Taras Shevchenko National University of Kyiv
Department of Astronomy and Space Physics

28th Young Scientists' Conference on Astronomy and Space Physics

Abstracts

Kyiv, 2022

28th Young Scientists' Conference on Astronomy and Space Physics

October 24 – 28, 2022
Kyiv, Ukraine

Scientific Organizing Committee

Vasyl M. Ivchenko (chair), Kyiv, Ukraine
Vasyl Ya. Choliy (co-chair), Kyiv, Ukraine
Gennadi P. Milinevsky, Kyiv, Ukraine
Bohdan I. Hnatyk, Kyiv, Ukraine
Ivan L. Andronov, Odessa, Ukraine
Liudmyla Kozak, Kyiv, Ukraine
Nataliya G. Shchukina, Kyiv, Ukraine
Vasilij Shevchenko, Kharkiv, Ukraine

International Advisory Committee

Ericson Lopez, Ecuador
Agnieszka Pollo, Krakow, Poland

Local Organizing Committee

R. Akhmetshyn (chair), Ye. Zhyhaniuk (secretary), I. Chemerynska, D. Trotsenko, P. Plotko, O. Torbaniuk, D. Orikhovskyi, O. Kompaniiets, M. Chupira, O. Ostapenko, Ye. Sheputa, K. Kulish, Yu. Yukhimchuk, A. Nahurna, O. Shubina.

Address for correspondence:

Dr. V. M. Ivchenko, P.O. Box 7, Kyiv-22, 03022, Ukraine
e-mail: *ysc.kyiv@gmail.com*

Address:

Astronomy and Space Physics Department,
Faculty of Physics,
Taras Shevchenko National University of Kyiv,
Glushkova ave., 4, Kyiv, 03127, Ukraine.
Phone: +(380) 44-526-44-57
Fax: +(380) 44-526-45-07

Preface

This year Young Scientists' Conference on Astronomy and Space Physics is held for the twenty eightth time. We all have been looking forward to the annual meeting of astronomers at the Taras Shevchenko National University of Kyiv (KNU). Now it has friendly opened its doors for participants from all over the world.

Young Scientists' Conference has a long history. The first meeting was organized by Faculty of Physics of KNU as a students' conference in 1994. Since 1996 our conference has welcomed young researchers from other universities and scientific institutions. During 1994-2017 participants from Ukraine, Russia, Poland, France, Germany, Spain, Sweden, Libya, Egypt, Japan, Finland, Turkey, China, Slovakia, Armenia, USA, Romania, Iran, Armenia, Georgia, Morocco, South Africa and other countries participated in Young Scientists' Conference.

The conference is aimed at strengthen the position of astronomy and promote space physics research. The lectures and reports presented by the participants traditionally reflect modern trends and actual problems of the science, the sessions facilitate informational exchange about the latest innovations and achievements.

We would like to express our gratitude to the invited lecturers and participants for contributing lectures and reports, and to Prof. V. M. Ivchenko for the help in conference organization.

Roman Akhmetshyn and
the Local Organizing Committee

PROGRAMME

Monday, October, 24

10.30-11.00 - Official opening

Section 'Extragalactic astrophysics and cosmology'

11.00-11.45 Prof. Wojciech Hellwing *(Center for Theoretical Physics of PAS, Warsaw, Poland)* In a quest to understand cosmic acceleration: testing gravity and beyond **(invited)**

11.45-12.00 Suhani Gupta, W. Hellwing, M. Bilicki, J. Garcia-Farieta *(Center for Theoretical Physics of PAS, Warsaw, Poland)* Imprints of modified gravity on non-linear structure formation **(12+3)**

12.00-12.15 Dr. Olga Avsajanishvili, Y. Huang, L. Samushia, T. Kahniashvili *(E.Kharadze Georgian National Astrophysical Observatory, Tbilisi, Georgia)* Reconstruction and analysis of cosmological scalar field φCDM models **(12+3)**

12.15-12.30 Olexandr Gugnin, A. Tugay, L. Zadorozhna *(Taras Shevchenko National University of Kyiv, Kyiv, Ukraine)* Predicting large scale structure of the Universe using deep learning methods **(12+3)**

12.30-12.45 Sergey Skolota, E. Bannikova *(Institute of Astronomy of V.N. Karazin Kharkiv National University, Kharkiv, Ukraine)* New approximate expressions for the outer gravitational potential of a torus with an elliptical cross-section **(12+3)**

12.45-13.00 Magdalena Krupa, A. Pollo, M. Bilicki *(Astronomical Observatory of the Jagiellonian University, Kraków, Poland)* The choice of the Zone of Avoidance compensation method to estimate clustering dipole in galaxy catalogs **(12+3)**

13.00-13.05 Iryna Chemerynska, H. Atek *(Institut d'Astrophysique de Paris, Paris, France)* Early star-forming galaxies through Gravitational telescopes **(poster)**

13.05-13.40 coffee-break

13.40-13.55 Subhrata Dey, A. Goyal, K. Małek, T. Galvin, N. Seymour, T. Santos, J. Piotrowska, V. Charmandaris *(Astronomical Observatory of the Jagiellonian University, Kraków, Poland)* Low frequency radio continuum imaging and SED modeling of 11 local luminous infrared galaxies in radio and infrared domains **(12+3)**

13.55-14.10 Marcos Muñiz Cueli, L. Bonavera, J. González-Nuevo, D. Crespo, J. Casas, A. Lapi *(Facultad de Ciencias de la Universidad de Oviedo, Oviedo, Spain)* Tomography-based observational determination of the abundance of dark matter halos using the submillimeter galaxy magnification bias **(12+3)**

14.10-14.25 Unnikrishnan Sureshkumar, A. Durkalec, A. Pollo *(Astronomical Observatory of the Jagiellonian University, Kraków, Poland)* Galaxy properties as tracers of environment in the cosmic web **(12+3)**

14.25-14.40 Dr. Olena Torbaniuk *(University Federico II in Naples, Naples, Italy)* Improved technique for quasar continuum prediction in the Lyα forest based on composite spectra **(12+3)**

14.40-14.55 Ian Hendricksen *(McGill University, Montréal, Canada)* Preliminary Global 21cm Observations with MIST from the Canadian High Arctic **(12+3)**

14.55-15.10 Vadym Bidula, R. Monsalve, J. Sievers *(McGill University, Montréal, Canada)* Dynamic model of the ionosphere for wide-field radio experiments **(12+3)**

15.10-15.25 Christopher Barbarie *(McGill University, Montréal, Canada)* Drone-Based Calibration Technique for The Array of Long Baseline Antennas for Taking Radio Observations from the Sub-Antarctic (ALBATROS) **(12+3)**

15.25-15.30 Aditya Narendra *(Jagiellonian University, Kraków, Poland)* Predicting the redshift of gamma-ray loud AGNs using supervised machine learning **(poster)**

Tuesday, October, 25

Section 'Stellar Astrophysics and Interstellar Medium'

10.10-10.55 Dr. Ivan Andronov, L. L. Chinarova, L. S. Kudashkina *(Physics and Astronomy Odesa National Maritime University, Odesa, Ukraine)* Mathematical modeling of the light curves of variable stars: review and atlas of the light curves **(invited)**

10.55-11.10 Alaxender Panchal *(Aryabhatta Research Institute of Observational Sciences, Nainital, India)* Photometric and spectroscopic analysis of contact binaries **(12+3)**

11.10-11.25 Katarzyna Nowak *(University of Hertfordshire, Hatfield, United Kingdom)* Could kilomasers pinpoint supermassive stars? **(12+3)**

11.25-11.40 Polina Dimitriieva *(Taras Shevchenko National University of Kyiv, Kyiv, Ukraine)* Study of the Lithium abundance in solar-type stars **(12+3)**

11.40-11.45 Olivia Muzyka *(Gimnasium "Academiia", Kyiv, Ukraine)* Close binary star system Cygnus X-1. Relative and absolute photometry **(poster)**

11.45-12.30 coffee-break

12.30-12.45 Dr. Vitalii Breus *(Odesa National Maritime University, Odesa, Ukraine)* Spin and orbital variability of the intermediate polar RX J2133.7+5107 **(12+3)**

12.45-13.00 Dr. Devendra Bisht *(Indian Centre for Space Physics, Netai Nagar Kolkata, India)* Study of open cluster King 13 using CCD VI, 2MASS and Gaia DR2 Astrometry **(12+3)**

13.00-13.15 Dr. Vitalii Breus *(Odesa National Maritime University, Odesa, Ukraine)* Photometric monitoring of short-period eclipsing binaries discovered at Astronomical Observatory on Kolonica Saddle **(12+3)**

13.15-13.20 Jakub Tokarek *(Astronomical Observatory Institute, Adam Mickiewicz University in Poznań, Poznań, Poland)* Search for hierarchical systems in the Gaia EDR3 **(poster)**

Wednesday, October, 26

Section 'Solar System & Exoplanets'

10.00-10.15 Olena Shubina, M. Husárik, O. Ivanova *(Astronomical Institute of the Slovak Academy of Sciences, Tatranská Lomnica, Slovak Republic; Main Astronomical Observatory of National Academy of Sciences of Ukraine, Kyiv, Ukraine)* Multiwavelength photometry of comet C/2013 X1 (Pan-STARRS) **(12+3)**

10.15-10.30 Kateryna Kulish, O. Ivanova *(Comenius University in Bratislava, Slovakia)* Investigation of dust component of hyperbolic comet C/2015 VL62 **(12+3)**

10.30-10.45 Oleksandra Pyshna, A. Baransky, S. Borysenko *(Astronomical Observatory of Taras Shevchenko National University of Kyiv, Ukraine)* Photometry, astrometry and dust productivity analysis of comet 67P/Churyumov-Gerasimenko in 2021-2022 **(12+3)**

10.45-11.30 Dr. Oleksiy Golubov *(Institute of Astronomy Kharkiv National University, Kharkiv, Ukraine)* Search for metallic asteroids **(invited)**

11.30-11.45 Valeriia Rychahova, I. Slyusarev *(Institute of Astronomy Kharkiv National University, Kharkiv, Ukraine)* Phase and color ratio method for searching areas with ananomalous optical roughness on the Vesta surface **(12+3)**

11.45-12.00 Varnana M. Kumar, T. E. Girish, T. N. Sathyan, B. Longhinos, J. Binoy *(Department of physics Marivanious College Trivandrum, Kerala, India)* Tidal heating in potentially habitable extrasolar planets **(12+3)**

12.00-12.15 Roman Akhmetshyn, S. Metchev, R. Brown, M. Mazur, B. Amblard *(Taras Shevchenko National University of Kyiv, Kyiv, Ukraine)* Research of Kuiper belt objects and exoplanet transits using robotic telescope array **(12+3)**

12.15-12.45 coffee-break

12.45-13.30 Prof. Stanimir Metchev *(Western University, London, Canada)* Weather on other worlds: from studying clouds and winds to seeking life **(invited)**

13.30-13.45 Samantha Lambier, S. Metchev, G. Suárez, J. Hales, J. Martinovic *(Western University, London, Canada)* Characterizing the Input Sample for the POET Transiting Exoplanet Microsatellite Mission **(12+3)**

13.45-14.00 Burçak Yeşilirmak *(Akdeniz University, Antalya, Turkey)* Implementation of Floating Point Arithmetics with Accurate Rounding to the Two Body Problem **(12+3)**

14.00-14.15 A. Nahurna, Mykhailo Solomakha, M. Lobodenko, A. Baransky *(Taras Shevchenko National University of Kyiv, Kyiv, Ukraine)* Investigation of planetary systems of WASP, TrES, Qatar and Kepler projects by using transit photometry with O-C parameter tracking and TTV method application on Kyiv Comet Station **(12+3)**

