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ABSTRACTS

ORGANIZERS:

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GAIA ALERTS AND BULGARIAN-SERBIAN COOPERATION FROM 2014 TO 2022

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We started to observe the Gaia Alerts (or Gaia-FUN-TO) from October 2014, and because of better results we estabished the local cooperation "the Serbian-Bulgarian mini-network telescopes" using 6 instruments. There are two sites in Bulgaria (at Belogradchik and Rozhen) and one site in Serbia (Astronomical Station Vidojevica - ASV). Before the Covid-problem and during 2020, we did about 15 Gaia Alerts objects per year. During 2021, we observed just 5 Gaia Alerts (Gaia19dke, Gaia21awo, Gaia21azb, Gaia21efs, Gaia21ehu) but Gaia19dke 11 times and Gaia21azb 13 times; about 300 CCD images were done. Also, during 2022 (until 1st October 2022), we did 5 Gaia Alerts (Gaia21cgt, Gaia22aeu, Gaia22atp, Gaia22btj, Gaia22btc); about 50 CCD images. During last two years, mostly the 60 *cm* and 1.4 *m* ASV telescopes were used to do that. We present some results, here.

SEVERAL COSMOLOGICAL NUCLEOSYNTHESIS CONSTRAINTS ON NEUTRINO AND NEW PHYSICS

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We provide short review of the contemporary Big Bang Nucleosynthesis (BBN) and the new more precise measurements of the primordially produced abundances of the light elements D and He-4. We present several cosmological constraints, based on contemporary BBN, on the physical characteristics of neutrino and on beyond Standard Model sterile neutrino.

LINKING THE MILKY WAY STELLAR DYNAMICS WITH INTRAGALACTIC HABITABILITY

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We review the somewhat neglected field of kinematical and dynamical influences on habitability of planetary systems in the context of the Milky Way. Here we attempt to list and categorize major causal factors and processes influencing habitability on spatial scales in the 10 – 10.000 *pc* range. The interval spans between habitability of individual planetary systems and habitability of large galaxies. While there has been a sharp increase in attention devoted to both small-scale (planets/planetary systems) and large-scale (galaxies) habitability, this "middle ground" between the two has largely been excluded so far.

We further argue that the best methodology is to use modern large-scale computing to compile an atlas of orbits of the existing objects in the Gaia catalogue, using an approximate analytical potential. We present preliminary results on a small subsample of the Gaia DR2 objects whose orbits are integrated in a simplified 3-component Galactic potential, with astrobiologically-interesting results such as the number of disc plane crossings. Future work will enable integrating a larger number of orbits with more realistic potential and much higher precision, as well as formulating more precise quantitative criteria for the dynamical aspects of habitability.

STARK BROADENING OF FE XXV LINES FOR NEUTRON STARS AND THEIR ENVIRONMENT INVESTIGATIONS

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Stark broadening of spectral lines, or broadening by collisions with charged particles is significant for many important topics in astrophysics as for example modelling of stellar plasma, analysis and synthesis of spectral lines, opacity, radiative transfer, abundance determination, acceleration of gravity etc. In the conditions of neutron star atmospheres and their envirionment. Stark broadening is the most important pressure broadening mechanism of spectral lines

In spite of importance of Stark broadening parameters for analysis and modelling of neutron star atmospheres and their environements, we can see in literature that they are calculated very approximately, and without taking into account the magnetic field.

In order to provide reliable Stark broadening parameters needed for investigations of neutron stars, we calculated widths and shifts of 18 Fe XXV spectral lines, broadened by collisions with important charged constituents of neutron star atmospheres, electrons, protons and Fe XXVII ions. Calculations have been performed for plasma conditions of interest for neutron star atmospheres and their environments. Plasma temperatures were berween 300 000 K and 20 000 000 K and electron densities from 1017 cm^{-3} to 1024 cm^{-3}. Since such results are also of interest for Virtual Observatories we will prepare them additionaly for implementation in STARK-B database (***http://stark-b.obspm.fr/***), which is also a part of Virtual Atomic and Molecular Data Center – VAMDC (***https://vamdc.org/***).

LATEST ACHIEVEMENTS FROM BELOGRADCHIK OBSERVATORY

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We present recent results on blazar variability, obtained with the 60-*cm* telescope of Belogradchik Observatory. More specifically some new results on intra-night polarization variability (in both – polarization rate and angle) for specific objects will be discussed.

THERMODYNAMICS OF FLUID ELEMENTS IN THE CONTEXT OF SATURATED ISOTHERMAL TURBULENCE IN MOLECULAR CLOUDS

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In the presented paper we try to make use of powerful tools of the classical thermodynamics in order to investigate dynamical states of an hydrodynamical isothermal turbulent self-gravitating system. Our main assumption, inspired by the paper of Keto et al. (2020), is that turbulent kinetic energy can be substituted for the macro-temperature of chaotic motion of fluid elements. As a proper sample for our system we use a model of turbulent self-gravitating isothermal molecular cloud which is at final stages of its life-cycle, when the dynamics is nearly in steady state. Starting from this point we write down the internal energy for a physically small cloud's volume, and then using the first principle of thermodynamics obtain in explicit form the entropy, free energy, and Gibbs potential for this volume. Setting fiducial boundary conditions for the latter system (small volume) we explore its stability as a grand canonical ensemble. Searching for extrema of the Gibbs potential we obtain conditions for its minimum, which corresponds to stable dynamical state of hydrodynamical system. This result demonstrates the ability of our novel approach.

WAVELET COHERENCE OF TOTAL SOLAR IRRADIANCE AND ATLANTIC CLIMATE

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The oscillations of climatic parameters of North Atlantic Ocean play important role in various events in North America and Europe. Several climatic indices are associated with these oscillations. The long terms of Atlantic temperature anomalies are presented by Atlantic Multidecadal Oscillation (AMO). The Atlantic Multidecadal Oscillation also known as Atlantic Multidecadal Variability (AMV), is the variability of the sea surface temperature (SST) of the North Atlantic Ocean on the timescale of several decades. The AMO is correlated to air temperatures and rainfall over much of the Northern Hemisphere, in particular in the summer climate in North America and Europe. The long term variations of surface temperature are driven mainly by the cycles of solar activity, represented by the variations of Total Solar Irradiance (TSI). The frequency and amplitude dependence between the TSI and AMO is analyzed by wavelet coherence of millennial time series since 800 AD till now. The results of wavelet coherence are compared with the detected common solar and climate cycles in narrow frequency bands by the method of Partial Fourier Approximation. The long term coherence between TSI and AMO may help better understanding the recent climate change and may improve the long term forecast.

