysis

(2003ASPC..292..391A) shows similar multiple peaks. The "Running sine" (2013CKA....10..171A) approximation (with a period 160^d listed in the GCVS) shows drastic changes of the phase curve. In an addition to pulsations, we suggest a possible binarity for a 17 kiloday variability, and weakenings due to the dust events like that recently observed in Betelgeuse, DY Per (2020AANv....1..179A) and other stars.

TYC5594-576-1: r-PROCESS ENRICHMENT METAL-POOR STAR

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Atmospheric parameters and elemental abundances of metal-poor star TYC5594-576-1 ([Fe/H] = -2.8), including elements of neutron (n-) capture processes, which are important in the analysis of enrichment sources of early Galaxy, have been studied. Na, Mg, Al, Co, Sr, Y, Zr, Mo, Ba, La, Ce, Pr, Sm, Eu, Gd, Dy, Os, and Th abundances were calculated using the synthetic spectrum method, taken into account the hyperfine structure (HFS) for the Ba, La, Eu II lines. Si, Ca, Sc, Ni abundances were determined based on the equivalent widths of their lines. The carbon abundance was obtained by the molecular synthesis fitting for the region of CH (4300-4330 ÅÅ). For the abundances determinations of C, Na, Mg, Al, Ba, and Th the NLTE corrections have been applied.

We have determined for the first time the abundances of several n-capture elements and found that the behaviours of these elements show a significant trend with increasing atomic number, that support the TYC5594-576-1 status as a r-process enrichment star.

INVESTIGATION OF PLANETARY SYSTEMS TRES-3, KEPLER-17, WASP-3, QATAR-1 AND QATAR-2 BY TRANSIT PHOTOMETRY

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We present the results of investigation of five exoplanets tranzits: TrES-3b, Kepler-17b, WASP-3b, Qatar-1b and Qatar-2b. Observations were carried out for eight nights (from 2 April to 10 July 2021) by using a 70-cm reflecting telescope AZT-8 on Observing station Lisnyky (Kyiv, Ukraine). Photometric processing of the observation results was performed by using the Muniwin program. The obtained exoplanet transit brightness curves were published in Exoplanet Transit Database (ETD). The accuracy and quality of our observations on the ETD database scale ranged from 1 to 3.

For the exoplanets TrES-3b, Kepler-17b, WASP-3b and Qatar-1b, the obtained results of the center-transit time, depth and length of transit agree with the ephemeris data, while for two observations of the Qatar-2 system for the planet Qatar-2b there is a clear decreasing trend of the value of the O-C parameter. Additionally, using the method of time variation (TTV), we found a possible gravitational effect on the orbit of the exoplanet Qatar-2b of another massive body. This suggests that the assumption of the existence of the planet Qatar-2c conjectured in the article Bryan (2011) is true.

HIGH-RESOLUTION SPECTROSCOPY OF THE B[E] STAR MWC 645

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Optical high-resolution spectroscopic observations of the emission-line star MWC 645 are presented. The spectrum exhibits strong variable double-peaked Balmer emission lines as well as low-excitation emission lines of Fe II, [Fe II], and [O I] which are signatures of the B[e] phenomenon, while lines of helium have not been found.

In addition to the emission lines, for the first time we identified absorption lines of neutral metals (e.g., Li I 6708 Å, Ca I 6717 Å, and a number of Fe I and Ti I lines) that indicate the presence of a cool component in the system. The heliocentric radial velocity measured in our best spectrum was found to be -65.1 ± 1.0 km/s for the emission lines and -23.2 ± 0.4 km/s for the absorption lines. Using a combination of photometric and spectroscopic data as well as the Gaia EDR3 distance (D=6.5±0.9 kpc), we disentangled the components' contributions and estimated their temperatures and luminosities (~15000 K and ~4000 K, $\log L/L_{\odot} \sim 3.7$ and $\log L/L_{\odot} \sim 3.3$ for the hot and cool component, respectively).

SPECTROSCOPIC INVESTIGATIONS OF GALACTIC OPEN CLUSTER *Collinder 394* – NEW RESULTS

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We present the results of a spectroscopic investigation of 11 objects from the open cluster Collinder 394, which contains the Cepheid BB Sgr. We used the spectroscopic data obtained by SALT (South Africa) and TCO (North Carolina, USA) telescopes. Besides the Cepheid, we studied 10 confident cluster members, including 9 main sequence stars and one post-MSTO object. These confident clusters' members have been found by the using of radial velocities (RV), T_{eff}, log g, obtained spectroscopically, and proper motions and distances from GAIA DR2 catalogue. We have derived the color-excesses, reddenings, intrinsic colors and absolute magnitudes for these stars to compare with ones, obtained from photometry. Moreover, we made an attempt to resolve the inverse problem – using the $T_{eff} - R - M_v$ relations for main sequence stars to check the distances, obtained by GAIA telescope.

THREE REMARKABLE OBJECTS IN GALACTIC OPEN CLUSTER *Collinder 394* – HD 174403 (V4088 Sgr, HD 174652 and BB Sgr)

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We present the results of a spectroscopic investigation of 3 remarkable objects from the open cluster Collinder 394: post-MSTO object HD 174403 that is an eclipsing binary V4088 Sgr, Be-star HD 174652 and Cepheid BB Sgr. Till recently these objects were researched spectroscopically very poorly, but we have fill up the gap using the spectroscopic data obtained by SALT (South Africa) and TCO (North Carolina, USA) telescopes.

SUBSECTION "ASTROINFORMATICS"

FIRST RESULTS OF PROCESSING DIGITIZED V-PLATES TAKEN WITH THE TAUTENBURG 2M SCHMIDT TELESCOPE

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The process of treatment of about 500 digitized plates has started in MAO NAS of Ukraine. Plates were taken in the V-band of the Johnson color system with the Tautenburg 2m Schmidt telescope in 1963-1989. The plate reduction is carried out in the GAIA DR2 reference system. Linear dimensions of plates are 24x24 sm with a working field of 3.3x3.3 degrees and a scale of 51.4 "/ mm. Astronegatives were digitized on the Tautenburg Plate Scanner in five strips with linear dimensions of 5400x23800 px. The software developed in MAO NAS of Ukraine for the image processing of these scans takes into account the horizontal overlap and the vertical offset of strips. The photometric range of fixed objects is 12 magnitudes, around V = 7^m - 19^m, due to the separation of objects into faint and bright parts by their images' diameters.

REDSHIFT RECONSTRUCTION WITH MACHINE LEARNING METHODS FOR THE SDSS GALAXIES

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We estimate a data-driven approach as an option instead of traditional photometric techniques to determine distance moduli m-M to the galaxies. In our previous work (Elyiv et al., 2020, Astron. & Astrophys.), we worked with five machine learning regression techniques for inference of m-M: Linear, Polynomial, K-Nearest Neighbors, Gradient boosting, and Artificial Neural Network, and obtained RMS error 0.35 mag, which corresponds to relative error 16%. We compiled two samples of galaxies from the NED and limited velocities to 1500 km/s < VLG < 60000 (30000) km/s.

In this work, our target dataset consists of 464 208 galaxies at 0.2<z<1.0 from the SDSS DR14. We used key observable parameters such as the corrected Petrosian fluxes, Petrosian radii, inverse concentration index R50/R90 in g-, r-, i-, z- bands, color indexes g-r, g-i, g-z and celestial coordinates in 3-D cartesian representation as input explanatory variables for training and redshift as the target parameter. We tested the usage of five machine learning regressions (Linear, Polynomial, K-Nearest Neighbors, Gradient boosting, and Artificial Neural Network) to predict redshifts applying these observable parameters.