14.15-14.30 Mariia Lobodenko, I. Kulyk, Ya. Pavlenko, A. Nahurna, M. Solomakha, A. Baransky *(Taras Shevchenko National University of Kyiv, Kyiv,*

Ukraine) Comparative analysis of observations of the selected exoplanet transits obtained at the Kyiv Comet station, with TESS and Kepler Space Telescopes **(12+3)**

Thursday, October, 27

Section 'Atmospheric studies and space geophysics'

12.00-12.15 Thara N Sathyan, V. M. Kumar, T. E. Girish, J. Binoy *(University College Of Engineering Kariavattom, Thiruvananthapuram, India)* Comparison of radioactive element distribution in Earth, Moon and Mars **(12+3)**

12.15-12.30 Maksym Vasiuta, H. Järvinen *(Institute for Atmospheric and Earth System Research, University of Helsinki, Helsinki, Finland)* Validation of the Earth planetary albedo using top-of-atmosphere fluxes of numerical weather prediction model **(12+3)**

12.30-12.45 Yuliia Yukhymchuk *(Laboratoire d'Optique Atmosphérique, Villeneuve-d'Ascq, France)* Air quality monitoring in Kyiv with the AirVisual network: pollution by PM 2.5 and PM 10 **(12+3)**

12.45-13.00 Anastasiia Sokareva, O. Ivaniga, N. Tkachenko *(Taras Shevchenko National University of Kyiv, Kyiv, Ukraine)* Antarctic tropopause above Marambio station in the conditions of the ozone hole during 2004-2019 **(12+3)**

13.00-13.15 Bohdan Petrenko, L. Kozak, E. A. Kronberg, R. Akhmetshyn *(Taras Shevchenko National University of Kyiv, Kyiv, Ukraine; Space Research Institute of the National Academy of Sciences of Ukraine and the State Space Academy of Ukraine, Kyiv, Ukraine)* Dispersion wave analysis of kink-like and stationary-like current sheet flapping motions in the Earth's magnetotail **(12+3)**

13.15-13.20 Sergei Petrishchevskii, Yu. Rapoport, V. Grimalsky, V. Reshetnyk, A. Grytsai, A. Liashchuk, A. Fedorenko *(Taras Shevchenko National University of Kyiv, Kyiv, Ukraine)* Penetration of electric field from the near-ground source to the ionosphere. Problem of dynamic-quasistatic limiting pass **(poster)**

13.20-13.25 Dr. Serhiy Cheremnykh, O. Cheremnykh, D. Vlasov, T. E. Kaladze, E. Kronberg *(Space Research Institute under NAS Of Ukraine and State Space Agency of Ukraine, Kyiv, Ukraine)* Evanescent acoustic-gravity waves in a rotating stratified atmosphere **(poster)**

Section 'Solar physics and heliosphere'

13.25-14.10 Dr. Olena Podladchikova, A. Warmuth and Extreme Ultraviolet Consortium on Solar Orbiter *(Astrophysical Institute of Potsdam, Potsdam, Germany)* Picoflares in the Solar corona observed by Solar Orbiter **(invited)**

14.10-14.15 Anitha Ravishankar, G. Michalek, S. Skone, E. Spanswick, R. Gillies *(University of Calgary, Calgary, Canada)* Kinematics of coronal mass ejections and auroral science **(12+3)**

14.15-14.30 Sanghita Chandra, Ch. Saha, D. Nandy *(Max Planck Institute for Solar System Research, Göttingen, Germany)* Persistence of weak magnetic cycles during solar grand minima episodes **(12+3)**

14.30-14.45 Ashutosh Pattnaik, A. Ravishankar, G. Michalek *(Jagiellonian University, Krakow, Poland)* Transit time estimation of earthbound CMEs **(poster)**

14.45-15.00 Jatav Bheem Singh *(Department of physics, Sikkim University, Gangtok, Sikkim, India)* Coherent structures of kinetic Alfvén wave to study solar wind at 1 AU **(12+3)**

15.00-15.45 Dr. Oleksiy Agapitov *(SSL UC Berkeley, Berkeley, USA)* Magnetic switchbacks in the young solar wind: generation and evolution **(invited)**

Friday, October, 28

Section 'High energy astrophysics'

12.15-13.00 Prof. Iurii Sushch *(North-West University, Potchefstroom, South Africa)* Supernova remnants are sources of Galactic cosmic rays, or are they? **(invited)**

13.00-13.15 Natia Kevlishvili, *(Institute of Theoretical Physics, Ilia State University, Tbilisi, Georgia)* The curvature emission model of unusual neutron star candidate 1RXS J141256.0+792204 (Calvera) **(12+3)**

13.15-13.30 Angel Priyana Noel, H. Gaur, A. Gupta, A. Wierzcholska, M. Ostrowski, V. Dhiman, G. Bhatta *(Astronomical Observatory of Jagiellonian University, Krakow, Poland)* X-ray intraday variability of the TeV blazar Mrk 421 with XMM-Newton **(12+3)**

13.30-13.45 Pavlo Panasiuk, V. Sagun, K. Hamaguchi, N. Nagata *(Taras Shevchenko National University of Kyiv, Kyiv, Ukraine)* Rotochemical heating in hybrid stars **(12+3)**

13.45-14.15 coffee-break

14.15-14.30 Edoardo Giangrandi, V. Sagun, O. Ivanytskyi, C. Providência, T. Dietrich *(CFisUC, University of Coimbra, Coimbra, Portugal)* Impact of asymmetric bosonic dark matter on neutron star properties **(12+3)**

14.30-14.45 Dr. Anton Rudakovskyi, M. Khelashvili, S. Hossenfelder *(Bogolyubov institute for theoretical physics Kyiv, Ukraine)* Dark matter profiles of SPARC galaxies **(12+3)**

14.45-15.00 Pavlo Plotko, A. van Vliet, X. Rodrigues, W. Winter *(Deutsches Elektronen-Synchrotron DESY, Zeuthen, Germany)* Indication of a Local Source of Ultra-High-Energy Cosmic Rays in the Northern Hemisphere **(12+3)**

15.00-15.30 Official closure

INVITED LECTURES

In a quest to understand cosmic acceleration: testing gravity and beyond

Wojciech Hellwing

Center for Theoretical Physics of PAS, Warsaw, Poland

wojtek.hellwing@gmail.com

The GR is over 100 years old. Einstein's relativity theory of space-time and gravity is one of the founding blocks of modern physics and cosmology in particular. In my talk, I shall discuss why one would like (and actually really need) to design and convey tests of the theory on cosmological scales. Then, I will also present a handful of theories (called Modified Gravity) that aim to rival the ruling of GR at the cosmological distances.

Such theories are usually conveyed in order to explain observed accelerated expansion of the Universe without Einstein's cosmological constant.

Finally, I will present and discuss some reasonable ways for conveying the cosmological test of gravity, discuss why most of them might fail and present some potentially promising avenues for new classes of such tests. Concluding with why you might want to stay tuned for the future in that field!

Mathematical modeling of the light curves of variable stars: review and atlas of the light curves

Ivan Andronov, L. L. Chinarova, L. S. Kudashkina

(Odesa National Maritime University, Odesa, Ukraine

tt_ari@ukr.net

We review the study of variable stars using mathematical modeling of their mean light curves. The simulation is carried out by various methods, using the observational databases AAVSO, AFOEV, VSOLJ, TESS, ZTF, ASAS-SN, etc. The purpose of the simulation is to "digitize" the light curves to determine statistically optimal numerical parameters that characterize brightness changes with time. One of the simulation results is the compilation of an "atlas" of mean and individual light curves and "phase portraits" for stars of different types. This study is within the frames of the international projects "Virtual Observatory", "AstroInformatics", "Inter-Longitude Astronom".

Search for metallic asteroids

Oleksiy Golubov

Institute of Astronomy of V. N. Karazin Kharkiv National University, Kharkiv, Ukraine

oleksiy.golubov@karazin.ua

Metal asteroids are lurking somewhere in the asteroid belt, concealing a source of extraterrestrial resources, presenting a danger to life on Earth, and holding keys to the early history of the Solar System.

We know their existence for sure as their fragments are regularly falling on the Earth's surface as iron meteorites.

We understand how metal asteroids originated at the molten interiors of planetesimals during the first few million years of the Solar System's history and later were liberated in planetesimal collisions.

But by and large, we still cannot point out particular asteroids and say with certainty that they are metallic.

How could we? Should we study their spectra? Colors? Albedos? Radar albedos? Thermal properties? Could we do the impossible and measure their densities?

I will review the status of the search for metal asteroids and try to persuade you that the present-day negative results can conceal neither the beautifully rich physics of asteroids nor the scent of shortly approaching discoveries.

Weather on other worlds: from studying clouds and winds to seeking life

Stanimir Metchev

Western University, London, Ontario N6A 3K7, Canada

smetchev@uwo.ca

Weather systems are now known to be ubiquitous on brown dwarfs, and probably also on all extrasolar planets with atmospheres. Brightness monitoring of rotating brown dwarfs and exoplanets has revealed storm- and band-like cloud structures, much like on solar system planets. Spectroscopic monitoring has probed the altitudes and chemistry of the constituent cloud layers. Astronomy is thus rapidly revealing the structure of exoplanetary atmospheres.

The unprecedented observational precision that enabled these developments has also offered an interesting new opportunity: to efficiently seek habitable Earth-like exoplanets around very low-mass stars or brown dwarfs. This is the goal of a new

small-satellite telescope mission, POET, proposed to the Canadian Space Agency and recently endorsed in the 2020 Long Range Plan for Canadian Astronomy. Any planets discovered by POET may well offer the first opportunity to discover extra-solar life.

Picoflares in the Solar Corona observed by Solar Orbiter

Olena Podladchikova[1], A. Warmuth[1], Extreme Ultraviolet Consortium on Solar Orbiter[2]

[1] *Astrophysical Institute of Potsdam, Potsdam, Germany*
[2] *Euroepan Space Agency*

epodlad@gmail.com

X-ray monitoring of the Sun inspired Eugen Parker's description of the elementary unit of energy release in the corona as nanoflare. He predicted the observation of even smaller events with more sensitive instruments of the 21st century. Until recently, it was impossible to confirm their existence in the corona. Moreover, the physical threshold for solar flares has been set at 10^{24} ergs (one nanoflare). On May 30, 2020, the Solar Orbiter High-Resolution EUV Imager, designed to minimize stray light and being half the distance to the Sun, recorded heating events with more minor space-time characteristics than nanoflares. We estimated the thermal input of events from the derived increase of emission measure and temperature. We compared these events with the STIX X-Ray microflares recorded during the same period of Solar Orbiter's commissioning. We found that observed events emit thermal energy in the picoflare range of 10^{21}–10^{24} ergs per event, lowering the limit of minimal known solar flares. Events demonstrate the same relationship between the physical characteristics of solar X-ray flares but at lower ranges. They are GOES class flares, which are at least five times lower than A-class GOES flares. (1) Discovered with Solar Orbiter picoflares provide 3% of the additional, previously unobserved power of the total amount needed to heat the solar corona. (2) Their detailed morphology, observed at unprecedentedly small scales, is studied using stereoscopic methods.