GENERALIZED SMOOTHING SPLINES FOR DATA ANALYSIS IN ASTRONOMY

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In the present lecture we provide some new methods of generalized smoothing splines for Data analysis of Big Data, based on joint work with Hermann Render. We show the influence of the smoothing parameter and the rest of the parameters of the generalized splines, on the trends forecasting.

THE NEW 1.5-M ROBOTIC TELESCOPE FOR THE ROZHEN OBSERVATORY

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Bulgarian National Astronomical Observatory Rozhen is located in the Rhodope Mountains at about 1750 *m* above sea level. The astronomical observatory is the biggest one-time Bulgarian investment in scientific infrastructure and a leading astronomical center in the South-East Europe. So far, the observatory has four telescopes: 2 *m* RCC multipurpose telescope equipped with four new professional CCD cameras, coudé and éshelle spectrographs, 50/70 *cm* Schmidt telescope, 60 cm Cassegrain telescope and 15 *cm* Lyot-coronagraph.

In order to expand the capability for astronomical observations and to increase the efficiency of the Observatory, in 2020 a contract was signed with the company ASA Astrosysteme GmbH for the supply and installation of a new 1.5 *m* telescope in NAO Rozhen. The telescope will be installed in a new dome with a diameter of 6 *m* and a height of 8 *m* and will be fully robotic. The main objects for observation will be: small bodies from the Solar system, various types of variable stars, blazars and active galactic nuclei. The telescope will initially work only in photometric mode, but in the future the delivery of a low-dispersion spectrograph is also planned.

The new 1.5 *m* robotic telescope has already been produced and the delivery and installation is expected to take place in July-August. We hope to start the first test observations in September this year, after which it will be put into regular operation.

OPTICAL SPECTROSCOPY AND X-RAY OBSERVATIONS OF THE D-TYPE SYMBIOTIC STAR EF AQL

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We performed high-resolution optical spectroscopy and X-ray observations of the recently identified Mira-type symbiotic star EF Aql. Based on high-resolution optical spectroscopy obtained with SALT, we determine the temperature (~55 000 *K*) and the luminosity (~5.3 $L_{\odot}$) of the hot component in the system. The heliocentric radial velocities of the emission lines in the spectra reveal possible stratification of the chemical elements.

We also estimate the mass-loss rate of the Mira donor star. Our Swift observation did not detect EF Aql in X-rays. The upper limit of the X-ray observations is 10^{-12} erg cm^{-2} s^{-1}, which means that EF Aql is consistent with the faintest X-ray systems detected so far.

Otherwise we detected it with the UVOT instrument with an average UVM2 *magnitude* of 14.05. During the exposure, EF Aql became approximately 0.2 UVM2 *magnitudes* fainter. The periodogram analysis of the V-band data reveals an improved period of 320.4±0.3 *d* caused by the pulsations of the Mira-type donor star.

PROPERTIES OF MILKY WAY GLOBULAR CLUSTERS ASSOCIATED WITH X-RAY SOURCES

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The integral X-ray luminosities of 89 Milky Way globular clusters within 2 rc (core radius) have been estimated by the average X-ray fluxes of individual sources in obtained from modern missions Chandra, XMM-Newton, Swift and Beppo-Sax. The X-ray luminosity function is constructed and a limit luminosity is defined LX([0.5–7] keV) = 1033.65 erg s^{-1}, which divides the sample into two groups: 18 high-luminosity clusters and 71 low-luminosity clusters. For both subsamples the Kolmogorov-Smirnov test was applied for the parameters ellipticity, eccentricity of the orbit and estimated number of intermediate mass black holes. The test results show that at a confidence level of 99.9%, the high X-ray luminosity clusters have fewer black holes with intermediate mass than the low X-ray luminosity clusters. In addition, the former have lower ellipticity and higher eccentricity compared to the latter, but at significantly lower confidence levels of 80%.

Keywords: Globular clusters in the Milky Way, X-ray sources
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SPACE WEATHER CATALOGS: ENERGETIC PARTICLES, RADIO EMISSIONS, FLARES AND GEOMAGNETIC STORMS

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We present the current status of an open access database of space weather-related phenomena: ***(https://catalogs.astro.bas.bg/)***. A focus on the recently obtained results on the association between in situ observed energetic electrons and the remotely observed radio emission signatures is put forth here. The so-called type II, III and IV radio bursts are visually identified in freely provided dynamic spectra by radio observatories over the last two solar cycles. This is the first study on the link between in situ electrons and the electron-related radio emissions to date that is also organized as a freely available catalog. Other space weather events that are added to the database include solar energetic protons, large solar flares (X and M-class) and geomagnetic storms. A new catalog of type II radio bursts in the high corona is under construction and will be briefly outlined.

FLICKERING IN POLARS

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Flickering is a stochastic variability that can be detected on all time-scales – from milliseconds to hours. Flickering is always associated with accretion and can be detected in cataclysmic variables as well as in active galactic nuclei. While the physical origin of flickering is not known it has been hypothesized that it may originate in accretion discs. Here I will present a study of flickering in cataclysmic variables without accretion disc – polars. This study will help us understand the location of flickering source in these systems.

STUDY OF VARIATIONS DURING LAST CYCLE OF PLEIONE - PROTOTYPE BE/SHELL STAR

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Pleione is well known Be/shell star studied spectroscopicaly for more than 120 *years*. During this period of time the star underwent several changes between different spectral phases: B, Be and Be shell. It is generally accepted that phase transitions of Pleione are caused by the binary (or multiple) nature of the stars but there is no final solution yet. In the present study we try to obtain more precise picture of recent spectral phase connected changes of Pleione by data-mining in existing archives of Be star spectral observations.

MULTI-WAVELENGTH VARIABILITY AND QPOS IN BLAZARS

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Blazar belongs to the subclass of radio loud AGN. These objects show flux, polarization and spectral variations in the complete electromagnetic spectrum and its emission neing predominantely nonthermal. In the present talk, I will report some of recent results by my group in which multi-wavelength variability and quasi period oscillations in blazars will be discussed.