We found that usage of the ANN regression model with two hidden layers is the most effective. The obtained root-mean-square error for the calculated redshifts is equal to 0.046, corresponding to a relative error of 8%. The proposed model is complementary to the existing photometric redshift methodologies.

FON-DUSHANBE CATALOG. RESULTS OF PROCESSING IN THE TYCHO-2 SYSTEM

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In the Tycho-2 catalog system the processing of FON-Dushanbe plates from the collection of the Institute of Astrophysics of the Academy of Sciences of the Republic of Tajikistan was completed. Approximately 1560 plates with the size of 8º×8º (30x30 cm) were exposed in the period of 1985-1992 in the zones from -10º to + 86º. The plates were digitized using a Microtek ScanMaker 1000XL Plus scanner with the resolution of 1200 dpi, so the size of the digitized images is near 13000x13000 px. The average internal accuracy of the catalog for all objects is $\sigma_{\alpha\delta}$ = ±0.32" and σ_B = ±0.13^m (for stars in the range of B = 7^m -14^m the errors are $\sigma_{\alpha\delta}$ = ±0.20" and σ_B =±0.08^m) for equatorial coordinates and stellar B -magnitudes respectively. The convergence between our calculated and reference positions from the Tycho-2 catalog is $\sigma_{\alpha\delta}$ = ±0.12", σ_{BT} = ±0.19^m, and the convergence with photoe-lectric B-magnitudes is σ_B = ±0.16^m. The root-mean-square value of the difference between the coordinates of our catalog and the UCAC-4 catalog is $\sigma_{\alpha\delta}$ = ±0.40". Five astronomical institutions took part in the processing of the photographic plates and the creating of the FON-Dushanbe catalog: 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.

REREARCHES OF HOST STAR CHROMOSPHERIC ACTIVITY VARIATIONS IN EXOPLANET SYSTEMS HD 189733 AND HD 68988

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Some results for research of interactions between extrasolar giant planets and their parent stars based on variability of host star chromospheric activity are presented in paper. We used original photometrical data obtained for two exoplanet systems HD 189733 and HD 68988 with close giant planets having short orbital periods. Presumably such planets may cause chromospheric activity variations of host stars by resonance gravitational influence. Possible mark of chromospheric activity for sun-like stars is periodical variability of the most strong lines H CaII, K CaII and H-alpha. In photometrical observations it is possible to expect appearance of variability in B, R bands containing these lines, respectively.

Multicolor photometrical observations were carried out using telescope Celestron-14″ in BVRI Johnson filters at Lisnyky observational station (Kyiv). For exoplanet systems HD 189733 and HD 68988 it were obtained data during 2020 year (23 nights). Data processing was carried out using Maxim DL 4.60. Light curves were folded with exoplanet orbital periods 2.2 days (HD 189733 b) and 6.3 days (HD 68988 b), phase light curves are presented. Analysis of photometric time series in search for hidden periods was done by light curve and period analysis software Peranso. Estimates of the coincidence of found periods with exoplanet orbital periods and brightness variation amplitudes are made.

SOFTWARE FOR DETERMINING OF THE OPEN CLUSTERS 3D STRUCTURE

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Catalogs with an unprecedented level of accuracy were obtained as a result of the Gaia space mission. The use of data from these catalogs for the open clusters research allows clarifying of their star population and obtaining more accurate estimates of their parameters. The software, developed by the MAO Research Institute, uses astrometric data (proper motions and parallaxes) to determine the size, mean parallaxes, and proper motions of open clusters and their populations. The software can work with any modern catalogs that contain the necessary astrometric parameters. The ultimate goal of the software is to refine the population and study the 3D structure of open star clusters. This report presents the results of processing of the selected 40 clusters from the open clusters catalog (Dias +, 2002, CDS VII / 229) with current updates according to the catalogs GAIA DR2 and GAIA EDR3. The selected clusters are at distances not exceeding 1 kPs, because in this version only original parallax values are used as measure of distances. The algorithm for calculating and separating background and cluster stars in the selected sky areas is based on the assumption that the clusters stars have similar values of their proper motions and parallaxes. The calculation is performed by the method of confidence intervals by successive iterations. Analysis of the results obtained with the catalogs GAIA DR2 and GAIA EDR3 did not reveal statistically significant differences between the obtained data for the most of the selected clusters. Comparison with the data of the catalog (Cantat-Gaudin +, 2020, J/A+A/633/A99) mostly showed good consistency in distances and proper motions, but the population differs significantly in some cases. That leads to differences in other parameters. The probable reasons for such discrepancies and a detailed analysis of several clusters are given.

ANALYSIS AND REPROCESSING OF EARLY KYIV OBSERVATIONS OF ASTEROIDS WITH MODERN REFERENCE CATALOGUES

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Based on the results of processing all photographic observations of minor planets carried out in 1908–1995 at AO TSNU and MAO NASU, data were collected from publications and the MPC database. In total, more than 6,000 positions and magnitudes of asteroids have been cataloged. From the analysis of the collected data, different values of positional accuracy were obtained for different series of observations depending on the reference catalogue of stars.

Taking into account the high accuracy and representativeness of the new modern reference catalogues of stars, the possibilities of processing some of the earliest observations of asteroids are estimated.

As a result, using the catalogues Tycho-2, Gaia DR2, and Gaia EDR3 as a reference, 590 plates exposed on the MAO NASU Double Long-Focus Astrograph in 1951-1986 were reprocessed based on previous old measurements. All new and preceding asteroid positions were compared with the JPL ephemeris. The comparison results show a significant increase in the systematic and random components of positional accuracy for new asteroid positions compared to preceding positions. However, on the whole, the new positions of the asteroids determined in the Tycho and Gaia catalogue systems do not differ significantly from each other.

THE ALGORITHM FOR AUTOMATIC IDENTIFICATION OF ASYMMETRIC TRANSITS IN THE TESS DATABASE

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Currently, the Transiting Exoplanet Survey Satellites (TESS) searches for Earth-size planets around nearby F, G, K - dwarf stars. Analysis of High-quality light curves collected by this space mission ALLOWs potentially identify some specific variations in the star. Sophisticated data processing methods and analysis of the brightness curve shapes should be developed to solve the problem because of the vast data sets and the very weak manifestation of this physical phenomenon. We report some preliminary results of the work in progress to identify the minima in the star brightness from the TESS pipeline data collected in the MAST database. We discuss the developed code based on the Python package "lightkurve" (Barensten et al., 2019) for the processing of the short-cadence (2-min) TESS light curves. The code allows identifying minima in the light curves taking into account the specific variation of the light curves and some artifacts that pollute the data. The proposed results are intermediate and will serve for the identification of exocometary transits applying machine learning methods.

PRELIMINARY RESULTS OF THE SEARCH FOR ASTEROIDS AND COMETS ON THE PLATES OF THE TAUTENBURG OBSERVATORY (1963-1965)

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The search for small bodies images was carried out on the basis of photographic observations at the Tautenburg Observatory "Karl Schwarzschild" (TLS, [033], 11° 42'40.5"E, 50°58'48.5"N, h = 347,7 m). The observatory archive contains several thousand photographic plates (9213) filmed in 1963-1989 in UBVR bandwidths. The linear dimensions of the plates are 24x24 cm. The working field and the scale are 3.3 x 3.3 degrees and 51.4 "/mm respectively.

Approximately 200 photographic plates were selected and captured between 1963 and 1965 in the V Johnson color system. The reduction of observations was carried out in the GAIA DR2 reference frame. Internal reduction accuracy: rmsA ~ .04, rmsD ~ .05, rmsMg ~ .11. (O-C) differences for the asteroids positions identified on the plates were obtained from their comparison with JPL-ephemeris values.