Magnetic Switchbacks in the Young Solar Wind: Generation and Evolution

Oleksiy Agapitov[1], J. Drake[2], M. Swisdak[2]

[1] *SSL UC Berkeley, Berkeley, USA*
[2] *University of Maryland, College Park, Maryland, USA*

agapitov@ssl.berkeley.edu

A major discovery of Parker Solar Probe (PSP) was the presence of large numbers of localized increases in the radial solar wind speed and associated sharp deflections of the magnetic field — switchbacks (SB). A possible generation mechanism of SBs is through magnetic reconnection between open and closed magnetic flux near the solar surface, termed interchange reconnection that leads to the ejection of flux ropes (FR) into the solar wind. Observations suggest that SBs undergo merging, consistent with a FR picture of these structures. The role of FR merging in controlling the structure of SBs in the solar wind is explored through direct observations, analytic analysis, and numerical simulations. Analytic analysis reveals key features of the structure of FRs and their scaling with heliocentric distance R that are consistent with observations and demonstrate the critical role of merging in controlling the structure of SBs. FR merging is shown to energetically favor reductions in the strength of the wrapping magnetic field and the elongation of SBs. A further consequence is the resulting dominance of the axial magnetic field within SBs that leads to the observed characteristic sharp rotation of the magnetic field into the axial direction at the SB boundary. Finally, the radial scaling of the SB area in the FR model suggests that the observational probability of SB identification should be insensitive to R, which is consistent with the most recent statistical analysis of SB observations from PSP.

Supernova remnants are sources of Galactic cosmic rays, or are they?

Iurii Sushch

North-West University, South Africa

iurii.sushch@gmail.com

Supernova remnants (SNRS) are widely considered to be the main candidates for sources of Galactic cosmic rays. The main argument for this remains the energy budget provided by SNRs, which is sufficient to explain the cosmic-ray energy density. It is also established that SNRs can effectively accelerate particles at their shocks, which is confirmed by detection of non-thermal X-ray and gamma-ray emission from a number of remnants. There are still, however, quite a few problems with this scenario, which will be extensively discussed in the lecture.

EXTRAGALACTIC ASTROPHYSICS & COSMOLOGY

Universality of halo mass function in modified gravity cosmologies

Suhani Gupta, W. Hellwing, M. Bilicki

Center for Theoretical Physics of PAS, Warsaw, Poland

gupta@cft.edu.pl

Large-scale structures (LSS) form via relentless action of gravitational forces on density perturbations over cosmic length and time scales. Thus, the non-linear regime of LSS formation is sensitive to the underlying theory of gravity, and hence provides estimates for observables that can help distinguish modified gravity effects from the expected standard GR results. In this work, I focus on two modified gravity models: namely variants of f(R) and nDGP gravity models. These MG theories offer a very good test bed to explore the freedom of modifying the Einstein-Hilbert action to produce a physical mechanism effectively mimicking the action of the cosmological constant, that would result in cosmic acceleration. These MG models are constructed in such a way that they have negligible consequences at early times and share the same expansion history and cosmological background as ΛCDM.

As a result, the effect of these MG models is incorporated in the perturbation equations that govern the gravitational dynamics of LSS, and can potentially impact the formation and evolution of dark matter halos. Thus, the statistical properties of dark matter halos, that form the building blocks of cosmological observables associated with large-scale structures in the universe, offer opportunities for testing modifications to the gravitational forces.

In this work, I focus on halo statistics: halo mass function, halo bias and halo density profile, using results generated from MG N-body simulations. We obtain systematic trends in these quantities on comparing MG results with standard GR cases. These trends can be further used to compute semi-analytical modeling for these MG cosmologies and make robust estimates for cosmological observables. This will be advantageous as N-body simulations are prohibitively expensive for the case of most nontrivial MG scenarios.

Reconstruction and analysis of cosmological scalar field φCDM models

Olga Avsajanishvili[1], Y. Huang[2], L. Samushia[3,1], T. Kahniashvili[4,5,1,6]

[1] *E. Kharadze Georgian National Astrophysical Observatory, Tbilisi, Georgia*
[2] *University of California, USA*

[3] *Kansas State University, USA*
[4] *Carnegie Mellon University, USA*
[5] *Ilia State University, Georgia*
[6] *Laurentian University, Canada*

olga.avsajanishvili@iliauni.edu.ge

We studied scalar field φCDM models: ten quintessence models and seven phantom models. We reconstructed these models, using the phenomenological method developed by us. Resulting in, for each potential the following ranges were found: (i) model parameters; (ii) EoS parameters; (iii) initial conditions for differential equations, which describe the dynamics of the universe. Using the MCMC analysis, we obtained constraints on scalar field models by comparing observations for: the expansion rate of the universe, the angular diameter distance and the growth rate function with corresponding data generated for the fiducial ΛCDM model. We applied the Bayes statistical criteria to compare scalar field models. To this end, we calculated the Bayes factor, as well as the AIC and BIC information criteria. The results of this analysis showed that we could not uniquely identify the preferable scalar field φCDM models compared to the fiducial ΛCDM model based on the predicted DESI data, and that the ΛCDM model is a true dark energy model. We investigated scalar field φCDM models in the w0–wa phase space of CPL–ΛCDM contours. We identified subclasses of quintessence and phantom scalar field models, which at the present epoch: (i) can be distinguished from the ΛCDM model; (ii) cannot be distinguished from the ΛCDM model; (iii) can be either distinguished or undistinguished from the ΛCDM model. We found that all studied models can be divided into two classes: models that have attractor solutions and models whose evolution depends on initial conditions.

Predicting large scale structure of the Universe using deep learning methods

Olexandr Gugnin[1], A. Tugay[1], L. Zadorozhna[2]

[1] *Taras Shevchenko national university of Kyiv, Kyiv, Ukraine*
[2] *Jagiellonian university, Faculty of physics, astronomy and applied computer science, Krakow, Poland*

alexgugnin21@gmail.com

Machine learning plays an important role in all of the contemporary sciences, especially its deep learning part. Neural networks are used to classify objects, to clusterize different groups, to predict data structures and lots more. The main aim of our report is to review the role of machine learning in the astronomy and cosmology and usage of deep learning methods, such as transformers, for studying

the large scale structure of the Universe. In this case we provide two possible tasks. First one was to predict coordinates of galaxies from known coordinates from SDSS catalogue via machine learning. Second problem was to predict snapshots of dark matter halos from well known ILLUSTRIS simulations using deep learning transformer methods. These studies are regarded as those who might highly increase today's knowledge about evolution of large scale structure of the Universe.

New approximate expressions for the outer gravitational potential of a torus with an elliptical cross-section

Sergey Skolota[1], E. Bannikova[2,3]

[1] *Institute of Astronomy of V.N. Karazin Kharkiv National University, Kharkiv, Ukraine*
[2] *INAF – Capodimonte Astronomical Observatoty, Naples, Italy*
[3] *Institute of Radio Astronomy of NAS of Ukraine*

sergeyskolota@gmail.com

Toroidal (or ring) structures are quite common objects in the Universe. For example, these are obscuring dust tori in active galactic nuclei (ANGs), protoplanetary and accretion disks, ring galaxies, etc. In some objects, where the torus can be massive enough, it affects the motion and dynamics of matter. N-body simulations of the torus in the field of the central mass show that the equilibrium cross-section of the self-gravitating torus can take an elliptical (or oval) shape depending on the initial conditions. All these facts motivate the study of the gravitational potential of toroidal bodies. This is important to understand the dynamic in such a kind of astrophysical objects and to develop the theory of gravitational potential as a whole.

This work is devoted to the study of the gravitational potential of a torus with an elliptical cross-section in the outer region (outside the volume of the torus) for an arbitrary ellipticity parameter. We use an integral expression for the gravitational potential of the elliptical torus which is valid at an arbitrary point. This expression was obtained by the following method. We consist the torus of a set of the massive circles. In this case, the torus potential is a sum of the potential of the massive circles. Such consideration allows us to obtain the approximate expression due to expand the potential of component ring in a Maclaurin series in the vicinity of the center of the elliptic cross-section. Restricting ourselves to terms of the second order, we expressed the outer potential of the elliptic torus in terms of the potential of the massive circle located in the equatorial plane with a radius equal to the torus major radius. The obtained approximate expression for the outer potential of the torus is valid in a wide range of cross-sectional ellipticity parameters. One of the interesting results is the representation of the potential of the elliptic torus via two massive circles located at some distance from the foci

of the cross-section. We obtained the corresponding approximate expression for this case. The good agreement between the approximate expressions for the outer potential of an elliptic torus and the exact integral expression is confirmed by the corresponding error maps.

Galaxy properties as tracers of environment in the cosmic web

Unnikrishnan Sureshkumar[1], A. Durkalec[2], A. Pollo[1,2]

[1] *Astronomical Observatory of the Jagiellonian University, Kraków, Poland*
[2] *National Centre for Nuclear Research, Warsaw, Poland*

uk.potty.s@doctoral.uj.edu.pl

Galaxies live in dark matter haloes and hence the galaxy properties are majorly defined by the properties of the haloes. Thus the environmental dependence of dark matter halo properties prompts a correlation between galaxy properties and the environment. In this talk, I will discuss the results from our recent works, that explored how luminosities in optical to mid-infrared bands, stellar mass, and star formation rate are correlated with the environment. We use a set of stellar mass-selected and 3.4μm luminosity-selected galaxies from the Galaxy and Mass Assembly (GAMA) survey. We utilize the galaxy two-point correlation functions and marked correlation functions to investigate the environmental correlations. I will also discuss the impact of various selection effects on the galaxy clustering measurements.

Early star-forming galaxies through Gravitational telescopes

Iryna Chemerynska, H. Atek

Institut d'Astrophysique de Paris, Paris, France

chemerynskaira@gmail.com

The standard hierarchical model of galaxy formation predicts that small objects form first before growing and merging into more massive objects. In this context, the shape of the luminosity and mass distribution of galaxies provides a direct constraint on galaxy formation models. The interplay between gas accretion and feedback is likely reflected in the shape of the luminosity function (LF) few hundred million years after the Big Bang. It is therefore possible to constrain the growth rate of early star-forming galaxies by looking at the evolution of the luminosity functions as a function of redshift.

The developed completeness simulations allow us to directly estimate survey completeness in stellar mass through strong lensing clusters to select such high-redshift galaxies.

Together with the BUFFALO program that combines Hubble Space Telescope observations and strong gravitational lensing of massive galaxy clusters to study high-redshift galaxies, it is possible to observe distant galaxies. In this work, we have detected a sample of $z \sim 6 - 9$ galaxy candidates from six massive lensing clusters.It includes 199 galaxy candidates identified in the Lyman break selection.

Low frequency radio continuum imaging and SED modeling of 11 local luminous infrared galaxies in radio and infrared domains

Subhrata Dey[1], A. Goyal[1], K. Małek[2], T. Galvin[3], N. Seymour[3], T. Santos[4], J. Piotrowska[1], V. Charmandaris[4]

[1] *Astronomical Observatory of the Jagiellonian University, Kraków, Poland*
[2] *National Centre for Nuclear Research, Warsaw, Poland*
[3] *International Centre for Radio Astronomy Research, Curtin University, Bentley, WA 6102, Australia*
[4] *Institute of Astrophysics, Foundation for Research and Technology-Hellas, GR-71110, Heraklion, Greece*

sdey@oa.uj.edu.pl

We present the detailed analysis of 11 local luminous infrared galaxies (LIRGs) from ultraviolet, through far-infrared to radio ($\sim$70 MHz to $\sim$15 GHz) bands. We derive the physical properties through spectral energy distribution (SED) modeling using the Code Investigating GALaxy Emission (CIGALE) and UltraNest codes. The radio SEDs include our new observations at 325 and 610 MHz from the GMRT, and the measurements from public archives. Our main results are (1) radio SEDs show turnovers and bends, (2) the synchrotron spectral index of the fitted radio spectra range between -0.5 and -1.9, and (3) the infrared luminosity, dust mass, dust temperature, stellar mass, star-formation rates (SFRs) and AGN fraction obtained from CIGALE falls in the range exhibited by galaxies of the same class. The ratio of 60μm infrared and 1.4 GHz radio luminosity, the 1.4 GHz thermal fraction, and emission measure range between 2.1 and 2.9, 0.1% and 10%, 0.01 and 269.5×10^6 cm^{-6} pc, respectively. We conclude that the turnovers seen in the radio SEDs are due to free-free absorption; this is supported by the low AGN fraction derived from the CIGALE analysis. The decomposed 1.4 GHz thermal and nonthermal radio luminosities allowed us to compute the SFRs using scaling relations. Higher infrared SFRs are noted for merger classes than nuclear galaxies with similar nonthermal fractions, indicating a better calorimetric behavior. Furthermore, a positive correlation is noted between infrared SFR obtained 10 Myr ago (as compared to 100 Myr ago) and 1.4 GHz radio (total and nonthermal) SFRs because similar synchrotron lifetimes are expected for typical magnetic field strengths ($\approx$50μG).