ANALYSIS OF CALCULATED STARK BROADENING PARAMETERS OF SINGLY IONIZED SILICON LINES

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Analysis of recently calculated Stark broadening parameters of Si II spectral lines is presented. Plasma conditions of interest covered temperatures: 5 000 *K*, 10 000 *K*, 20 000 *K*, 30 000 K, 50 000 *K* and 10 0000 *K*, and perturber densities from 10^{13} cm^{-3} to 10^{20} cm^{-3}. Electrons, protons, and ionized helium atoms are examined as perturbers. Validity conditions for application of obtained results are discussed.

SUPERMASSIVE BINARY BLACK HOLES ON SUB-PC SCALE AND ACTIVITY OF GALAXIES

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We can observe many galaxy mergers where a collision occurs on a kpc scale. This indicates that colliding galaxies should evolve into sub-pc phase, where two supermassive black holes (SMBHs) are close to each other, making a super-massive binary black hole (SMBBH) system. The sub-pc phase is one before the coalescence of two SMBHs, which is expected to be a source of gravitational waves (GWs). Therefore, the sub-pc SMBBH detection and location in the sky are very important in order to support existing and future GW missions (telescopes).

However, detection of the sub-pc SMBBHs is a very hard task. First of all, it is not possible to resolve the sub-pc SMBBH components with current telescopes (as it possible in the case of *kpc* mergers) . However, one can expect that the tasub-pc SMBBH system produces activity in the center of galaxies, forming an active galactic nucleus (AGN). Exploring the activity of AGNs as e.g. variability in the short and long scale as well as line shapes changing can indicate the presence of an SMBBH in the AGN (*see Popovic 2012, NewAR, 56, 74 ;Popovic et al. 2021,MNRAS, 505, 5192; Simic et. al. 2022, AN, 343, id. E210073*).

Here we discuss perspectives to detect sub-pc SMBBH systems using long-term photometric and spectroscopic monitoring campaigns of active galactic nuclei-AGNs (*Popovic et al. 2021, Simic et al. 2022*).

FOR OPTICAL FLICKERING IN SYMBIOTIC STAR MWC 560

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This study is based on observations of MWC560 during the last two observational seasons (2020/2021 and 2021/2022). Other than looking for flickering we were interested in following the variability of brightness in the same period. Looking for similarities in the spectra with other types of stars is also of great interest to us because it could help clarify the stellar configuration of such objects. Our observations during the last two observational season of MWC 560 confirm the absence of flickering. From the similarities of the gathered spectra of XX Oph and MWC 560 we assume that the components in XX Oph are a red giant and a white dwarf, which are also surrounded by a common shell.

B[E] STAR CI CAM IN THE OPTICAL RANGE

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We report the results of a photometric and spectroscopic monitoring of the B[e] object CI Cam since its multiwavelength outburst in 1998. We found a system component, which radiates in the He II 4686 A emission line, on an elliptical orbit around an early-B type star with an orbital period of 19.407+/–0.004 *days* and an eccentricity of 0.43–0.49. The amplitude of the He II radial velocity variations is ~380 *km/s*. The line intensity gradually increases with time. A slow secular change of the radial velocity of iron emission lines and a forbidden nitrogen line has been de-

tected at high resolution. This phenomenon can be due to the presence of a third component on an eccentric orbit or to precession of the rotational axis of the B-type star and its polar outflows. The B-type star, turned out to be a multiperiodic pulsating variable with periods of 0.5223, 0.41539, and 0.26630 *days*. However, since 2012 it pulsates in a single mode with a range of periods between 0.403 and 0.408 *days* depending on the star's luminosity. The pulsational data constrain the spectral type of the B-star at B0-B2 III, the distance to the system at 2.5–4.5 *kpc*, and the absolute visual *magnitude* at –3.7 – –4.9 *mag*. The previously suggested classification of the object as a B[e] supergiant is rejected because of the observed pulsations periods.

POWER-LAW TAILS OF THE DENSITY DISTRIBUTION IN STAR-FORMING CLOUDS: POSSIBLE EFFECTS OF ROTATION AND/OR THERMODYNAMICS

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The analysis of the probability distribution of (column-)density is a widely used tool to investigate physics and evolution of molecular clouds. It is well known that the development of a power-law tail (PLT) at the high-density end of the distribution reflects the increasing role of self-gravity in evolving star-forming clouds. Recently a growing number of observational, numerical and theoretical works discuss the existence of double PLTs at the stage of formation of protostars as the second PLT is explained with support through centrifugal forces and/or with a change in the equation of state near to the cloud core. This report aims to contribute to this research. We study the evolution of the (column-)density distribution from high-resolution simulations of contracting star-forming clumps and demonstrate the development of multiple (double or tripple) PLTs with the emergence of protostars and formation of disks in their vicinity. The obtained slope of each PLT is indicative of different physical picture at the corresponding spatial scale in the star-forming clump.

THE ACTIVE ZONE MOBILITY IN A MAGNETIZED DISK WITH ADVECTION

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In this paper we consider some active processes in the accretion disk of a compact object. The active zone and its construction in the various objects is consequence of the advection action in the disk. We analyses where it is located and how the active zone develops in the disk. We will estimate alteration in the active zone behaviour from the outer to the inner parts. We will estimate alterations in the active zone for different real sources. We will discuss the similarities and differences.

MAGNETIC FIELDS AND ACTIVITY IN AGB AND OTHER EVOLVED GIANT STARS

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Surface magnetic fields have been directly measured in recent years in many cool evolved (AGB, post-AGB and RSG) stars using high-resolution spectropolarimetry. We present and compare the observed variations in the magnetic activity of some of these cool giant stars, and discuss possible physical explanations for the origin and structure of their respective magnetic fields.

SEARCHING FOR COMMON PROPERTIES OF CO SPECTRA IN ROSETTE MOLECULAR CLOUD USING GAUSSIAN MIXTURE MODEL CLUSTERING ALGORITHM

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We make use of 13CO line emission map toward the molecular cloud Rosette and segment the map into individual spatial components that share similar spectral properties. Leveraging the fact that the shape of each spectrum in the data cube is confined by the local physical conditions we use Gaussian Mixture Model technique for grouping spectra into clusters with similar properties. In order to derive the physical properties of these spectrally similar regions, we apply dendrogram analysis and obtain the mass and velocity scaling relations in each cluster represented by its spatially confined zone. Additionally we quantify the importance of gravity in each cluster (in the PPV space) by applying the G-virial method developed by Guang-Xing Li et al. (2015). Larger G-virial is related to a larger importance of gravity, and as a result the importance of gravity at a given region is quantified by measuring the amount of gas at different thresholds of the G-virial parameter.