As a result, a preliminary catalog (in the GAIA DR2 system) of 13 topocentric positions for 8 asteroids.

RADIOASTRONOMY

MONITORING OF THE INTERFERENCE SITUATION AT THE URAN-4 RADIO TELESCOPE

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In decameter radio astronomy, there are two problems that are not so critical at higher frequencies. This is a strong influence of the ionosphere on the characteristics of the received signals and a high level of interference. High levels of interference are also associated with the ionosphere. Due to the ionospheric propagation of radio waves, sources of radio interference can be located at a great distance from the point of radio astronomy observations. Therefore, the interference situation is associated with the state of the ionosphere, that is subject to daily changes, the influence of regular and spontaneous manifestations of solar activity. In recent years, there has been an increase in interference from remote sources. The share of broadband interference is growing. This is due to the development of new radio engineering systems and the use of digital methods in communications and radio broadcasting.

In addition to remote sources of interference, local sources of electromagnetic radiation contribute to the formation of an interference environment: radio transmitters, industrial and household electrical equipment. One of the ways to limit local interference is to establish a protective zone for the radio telescope, in which it is not allowed to create interference sources that can significantly worsen the conditions of radio astronomy observations. Unfortunately, radio astronomers, in their efforts to establish a protected zone, are deprived of regulatory state support and remain face to face with local authorities and government departments.

The organization of the observations, planning of the development and application of technical and software tools for countering interference, the establishment and observance of the protected zone regime of the radio telescope, require systematic monitoring and analysis of the interference situation.

This paper discusses the issues of monitoring the interference situation at the URAN-4 radio telescope, that located in the Belyaevka district of the Odessa region of Ukraine.

OBSERVATION CONTROL DEVICE FOR THE URAN-4 DECAMETER RADIO TELESCOPE

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Low-frequency radio astronomy is now widely developing. It is worth mentioning already built instruments such as Lofar, NenuFAR, the Uran interferometer system, UTR-2 and the GURT radio telescope under construction.

Most low-frequency instruments antennas are, of different design, phased antenna arrays with discrete control of the patterns. Each of these instruments is equipped with radiometers with a variety of receiving and recording equipment and systems for controlling the operation of radio telescopes.

Since 1986, the URAN-4 radio telescope has been operating at the Odessa Radio Astronomy Observatory of the RI of the National Academy of Sciences of Ukraine. The instrument is an element of a decameter long-base interferometer, the radio telescopes of which are located across the territory of Ukraine from west to east. The radio telescope consists of a 128-element phased array antenna with dimensions of 232.5 x 22.5 m.

The instrument operates in the 10 - 30 MHz range, and its receiving equipment is capable of separating two polarization components of the received signal. The radiation pattern of the radio telescope is 3 x 22 degrees at 25 MHz. In the interferometer mode, a resolution of 2 seconds is realized.

The instrumental complex of the radio telescope includes a device for controlling the operation of the instrument. Structurally, this device is made in the form of a separate unit, in which a board with an ATMEL 8515 microcontroller is mounted with registers and a communication circuit between the unit and a computer.The device carries out, at a given time during the observation period, a discrete movement in space of the antenna directional pattern, sets the required attenuation in the attenuator during calibration measurements. It also allows you to adjust the current time of the computer using GPS, controls the observation process.

All actions of the control device are carried out on the basis of the protocol of upcoming observations drawn up by the operator, as well as working programs: microcontroller programs, time adjustment programs and the main program itself, which controls the measurement process, recording the current working information and its visualization on the monitor screen.

SECULAR CHANGES IN THE FLUX DENSITY OF THE CAS A SUPERNOVA REMNANT, FROM CENTIMETER TO DECAMETER WAVELENGTHS

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The purpose of this work is to summarize a large amount of observational data about the secular decrease of Cas A flux in the radio range, as an indicator of physical processes both in the source itself and as a consequence of

the influence of the propagation medium. This paper presents results of observations Cas A and Cyg A on radio telescopes of International Radio Astronomy Center (Latvia), and URAN-4 phased array antenna (Institute of Radio Astronomy NAS of Ukraine). According to URAN-4 observations, there were seasonal–diurnal changes in Cas A/Cyg A flux ratios due to the effects of solar activity on the ionosphere, and there may be no secular decrease in Cas A flux density, or a weak tendency to decrease it. The significant influence of the ionosphere makes it difficult to use Cyg A as a reference source in the decameter radio range. In the centimeter radio range,there were episodic intra-day variations at the level 8–10% of Cas A averaged flux. Additionally, in the period January–February 2021, Cas A flux was about 1.7 times that of Cyg A. Taking into account the observed complex type of secular decrease in Cas A flux against the background of changes in space weather variations, further observations of Cas A were planned at radio observatories in Latvia and Ukraine.

NEAR REAL-TIME TOMOGRAPHY OF THE ATMOSPHERE ESTIMATION USING GPS, GLONASS AND GALILEO OBSERVATIONS

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The assimilation of zenith tropospheric delays (ZTDs) estimated using the observations of Ground Based Augmentation Systems (GBAS) of GNSS has a positive effect on the accuracy of the predicted meteorological parameters, such as relative humidity, surface temperature and cumulative precipitation.

In the cross-border region between Hungary, Slovakia, Romania and Ukraine a near-realtime GNSS processing facility has been realized to provide hourly ZTD estimates using the Bernese V5.2 GNSS software.

The available GBAS observations in the region stem from four different data sources, namely the IGS, the EUREF Permanent Network, the ZAKPOS permanent network of Ukraine and a Hungarian private network maintained by Infobex Ltd. Altogether the observations of 94 stations are routinely processed on an hourly basis to provide ZTD estimates with low latency for meteorological applications. The processing is done using GPS only, GPS/GLO and GPS/GLO/GAL observations.

The relatively dense GBAS network enables us to study the tomographic reconstruction of atmospheric water vapor distribution. A multiplicative algebraic reconstruction algorithm was developed in Matlab environment for this purpose aiming to provide vertical profiles of atmospheric water vapour distribution.

The paper introduces the algorithms and techniques applied in the automated ZTD estimation process and shows some preliminary results of orbit determination, ZTD estimation and the tomographic reconstruction of atmospheric water vapor in the HU-SK-RO-UA cross-border region. The effect of the application of various satellite systems is studies in terms of the uncertainty of the estimated ZTD parameters.

RADIO METEOR INFORMATION AND ITS PROCESSING

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Radar (radiolocation) astronomy on the one hand is a part of radio astronomy, and on the other hand differs from radio astronomy in that the latter is a passive observation and the former an active one. At the dawn of radio astronomy a British physicist and radio astronomer Sir Bernard Lovell (1913-2012) attempted to continue his studies of cosmic rays with an ex-military radar detector unit before constructed the then-largest steerable radio telescope in the world, which now bears his name: the Lovell Telescope. Radiolocation research with an ex-military radar detector by Lovell served as an impetus for the development of radar studies of meteors.

Today radar astronomy is a technique of observing nearby astronomical objects by reflecting microwaves off target objects and analyzing the reflections. With the use of radio technology in meteor research, we operate with meteor radio information. We do not consider the intrinsic radio emission of a meteor body (it is very small) in this work. We will talk about a radar method based on the property of a meteor trail to scatter radio waves. Radio meteor sounding and the study of the movement of meteor trails provide important information about the state and dynamics of the atmosphere at altitudes of about 100 km. It is possible to create meteor radio communication channels. Here the main attention will be paid to radar research in meteor astronomy. The program of the international project GLOBMET in the 80s of the XX century can serve as a good summarizing result of the development of meteor radar and meteor radio astronomy during 1950s – 1980s (Ovezgeldyev, Kashcheyev, Nechitaylenko 1986; Hocking & Kolomiyets 2020; etc.). During this period and subsequently, various information technologies were developed and applied to the processing of radio meteor data (e.g., Voloshchuk, Kashcheev, Tkachuk, 1982). Having paid the necessary attention to historical aspects, we will focus on the description of methods, algorithms and programs for processing and interpreting radio meteor information for general and specific cases.