Tomography-based observational determination of the abundance of dark matter halos using the submillimeter galaxy magnification bias

Marcos Muñiz Cueli[1], L. Bonavera[1], J. González-Nuevo[1], D. Crespo[1], J. Casas[1], A. Lapi[2]

[1] *Facultad de Ciencias de la Universidad de Oviedo, Oviedo, Spain*
[2] *Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy*

mcueli@uniovi.es

Within the standard paradigm of cosmology, the hierarchical growth of dark matter perturbations is an essential assumption to explain galaxy formation. As a consequence, the relevance of dark matter halos for probing large-scale structure has motivated the search for a quantitative understanding of their abundance. Although computational cosmology has so far been the main arena for determining the number density of halos, numerical simulations are subject to systematic differences regarding, for instance, the modelling of baryon physics. In this talk, a method is presented to pursue the objective of determining the halo mass function through the observation of the weak lensing magnification bias effect on high-redshift submillimeter galaxies, given the suitability of these sources for a study of this kind. A tomographic approach is adopted in order to look for differences in the results obtained in a non-tomographic analysis. We obtain a remarkable improvement regarding uncertainties with respect to the non-tomographic case and predict a higher number density of halos below $10^{13} M_{\odot}/h$ and a lower one above $10^{14} M_{\odot}/h$, in disagreement with standard N-body results at 2 or 3σ, depending on the exact model.

The choice of the Zone of Avoidance compensation method to estimate clustering dipole in galaxy catalogs

Magdalena Krupa[1], A. Pollo[1,2], M. Bilicki[3]

[1] *Astronomical Observatory of the Jagiellonian University, Kraków, Poland*
[2] *National Centre for Nuclear Research, Warsaw, Poland*
[3] *Center for Theoretical Physics PAS, Warsaw, Poland*

magdalena.krupa@alumni.uj.edu.pl

Zone of Avoidance (ZoA) is the sky area that is blocked from extragalactic observations by the plane of our own Galaxy. It covers approximately 20% of the sky in the optical and poses significant problems for these cosmological tests that require full-sky coverage, necessitating compensation, usually by artificial filling. There are many possibilities of filling the ZoA with artificial sources, therefore it is of vital importance to determine the optimal method prior to performing any

cosmological tests, as the method chosen may naturally influence the results. We want to establish an optimal way of populating the ZoA with artificial sources, in order to reliably calculate the clustering dipole of galaxies. Such a dipole (its direction and amplitude) informs us about the acceleration of the Local Group of galaxies (which the Milky Way is a part of) with respect to the rest-frame density field of galaxies and dark matter, independently of the CMB-based estimations. In my talk I will present the tests of the methods of populating the ZoA performed on simulated galaxy catalogs, such as Millennium XXL. Then I will show how the resulting optimal ZoA compensation method is used to populate the ZoA of the 2MPZ galaxy catalog and what effect it has on the clustering dipole estimation based on this catalog.

Improved technique for quasar continuum prediction in the Lyα forest based on composite spectra

Olena Torbaniuk

Department of Physics, University Federico II in Naples, Naples, Italy

el.torbaniuk@gmail.com

The intergalactic medium is revealed by the numerous absorption lines of neutral Hydrogen H I (the so-called Lyα forest) seen in the spectra of distant quasars ($z > 2$), which traces the thermal and radiative history of the Universe, as well as the evolution of underlying matter distribution over a wide range of scales and redshifts. It is possible due to the relation of the Lyα opacity of the intergalactic H I to its density and other physical parameters. As a measure of opacity, the value of mean transmission is used, which is defined as a ratio of observed (transmitted) and emitted fluxes. One of the main problems in these studies is related to the determination of emitted flux, i. e. the continuum level in quasar spectra. Most of the currently available methods of continuum determination are based on interpolation of absorption-free regions within Lyα forest or continuum extrapolation from wavelengths longer than 1215 Å. However, both of these methods work poorly for strongly absorbed spectra at high redshifts and do not consider the spectral and physical properties of each individual quasar (e.g. luminosity, spectral index etc), which may also affect the shape of the intrinsic quasar continuum and spectral lines.

In this work, we present a new method for determination of the intrinsic continuum level based on the composite spectra of quasars. For this purpose, we selected 10096 medium-resolution quasar spectra from the Sloan Digital Sky Survey Data Release 10 without own quasar absorption lines (BAL) and DLA systems. To take into account the properties of individual quasars, we compiled 92 composite spectra from subsamples of quasars with similar monochromatic luminosity at 1450 Å and similar spectral index within the wavelength range 1215–1450 Å. The intrinsic

continuum in the Lyα forest for each individual quasar spectrum was found by the selection of the most optimal composite spectrum. The resulting continuum for individual quasars was used to measure the mean transmission in the Lyα forest and its dependence on the redshift.

Preliminary Global 21cm Observations with MIST from the Canadian High Arctic

Ian Hendricksen

McGill University, Montréal, Canada

ian.hendricksen@mail.mcgill.ca

The global redshifted 21 cm signal emitted by neutral hydrogen at radio frequencies offers novel insights into the birth of the first stars, known as the Cosmic Dawn, which is currently a largely unexplored chapter in our universe's history. The Mapper of the IGM Spin Temperature (MIST) is a multi-institutional collaboration that aims to observe the global 21 cm signal from some of the most remote sites on Earth. The MIST instrument corresponds to a single-antenna radio spectrometer and the experiment has been designed to minimize systematic effects from the instrument and the environment. The MIST instrument operates directly above soil with no ground plane, which helps to reduce possible structure in the beam. However, the lack of a ground plane makes the instrument particularly sensitive to the electrical properties of the soil. I will discuss several methods used by MIST to measure the soil electrical properties, which is crucial to minimizing systematic effects. I will then discuss a recent field deployment to the McGill Arctic Research Station (MARS) on Axel Heiberg island in Nunavut, Canada. The MARS site is characterized by minimal radio frequency interference (RFI), making it an optimal site for MIST to detect the 21 cm signal with minimal RFI occupation of data. I will then show preliminary measurements taken at MARS, as well as discuss plans for future deployments.

Dynamic model of the ionosphere for wide-field radio experiments

Vadym Bidula[1], R. Monsalve[2], J. Sievers[1]

[1] *McGill University, Montréal, Canada*

[2] *University of California, Berkeley, CA, USA*

vadym.bidula@gmail.com

Ionosphere impact may be critical for radio observations below 100 MHz. The three dominating effects in the ionosphere — attenuation, emission and refraction — not only depend on the observational frequency but also change with time due to

day-to-day variations in electron density. To account for these temporal variations, we created a global, dynamic model of the ionosphere. Our model uses a system of spherical layers to simulate the radio wave passage through the plasma. To precisely capture the temporal effects, the model employs data for time-dependent altitude profiles of electron density and temperature provided by the International Reference Ionosphere project. Within the model, the attenuation factors and refraction angles are calculated, allowing to correct observational data for ionospheric influence. I discuss how our modelling works in theory and practice and present the Python package available for public use.

Drone-Based Calibration Technique for The Array of Long Baseline Antennas for Taking Radio Observations from the Sub-Antarctic (ALBATROS)

Christopher Barbarie

Department of Physics, McGill University, Montréal, Canada

christopher.barbarie@mail.mcgill.ca

The ALBATROS experiment is composed of an array of radio telescopes operating in the 1.2–125 Mhz range with the aim of laying the groundwork for probing the cosmic dark ages (< 30 Mhz) through measurement of the 21 cm redshifted emission of neutral hydrogen. To better understand the behaviour of the antennas used in this array, we propose to fly a transmission source mounted to a custom-built multi-rotor unmanned aerial vehicle (UAV) in the far field region of the antenna. By studying the power received by the ground antenna from the transmission source as well as the telemetry data from the UAV, we can generate beam maps for the ground antenna at various frequencies. From this data we can properly calibrate our instrumentation to maximize efficiency, as well as gain a better understanding of our data at different frequencies.

Predicting the redshift of gamma-ray loud AGNs using supervised machine learning

Aditya Narendra

Jagiellonian University, Kraków, Poland

narendraaditya8@gmail.com

AGNs are very powerful galaxies characterized by extremely bright emissions coming out from their central massive black holes. Knowing the redshifts of AGNs provides us an opportunity to determine their distance to investigate important astrophysical problems such as the evolution of the early stars, their formation along

with the structure of early galaxies. The redshift determination is challenging, because it requires detailed follow-up of multiwavelength observations, often involving various astronomical facilities. Here, we employ machine learning algorithms to estimate redshifts from the observed γ-ray properties and photometric data of γ-ray loud AGN from the Fourth Fermi-LAT Catalog. The prediction is obtained with the Superlearner algorithm, using LASSO selected set of predictors.

We obtain a tight correlation, with a Pearson Correlation Coefficient of 71.3% between the inferred and the observed redshifts, an average $\Delta z_{norm} = 11.6\times10^{-4}$, where $\Delta z_{norm} : (z_{spetroscopic} - z_{predicted})/(1 + z_{spectroscopic})$ and $\sigma_{NMAD} = 0.192$, where $\sigma_{NMAD} : 1.48\times\text{median}|\Delta z_{norm}|$. We stress that notwithstanding the small sample of γ-ray loud AGNs, we obtain a reliable predictive model using Superlearner, which is an ensemble of several machine learning models.

STELLAR ASTROPHYSICS & INTERSTELLAR MEDIUM

Photometric and spectroscopic analysis of contact binaries

Alaxender Panchal, Y. C. Joshi

Aryabhatta Research Institute of Observational Sciences, Nainital, India

alaxender@aries.res.in

We present the photometric and spectroscopic analysis of 9 W Uma type contact binaries. The studied targets are selected from the CRTS catalog. The photometric data is collected using the 1.3-m Devasthal Fast Optical Telescope (DFOT) and 1.04-m Sampurnanand Telescope (ST). We use the PHOEBE-legacy code for light curve modeling. The temperature is determined using different color-temperature relations. Due to the absence of multi-epoch radial velocity data, photometric mass ratio is used for model fitting. Archival data from SuperWASP, CRTS, ASAS-SN, Kepler and TESS is used for O-C period analysis. The linear and quadratic ephemeris are updated for all the targets. Five sources show change in orbital period which is explained on the baisis of mass-transfer between components. LAMOST low-resolution spectra is used for chromospheric activity analysis. The chromospheric flux contribution is determined by subtracting the template spectra from the contact binary spetra. Small excess emission is found in subtracted spectra. Due to the low-resolution of the used spectra, it is very hard to confirm the individual activity level of the components.

Could kilomasers pinpoint supermassive stars?

Katarzyna Nowak

University of Hertfordshire, Hatfield, United Kingdom

k.nowak@herts.ac.uk

22.2 GHz water masers are generally associated with massive star formation. Recently, a very strong nuclear kilomaser, W1, has been found in a nearby galaxy (NGC 253) that is associated with a forming super star cluster. It has been proposed that kilomasers could arise from the accretion disc around supermassive stars ($> 1000\ M_{Sun}$). Such hypothetical stars are proposed candidates for polluters responsible for the chemical peculiarities in the globular clusters, i.e. large variations in light elements; the main one being O-Na, C-N and Mg-Al anticorrelations.