PHYSICAL AND DYNAMICAL PROPERTIES OF SELECTED EARTH CO-ORBITAL ASTEROIDS

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We present our investigations of the physical and dynamical properties of selected Earth co-orbital asteroids. The photometric optical light curves as well as rotation periods, pole solutions and 3D shape models for a sample of four Earth co-orbital asteroids, namely (138175) 2000 EE104 (P=13.9476±0.0051 *hrs*, (418849) 2008 WM64 (P=2.4077±0.0001 *hrs*), 2016 CA138 (P=5.3137±0.0016 *hrs*) and 2017 SL16 (P=0.3188±0.0053 *hrs*), are determined or improved and presented in this work. For this investigation, we combine observations carried out at the Bulgarian National Astronomical Observatory - Rozhen using the FoReRo2 instrument attached to the 2mRCC telescope as well as sparse data from AstDys2 database. Parallel to the rotational and shape properties we did numerical dynamical simulations to investigate the orbital stability of those objects and to find out if there is a relation with their rotational properties. Our results show that the orbit stability is affected by the orbit itself and mainly its eccentricity and inclination, which are responsible for the close encounters with other Solar system planets.

We cannot make a definitive conclusion about the relation between orbit stability and the rotational state of the asteroids, so we need further investigations and observations in order to prove or disprove it.

MANKIND'S FIRST ATTEMPT TO CHANGE THE ORBIT OF AN ASTEROID

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This review describes the Double Asteroid Redirection Test (DART), the first mission to test technology for defending Earth against potential asteroid or comet hazards. A kinetic impact onto Dimorphos, the smaller component of the binary asteroid (65803) Didymos will change its orbit. The parameters of the Didymos system and the DART spacecraft will be outlined. The momentum transfer efficiency resulting from the kinetic impact will be estimated. The modification of the orbital velocity of Dimorphos and the corresponding change of the orbital period of the system will be presented. Ground based observations after the impact can be used for determination of the new orbital period, what will be the ultimate confirmation for the success of the DART mission. Different scenarios of the particle ejection events will be discussed theoretically, and opportunities for their observational confirmation based on photometric predictions will be described. Comparisons with the material released after the Deep impact mission will be made, similarities and differences between DART and Deep impact will be discussed. Finally I will present the main goals of the HERA mission, an ESA project which will characterize the outcome of the DART mission, using in situ observations of the Didymos system at the end of 2026. Under the main goals of HERA are characterization of the crater produced by DART, investigation of the surface and interior of Dimorphos, and all the observables needed to fully determine the momentum transfer efficiency from the DART impact.

ADVANCED IMAGE PREPROCESSING AND FEATURE TRACKING FOR REMOTE CME CHARACTERIZATION WITH CONVOLUTIONAL NEURAL NETWORK

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Coronal Mass Ejections (CMEs) influence the interplanetary environment over vast distances in the solar system by injecting huge clouds of fast solar plasma and energetic particles (SEPs). A number of fundamental questions remain about how SEPs are produced, but current understanding points to CME-driven shocks and compressions in the solar corona. At the same time, unprecedented remote (AIA, LOFAR, MWA) and in situ (Parker Solar Probe, Solar Orbiter) solar observations are becoming available to constrain existing theories, nevertheless, reliable training sets for classification, segmentation and tracking of CME-related phenomena with CNN models are missing as well as pre-trained models themselves.

Recently (*Stepanyuk et.al, J. Space Weather Space Clim. Vol 12, 20 (2022)*), we have demonstrated the method and the software (***https://gitlab.com/iahelio/mosaiics/wavetrack***) for smart characterization and tracking of solar eruptive features based on the a-trous wavelet decomposition technique, intensity rankings and a set of filtering techniques.

In this work we use Wavetrack outputs as training sets for CNN data-driven Solar Eruptive Feature Extraction and Characterization. We adopt U-Net – a convolutional neural network that was developed for biomedical image segmentation at the Computer Science Department of the University of Freiburg *(Ronneberger O, et. al (2015))*. This network and training strategy relies on the strong use of data augmentation to use the available annotated samples more efficiently and can be trained end-to-end from a very limited set of images, while feature engineering allows to improve this approach even further by expanding available training sets.

Here we demonstrate data-driven characterization and tracking of solar eruptive features on a set of CME-event related datasets obtained from SDO/AIA telescope.

RS OPH - ASYMMETRY OF THE EJECTED MATERIAL AFTER THE 2021 OUTBURST

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With its 7th recorded outburst, RS Oph is perhaps the best-studied recurrent nova. It belongs to a small group of objects where a white dwarf (WD) accretes from the wind of its red giant companion, and when significant material has accumulated on its surface, it is ignited under degenerate conditions with a sudden and important increase of luminosity. Detailed observations during the previous outburst allowed to identify asymmetric structures on the expanding material.

Spectropolarimetry is a powerful tool for diagnostic of the geometry of the ejected material after the novae outbursts. The spectropolarimetric observations of the RS Oph after the 2021 outburst were obtained with the 2-Channel-Focal-Reducer Rozhen (FoReRo2) attached to the Cassegrain focus of the 2.0m RCC telescope of the Bulgarian Rozhen National Astro-nomical Observatory. An intrinsic variable linear polarization was detected. The position angle is ≈90° and aligned with the highly collimated outflows detected during the previous outburst in 2006. Strong depolarization effects are well visible in the emission lines. The spectropolarimetric observations suggest the early development of asymmetries in the outflow.

COMPARISON AND CONTROL STARS AROUND QUASARS SUITABLE FOR THE ICRF – GAIA CRF LINK

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To link International and Gaia Celestial Reference Frame is necessary to observe and monitor set of sources (mostly blazars) visible in radio and optical wavelengths. From 2013 until 2019, we observed 47 active galactic nuclei (AGNs) which are candidate sources for the link between the frames. Our observations, in optical V and R bands were performed using eight telescopes from Serbia, Spain, Bulgaria, and Austria. The brightness of the sources and control stars were determined by differential photometry using suitable comparison stars. The obtained light curves of blazars are significant for the understanding of the physical processes inside them. We tested the brightness in V, and R bands, and V-R colour (of sources, and their comparison, and control stars) with two statistical tests (Abbe's criterion, and F test), and some results are presented here.