NEW DETECTIONS IN THE SECOND DECAMETRE PULSAR CENSUS AT UTR-2 RADIO TELESCOPE

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Last year, we announced the start of the second decametre pulsar census. It should be recalled that at the beginning of 2020 there were 163 pulsars potentially available for UTR-2 radio telescope (with rotation period more than 100 ms, the dispersion measure value up to 30 pc/cm^3, declination $\delta > -10°$). Compared to the first census, the accumulation time for each pulsar was doubled (from 90 to 180 minutes). At the first stage of the second pulsar census a necessary to refine rotation periods arose and this parameter for PRS J1426+52 was specified. This is due to the fact that for many pulsars (especially recently discovered at higher frequencies ones) their parameters are measured with a low accuracy (in particular, the dispersion measure values and rotation periods) or aren't measured at all (flux densities, pulse widths etc.). A need to clarify the rotation period of pulsars has led to the modernization of our searching pipeline for data processing. In addition to PSR J1426+52, decameter radio emission of two more pulsars was detected at the same time (at the first stage of census).

In this work, we present new results of further rotation periods refinement, measurement of dispersion measure values and other parameters of pulsars, detected on UTR-2 radio telescope. In addition, we discuss the prospects of pulsar research with a longer accumulation time and further improvement of data processing pipeline. At this stage, rotation periods of all pulsars for which this parameter is measured with low accuracy (less than 6-7 significant digits) are refined, the dispersion measure values are actually searched in a wide range. The flux densities, pulse widths of detected on decameter waves pulsars, scattering time constants for strong pulsars are measured etc.

SIMULTANEOUS OBSERVATIONS OF IONOSPHERIC SCINTILATION WITH SPATIALLY SEPARATED URAN RADIO TELESCOPES

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The amplitude and phase fluctuations of an incident electromagnetic wave field are observed upon diffraction by a plasma layer with inhomogeneities of electron density. This phenomenon is observed in the interstellar medium, interplanetary plasma, and in the Earth's ionosphere. Of them namely the ionosphere has the strongest effect on an accuracy of radio astronomy observations at decameter waves. In this work we studied temporal and spatial characteristics of ionosphere scintillations to determine their relationship with terrestrial phenomena and the space weather. For the purpose, simultaneous observations of powerful extended radio sources were carried out: the radio galaxy Cygnus A and the supernova remnant Cassopeia A using radio telescopes of the URAN network. These radio sources due to their large angular size do not scintillate on the irregularities solar wind plasma, that excludes the influence of interplanetary medium on the study. The observations were carried out at frequencies of 20 and 25 MHz using the URAN-1 and URAN-4 radio telescopes spaced 650 km. The large distance between telescopes allows distinguishing local factors, such as atmospheric fronts, from external causes associated with the space weather, which influence the scintillation level. Preliminary results of data processing of these observations, as well as an analysis of archived data of the URAN network are presented in the report. It is found in some cases that an increase of the scintillation index measured at separated sites coincides in time with shock waves in the interplanetary medium detected by satellites at the Earth's orbit.

PROCESSING OF RADIO ASTRONOMY SIGNALS IN CONDITIONS OF SHORT-TERM INTERFERENCE

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The development of technology for constructing antenna arrays and hardware for receiving and processing signals in radio astronomy made it possible to carry out observations in very wide frequency bands, which are often covered by the out-of-band radio emission of television transmitters, communication systems, navigation and other sources of artificial origin. Radio astronomy shares most of the bands with active services that transmit signals for various purposes. The most severe interference situation occurs in the decameter wavelength range, which is used by systems of broadcast, digital data transmission and remote sensing.

Since the intensity of radio astronomy signals is low compared to signals from active services, radio astronomy observations are very susceptible to radio interference. The criterion for determining the intensity at which an interfering signal is considered unacceptable is the level of unwanted radio emission, which leads to an increase of 10% in measurement errors compared to errors due to system noise alone.

Possibilities of algorithms for compensation of short-term interference in tasks of radio astronomy for systems of radiometry and radio interferometry are considered. A method for reducing the computational complexity of algorithms by implementing them on lattice filters is proposed. Requirements for the volume of the training sample of interference are determined when adapting signal processing systems to suppress short-term interference with an unknown shape of the spectrum. It is shown that the application of the proposed algorithms based on lattice structures can significantly reduce the amount of computations and suppress correlated short-term interference to the level of internal noise of the receiving system.

THE METHOD FOR RT-32 RADIOTELESCOPE ERROR MATRIX CONSTRUCTION IN AUTOMATIC MODE. AUTOMATIC ASSESMENT OF TRACKING ERRORS

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On March 15th, 2021, scientists of the National Space Facilities Control and Tests Center and the Radio Astronomical Institute of the National Academy of Sciences of Ukraine by the Ukrainian new generation radio telescope RT-32 (Zolochiv, Lviv region) have observed and successfully recorded the extragalactic radiation of radio galaxy 3C84 (Perseus-A), masers from the galactic molecular cloud W3, radio emission of methanol maser from the galactic radio source G188.946 + 0.886. These researches were performed in order to prepare for the implementation of a joint Ukrainian-Latvian radio astronomy project lzp-2020/2-0121.

The results of the observations confirmed the world level of RT-32 radio telescope characteristics, the efficiency of the primary error matrix and revealed several shortcomings in the tracking system functioning. In particular, the primary tracking error matrix has insufficient discreteness, contained errors of the first and second types.

There is presented the method of automatic construction of the radio telescope error matrix according to the data of a radiometric receiver and receivers-recorders (another types of data). The method provides automatic processing of the obtained radiometric data. The results of verification of the developed method with the use of reference radio sources and the elements of tracking errors matrix by the elevation and azimuth that obtained are presented. Application of the developed method to the radio telescope control system allowed to increase the aiming accuracy of the RT-32.

THE BULGARIAN LOFAR PROJECT

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Until recently, although an interesting and popular field of science, radio astronomy had a relatively small share in the space exploration sciences in Bulgaria. The main reason for that underrepresentation was the lack of proper instrumentation, requiring large governmental funding and support. With the help of recently granted resources from EU and Bulgarian governmental initiatives, a large LOFAR array is under construction. The present paper describes the core of the project along with some local specifics.

PROPERTIES OF INTRA-DAY VARIABILITY OF THE RADIO GALAXY PERSEUS A (3C 84) ACCORDING TO COORDINATED OBSERVATIONS IN LATVIA AND UKRAINE WITH RT-32 RADIO TELESCOPES IN THE 4.5 - 8.8 GHZ RANGE

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Radio galaxy (Sy II) NGC 1275 (also known as radio source 3C 84 or Per A) is the most massive central galaxy in the Perseus cluster. Interacting with the galaxies of the cluster and the enormous gas envelope, the 3C 84 nucleus exhibits extreme activity from gamma to radio range. In the gamma and X-ray ranges, the 3C 84 has irregular flashing activity with timescale from 1 to 2 hours. In the optical range, since the 1970s, various authors have carried out a huge number of observations multicolor photometry of the nucleus of the galaxy NGC 1275, and it has been shown that the radio galaxy has different phases of variability, during which the characteristic time of brightness variations varied from 12-15 days to 63. However, in the radio range, there are very few data about rapid variability of 3C 84 in the literature. There was practically no data and long-term observations in order to find and reliably register intra-day and inter-day variability episodes. For this purpose, within framework of the research grant no. Izp - 2020 / 2-0121 "Coordinated research of the peculiar radio galaxy "Perseus A" in radio and optical bands" many sessions of coordinated observations of the radio galaxy Per A were carried out on the RT-32 and RT-16 VIRAC radio telescopes, (Latvia) and on RT- 32 of Ukrainian National Space Facilities Control and Test Center in Zolochiv city. The observations were carried out in the centimeter radio range (4.5 - 8.8 GHz). We also used data of observations of ionosheric scintillations the Per A flux, carried out on the decameter radio telescopes UTR-2 and URAN-4 (IRA NASU) in the frequency range 10 - 30 MHz.