Additionally most of the globular clusters demonstrate multiple sequences in the colour-magnitude diagram, proving that they host multiple stellar populations. It has been suggested that the second population forms from the hot-hydrogen burning yields of the first population via self-enrichment. At the present time it is very hard to observe supermassive stars due to their location. The candidate forming massive clusters are located outside the Milky Way with very dense centers, where the hypothetical star would be obscured by gas and dust. The supermassive stars would form via runaways collisions, simultaneously with the cluster, hence their disc is perturbed by stellar flybys, inspiralling and colliding stars. This raises the question if an accretion disc would at all be able to survive in such a dynamic environment and mase water lines.

We investigated what the predicted MASER spectrum of such a disc would look like using 2D hydrodynamic simulations and compared this to the W1 kilomaser in NGC 253. We derived model maser spectra from the simulations by using a general maser model for appropriate disc temperatures against velocity along the line of sight. All our our model discs survived. The model maser spectra for the most destructive case for the simulations of $M = 1000 M_{Sun}$ are a good match with W1 kilomaser spectrum in terms of scaling, flux values and some of the signal trends. For the more massive star of 10,000 M_{Sun} the spectra start to resemble megamasers from AGNs rather than stellar masers. Our investigations thus support the hypothesis that kilomasers could pinpoint supermassive stars.

Close binary star system Cygnus X-1. Relative and absolute photometry

Olivia Muzyka[1], A. Baransky[2]

[1] *Gimnasium "Academiia", Kyiv, Ukraine*
[2] *Astronomical Observatory of Taras Shevchenko national university of Kyiv, Ukraine*

ol.1160936@gmail.com

The subject matter of the research is studying and conducting relative and absolute photometry of Cygnus X-1 in optic range.

Relevance: the accretion of matter in the close binaries is an effective mechanism for releasing a huge amount of energy, because of which we observe many astrophysical objects that are at the late stages of their evolution.

The task of the research work is to conduct the optical photometry of Cygnus X-1 at the Lisnyky observatory of KNU, to build and analyze the light curve in the photometry programs, compare to the AAVSO light curve chart, make calculations according to the photometry results, establish the reason for variability of Cygnus X-1.

Relative and absolute photometry of V1357 Cyg was done in filters: $R = 8.4$, $B = 10.1$, $I = 7.7$, and $V = 9.3$. Photometry was uploaded to AAVSO database. The average period of light micromodulation equals 8.6 min. Calculated on the basis of the received data: Visual, absolute and photographic magnitude of HDE 226868: $m = 9.3$, $M = -2.4$, $mph = 10.1$. Color temperature HDE 226868 equals 5177°; $C(B - V) = 0.81$; $(R - I) = 0.7$; $(V - R) = 0.9$. Luminosity: $L = 745$ Ls; radius of the star equals $37R_o$; distance = 2187.8 Parsecs.

We believe that inflow fenomena on the black hole's accretion disk are the cause of the variability of Cygnus X-1.

Study of the Lithium abundance in solar-type stars

Polina Dimitriieva[1], Ya. Pavlenko[2]

[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
[2] *Main Astronomical Observatory NAS of Ukraine, Kyiv, Ukraine*

ps_dimitrieva@ukr.net

In this work, we consider the origin of the chemical element lithium (Li) in the Universe, and calculate its abundance in six solar-type stars.

Li is a very light, soft alkali metal. This is a special element, because it is one of the three elements created during the Big Bang. With the evolution of stars, lithium is modified by the process of nucleosynthesis inside and becomes hardly noticeable.

The evolution of the abundance of lithium in the atmospheres of stars of late spectral types is the subject of numerous studies. Among others, there is the problem of low abundance of Li in the solar atmosphere, which cannot be explained by the existing theories of stellar evolution. On the other hand, a relatively large amount of lithium is observed in the atmospheres of a number of solar-type stars, which also requires explanation.

High-quality observational spectra of just such stars that were used in this work were obtained with the HARPS ESO spectrograph.

The method of synthetic spectra was used in the work. We calculated the theoretical spectrum of stars using a Fortran program. Python programs were also written to adequately compare the theoretical line profiles with the observational spectrum (convolution with the instrumental profile and the stellar rotation profile).

Spin and orbital variability of the intermediate polar RX J2133.7+5107

Vitalii Breus[1], I. L. Andronov[1], P. Dubovsky[2], K. Petrik[3]

[1] *Odessa National Maritime University, Odessa, Ukraine*
[2] *Vihorlat Astronomical Observatory, Humenne, Slovak Republic*
[3] *Hlohovec Astronomical Observatory, Hlohovec, Slovakia*

bvv_2004@ua.fm

We report the results of long-term time series photometry on RX J2133.7+5107. Using data taken during 2007–2022 (15 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 $1.511(3)\times10^5$ 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.

Study of open cluster King 13 using CCD VI, 2MASS and Gaia DR2 Astrometry

A. Durgapal[1], Devendra Bisht[2], G. Rangwal[1], H. Kaur[1], R. K. S. Yadav[3]

[1] *Department of Physics, DSB Campus, Nainital 263002, Uttarakhand, India*
[2] *Indian Centre for Space Physics, Netai Nagar Kolkata, India*
[3] *Aryabhatta Research Institute of Observational Sciences, Manora Peak, Nainital 263 002, India*

devendrabisht297@gmail.com

In this paper, we present astrophysical parameters of the open cluster King 13 based on the VI CCD and 2MASS JHK s photometric data. This is a poorly studied cluster, for which new results have been found in the present work. To identify probable members, we use proper motion data from Gaia DR2 catalogue. The mean proper motion of the cluster is determined as -2.8 ± 0.2 and -0.88 ± 0.14 mas yr^{-1} and cluster extent is derived as $3.2'$.

Using color-magnitude diagrams, we estimate the age and distance of the cluster as 510 ± 60 Myr and 3.84 ± 0.15 kpc respectively. Interstellar reddening E (B-V) in the direction of the cluster is determined as 0.80 ± 0.2 mag mag using color-color diagram. Mass function slope of the cluster is found to be comparable with the Salpeter value. The total mass of this cluster is derived as $270M_{Sun}$. The present analysis shows that King 13 is a dynamically relaxed cluster.

Photometric monitoring of short-period eclipsing binaries discovered at Astronomical Observatory on Kolonica Saddle

Vitalii Breus[1], I. L. Andronov[1], P. Dubovsky[2]

[1] *Odessa National Maritime University, Odessa, Ukraine*
[2] *Vihorlat Observatory, Humenne, Slovakia*

bvv_2004@ua.fm

We analyzed the photometric data obtained for 4 short-period EW-type binary systems discovered at Astronomical Observatory at Kolonica Saddle using different instruments between 2009 and 2019. The stars USNO-B1.0 1411-0397871 (VSX J213321.5+510857) and USNO-B1.0 1411-0397855 (VSX J213320.0+510819) are W UMa type eclipsing binaries. These stars got GCVS names V2833 Cyg and V2832 Cyg respectively. V483 And (Kol003) and USNO-B1.0 1236-0432303 (VSX J200553.2+334157, Kol009) are also EW-type binaries.

The largest set of photometric data used in this research was obtained with the 1m Vihorlat National Telescope at the Astronomical Observatory on Kolonica Saddle, Slovakia (VNT). V2832 Cyg and V2833 Cyg were also observed with 60 cm Zeiss Cassegrain telescope at the Observatory and Planetarium of M. R. Stefanik in Hlohovec, Slovakia. Some time series were obtained using Meade LX-200 instrument at the same observatory. In 2014–2016 we gathered photometric observations of V2832 Cyg and V2833 Cyg with the the 40 cm Maksutow telescope at the Astronomical Observatory of the Jagiellonian University in Krakow, Poland.

The reduction, consisting of calibration of scientific images for bias, dark and flat-field and extraction of instrumental magnitudes, was carried out with the MUNIWIN software or CoLiTecVS.

Using O-C analysis, we determined more accurate values of the orbital period and initial epochs of these systems. Using New Algol Variable method, we determined phenomenological characteristics of light curves. Its worth to mention that for V2833 Cyg Lafler-Kinman-Kholopov method applied for long time series allowed to derive the same value of the period, which was obtained later using O-C analysis. We confirm the presence of O'Connell effect in the V483 And. The spots may explain asymmetric light curves and significant changes of the shape from season to season. Light curves of V2832 Cyg, V2833 Cyg and VSX J200553.2+334157 are stable. No variations of the orbital period found.

Search for hierarchical systems in the Gaia EDR3

Jakub Tokarek

Astronomical Observatory Institute, Adam Mickiewicz University in Poznań, Poznań, Poland

jakub.tokarek@amu.edu.pl

Binary and multiple systems make up the majority of the observed stars — more than 50% of the stars near the sun allow us to assume that a similar situation occurs throughout the Galaxy. Both observations and simulations show that all stars have one or more companions at the beginning of their evolution. They are formed when molecular clouds collapse — one cloud thickens independently in many places, creating a star cluster. Depending on the mutual distance between them, they are more or less connected by gravity with their neighbors. Thanks to the Gaia mission, with each successive portion of published data, we are able to learn more and more precisely the positions and velocities of stars. In my work I used Gaia Early Data Relase 3 to search for potential visual companions of known multiple systems with the LITE effect. In my poster I will briefly discuss the issue of double and multiple star discovery and the current results of my work.

SOLAR SYSTEM & EXOPLANETS

Multiwavelength photometry of comet C/2013 X1 (Pan-STARRS)

Olena Shubina[1,2], M. Husárik[1], O. Ivanova[1,2,3]

[1] *Astronomical Institute of the Slovak Academy of Sciences, SK-05960 Tatranská Lomnica, Slovak Republic*
[2] *Main Astronomical Observatory of NAS of Ukraine, Kyiv, Ukraine*
[3] *Astronomical Observatory of Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*

oshubina@ta3.sk

We present the results of photometrical observations of hyperbolic comet C/2013 X1 (Pan-STARRS) in broadband Johnson-Cousins filters. Data were obtained during the pre-perihelion passage of the comet in the period December 2015 – January 2016 using the 61-cm telescope at the Scalnaté Pleco observatory. Analyzing the dust productivity via $Af\rho$ proxy, we revealed a sharp increase in cometary activity at the end of December. Also, we detected colour slope variations during the observed period. Constructed morphology maps demonstrated non-uniform dust distribution over the cometary coma with at least one jet-like structure.

Investigation of dust component of hyperbolic comet C/2015 VL62

Kateryna Kulish[1], O. Ivanova[2,3,4]

[1] *Comenius University in Bratislava, Slovakia*
[2] *Astronomical Institute of the Slovak Academy of Sciences, SK-05960 Tatranská Lomnica, Slovak Republic*
[3] *Main Astronomical Observatory of NAS of Ukraine, Kyiv, Ukraine*
[4] *Astronomical Observatory of Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*

kulish.kateryna@gmail.com

The processing and analysis of photometric and spectral data obtained for the long-period comet C/2015 VL62 (Lemmon-Yeung-PanSTARRS) on the 2nd SAO 6-m telescope in 2015 was processed and analyzed. The comet was observed at a heliocentric distance of 3.8 au, where sublimation of water ice is not significant. Several different programs were used for processing (basic reductions) and analysis, including Maxim DL, IDL, Astrometrica and Astroart 7. Analysis of spectral data showed that there are no gaseous emissions in the spectrum, only a dust continuum.

Since no gaseous emissions were detected in the spectrum, this allowed the study of the dust component from photometric data obtained in wide sloan g- and r-sdss filters. The analysis of photometric data allowed to analyze the morphological features of the cometary coma and tail, to assess the dust productivity and the color of the dust coma. The magnitude, Afρ parameter, and color index in the g- and r-sdss filters were determined. The errors of these calculations are estimated. Graphs of comet profiles in different directions were constructed using a number of digital filters, and low contrast structures in comet coma were investigated. From the analysis of spectral data, the amount of redness for the studied comet was obtained. The value of the work is that it is one of the few works where comets are studied at large heliocentric distances.