THE „SPACE EDUCATION FOR BULGARIA" (SPACEEDU4BG) PROJECT

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The report will present the „Space Education for Bulgaria" (SpaceEdu4BG) project. The goal and the scope of the project is to develop nine new university courses about space technology and its practical applications, including syllabi, presentations and lecture notes for each course. The topics of the courses are selected to be in line with ESA's main thematics and strategic vision for space sector development in Bulgaria and the cooperation between Bulgaria and ESA. The successful implementation of the project will strengthen the theoretical and practical preparation of young professionals for a career in space industry. Furthermore, "SpaceEdu4BG" will further increase the image of the Faculty of Physics at the Sofia University "St. Kl. Ohridski" as the leading place for state-of-the-art education in the field of space research in Bulgaria.

The „Space Education for Bulgaria" (SpaceEdu4BG) project is funded by the European Space Agency (ESA) in the framework of the Plan for European Cooperating States (PECS), ESA Contract No. 4000133835/21/NL/Cbi with the Sofia University „St. Kl. Ohridski". The project started in February 2021 and has a duration of 24 months.

BEAUTIFUL, BUT NOT HOSTABLE – ORGANOLEPTIC PROPERTIES OF THE SOLAR SYSTEM'S PLANETS.

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The intensive development of the space research and remote sensing to other planets during the last years brings new more accurate knowledge about the physical, chemical and biological conditions to the planets of the Solar system. New and advanced technologies and better communications help the transformation of the scientific data even to the organoleptic and adaptive to the human senses properties like smell, taste, sound and even more abstract feelings like beautifulness, perception of acceptance to the humans, etc. These properties are frequently used by the mass-media and popular presentations of the science to the wide public. This approach and these properties are under presentation in this short report and cover except the planets as well as some other space objects like satellites, comets, even galaxies.

WAVE-PARTICLE RESONANT INTERACTIONS IN HELIOSPHERE PERIPHERY

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A theoretical study of the wave-particle resonant interactions in heliosphere periphery in area of calm and homogeneous space plasma is performed. The work has been carried out by the numerical solution of second order nonlinear nonstationary differential equation for the wave phase on the particle's trajectory upon satisfying all the requirements for Cherenkov resonance. For the conducted analysis is assumed that the particles the initial energy does not exceed 1 *MeV* and the speed of the electromagnetic wave can be considered relativistic. Based on the accomplished numerical experiments detailed information for the particles behavior on the stage of resonance acceleration is supplied. The phase plane structure, particle relativistic factor its analytical approximation and particle speed components during active resonant wave-particle interaction are computed and discussed. The duration of the resonant acceleration period, the maximum output energy, as well as the net acquired energy from the particle for the same period are estimated and presented in graphical form. Conclusions about wave-particle interactions in heliosphere periphery and ability to generate high-speed streams of relativistic particles in this area by the resonant mechanisms are made.

IMPACT BROADENING PARAMETERS FOR SOME TRANSITION METALS IN A TYPE STAR

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In previous years, we published research with data on Stark parameters for heavy metal elements where we mainly considered singly charged ions in stellar plasma. These elements such as Ir II, Rh II and Re II deserve special attention because they have already been seen in the spectra of chemically unusual stars as well as white dwarfs. Here, we make a shortened report on the research so far in order to see the scale and interrelationships so far. The total number of calculated parameters implies the processing of about 400 transitions for these elements, which are necessary in the Spectroscopy of stellar plasma.

THE LARGE-SCALE MAGNETIC FIELDS OF THE M DWARF DOUBLE-LINE SPECTROSCOPIC BINARY FK AQR

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We present the double-line spectroscopic binary FK Aqr (GJ 867A) as a part of the BinaMIcS project. The system consists of two dM1-dwarfs with masses of 0.55 and 0.44 *solar masses*. Based on spectropolarimetric observations with ESPaDOnS@CFHT, we were able to reconstruct the large-scale magnetic fields topology on the surface of both components of the system. Radial velocities of both components were measured from the mean Stokes I profiles. Then, we used them along with interferometric observation to refine the orbital parameters with Phoebe software. Stokes V signatures were detected from all observations. Zeeman Doppler imaging method was employed to reconstruct the maps, which show that both M-dwarfs have strong poloidal components of about 91% for the primary and 99% for the secondary. The magnetic analysis shows that both stars posses slightly stronger magnetic fields compared to single M-dwarfs with similar masses and spectral class.

SUPERNOVA REMNANTS - A PERSPECTIVE FROM NAO ROZHEN

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Observations with aim of detection of extragalactic supernova remnants have been done from National Astronomical Observatory Rozhen for more than a decade. By using narrow band photometry in Halpha and [SII] lines, we have detected supernova remnants and HII regions in six nearby galaxies. In this talk we will review results achieved in through this long-term project.

LOW-MASS CONTACT CLOSE BINARY SYSTEMS AND THEIR STABILITY

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Contact binaries are close binary systems in which both components fill their inner Roche lobes so that the stars are in direct contact and in potential mass and energy exchange. In the last few years, there is a growing interest of the astronomical community in stellar mergers, primarily due to the detection of gravitational waves (mergers of black holes and neutron stars), but also because of an alternative model for type Ia supernovae (merger of two white dwarfs), which are again particularly important in cosmology where they played an important role in the discovery of dark energy and the accelerated expansion of the Universe. In that sense, contact systems of W UMa-type with extremely low mass ratio are especially interesting because there are indications that in their case, too, stars can merge and possible form fast-rotating stars such as FC Com stars and the blue-stragglers, or (luminous) red novae such as V1309 Sco. Namely, previous theoretical research has shown that in the cases when the orbital angular momentum of the system is only about three times larger than the rotational angular momentum of the primary, a tidal (Darwin) instability occurs, the components can no longer remain in synchronous rotation, orbit continue to shrink and they finally merge into a single star. The above stability condition for contact systems can be linked to some critical mass ratio below which we expect a system to be unstable. We reanalyze this condition and show how it can be used to identify potential mergers.