STUDY OF VARIABILITY PROPERTIES OF PECULIAR EXTRAGALACTIC RADIO SOURCES WITH FEATURES OF DOUBLE NUCLEI

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During implementation of project lzp-2020/2-0121 "Joint Latvian-Ukrainian study of peculiar radio galaxy "Perseus A" in radio and optical bands" by means radio and optical observations in Latvia (VIRAC) and Ukraine (IRA

NASU), properties of rapid intensity variations of radio source Perseus A were determined, which have been insufficiently studied earlier. Especial interesting are properties of previously unrecorded short-periodic variations in radio flux of this Seyfert galaxy, obtained independently on radio telescopes in Latvia and Ukraine. Those were low amplitude variations with characteristic time about 40-120 minutes. The nature of discovered effect has not yet been determined. Therefore, further studies require observations of similar objects in galaxy clusters which potentially contain double black holes. Another important task is separate intrinsic variability and rapid variations caused by atmospheric gravitational waves that create moving ionospheric disturbances with close periods. This requires intensive monitoring using optical and EVN observations of unique objects of this type (CygA, VirA, 3C454.3). These sources have special type of jet structure, with stationary components. This will make it possible to clarify the nature of physical processes in radio sources with anomalous activity. Continuation of this theme with longer observations will provide new information about radio galaxies and will expand scientific cooperation between Latvia, Ukraine and the EU.

IONOSPHERE VARIABILITY AS A TOOL FOR PULSAR ROTATION MEASURE SIGN DETERMINATION

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The UTR-2 radio telescope, which detects radio emissions in the 8-33 MHz band and has an effective area of 150 000 m^2, can be used to study a variety of signals. Our group uses UTR-2 to search for anomalously intense pulses of pulsars and to study their characteristics. In previous works, a method for determining the absolute value of the rotation measure in the pulsar direction using the detected anomalously intense pulses with the Faraday effect manifestation was presented. This effect is a consequence of the influence of the longitudinal magnetic field present in the propagation medium on linearly polarized radiation; the characteristic of this influence is the rotation measure. To estimate the Faraday effect, we use data recorded by dipoles with one linear polarization, which make up the UTR-2 radio telescope. Registering radio emission with a high level of linear polarization that has passed through a medium with the magnetic field component longitudinal to the line of sight, we see the stripes of intensity modulation with frequency in the dynamic spectrum. This effect can be seen in the decameter range and allow us to determine not only the average absolute value but also the instantaneous values of the rotation measure depending on the pulse phase.

Unfortunately, we cannot determine the direction of rotation of the linear polarization plane using a radio telescope with one linear polarization. To determine the sign of the rotation measure, which characterizes the direction of rotation, a method of observations and taking into account the ionospheric contribution to the total value of the rotation measure was proposed. We can determine the sign of the rotation measure using a comparison of the estimates of the rotation measure absolute values from pulsars observations held in day and night time or winter and summer time, which will have different contributions due to the different ionosphere states. In order to prove the concept several sessions of pulsars observations during the day and night time have been held.

THE UTR-2 LOW FREQUENCY NORTHERN SKY CONTINUUM SURVEY. Part III

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We present maps of the Northern sky survey, which were not previously included in the UTR-2 Survey Part 1 On the maps, this region of the sky covers the coordinates:19^h < R.A. < 24^h, and $+29°$ < Dec. < $+55°$. These radio continuum observations were made with the UTR-2 radio telescope at five very low frequencies 12.6, 14.7, 20 and 25 MHz. The maps include a section of the Galaxy disk and its surroundings. This is a difficult region of the sky to observe due to the proximity of the most powerful radio sources Cassiopeia A and Cygnus A. The main observational parameters are briefly discussed.

PROPERTIES OF THE LOW-REDSHIFT ISOLATED GALAXIES WITH ACTIVE NUCLEI IN THE RADIO SPECTRAL RAHGE

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We consider properties of 36 isolated galaxies with active galaxy nuclei (isolated AGNs) in the northern sky ($\delta \geq -15\circ$). The sample was obtained by cross-matching the 2MIG (2MASS isolated galaxy) catalogue with the V'eron-Cetty catalogue of quasars and AGNs limited to Ks ≤ 12.0 mag and Vr < 15 000 km/s. The multiwavelength physical properties were studied by us in optical, UV, IR, radio, and high-energy spectral range using various databases and archive of ground-based and space missions. In this report, we accentuate on their parameters in radio bands, which were obtained at different radiotelescopes.

We derived the available measured radio fluxes at 1.4 GHz or at 5GHz for 31 of 36 the 2MIG isolated AGNs in the northern sky. The parameters of radio fluxes at 1.4 GHz are mostly in the range 6-20 mJy, several galaxies have 60-100 mJy (NGC5664, NGC6951, NGC7479) as well as 7 isolated AGNs have fluxes < 4 mJa. We calculated R-ratio of radio to optical flux density and note that Kellermann et al. (1989) used the flux at 5 GHz for calculation of R-ratio. Because of only 3 of 31 the 2MIG isolated AGNs have the measured fluxes at 5 GHz, we used the radio flux at 1.4GHz for calculation of R-ratio. It is an interesting fact that 29 of 31 isolated 2MIG AGNs with the measured radio fluxes are the radio quiet ones (R < 10) and two galaxies, NGC 5664 and UGC10774, are the

radio loud (R = 14.71 and 18.75, respectively). This result for radio loud objects should be confirmed because of a typical radio flux at 5 GHz is smaller than at 1.4 GHz.

We present these results in contest of possible monitoring observational program of these objects at the RT-32 (Space Research and Communication Center of the National Space Facilities Control and Test Center, State Space Agency of Ukraine, Zolochiv town, L'viv region, Ukraine) and other radiotelescopes.

ON THE PERSPECTIVES FOR SEPARATING THE CONTRIBUTION OF THE NUCLEUS AND THE JET TO THE RADIO VARIATIONS OF ACTIVE GALACTIC NUCLEI BASED ON DATA FROM MONITORING PROGRAMS AND VLBI OBSERVATIONS

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In a significant part of the work devoted to the study of the variability of radio emission of the active nuclei of galaxies, the variability of the flux from the entire radio source is analyzed. By means of wavelet analysis in the works, a detailed analysis of the main periods of variability of the results of the MIchigan review of variations in the fluxes of extragalactic radio sources at frequencies 4 . 8, 8 and 14.5 GHz over a period of more than 40 years. The catalogue of variability of radiogalaxy and quazars 3C120, 3C273, 3C279, 3C286, 3C345, 3C446, 3C454.3, BL Lac, CTA 102, DA 55, OT 281, OJ287 has been made public. VLBI MOHAVE observation data contain information about radio core fluxes at 14 GHz. These data make it possible to separate the contribution of the nuclear component and the jet to the variability of radio sources.A comparison of the main periods present in the nuclear component and the jet at different phases of manifestation of activity is carried out.At the same time, a number of radio sources under study are characterized by different periods for the nucleus and jet: 3S120 (core 2.1 years, jet 5, 1.5, 1, 0.58 years), 3S273 (core - 4 and 2 years, jet - 2.6 and 1.5 years), 3S454.3 (core - 2.3 and 6.4 years, jet - 2.6 and 1.3 years). A comparison of changes in the angular structure of the jet by VLBI observations and the main periods of variability is carried out.