Photometry, astrometry and dust productivity analysis of comet 67P/Churyumov-Gerasimenko in 2021-2022

Oleksandra Pyshna[1], A. Baransky[1], S. Borysenko[2]

[1]*Astronomical Observatory of Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
[2]*Main Astronomical Observatory of NAS of Ukraine, Kyiv, Ukraine*

pyshnaya.sasha@gmail.com

In this work, we are presenting the results of astrometric, photometric, and dust productivity analysis of comet 67P/Churyumov-Gerasimenko. The results are based on 14 nights of observations at the Kyiv Comet Station (MPC Code 585) during the near-perihelion and Earth approach periods of 2021–2022. We also analyzed the photometric and astrometric data of 67P comet appearance in the 1969–2022 period of observations published in Minor Planet Center and Comet OBServation databases. For observations, we used the 0.7 m (f/4) reflector AZT-8 with the FLI PL4710 CCD camera. On the basis of our images, we have measured precise astrometrical positions, magnitudes of 67P in different apertures for all the period of our observations, and values of $Af\rho$ parameter for most of our observations. Based on observations published in the MPC database, we calculated orbital elements of 67P during 11 epochs. Also, on the basis of the Comet OBServation database, we calculated photometrical parameters for comet appearances in 1982–2022 and analyzed the dynamics of their change. Astrometrica and FindOrb software was used for astrometric analysis and orbital elements calculations, and Comet for Windows and FoCAs 3.70 software was used for photometric and dust productivity analysis.

We checked the accuracy of our astrometric results by comparing them with MPC data from the last 6 months in FindOrb software. We sent the results of 7 nights of observations to the MPC database with O-C residuals less than $1.4''$ Overall, 157 results of observations were published in MPC database, and the observations with the highest precision were published in Minor Planet Circulars. The

RA (O-C) residuals of published results of observations vary from 0.02+ to 1.4− arcseconds and Declination (O-C) residuals vary from 0.01+ to 1.4+ arcseconds. The mean residuals of elements of 67P orbit, calculated considering gravitational and non-gravitational effects of A_1 and A_2 comet model, vary from $0.87''$ to $0.34''$. As a result of our photometric research, we measured that the photometric parameters of 67P for 2021-2022 appearance are $H_0 = 9.59^m$ and $K = 5.65$, and the values of the $Af\rho$ dust productivity parameter were changing from 102 cm (1 month before the perihelion) to 317 cm (2 months 2 weeks after the perihelion) without phase correction. As a result of our photometrical analysis, we report asymmetry between the maximum of apparent magnitude and the moment of perihelion.

Phase and color ratio method for searching areas with ananomalous optical roughness on the Vesta surface

Valeriia Rychahova, I. Slyusarev

Institute of Astronomy Kharkiv National University, Kharkiv, Ukraine

richagova_valeriya@ukr.net

The last decade has become a significant period for robotic exploration of the Solar system bodies. Among such research programs was The Dawn Mission to asteroid Vesta and dwarf planet Ceres. Results obtained during the mission allow us to carry out a detailed analysis of asteroid (4) Vesta surface properties by using methods that were developed and effectively used in the analysis of the Moon data.

Using the phase-ratio method provides new ways of searching areas with altered structure of regolith on the Vesta's surface. In our research we used images obtained by the Framing Camera instrument (FC) during HAMO and LAMO orbital phases. We could employ a phase-ratio method after several steps of image processing aimed to transform images to the same map projection, perform radiometric calibration, spectral and photometric scaling. The resulting phase-function slope has a greater functional dependence on the structural properties of surface. Moreover, the phase dependencies of several color indexes $C(\alpha) = \frac{R(\lambda_1,\alpha)}{R(\lambda_2,\alpha)}$ were obtained for each studied area. Comparison of maps of the relative reflectance, color index and phase ratio allows to identify evidence of slope processes and variations of chemical composition.

We built maps of the spatial distribution of phase ratio and color index for areas around five craters: Antonia, Vibidia, Serena, Helena, Laelia. The main results of the investigation will be presented at the conference meeting.

Implementation of Floating Point Arithmetics with Accurate Rounding to the Two Body Problem

Burcak Yeşilirmak

Akdeniz University, Antalya, Turkey

yesilirmak.burcak@gmail.com

A double-precision format can be used easily for single-precision computa- tions, while for double-precision computations, extended or higher precision may not be enough in some formats such as binary64 in IEEE 754-2008 standard. In this study, by using floating-point arithmetics, the required algorithms to solve the N-body problem more accurately than ordinary computations have been researched. The pair-precision technique has been used for representing the exact number and pairs are the representation of double type as a sum of two double variables. The chosen mathematical approaches for algorithms are particularly based on the type of series used. Therefore, it was identified that if the series is absolute convergent, the order of operations needs to be inverted. As expected, the results for ordinary and arithmetic operation calculations were acquired to be less than half the machine epsilon which is the maximum relative error of the rounding mode in effect.

Research of Kuiper belt objects and exoplanet transits using robotic telescope array

Roman Akhmetshyn[1], S. Metchev[1], R. Brown[1], M. Mazur[1], B. Amblard[2]

[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
[2] *Western University, London, Canada*
[3]

roman_akhmetshyn@univ.kiev.ua

Currently, an array of 3 telescopes are used to detect objects of the Kuiper belt. In practice, this is identical to photometric observations of exoplanet transits, but there is a significant difference in the time of star occultation and the shape of the light curve. This line of research is relatively new and relevant in the field of solar system astronomy. To successfully capture the light curve of a star during the passage of an asteroid over it, a high frequency of image capture is required. For a 1-kilometer body on a distance of 40 au, the occulation time of the star is 160–260 ms if Fresnel diffraction is taken into account. Another field of observations with Colibri telescope aaray is exoplanet transits. A simple approach is to follow TESS-detected exoplanet systems for longer periods of time on small ground-based telescopes. The idea is that if transit observations show that the system has an exoplanet in a close orbit, then there is a probability that on there are also planets in distant orbits,

that is, longer periods. Long-term observations of TESS-detected exoplanets will also help clarify their orbital characteristics for observational candidates for new James Webb telescope.

Characterizing the Input Sample for the POET Transiting Exoplanet Microsatellite Mission

Samantha Lambier, S. Metchev, G. Suárez, J. Hales, J. Martinovic

Western University, London, Canada

slambier@uwo.ca

Earth-like exoplanets, defined to be rocky extrasolar planets in the habitable zone of their host stars, are of particular interest in the search for life in the universe. The Photometric Observations of Exoplanet Transits (POET) satellite is a microsatellite in development with a mission to discover Earth-like exoplanets around ultracool dwarfs (UCDs) through the transit method. UCDs are M7 or cooler stars and brown dwarfs. These UCDs are the best targets for detecting Earth-like exoplanets for numerous reasons. Here, we present the process of building a parent catalogue of all UCD candidates from Gaia Data Release 3 within 100 pc and brighter than a 2MASS J magnitude of 14. Ultimately, the goal is to choose approximately 100 UCDs with small radii and inclinations close to 90° to observe with POET to maximize the probability of detecting Earth-like exoplanets.

Tidal heating in potentially habitable extrasolar planets

Varnana M. Kumar[1], T. E. Girish[2], T. N. Sathyan[3], B. Longhinos[4], J. Binoy[5]

[1]*Department of physics Marivanious College Trivandrum, Kerala, India*
[2]*Department of Physics, University College, Trivandrum, Kerala, India*
[3]*Department of Applied Science, University Engineering College, Trivandrum, Kerala, India*
[4]*Department of Geology ,University College , Trivandrum ,Kerala , India*
[5]*Department of Physics, Government College for Women , Trivandrum, Kerala, India*

mvarnana@gmail.com

Even though more than 4000 extrasolar planets are discovered so far, Earth is the only planet in the Universe known to have life till date. Among them around 60 planets were listed as Potentially Habitable Extrasolar Planets. This list was prepared on the basis of the details from the Habitable Extrasolar planets Catalog

(HEC) which is maintained by the Planetary Habitability Laboratory at the University of Puerto Rico at Arecibo. We have studied the internal heat contribution due to tidal interactions in 60 extrasolar planets which are identified as potentially habitable. The internal heat due to tidal interactions between host star and extrasolar planets can be calculated if we know the orbital parameters and the properties of the host star. The estimated total internal heat at the time of formation of these extrasolar planets is compared with the current tidal heat contributions. The possibility of extreme volcanism in tidal extrasolar planets and its implications on its habitability will be discussed in detail.

Investigation of planetary systems of WASP, TrES, Qatar and Kepler projects by using transit photometry with O-C parameter tracking and TTV method application on Kyiv Comet Station

A. Nahurna[1], Mykhailo Solomakha[1], M. Lobodenko[1], A. Baransky[2]

[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
[2] *Astronomical observatory of Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*

muraveidimenn@gmail.com

We report the results of the investigation of five planetary systems TrES-3b, Kepler-17b, WASP-3b, Qatar-1b, and Qatar-2b. 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.

Observations were carried out from 2 April 2021 to 14 February 2022 by using a 70-cm reflecting telescope AZT-8 on the Astronomical Observatory of Taras Shevchenko National University of Kyiv/Kyiv comet station (Kyiv, Ukraine). Photometric processing of the observation results was performed by using the Muniwin program. The obtained exoplanet transit brightness curves were published in ETD. The accuracy and quality of our observations on the ETD database scale ranged from 1 to 3.

Additionally, applying the method of time transit variation (TTV) to our and Exoplanet Transit Database (ETD) data, 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 Bryan et al. (2011) is true.

Comparative analysis of observations of the selected exoplanet transits obtained at the Kyiv Comet station, with TESS and Kepler Space Telescopes

Mariia Lobodenko[1], I. Kulyk[2], Ya. Pavlenko[2], A. Nahurna[1], M. Solomakha[1], A. Baransky[3]

[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
[2] *Main Astronomical Observatory of the NAS of Ukraine, Kyiv, Ukraine*
[3] *Astronomical observatory of Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*

lobodenkomo@ukr.net

We present a comparative analysis of observations of the selected exoplanet transits obtained at the Kyiv Comet station with the database of the TESS (Transiting Exoplanet Survey Satellite) and Kepler space telescopes. The light curves obtained by the TESS and Kepler orbital telescopes were processed using a program based on the Python package Lightkurve 2.3v which is freely available in the MUST archive (Barbara A. Mikulski Archive for Space Telescopes). The ground based observations were carried out with the 70-cm telescope AZT-8 (Lisnyky). Photometric processing of the ground based observation was performed by using the Muniwin program. The light curves and parameters of the observed transits as well as the exoplanet orbital parameters obtained from ground based observations were published in the ETD (Exoplanet Transit Database). Determined transit parameters were compared with the results of the TESS command, which are stored in the MUST archive. Here we presents a comparison of the parameters of transit phenomena (period, depth, transit duration) and some orbital parameters obtained from two independent sets of observations, terrestrial and orbital, performed in different epochs.

ATMOSPHERIC STUDIES & SPACE GEOPHYSICS

Comparison of radioactive element distribution in Earth, Moon and Mars

Thara N Sathyan[1], V. M. Kumar[2], T. E. Girish[3], J. Binoy[4]

[1] *University College Of Engineering Kariavattom, Thiruvananthapuram, India*
[2] *Mar Ivanios College, Trivandrum, Kerala, India*
[3] *University College , Trivandrum, Kerala, India*
[4] *Govt. College For Women, Trivandrum, Kerala, India*

tharasathyann@gmail.com

We have studied the maps of radio active mineral distribution in Earth, Moon and Mars obtained from in situ and remote sensing observations. The distribution of U and Th in these rocky planets show some interesting features in association with internal heat distribution and volcanism. The results of our studies will be helpful for mining, space exploration and understanding the geophysical history of these planets.