ONLINE CATALOG OF SOLAR ACTIVITY EVENTS OF SOLAR CYCLE 24

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We are currently running in the 25th solar cycle (since 1755 when extensive recording of solar activity began) and we are capable of summarizing the available data for the recently completed solar cycle, considered as the weakest since solar cycle 14 (1902-1913). Our study aims to reveal more on the relationship between different solar activity phenomena and thus help in better understanding and forecasting the behaviour of the active Sun. We prepared an open-access online catalog that consists of 1533 active regions from solar cycle 24 (December 2008 – December 2019) that generated at least one solar flare and/or coronal mass ejection. The final version includes 18053 rows that summarize data about 15140 active region-associated flare events and 5202 active region-associated coronal mass ejections (of which 12492 SF and 8126 CME unique records).

OPTICAL OBSERVATIONS OF THE SOLAR CHROMOSPHERE BY NAO ROZHEN

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H-alpha observations

MODELING ASTEROID SHAPES USING BNAO ROZHEN AND AS VIDOJEVICA PHOTOMETRIC DATA IN COMBINATION WITH SPARSE DATA

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Increasing the number of asteroids with a known model is helpful for a better understanding of the evolution of our planetary system. Asteroid model determination involves three aspects: solving the problem about its shape, its sense of rotation, and calculating the coordinates of the asteroid rotation poles. The solution to such a problem is not straightforward. Namely, it requires long-term observations of a particular target, since we need information from different parts of the asteroid surface i.e. different observing geometries. In this work, we construct the asteroid models using the lightcurve inversion method, in combination with the observational data from the National Astronomical Observatory Rozhen (Bulgaria), the Astronomical Station Vidojevica (Serbia), and sparse data from the AstDys database.

ANALYSIS OF METEOROLOGICAL OBSERVATIONS FOR BULGARIA (1905-2022)

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DARK MATTER HALOES IN GALAXY MERGERS

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In this paper, we investigated the influence of dark matter in galactic halos on the dynamics of galaxies in merger events. In the standard cosmological picture, large massive galaxies are formed by mergers of the smaller ones. These mergers are very important for galactic dynamics and evolution. The largest portion of the galactic mass is the dark matter halo. Dark matter has a very important role due to dynamical friction and the formation of observed substructures. Here we investigated how properties of spherical dark matter halos and merger circumstances influence the formation of these morphological structures.

DUST EXTINCTION, 3D STRUCTURE, AND STELLAR PROPERTIES FROM RESOLVED STARS IN NEARBY GALAXIES

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Large photometric surveys present rich information encoded in high-resolution multiband observations of spatially resolved stars. I show how by modeling the photometric dust-extinguished spectral energy distribution (SED) of stars observed in nearby galaxies in the near-UV to near-IR, we can extract information about the dust, stellar and 3D structure properties. We use a probabilistic Bayesian approach to modeling the SED and account for observational uncertainties inherent in large photometric surveys. The SED fitting results can be used to:

1) Produce high quality catalogs with stellar and dust extinction parameters for millions of stars in the local universe

2) Better understand the relationships among the stars, dust, 3D geometry and the interstellar medium (ISM; CO, HI, dust mass surface density) on the scales of individual star-forming and/or molecular cloud regions, and obtain clues about dust grain formation processes in the ISM.

3) Specifically in the SMC and other low-metallicity galaxies, to understand the properties of dust extinction at low metallicity (and potentially high-redshift) galaxies.

4) Identify stars, sightlines, or regions of interest for follow up observations. (HST, ALMA, JWST, etc.)

5) Calibrate dust grain models by comparing the dust column density, A(V), calculated from photometry with A(V) derived from the dust surface mass density from IR emission (where the latter uses a dust grain model assumption).

A PHOTOMETRIC STUDY OF HIGH-REDSHIFT QUASARS

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We present and discuss results of a photometric study of a different type AGNs with the 2 *m* RCC and the 50/70 *cm* Schmidt telescopes at National Astronomical Observatory (NAO) – Rozhen. For a period of 15 *years* 11 high-redshifted sources were observed with standard Johnson-Cousins photometric filters. We have obtained light curves with variability up to 0.4 *magnitude* and some physical parameters were determined. One of the sources (QSO B1312+7837) shows signs of periodic variability that may be due to presence of two supermassive black holes.

BG TRIANGULUM WITH/WITHOUT SUPERHUMPS

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In this study we present the energy distribution in the optical range of the flickering light source of BG Triangulum in two nights with and without the presence of negative superhumps, respectively. The flickering source parameters for both that states are also determined and the obtained results are briefly discussed.

A LONG-TERM STUDY OF QUASAR VARIABILITY IN THE NEAR-INFRARED

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We quantify the ensemble long-term near-infrared variability for 6134 active galactic nuclei (AGNs) with z up to 5.1. The monitoring data combine 2MASS and VHS spanning a baseline of more than a decade. We examine the correlations of the ensemble variability with the physical parameters of the AGNs: luminosity, redshift, rest-frame wavelength and rest-frame time lag.

ACHIEVING EXPLAINABILITY: MODERN DEEP LEARNING METHODS ON VARIABLE STARS IN THE LOCAL GROUP

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The classic task of classifying variable stars provides a test bed for all machine learning techniques – not just as a research tool, but also as a way to automate tedious and error-prone work. Searching for variable stars presents unique challenges: ideally, the light curves should be used in their raw form, instead of as a vector of precomputed features; the time differences between observations are not regular; the models need to account for many surveys (hence, cameras, filters, etc.); data for newly discovered objects is time- and noise-limited. Another type of challenge is to quantify model confidence in a robust way – hence, differentiate between false positives, and new discoveries.

Having already developed a multi-survey, multi-filter, transferable neural network classifier of variable stars in the Local Group, we now focus on the scientific challenge of explaining the model decisions. We apply local explainability by gradient methods, input perturbation, and via attention and saliency maps. We also cross-check with physical properties of the stellar systems (P – L relationship for Cepheids). We evaluate the explanations using both quantitative and qualitative techniques. We seek to create an improved confidence metric for the model (augmented with additional statistics), and rank candidates according to this metric on the probability of being a new discovery.

THE TILTED ACCRETION DISC OF LS CAM

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Evidence of a tilted disc in the cataclysmic variable LS Cam is presented. Periodogram analysis of the rich time series photometry from the TESS mission yields several periodicities in the light curve. They are interpreted as the orbital period, negative superhump, positive superhump and disc precession period. Changes in the irradiation of the secondary with respect to the varying disc tilt are also presented.