SOLAR ACTIVITY, SOLAR-TERRESTRIAL RELATIONS, ASTROBIOLOGY

CONNECTION OF THE INTENSITY OF THE FLUX OF SCR PROTONS WITH THE VELOCITY OF THE CME AND WITH THE FADING OF THE RADIO EMISSION OF THE SUN IN THE DECAMETER RANGE

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The relationship between SCR and CME and with fading of the continuum of noise storms and type IV radio bursts in the decameter range is investigated. It was shown earlier that about 60% of CMEs associated with solar proton events are accompanied by deep fading of the solar radio emission in the decameter range, which coincides in time with CME registration. It has also been shown that fading is characterized by fading depth, the frequency bandwidth in which the fading occurs, as well as the duration of the fade and the frequency at which the maximum fading depth is observed.

Further detailed studies have shown that for proton events accompanied by fading of the solar radio emission in the decameter range, the relationship between the intensity of the SCR proton flux and the CME velocity is much worse than for events without fading of the solar radio emission in the decameter range. However, it was found that for such events, the relationship between the flux of SCR protons and the CME velocity significantly increases if we take into account the fading depth of the solar radio emission in the decameter range.

ON THE CHARACTER OF DRAG OF THE INTERNATIONAL SPACE STATION IN DIFFERENT PHASES OF THE 24TH SOLAR CYCLE

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The analysis of the ISS drag data during the period from 2009 to 2019 years was carried out. In the analysis the B-star drag term was applied. This coefficient reflects the influence of changes in the state of the atmosphere on the movement of artificial objects in the Earth's orbit. The correlation analysis of the B-star drag term with the indices of solar and geomagnetic activity at different time intervals of 24 solar cycle activity was carried out. The time periods of the ISS movement when they were not made significant adjustments to the station's orbit and the reception of planned missions were selected. The analysis of changes in the ISS drag, using data on solar and geomagnetic activity, including episodes of strong drags and periods regular of changes was carried out. The main periods of the drag at different phases of the solar cycle and their possible causes are considered.

ON THE RELATIONSHIP OF TEMPORARY CHANGES IN THE GEOMAGNETIC FIELD AND TEMPERATURE ON THE EARTH'S SURFACE WITH SOLAR ACTIVITY

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According to experimental studies from the second half of the 20th century to the present, the geomagnetic field and temperature on the Earth's surface are characterized by significant changes. Of course, these changes may be due primarily to solar activity. The article presents the results of the analysis of changes in the geomagnetic field and temperature on the Earth's surface, as well as their time gradients due to solar activity in 19-24 cycles. It has been established that the decrease in the B_{IGRF} field on the planet's surface by 1800 nT, and the increase in temperature by 1°C are in good agreement with the decrease in solar activity from the 19th cycle to the present. The connection of time gradients of geomagnetic field and temperature with 11-year and 22-year (Hale) cycles of solar activity is revealed.

"STRUVE ARC" AS INDICATOR OF THE MANIFESTATION OF SOLAR AND GEOMAGNETIC ACTIVITY

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Struve's geodetic arc was famous project in past, related to study shape of the Earth. This is example of great cooperation between scientific teams of many countries, from Norway, Finland, Baltic countries to Ukraine, Moldova. From point of view of modern research, it is interest to study response Latvian-Ukrainian element of Struve Arc, to solar activity and tidal phenomena in the Earth's upper atmosphere, based on results of simultaneous radio astronomy and geomagnetic observations. Importance and relevance of this topic is especially in era of possible climatic variations in mid-latitude region and appearance of extreme solar activity in 25th cycle. In proposed project, planned to use Ukrainian low-frequency antenna arrays for joint study of ionospheric response (ionospheric scintillations and

seasonal diurnal, as well as tidal effects in mid-latitude ionosphere) with low-frequency antenna LOFAR-Latvia. Special feature, will be placement precision fluxgate magnetometer on territory of Ventspils Radio Astronomy Centre, to register short-periodic geomagnetic variations caused by ionospheric currents. This will allow not only make study, for first time, response of upper ionosphere over Latvia to solar activity at ongoing new 25th cycle, but also to lay foundations for Latvian space weather service, based on radio-geomagnetic measurements in cooperation with Radio Astronomy Institutes, Geophysics Institutes and Phys- Mechanical Institutes of NAS of Ukraine, which have long experience in solar-terrestrial relations.

ABOUT FEATURES OF GEOMAGNETIC FIELD VARIATION IN THE ZONE ODESSA MAGNETIC ANOMALY IN QUIET AND DISTURBANCE CONDITIONS SPACE WEATHER

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Measurements of the geomagnetic field were carried out at the Astronomical Observatory of the ONU. I.I. Mechnikov, which is located in the central area of the magnetic anomaly. For measurements, a precision ferrosond three-component magnetometer LEMI-008 developed by the Institute of Space Research of the National Academy of Sciences of Ukraine was used. Observations were carried out continuously from November 2017 to July 2019, with 1 second resolution.

Preliminary analysis of observations showed the predominance of quasi-harmonic and irregular pulsations with amplification or attenuation within the daytime. During magnetic storms, irregular variations are usually observed with a wide spectrum from 5 to 30 minutes with the highest amplitude in the band of 15 - 30 minutes. Sometimes stable quasi-harmonic variations are observed in sum with irregular, in the form of separate short-term bursts on different time scales. In the days of a calm and slightly stimulated geomagnetic field, long-term quasi-harmonic variations prevail in the band of 15 - 30 minutes, and on some days in the band of 5 - 15 minutes, less often this strip is filled with irregular variations. Variations with periods of less than 5 minutes most likely reflect the contribution of technological interference and noise of the city and cannot be considered reliable.

A cycle of measurements of variations in the geomagnetic field in the center of the Odessa regional magnetic anomaly demonstrated the promise of such studies to clarify the features of variation in the fluxes of cosmic radio sources in the decameter range reflecting the state of the ionosphere.

SOLAR SYSTEM AND SPACE ENVIRONMENT

RESULTS OF CLARIFYING OF ORBITAL ELEMENTS OF LOW-ORBIT SATELLITES BY MODERNIZED DOPPLER STATION OF THE RI "MAO"

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To reduce the error in determining the frequency and time by the Doppler station created in RI "MAO", the standard reference signal of the receiver RTL2832U with a frequency of 28.8 MHz was replaced by a signal generated by a specially designed synthesizer. The synthesizer contains a 28.8 MHz quartz oscillator, the frequency of which is adjusted to the frequency of the 10 MHz signal of the GPS receiver ThunderBolt-E using a phase-locked loop. The 10 MHz signal of the GPS receiver is also used to generate a pilot signal: 1 Hz packages of video pulses with a frequency of 100 kHz, which are fed to the antenna input of the station and synchronized using the pulse-per-second signal of the GPS receiver. Software for determining the frequency and time using the pilot signal was developed and implemented. The internal relative error in determining the frequency has been estimated which did not exceed 10^{-10}. The internal error of time determination did not exceed 30 ms. The report presents results of clarifying the orbit elements of low-orbit satellites obtained by the modernized Doppler station. The results are compared with the data of space-track.org.