Validation of the Earth planetary albedo using top-of-atmosphere fluxes of numerical weather prediction model

Maksym Vasiuta, H. Järvinen

Institute for Atmospheric and Earth System Research, University of Helsinki, Helsinki, Finland

maksym.vasiuta@helsinki.fi

The Earth Planetary (or Bond) albedo is one of the crucial indicators of the Earth system energy budget. State-of-the-art approach to estimate the Earth Bond albedo is by processing satellite measurements of the Earth outgoing short-wave radiation. An exceptionally large albedo values (up to 0.35 daily maximum) in December 2020 were obtained using the data by Earth Polychromatic Imaging Camera (EPIC) on board NOAA's Deep Space Climate Observatory (DSCOVR). We compared the finding to the Bond albedo from numerical weather prediction (NWP) model, called OpenIFS.

The reference Bond albedo by NWP does not capture the surge seen from EPIC processed data, showing maximum of 0.327 during December 2020. However, the EPIC-based albedo and its weather model reference match well during December 2016. In this study, we attempt to investigate the cause of discrepancy.

The retrieval of the Earth Bond albedo involves usage of radiation angular distribution models (ADMs), consideration of Earth-Satellite-Sun geometry, and footprint identification. NWP-based Bond albedo relies on accuracy of radiation transfer modelling. Among listed, we see flaws in applicability of available ADMs in certain geometry scenarios and for apparent footprints. While located close to L1 point during December 2020, DSCOVR receives the Earth outgoing radiation close to back-scattering, and vast Antarctic ice sheet is apparent.

To address the flaws, we applied ADMs, provided by Clouds and the Earth's Radiant Energy System (CERES), to the top-of-atmosphere fluxes from NWP model to estimate total Earth irradiance (W/m^2) that DSCOVR satellite receives. We compared our Earth irradiance simulation with measured by NIST Advanced Radiometer (NISTAR) on board DSCOVR. The simulation systematically underestimates the measurements during December 2020. We suggest that the reason of both discrepancies in irradiance and in albedo is underestimation of short-wave flux anisotrophic factors in conditions close to back-scattering.

Air quality monitoring in Kyiv with the AirVisual network: pollution by PM 2.5 and PM 10

Yuliia Yukhymchuk

Laboratoire d'Optique Atmosphérique, Villeneuve-d'Ascq, France

juliyuhim@gmail.com

Atmospheric aerosols significantly affect human health and climate change. These particles have a strong impact on the energy balance in the Earth's atmosphere. At the same time, intense aerosol contamination causes different diseases and decreases life quality. Therefore, many countries and cities already have systems and networks for monitoring air quality. The quantitative characteristics of aerosol influences still have not yet been determined properly in large cities of Ukraine and this work is devoted to this topic.

Particular matter (PM) is one of the most important air quality indicators. The collaboration of scientists from different Ukrainian institutes created four stations of AirVisual in early March 2020 in Kyiv. The last fifth station was installed in June 2020. AirVisual network allows for evaluating the level of PM2.5, PM10, and CO_2 loads. The stations are located to cover the city territory as much as possible and every station is equipped with an AirVisual Pro sensor.

The AirVisual network provides information about air quality in Kyiv in real-time and these results are available online. Furthermore, the two and half years set of data is used for analyzing the changing in PM2.5, PM10, and CO_2 concertation during this period. In addition, the AirVisual observations were compared with the Kyiv AERONET station data, including biomass burning in March–April 2020. This event indicated extraordinarily high PM2.5 aerosol contamination and low air quality for Kyiv city and the Kyiv region.

Antarctic tropopause above Marambio station in the conditions of the ozone hole during 2004-2019

Anastasiia Sokareva, O. Ivaniga, N. Tkachenko

Taras Shevchenko National University of Kyiv, Kyiv, Ukraine

s0kareva.a1@gmail.com

The object of study is the polar tropopause of the Southern Hemisphere. The subject of the study is the change in the height of thermal and ozone tropopauses in the ozone hole. The aim of this work is to improve the understanding of the distributions and variations of the ozone content of the upper troposphere – lower stratosphere in the polar region and the feedback between changes in ozone content and tropopause height. The project used high-resolution data from polar ozone probes emitted over the Marambio meteorological station. The main practical part of the work was the analysis of the peculiarities of the change of thermal and ozone tropopauses, their comparison, the concentration of ozone at their heights over the Antarctic region. The results are important not only in terms of establishing the general ratios of atmospheric parameters, but also in view of the significant impact of changes in altitude and clarity of the tropopause on metabolic processes (especially ozone) between the stratosphere and troposphere. The processes of stratospheric-tropospheric exchange and tropopause dynamics, in turn, play a significant role in regional climate change and through the chain "tropopause-ozone-ultraviolet content" affect the state of local ecosystems. Therefore, the study of processes in the field of the tropopause is of considerable practical and scientific interest and the continuation of work in this direction is very important.

Dispersion wave analysis of kink-like and stationary-like current sheet flapping motions in the Earth's magnetotail

Bohdan Petrenko[1,2], L. Kozak[1,2], E. A. Kronberg[3], R. Akhmetshyn[1]

[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
[2] *Space Research Institute of the National Academy of Sciences of Ukraine and the State Space Academy of Ukraine, Kyiv, Ukraine*
[3] *Department of Earth and Environmental Sciences, Ludwig Maximilian University of Munich, Munich, Germany*

bogdanart96@gmail.com

Comprehensive low-frequency multispacecraft wave study of flapping current sheet oscillations in the Earth's magnetotail with different morphologies of oscillation behavior was carried out. Measurements from the Magnetospheric Multiscale (MMS) mission during 2020/08/26 were analyzed. Comparison of the results calculated by methods of phase difference, wave surveyor and Multipoint Signal

Resonator technique was performed. It was found that the energy distribution of wavy magnetic field contains complex multi-branch dispersion dependencies on k_y, k_z. The phase velocities of propagation of flapping oscillations were estimated. The applied methods complement each other, and their differences made it possible to assess the presence of nonlinear wave packets and the azimuthal asymmetry of the current sheet profile.

Penetration of electric field from the near-ground source to the ionosphere. Problem of dynamic-quasistatic limiting pass

Sergei Petrishchevskii[1], Yu. Rapoport[2,1,3], V. Grimalsky[1], V. Reshetnyk[1], A. Grytsai[1], A. Liashchuk[3], A. Fedorenko[5]

[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
[2] *University of Warmia and Mazury in Olsztyn, Poland*
[3] *National Center for Control and Testing of Space Facilities of the State Space Agency of Ukraine, Kyiv, Ukraine*
[4] *Centro de Investigación en Ingeniería y Ciencias Aplicadas, Universidad Autónoma del Estado de Morelos, Mexico*
[5] *Space Research Institute National Academy of Sciences of Ukraine and State Space Agency of Ukraine, Kyiv, Ukraine*

msergiyp@gmail.com

The problem with penetration of the ULF electric field, exited by the current source in the atmosphere, into the upper ionosphere is investigated both within the dynamic and the quasi-electrostatic approach. It had been shown that (1) both approaches yield practically similar results for the penetration of the electric field in the case of closed geomagnetic field lines; (2) in the case of opened geomagnetic field lines, only dynamic model for the penetration of field from the atmosphere to the upper ionosphere is adequate.

There is a problem of limiting pass from dynamic to quasi-stationary determination of the electric field penetrating to the (upper) ionosphere and magnetosphere when the frequency of the current source located in the lower atmosphere decreases. At the corresponding limiting pass, the quasi-magnetostatic component should also be present, which wasn't taken into account earlier. We proposed the model of penetration of ULF electric field through the atmosphere-ionosphere system with given sources with including the problem of limiting pass from dynamic to quasistatic modelling.

Evanescent acoustic-gravity waves in a rotating stratified atmosphere

Sergii Cheremnykh[1], O. Cheremnykh[1], D. Vlasov[1], T. E. Kaladze[2], E. Kronberg[3]

[1] *Space Research Institute of NAS of Ukraine and State Space Agency of Ukraine*

[2] *Andronikashvili Institute of Physics, I. Javakhishvili Tbilisi State University, Tbilisi, Georgia*
[3] *Geophysics Department of Earth and Environmental Sciences University of Munich, Munich, Germany*
ikdchereremnykh@gmail.com

The influence of the rotation of the Earth's atmosphere on the properties of evanescent acoustic-gravity waves, which we studied earlier in the absence of rotation was studied. It is shown that evanescent acoustic-gravity waves (AGW) with a continuous spectrum can exist in an atmosphere rotating with an angular frequency Ω below the frequency 2Ω (the Coriolis parameter). It is also shown that the rotation of the atmosphere also leads to a modification of the previously discovered continuous spectrum of evanescent AGWs with frequencies higher than the Coriolis parameter, which fills the entire "forbidden" region in the diagnostic diagram between freely propagating acoustic and internal gravity waves. It is concluded that the AGW spectrum in the diagnostic diagram consists of regions of acoustic and gravity waves, as well as two regions of evanescent waves, and is continuous. The found new spectrum expands the full spectrum of evanescent waves and indicates the need to search for evanescent waves at ultra-low frequencies. The result is obtained for high-latitude regions from a system of linear hydrodynamic equations for perturbations that take into account the rotation of the Earth's atmosphere, by imposing an additional spatial relation on the components of the perturbed velocity vector of the elementary volume of the medium, which proposed by us for the first time. This made it possible to obtain an infinite number of solutions describing evanescent acoustic-gravity waves propagating in an isothermal atmosphere. The specified connection between the components of the perturbed velocity is characterized by the α parameter, which can only take real values. It has been established that the detected spectrum of evanescent acoustic-gravity waves can exist only at $0 < \alpha < 1$, while the previously found spectrum of these waves, modified by taking into account the Earth's rotation, is realized at arbitrary values of α. Analytical and numerical analysis of the obtained solutions is carried out. It is shown that these solutions, at certain values of the parameter α, pass into the previously studied evanescent modes. Also was shown that taking into account both components of the vector of the atmosphere rotation frequency $\overrightarrow{\Omega}$ — horizontal, $\Omega\cos\varphi$, and vertical, $\Omega\sin\varphi$, where φ is the Earth's latitude, the dominant role in the acoustic-gravity waves propagation is played by the vertical component. It is shown that the horizontal component leads to an insignificant modification on the diagnostic diagram of the boundaries of the areas of acoustic and gravity waves, which can be neglected. Also shown that the strongest vertical component of the frequency affects the lower limit of gravity waves, which depends at all wavelengths on the latitude of the observation site and is equal to $2\Omega\sin\varphi$.

SOLAR PHYSICS & HELIOSPHERE

Kinematics of coronal mass ejections and auroral science

Anitha Ravishankar[1], G. Michalek[2], S. Skone[1], E. Spanswick[1], R. Gillies[1]

[1] *University of Calgary, Calgary, Canada*
[2] *Astronomical Observatory of Jagiellonian University, Krakow, Poland*

anitha.ravishanka1@ucalgary.ca

An accurate understanding of the propagation of coronal mass ejections (CMEs) is crucial in the prediction of space weather. CMEs generate geomagnetic storms causing catastrophic damages to power grids on Earth and are a serious radiation threat to satellites on low-Earth orbit and their crew during spacewalks. Basic parameters such as their velocity and acceleration varying with time and heliospheric distance away from the Sun gives researchers the opportunity to predict their arrival time in the vicinity of the Earth. Once these clouds of charged particles reach the Earth, aurorae or Northern/Southern lights are generated at higher latitudes. Extreme geomagnetic storms (kp>4) are a matter of concern and also contribute to a beautiful sight with intense auroras. Ground based riometers have proven to be an efficient way to detect these KeV electron precipitation in the ionosphere during auroral formation. Absorption profiles offer a good approach towards studying various associated parameters and eventually help in building a model for predicting these events.