NEGATIVE SUPERHUMPS IN CATACLYSMIC VARIABLES

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We calculated relations between the orbital periods and the known periods of positive and negative superhumps for nova-like variables. Using the linear approximations were obtained the slopes around 0.90 and 1.06 for Porb – Psh+ and Porb – Psh– respectively.

These relations are not well underrstood but adding the new data confirm it.

Posters

CURVE FITTING METHOD OF STARK WIDTH DETERMINATION – EXAMPLE OF ZR IV LINE IN FEIGE 87 SPECTRUM

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Usual procedure of the Stark broadening theory usage for astrophysical purpose is to determine Stark width of particular spectral line with some theoretical calculation method, and then to compare measured spectral line with synthetic line simulated with Voight profile obtained by some spectral synthesis code and a proper model atmosphere code. We suggested here inverse approach – to determine Stark width from the best fitting of synthetic line with measured one. This method is applicable in the case when astrophysical spectrum of the object containing the isolated line we consider about is available, especially if we are not sure how much our calculation method is accurate. We tested the possibility of the use of this method in the example of Zr IV λ1184 line identified in Feige 87 spectrum. Stark width obtained in this way is compared with values estimated using the approximative formulae from *Majlinger et al (2017)*. Finally we discussed influence of Stark broadening on abundance determination comparing our result of zirconium abundance determined from considering spectral line with some previously published results *(Chayer et al, 2006, Pereira et al, 2006)*.

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SEARCHING FOR HIERARCHICAL SYSTEMS IN THE GAIA DATA RELASE 3

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Binary and multiple systems make up the majority of observed stars. Since more than 50% of the stars in the vicinity of the Sun are multiple systems, we can assume that a similar situation occurs throughout the Galaxy. Successive Gaia Data Releases provides us with new astrometric data on stars with accuracy never obtained before. During my research work a new method is being developed, that allows probability determination of physical bonding of two visual components of a system. This method will then be used to discover new hierarchical systems. In addition, the statistical relationship between the physical characteristics of close binary systems and companion stars that are in wide orbits is being conducted. The current results are presented in the poster.

REPRESENTATION OF ASYMMETRIC DATA DISTRIBUTIONS BY INTERGRAMS INSTEAD HISTOGRAMS

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The intergram is a proxy of the histogram. Contrary to the histogram and like to the discrete cumulative function it is unique for the data sample. The inter-gram is building by the method of the shortest intervals containing specified parts of the data among the sorted data. Four examples of inergram of asym-metric distribution shown: log-diameters and log-masses of 76 bodies of the Solar system, rotation velocities of 639 disk galaxies and inhabitants of 297 Bulgarian towns. The interrgram may prognosticate the extremely values for 1% of the population.

REVEALING OF REPEATING STRUCTURES IN TIME SERIES BY STRUCTURE LENGTH SELECTION

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TA conceptually simple method for structure length selection is proposed for revealing of periods in time series. The method builds a signal function whose maxima positions are indicators of the lengths of the repeating structures. The average shape of the repeating structure is building , It may be may be arbitrary. The method confirms that the major time mode of the solar cycle is 11.0 *y* with two minor modes at 10.0 *y* and 11.7 *y*.

The intra-year period of the Planetarium visits is 1/7 *y* = 7.46 *weeks* and the flickering quasi-periods the star RS Oph in B and V band are 9 *min* and 7 *min*, respectively.

LONG-TERM MULTICOLOR PHOTOMETRY OF YSOS IN THE FIELD OF THE OPEN CLUSTER TRUMPLER 37

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This poster presents the results from the multicolor photometric observations of young stellar objects (YSOs) collected in the period June 2008 – August 2022. The stars from our study are located in the field of the young open cluster Trumpler 37, in the vicinity of the pre-main-sequence star GM Cep. The objects were selected from the International Variable Star Index database of the American Association of Variable Star Observers by exact object type (YSO) and with the first condition that their location is within 25 *arcmin* of the star GM Cep, because our observations were carried out in the field centered on this star. The second condition was the stars are bright enough for the telescopes and cameras used. The CCD observations reported in the poster were obtained with four telescopes – the 2 *m* RCC, the 50/70 *cm* Schmidt and the 60 *cm* Cassegrain – administered by the Rozhen National Astronomical Observatory in Bulgaria, and the 1.3 *m* RC telescope – administered by the Skinakas Observatory in Greece. All frames were taken through a standard Johnson-Cousins set of filters. The photometric data were reduced by an IDL software package (standard DAOPHOT subroutine). Results from our study indicate that all of the investigated stars manifest photometric variability inherent in YSOs. The present study is a part of our program for photometric study of pre-main-sequence stars located in active star-forming regions.

ON THE DISC'S DENSITY DISTRIBUTION AND TEMPERATURE VARIATIONS OF TWO BINARY STARS WITH COMPACT OBJECTS

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In this work, we present our study on the accretion disc' properties of two binary stars. We estimate the density distribution in relation to the disc radius.

We apply observational data for the semi- regular (SR) symbiotic variable NQ Gem and the variable young stellar object FU Ori, from both the National Astronomical Observatory (NAO) Rozhen and the American Association of Variable Star Observers (AAVSO). Using their color indices from the observations, the temperature variations are calculated for both stars. Based on the accretion efficiency values of the two objects, we discuss possible mass transfer mechanisms between the binary components.

JET PARAMETERS FOR THE BLAZAR BL LACERTAE

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We present BVRI photometry of the blazar BL Lacertae on short-term and intra-night timescales from mid-July 2020 to mid-September 2020. The observations cover the onset of a new activity phase of BL Lacertae started in August 2020 and the analysis we performed is focused on the intra-night variability. We estimated a number of jet parameters, namely the magnetic field strength, the electron Lorentz factor, the radius of the emitting region, and the Doppler factor, on the base of the analysis of the observed light curves.

LOOKING FOR FLARES AND CME SIGNATURES IN THE SPECTRA OF SEVERAL COOL STARS

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It is critical to look for and estimate CME and flare signatures from late-type stars in order to understand stellar activity and its impact on space weather and planetary atmospheres. Spectroscopic observations of the Hα Balmer line is one of the methods.

We present spectroscopic observations of four stars of spectral types G, K, and M. The observations were made over a number of epochs using the NOT/ALFOSC on La Palma and the 2-*m* RCC telescope/ESPERO at the National Astronomical Observatory of Rozhen. In April, July, and September of 2021, we collected 303 spectra over two nights. With the ALFOSC instrument, we obtained 168 spectra and the ESPERO instrument, we obtained 135 spectra. The results do not show the events we are looking for, which raises concerns.