ASTROMETRY AND PHOTOMETRY OBSERVATIONS OF THE TROJAN ASTEROID (624)HEKTOR IN LISNYKY

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As NASA plans the Lucy space mission to the Trojan asteroids, comparative ground-based and space-based photometry is important to calibrate further ground-based photometric observations. In September -October 2020 we observed asteroid (624) Hektor with a 0.7-meter (f/4) reflector AZT-8 and FLI PL-4710 CCD camera at the Lisnyky observatory station (Code MPC – 585). During the three nights, 147 images were obtained, of which 123 were selected for astrometric and 93 for photometric measurements.

The orbit of (624) Hektor and the errors (O-C) for both coordinates (RA and Decl.) were determined using *Find Orb*, combining our own observations with those of other observa-tories from the Minor Planet Center (MPC) database for the past 2 years. For 2020-09-16 (30 obs.) the (O-C) RA residual is $-0.650 \pm \sigma\ 0.312''$, the (O-C) Decl. residual is $0.247 \pm \sigma\ 0.234''$; For 2020-10-05 (33 obs.) the (O-C) RA residual is $-0.404 \pm \sigma\ 0.159''$, the (O-C) Decl. residual is $0.433 \pm \sigma\ 0.182''$; for 2020-10-14 (60 obs.) the (O-C) RA residual is $0.082 \pm \sigma\ 0.092''$ and the (O-C) Decl. residual is $0.346 \pm \sigma\ 0.055''$. Observations with O-C errors less than 0.5" were selected for inclusion in the MPC database. Astrometric observations are published in M.P.S. 1351729-30.

Based on the photometric observed data, the physical parameters of (624) Hektor were calculated, namely: visible brightness (average value 2020/10/05 – 14.00^m and 2020/10/14 – 13.76^m), absolute brightness (7.92^m). As a result of the asteroid's rotation and its elongated shape, the visible surface decreased in this range – D 220km – 194 ± 28km (2020-10-05), respectively 2020-10-14, the visible surface (phasa) decreased in the range of 241km – 185 ± 28km. The geometric albedo was 0.021 – 2020-10-05 and 0.024 – 2020-10-14 and the surface temperature was 119.7K. Our results of physical parameters are in good agreement with the results of other researchers in the database Asteroids with Satellites Database-Johnston's Archive.

MULTISITE SIMULTANEOUS RSO PHOTOMETRY TO CHARACTERIZE THEIR ROTATION STATE

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The photometry of resident space objects (RSO) makes it possible to determine their state of rotation around the center of mass, orientation of the rotation axis and rotation speed in the most cost-effective manner. However, the methods for determining the attitude parameters from photometric data from a single observation site (OS) require long series of high-quality measurements. We propose a method for determining the orientation parameters of rotating RSO based on simultaneous multi-site photometry with a high temporal resolution. Preconditions for planning and building a local photometric network that can accomplish such a task have been tested via computer simulation. Synchronous network-based photometric observations acquired by three or more OSs enable us to calculate time lags between correlated light-curve segments and promptly determine the direction of rotation, as well as the spatial orientation of a SO's spin axis and its angular spin rate. A local network of several distributed observation sites for synchronous monitoring of the rotation of various SO in LEO will make it possible to determine the rotation parameters of also slowly rotating objects even that do not exhibit glints within their light curves.

NSFCTC'S SENSORS FOR SPACE SURVEILLANCE – RESULTS OF WORK IN 2020-2021

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The report presents the results of the sensors of the National Space Facilities Control and Tests Center (NSFCTC) of the State Space Agency of Ukraine both in the interests of the national space monitoring and analysis system and international programs. In particular, it represents the Near-Earth Objects observations for Minor Planet Center of International Astronomical Union and space debris observations in the campaigns of the Inter-Agency Space Debris Coordination Committee (IADC). The results of work on the development of ground infrastructure for the monitoring of outer space of the NSFCTC by modernizing existing and creating new sensors are highlighted.

ORBITAL ELEMENTS CATALOG OF GEO SATELLITES BASED ON OBSERVATIONS AT RI MAO IN 2020-2021

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Due to the uniqueness and importance of the geostationary orbit region, it is necessary to continuously track the working spacecraft and known objects of space debris. A regularly updated catalog of orbital elements can significantly help in solving this problem. Optical observations of 149 geostationary satellites (GEO) were carried out using Fast Robotic Telescope (F=1500 mm, D=280 mm, FOV=1.4°×1.4°) in RI "MAO" during 2020-2021. A combined method was used for CCD observations. Catalog of GEO orbital elements in TLE format was generated based on topocentric equatorial coordinates. Orbital elements was calculated by software developed in Astronomical observatory of Odessa National University and FindOrb software. Analysis of observational and orbital data quality was performed. The mean square error of observations of the GEOs in the magnitude range (9–14)^{mag} was ±0.5″ in right ascension and declination. Measured positions and computed orbital elements were compared with precise ILRS data. Obtained Orbital elements in TLE format were represented on Ukrainian Optical Station Network (UMOS) website.

PECULIARITIES OF OBSERVATIONS OF SATELLITES ON MOLNIYA-LIKE ORBITS

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Molniya orbits are typical highly elliptical orbit (HEO) orbit with inclination of about 65°, high eccentricity of about 0.7 and periods of one-half day. Most of the satellites on the HEO orbits are old rocket bodies and other space debris. Objects on as highly elliptical orbit are very danger for LEO satellites and for people in case of a fall because of increasing velocity near the perigee. The situation is complicated by the fact that the NORAD catalog does not contain the orbital elements for many of these objects.

This report is dedicated to observation of space debris on Molniya-like orbits with purpose of their reentry prediction. Six Molniya-like satellites were successfully observed at RI MAO during May-July 2021. The orbital elements for some of these objects are not presented in NORAD catalog. The estimates of the accuracy of the obtained positional observations are given. The mean square errors of position were ±(1.0–3.0)″ in right ascension and declination for the objects in (8–11)^{mag} range. Orbital elements of these satellites were calculated using FindOrb software and software developed in Astronomical observatory of Odessa National University. Orbital elements in TLE format were represented on Ukrainian Optical Station Network (UMOS) website.

PHOTOMETRIC OBSERVATION OF COMET C/2017 K2 (PANSTARRS) WITH THE AZT-8 TELESCOPE AT OBSERVATION STATION LISNYKY

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The comet C/2017 K2 (PANSTARRS) was active at the time of its discovery in May 2017. This comet is an Oort cloud comet with a hyperbolic orbit, discovered at a distance beyond the orbit of Saturn when it was 16 AU from the Sun. C/2017 K2 will approach its perihelion in December 2022. The long-term monitoring data is very valuable and helpful for studying the activity mechanism of C/2017 K2. We observed comet C/2017 K2 (PANSTARS) from September 29, 2017 to July 8, 2021. Photometric observations of the comet were conducted with the V and R broadband filters centred at 5450 Å and 6460 Å, respectively. We obtained over 700 images of the comet while monitoring comet C/2017 K2. The images were obtained during 35 observing runs at the 70 cm AZT8 telescope (observation station Lisnyky of the Astronomical Observatory of Taras Shevchenko National University, Ukraine). 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. Three fixed linear apertures of $ra_1 = 2000$ km, $ra_2 = 5000$ km and $ra_3 = 10000$ km were chosen to measure the brightness of C/2017 K2 respectively. Some physical parameters were determine from photometric observations. A detailed analysis of coma morphology was made.

RESULTS OF OBSERVATIONS OF NEW DISCOVERED NEAs DURING CLOSE APPROACH TO THE EARTH

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Current investigation is devoted to ongoing follow-up observations of fast-moving Near-Earth Asteroids (NEAs) carried out with RDS CCD technique on small-aperture telescopes in China and Ukraine. The observations were obtained during close approach to the Earth in order to get more observational points and extend observational arc for new discovered NEAs when high-precision astrometry is required (necessary) to determine and improve the orbital elements. The astrometric results of NEAs observations, including new discovered one, are presented and analyzed in order to refine their orbits. The comparative analysis of astrometric and ephemeris positions were done regarding to JPL's HORIZONS system and NEODyS-2 service. The residual differences (O-C) often show high values for newly discovered NEAs during observation date as well as big differences between ephemerid positions of mentioned services. The data for such NEAs is presented.