Persistence of weak magnetic cycles during solar grand minima episodes

Sanghita Chandra[1], Ch. Saha[2], D. Nandy[2]

[1] *Max Planck Institute for Solar System Research, Göttingen, Germany*
[2] *Indian Institute of Science Education And Research Kolkata, Mohanpur, Nadia – 741 246, West Bengal, India*

sanghita.chandra12@gmail.com

Sunspot observations over the past few centuries reveal that the Sun occasionally slips into quiescent phases, known as solar grand minima. In our dynamo model, we employ stochastic fluctuation in the source term of the polar fields to simulate such grand minima episodes. Our simulations detect a gradual decay of the polar field at the onset of a solar grand minimum followed by a halt in the polar field reversals. But, the large-scale meridional circulation continuously

dredges up magnetic fields to the solar surface and advects them further to the polar caps. This eventually builds up polar magnetic fields, strong enough to sustain the regular surface activity again, aiding in the recovery from the grand minimum. Spectral analysis of the hemispheric polar flux time series during simulated grand minima reveals the significant signature of multiple frequencies apart from the 11-year sunspot cycle. In this work, we focus on a ∼5-year component and establish its causal connection with the meridional circulation characteristic timescale. Our numerical results are in good agreement with the long-term reconstructed solar activity data.

Transit time estimation of earthbound CMEs

Ashutosh Pattnaik[1], A. Ravishankar[2], G. Michalek[1]

[1] *Jagiellonian University, Krakow, Poland*
[2] *University of Calgary, Calgary, Canada*

ashutosh.pattnaik@doctoral.uj.edu.pl

We are working on predicting the time a CME directed towards earth will require to reach earth. We are using Solar and Heliospheric Observatory (SOHO) and Solar Terrestrial Relations Observatory (STEREO) twin spacecraft when they are in quadrature configuration. This allows us to observe the CMEs from two additional directions and get rid of the projection effect.

In our studies we are using the maximum velocity of a CME in its trajectory (obtained from its velocity profile) as its initial velocity. This parameter is highly correlated to its final velocity. Using this method and by performing manual observation of 51 halo and partial halo CMEs ejected between 2009-2013 we have already measured transit time of CMEs from the Sun to the Earth (TT) with accuracy same as it is present in literature but with a significant improvement in error of maximum transit time estimation. In literature it was 50 hours however using our method we drastically reduced it to 29 hours.

Now we are adding observation from one more instrument Coronograph1 (Cor1) of STEREO (A or B) of the CMEs from 2009-2013 along with 2017-2021. As this instrument has a field of view closer to the Sun (1.4-5 solar radii) the measurement of the maximum velocity of CME will be more accurate.

The novelty of our work is it can be used for quick estimation of transit time (TT) which is necessary for any space weather forecasting and the error of TT estimation is significantly lower. And we believe incorporating Cor1 observation and with a larger dataset using our method, we will get an even more accurate measurement.

Coherent structures of kinetic Alfvén wave to study solar wind at 1AU

Jatav Bheem Singh

Department of physics, Sikkim University, Gangtok, Sikkim, India

bheemsinghj@gmail.com

Alfvén waves are fundamental low frequency electromagnetic plasma wave that permeate the universe. At small kinetic scale these waves known as kinetic Alfvén waves and at this scale these waves transfer the energy between electromagnetic fields and charged particle in solar wind. I study the kinetic Alfvén waves in solar wind at 1 AU, when the background plasma density is modified by parallel ponderomotive force and Joule heating. Numerical method has been used to analyse the evolution of KAW coherent structures in solar wind at 1 AU. These coherent structures at kinetic scale follow Kolmogorov scaling in inertial range. Steepened spectrum has been achieved in the dispersive range, which is continues in the dissipation range. Our obtained results reveal that the coherent structures of kinetic Alfvén waves plays an important role for transferring the energy from larger length scales to smaller length scales in solar wind at 1 AU.

HIGH-ENERGY ASTROPHYSICS

The curvature emission model of unusual neutron star candidate 1RXS J141256.0+792204 (Calvera)

Natia Kevlishvili

Institute of Theoretical Physics, Ilia State University, Tbilisi, Georgia

natia.kevlishvili.1@iliauni.edu.ge

The non-thermal emission theory is constructed, interpreting the observational properties of the unique pulsar 1RXS J141256.0+792204 (Calvera) in X-rays that is believed to be thermally emitting isolated neutron star. Calvera was observed in the X-rays with XMM Newton/EPIC twice for a total exposure time of 50 ks. It is unique isolated pulsar, because it cannot be detected by radio, optical and gamma-rays, however, it is detectable through the purely thermal emission in soft X-rays. A different approach of curvature emission scenario is considered, giving the spectral energy distribution that is in a good agreement with the XMM-Newton observational data, which can be also successfully fitted with the pure Planckian spectral shape. We do not argue against thermal emission scenario relying on spectral analysis results, as additional observational properties are acquired for distinguishing between existing emission scenarios.

The work was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG) [FR-18-14747].

X-ray intraday variability of the TeV blazar Mrk 421 with XMM-Newton

Angel Priyana Noel[1], H. Gaur[2], A. Gupta[2], A. Wierzcholska[3], M. Ostrowski[1], V. Dhiman[2], G. Bhatta[3]

[1] *Astronomical Observatory of Jagiellonian University, Kraków, Poland*
[2] *Aryabhatta Research Institute of Observational Sciences (ARIES), Beluwakhan, Uttarakhand, India*
[3] *Institute of Nuclear Physics, PAN, Kraków, Poland*

angel.priyana7@gmail.com

Markarian 421 is a bright high synchrotron energy peaked blazar showing wide featureless non-thermal spectrum. We analyse the large set of its X-ray observations taken with the EPIC-PN instrument onboard XMM-Newton satellite to probe into

the intraday variability properties observed in the source. The photon energy band of 0.3–10.0 keV, and its sub-bands, soft 0.3–2.0 keV and hard 2.0–10.0 keV, data are analysed over 17 years of observations. Fractional variability amplitude and the minimum variability timescale has been calculated. We also probed into the spectral variability by studying hardness ratio for each observation. The correlation between the variability in the two energy bands has been studied using the method of discrete correlation function and by inspecting the normalized light curves.

The fractional variability displays clear variability in 23 observations out of 25. The minimum flux variability time scale τ var ranges from 1.03 ks to 10.59 ks. The fractional variability is higher in the higher energy band than the lower energy band. In the HR-I diagram the source typically shows the harder-when-brighter trend. An interesting trend was revealed for the time lags observed in DCFs, which has the tendency to change sign with the observed lower and higher fractional variabilities. The circular loop structures observed in HR-I plots are accompanied by different signs of the measured time lag. From our single frequency band analysis, we speculate on the constraints for possible particle acceleration and emission processes in the jet, supporting the processes involving a turbulent behavior except of shocks.

Impact of asymmetric bosonic dark matter on neutron star properties

Edoardo Giangrandi[1], V. Sagun[1], O. Ivanytskyi[2], C. Providência[1], T. Dietrich[3]

[1] *CFisUC, University of Coimbra, Coimbra, Portugal*
[2] *University of Wroclaw, Wroclaw, Poland*
[3] *University of Potsdam, Potsdam, Germany*

eg@student.uc.pt

We propose a novel model of asymmetric bosonic dark matter (DM) with self-repulsion mediated by the vector field coupled to the complex scalar particles. By adopting the two fluid formalism, we study different DM distribution regimes, either, fully condensed inside the core of the star or, otherwise, distributed in a dilute halo around the neutron star (NS). We show that DM condensed in a core leads to a decrease of the total gravitational mass and tidal deformability compared to a pure baryonic star with the same central density, which we will perceive as an effective softening of the equation of state (EoS). On the other hand, the presence of a DM halo increases the tidal deformability and total gravitational mass.

As a result, DM could affect the NS properties by softening or stiffening the EoS. We demonstrate how observational data on compact stars could be employed to place constraints on strongly interacting matter at high densities. Moreover, we examine the limit where DM accrued in a core could cause the gravitational collapse. An implication of the proposed EoS and tests against astrophysical and

GW observations are performed for DM particles in a MeV-GeV mass-scale, various interaction strength, and relative DM fractions inside NSs.

Dark matter profiles of SPARC galaxies

Anton Rudakovskyi, M. Khelashvili, S. Hossenfelder

[1] *Bogolyubov institute for theoretical physics Kyiv, Ukraine*

rudakovskyi@gmail.com

Stellar and gas kinematics of galaxies are a sensitive probe of the dark matter distribution in the halo. The popular fuzzy dark matter models predict the peculiar shape of density distribution in galaxies: specific dense core with sharp transition to the halo. Moreover, fuzzy dark matter predicts scaling relations between the dark matter particle mass and density parameters. In this work, we use a Bayesian framework and several dark matter halo models to analyse the stellar kinematics of galaxies using the *Spitzer Photometry & Accurate Rotation Curves* database. We then employ a Bayesian model comparison to select the best halo density model. We find that more than half of the galaxies prefer the fuzzy dark model against standard dark matter profiles (NFW, Burkert, and cored NFW). While this seems like a success for fuzzy dark matter, we also find that there is no single value for the particle mass that provides a good fit for all galaxies.

Rotochemical heating in hybrid stars

Pavlo Panasiuk[1], V. Sagun[2], K. Hamaguchi[3], N. Nagata[3,4]

[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine*
[2] *CFisUC, University of Coimbra, Coimbra, Portugal*
[3] *Department of Physics, University of Tokyo, Tokyo, Japan*
[4] *Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU), University of Tokyo, Kashiwa, Japan*

pashka1201@gmail.com

The spin-down of a compact star causes perturbations in the internal chemical equilibrium state, and, consequently internal heating dubbed as rotochemical heating. Moreover, the fact that the cores of compact stars are thought to reach baryon densities as high as a few times the nuclear saturation density, renders them ideal candidates of being host to deconfined quark matter, the latter implying the existence of hypothetical objects such as hybrid stars and quark stars. We study the effect of this heating mechanism on the thermal evolution of millisecond pulsars with quark core, considering that both phases, i.e. hadron and quark matter,

departured from beta equilibrium. The main emphasis is given to the impact of deconfinement phase transition on the rotochemical heating.

Indication of a Local Source of Ultra-High-Energy Cosmic Rays in the Northern Hemisphere

Pavlo Plotko[1], A. van Vliet[2], X. Rodrigues[3], W. Winter[1]

[1] *Deutsches Elektronen-Synchrotron DESY, Zeuthen, Germany*
[2] *Department of Physics, Khalifa University, Abu Dhabi, United Arab Emirates*
[3] *Astronomical Institute, Fakultät für Physik und Astronomie, Ruhr-Universität Bochum, 44780 Bochum, Germany*

pavlo.plotko@desy.de

The Pierre Auger Observatory (PAO) and Telescope Array (TA) collaborations report significant differences in the observed energy spectra of Ultra-High-Energy Cosmic Rays (UHECRs) above 30 EeV. In this work, we present a joint fit of TA and PAO data using the rigidity-dependent maximum energy model, and including full marginalization over all relevant parameters. We show that the presence of a local astrophysical source in the Northern Hemisphere, which is only visible by the TA experiment, can reconcile PAO and TA measurements up to the highest energies. We demonstrate that the presence of that local source is favored at the 5.6σ level compared to the scenario where both experiments observe the same UHECR flux from a cosmological source distribution.

We also quantify that the astrophysical explanation can describe the current data better than a scenario where the differences in the observations are explained by experimental systematics (i.e., energy-dependent shifts). Having tested different mass compositions emitted from the local source, we conclude that the data are best described by a source lying at a distance of about 14 Mpc that emits cosmic rays dominated by the silicon mass group; we also discuss possible source candidates.

Table of Contents