BULGARIAN-SERBIAN COOPERATION: CCD OBSERVATIONS OF VISUAL DOUBLE STARS IN THE PERIOD 2004-2022

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In this work we present the review of the measurements of binaries whose frames were obtained using 2-meters telescope at NAO Rozhen in the period from 2004 to 2022. Distributions of measured pairs as functions of separation, the list of pairs measured for the first time, residuals (O-C) in both coordinates (separations and position angles) for those binaries which have had previously published orbital elements and two new orbits are given.

INVESTIGATION OF THE SUNRISE EFFECT IN THE IONOSPHERE

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The main idea of the present study is to track at what altitudes of the Earth's atmosphere the influence of the sun begins to be observed, before the sunrise has occurred. For this purpose, data on the Total Electron content (TEC) from the Center for Orbit Determination in Europe (CODE) were used for the point closest in terms of coordinates to Sofia. The results are presented for the hours after universal time when the TEC rise is observed and the corresponding altitude at which this occurs. Physical explanations of the obtained results are proposed.

THE APPLICATION OF THE X-RAY VS. UV LUMINOSITY RELATION FOR QUASARS

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Quasars are robust tracers of large-scale structure up to high redshifts (z~7.5). Variability of quasars is the main obstacle against their usage as standard candles. The correlation between the luminosities in the X-ray and UV (generally linking the 2 *keV* and 2500 *Å* monochromatic luminosities), reflecting the accretion disc vs. corona interplay, deserves attention due to its non-linearity and negligible redshift dependence. These can make possible the extension of the Hubble-Lemaître diagram (HLD) of supernovae to higher redshift ranges. Several filtering steps have been applied producing a cleaned sample with a drop in the relation dispersion. Its further reduction would be of high relevance for cosmology studies, in particular in the framework of the so called Hubble tension – the about 4σ discrepancy between the estimates based on cosmic microwave background (CMB) under the assumption of the Λambda Cold Dark matter (ΛCDM) model and the ones involving the cosmic distance ladder method using Cepheids and supernovae. The purpose of this study is to further minimize the dispersion of the HLD for a sample of quasars by accounting for the contribution of broad line emission and host galaxy to the UV through decomposing the quasar spectral energy distribution (SED; which would also provide a proper reddening correction). The resulting relation will be discussed in the context of the ΛCDM model.

PROCESSING DOUBLE STARS IMAGES USING MACHINE LEARNING

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We use Machine Learning to process observations of double stars obtained by lucky imaging technique. First, we generate a large number of images of a double star system, whose PSF is Gaussian in the shape distribution, in a wider range of separations and position angles, which serves us for learning the system. Once we have trained the system to recognize double stars, we input our images of a particular double star, which were made at the Astronomical Station at Vidojevica with the 1.4 *m* telescope attached CCD camera.

Andor iXon 897 Ultra, and as a result we get its separation and positional angle.

DIFFERENT TYPE PROMINENCE ERUPTIONS ASSOCIATED WITH CMEs

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Coronal mass ejections (CMEs) are closely related with prominence eruptions.

Here we focus on the prominence eruptions (PEs) and their associated CMEs in six events. The presented events differ by the type, pre-eruptive conditions and eruption evolution. We calculate kinematic parameters of the eruption and discuss magnetic properties of the region of origin as a main factor for the specific PE and CME evolution.

BILATERAL BULGARIAN-INDIAN PROJECT "ERUPTIONS, FLOWS AND WAVES IN SOLAR ATMOSPHERE AND THEIR ROLE IN SPACE WEATHER": OVERVIEW OF THE RESULTS

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We present the results from a collaborative project between scientists from the Bulgarian Academy of Sciences (BAS), Bulgaria and the Department of Physics, Kumaun University, Nainital, India. The goal of this project is to investigate the solar eruptions from small-to-large scales and probe the role of these activities on the space weather.

THE RADIATIVE PROCESSES INVOLVING ION-ATOM ALKALI SYSTEMS: SPECTRAL CHARACTERISTICS OF GEOCOSMIC PLASMAS

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Opacities of stellar atmospheres are caused by a huge number of radiative processes. As part of the development of more sophisticated stellar atmosphere models, we can further explore known processes and include all processes not previously discussed. The average cross-section for the photodissociation and the corresponding spectral absorption coefficients of the molecular ions Li2+, Na2+, LiNa+, H2+ and HeH+ are calculated for the wide region of temperatures and wavelengths ready for further use with a particular accent to the applications for astro plasma research and low temperature laboratory plasma research.

PYTHON, SCRIPT LANGUAGE IN JUNIOR HIGH SCHOOL

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This article discusses some guidelines related to the transition from block programming language to script text language, the main competence related to the teaching of Computer Modeling in 6th grade. Here are some sample tasks that may be useful in learning the Python scripting language.

PHOTOMETRIC VARIABILITY IN HII REGIONS IC 1795 AND NGC 2174

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We present the results of 3 *year* long multiepoch observations of the HII regions IC 1795 and NGC 2174. The purpose of the research is to scan the HII regions for variable objects inside them. For this task we used the 50/70 *cm* Schmidt telescope of NAO Rozhen. We detected 53 variable objects in total, 6 of them confirmed by AAVSO VSX. Estimated average absolute magnitudes for the variables range between 2.5 and 6.8 *mag*.

HIGH-ENERGY UV IRRADIANCE IS DANGEROUS TO EARTH'S BIOLOGICAL SPECIES

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High-energy UV irradiance is dangerous to Earth's biological species. Periodic terrestrial measurements of natural UV radiation are of essential preventive importance for humans. In high mountain conditions – secondary high-energy events in the atmosphere and corresponding peaks in the spectrum of UV-A, UV-B or UV-C irradiance associated with the reduced generation of stratospheric ozone, micro-ozone holes can be observed as well as vertical fluctuations of atmospheric transparency caused by the movement of aerosol and cloud formations. Comparative measurements of UV-A, UV-B irradiance are carried out at the BEO-Musala (2925 *m*) station and NAO-Rozhen (1759 *m*) using in-home developed digital UV sensor heads. High-resolution daily profiles of the visible solar irradiation and the corresponding UV component are compared. The latest summer campaign of UV measurement confirms the unexpected high values (>12.0) of UV index at NAO-Rozhen.