DETERMINATION AND ANALYSIS OF DISTRIBUTION OF COMETS OF THE SOLAR SYSTEM

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The work is devoted to the topical topic of statistical analysis of the spatial distribution of parameters of cometary orbits to confirm the hypothesis of the existence in the interplanetary space of a system of stable orbits, for which all elements are subject to some deterministic pattern. Estimates of its characteristics are obtained, and histograms act as information carriers on the distributions of the elements of the orbits of comets in the solar system.

USE OF THE MAIN SPHERICAL MIRROR IN TELESCOPES WITH COMPLEX OPTICAL SYSTEMS

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In this talk, we discuss a possibility of replacing the main telescope mirrors with surfaces of the second order and having different eccentricities with a spherical one with zero excentricity using planoidal mirrors with a surface of higher orders.

MONITORING OF THE ORBITAL COORDINATES OF ARTIFICIAL SPACE OBJECTS WITH UKRAINIAN NETWORK OF OPTICAL STATIONS

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We report on the state and efforts of the Ukrainian network of optical stations (UMOS) in recent years in the field of astrometric and photometric observations of artificial space objects for Low Earth Orbit (LEO) and Geostationary Earth Orbits (GEO).

UMOS was established in 2012 as a joint partnership of organizations interested in satellite observations for scientific purposes and practical monitoring. The main purpose of the UMOS is to combine scientific and technical means and regular optical (positional and/or non-positional) observation of objects in Earth orbits. The UMOS maintains its own "partial" catalog of the current osculating orbits of resident space objects (RSO), maintains operational interaction with the Space Observation Center of the State Space Agency of Ukraine.

Statistic information is done in a form of the tables and graphs. We developed a method of the photometric synchronous observations from several points (observatories) to improve accuracy of RSO attitude determination and practical use it.

The low level of financial support of governmental scientific organizations and the lack of understanding of the importance of Ukraine's awareness of the space situation at the level of senior administrations almost stopped the development of space research. It is needed to be refreshed.

THE ANALYSIS OF OPTICAL MEASUREMENTS EXCHANGE FORMATS IN THE SPACE SURVEILLANCE AND TRACKING DOMAIN

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The quantity of objects on the Earth orbit has been steadily increasing. ESA estimate the number of objects with the size lager than 1 cm about 750000. Every of these objects can damage or destroy other satellites, creating yet more fragments. Space Surveillance and Tracking (SST) comprises of technologies for detecting and cataloging of near-Earth objects and predicting of their orbital motion properties. Each SST system developed its own standard in the measurement exchange domain of space object tracking data. These standards are implemented as observation data message exchange formats.

In this work, we discuss the exchange formats of tracking data message in the context of optical measurements of space object visible positions. Last decade, the following formats are wide used in Ukraine for exchange of measurements:

- RES (or Telegram) – format for observation exchange in the International Scientific Optical Network (ISON),
- MPC-1992 – format for observation exchange with using Minor Planet Center (MPC),
- MEA – format for observation exchange and storage in The Ukraine Network of Optical Stations for near-Earth space research (UMOS),
- CKKP – the set of similar formats for observation exchange and storage in Space Monitoring and Analysis System of State Space Agency of Ukraine (SMAS).

The Consultative Committee for Space Data Systems (CCSDS) recommends the Tracking Data Message (TDM) format for exchange of tracking data between space agencies and observation networks.

In this work we consider:

- how the measurement exchange mechanism is implemented in RES, MPC-1992, MEA, CKKP, TDM formats,
- what problems in the interpretation of measurements occur as a result of the measurement exchange between two or more storages.

We propose the ways of solving the problems in measurements exchange between several storages.

USING PHOTOMETRIC DATA TO DESCRIBE THE BEHAVIOUR OF OBJECTS IN GEOSTATIONARY ORBIT

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One of the challenges of satellite characterisation is the ability to not only determine the spacecraft orbit, but also satellite operating status, orientation, size, bus type, and material properties. Positional observations allow us to determine and/or update orbital elements of satellites, but they do not afford an insight into the behaviour of a satellite in orbit.

The article discusses the results of solving the inverse problem of astrophysics. How you can use photometric, astrometric information about a satellite, its lighting conditions, supplemented by additional information, to understand the behaviour of a satellite in orbit. The results are shown using examples of four satellites in geostationary orbit. An algorithm for calculating the photometric and dynamic characteristics of geostationary objects is provided.

DYNAMICAL PROPERTIES OF BASALTIC ASTEROIDS OUTSIDE THE VESTA FAMILY

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Through numerical modeling, Nesvorny et al. (2008) showed that asteroids can migrate due to Yarkovsky drift and resonances to outside of the boundaries of the Vesta family.

We perform photometric observations and determine spins and shapes of V-type objects in Cell I and Cell II in order to characterize the dynamical properties of these asteroids more accurately. The results of dynamical modelling show that some asteroids may have migrated to their current location from the Vesta family within ~2 Gy. There are objects, however, whose origin in another parent body may also be plausible. This may support the hypothesis that the number of differentiated basaltic objects in the inner and middle Main Belt should be much higher than previously assumed.

Numerical integration for ~10 asteroids in Cell I and Cell II performed in different variants allowed us to estimate the maximum and average values of Yarkovsky drift that could potentially occur depending on the chosen rotation model.

COLORIMETRY OF METEORS

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This article describes our approach to quantifying the characteristics of meteors such as temperature, spectrum and chemical composition. We are using an approach based on colorimetry. We analyse an image of bright sporadic meteoroid. For determining the meteor characteristics we use the "tuning technique" in combination with a simulation model of intrusion. The progenitor of the meteor was found as an object weighing 300 kg at a speed of 40 km/s. The meteoroid reached a critical value of the pressure at an altitude of about 36 km in a time of about 3.5 sec with a residual mass of about 20 kg, and a residual speed of about 17 km/s. At this moment, a meteoroid exploded and destroyed. We use the meteor multicolour light curves revealed from a DSLR image in the RGB colour standard. We switch from the RGB colour system to Johnson's RVB colour system introducing colour corrections. This allows one to determine the colour characteristics of the meteor radiation. Colorimetry of BGR three-beam light curves allows the identification of the brightest spectral lines. Our approach based on colorimetry allows direct measurements of temperature in the meteor trail. We find a part of the trajectory where the meteoroid radiates as an absolutely black body. The R/G and B/G light curves ratio allow one to identify the wavelengths of the emission lines using the transmission curves of the RGB filters. At the end of the trajectory, the meteoroid radiates in the lines Fe I (376 nm), Ca I (423 nm), Mg II (449 nm), Mg I (517 nm), Na I (596 nm), O I (616 nm), as well as atmospheric O I (779 nm).

DAYTIME OBSERVATIONS OF SPACE INTRUSIONS

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Daytime observations of space intrusions have their own specifics. The brightness of the daytime sky is 4-6 magnitudes per square arc second. This makes it possible to observe stars up to magnitude 3 during the day with small telescopes. Objects of observation can be bright meteors, objects of artificial origin and of unknown nature. Devices and technologies for observing intrusions in the daytime sky have been developed. The hardware allows for subsecond exposures and a dynamic range of up to 96 decibels. The software implements 2D and 3D filtering and pattern recognition. We demonstrate observations of traces of meteor intrusions in the daytime sky, as well as objects of unknown nature with unusual properties for which we find no rational explanation.