Book of Abstracts

National Space Forum - 2025
(NaFSKI-VI)

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National Space Forum - 2025
(NaFSKI-VI)

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Abstracts

Monitoring deforestation trough Spatio-Temporal analysis of Landsat imagery in few regions in Bulgaria for period 2017-2024

Philipa Aleksandrova

Naval Academy 'Nikola Vaptsarov', Bulgaria

Abstract: This study investigates the temporal evolution of vegetation indices in few regions in Bulgaria, using remote sensing data from Sentinel-2 and MODIS satellites. The main focus is on assessing environmental changes and vegetation degradation over the period 2017-2024, with a particular emphasis on deforestation patterns. Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Enhanced Vegetation Index (EVI) were calculated for each summer season (June to August) using Google Earth Engine (GEE). Sentinel-2 surface reflectance data were pre-processed, filtered for cloud cover, and median composites were generated for each year. In addition, Land Surface Temperature (LST) data were extracted from MODIS (MOD11A2) products and averaged over the same seasonal periods. Annual maps and statistical summaries were produced to visualize changes in vegetation and water content. Linear regression analyses were performed for each index to evaluate temporal trends, including correlation coefficients (Rš) and regression equations. A combined change detection analysis was implemented, identifying areas where both NDVI and NDWI declined significantly. These zones were used as indicators of probable ecosystem degradation. Furthermore, spatial correlation between LST and NDVI was explored to understand the impact of surface temperature on vegetation health. The study also included land cover classification using ESA WorldCover to associate vegetation trends with specific land types such as forests, grasslands, and croplands. The results reveal spatially heterogeneous changes in vegetation, with notable losses in specific areas, highlighting the importance of continuous monitoring. The methodology demonstrated here can serve as a basis for future environmental assessments and early warning systems.

Interferometer for solar radio observations

Pavlina Aleksieva

Technical University of Sofia, Bulgaria

Abstract: The presentation explores the simulation and modeling process of two-element interferometer, designed for solar observations in the radio spectrum. The log-periodic antennas are among the commonly used antenna types in radio astronomy, especially for solar observations. It will be presented the analytical model for the antennas and the results, obtained after the simulations. The main function of an interferometer is to combine signals from two or more antennas, which are physically separated, in order to achieve higher resolution of the data from the desired direction in comparison to fewer or single element.

Student Club 'Aerospace vehicles and instruments' (e-poster)

Filip Andonov

Technical University of Sofia

Abstract: We are a group of 20+ self-organized students from different institutions (mainly from Technical University of Sofia), all with interest in engineering and science. Our main goal is to develop a rocket that will achieve a height of 100 kilometers and land back safely. We want to present our current progress, future plans, and also to meet many people from the space sector.

Overview of potential application of quantum computing in atmospheric remote sensing

Petya Angelova

Sofia University 'St. Kliment Ohridski', Bulgaria

Co-authors: Guergana Guerova, Georgi Kaludov Abstract: Quantum computing is rapidly advancing, moving from theoretical concepts to real-world hardware and software. Despite being early in development, quantum computing has significant potential for multiple domains, including atmospheric remote sensing. This presentation will provide an overview of the current state of the art of quantum computing, focusing on practical applications and accessibility with a short demonstration of composing and executing a circuit on IBM's quantum cloud using the Qiskit framework. The application of quantum computing for atmospheric science and Earth observation will be reviewed. Can quantum computing change climate and weather modeling? What are the main opportunities, challenges, and technical limitations of using quantum computers in atmospheric remote sensing, and what are the next steps?

Remotely Operated Astronomical Observatory 'Meshtitsa' - Supporting Professional and Citizen Science Activities

Nikola Antonov

Sofia University, Faculty of Physics, Department of Astronomy, Bulgaria

Abstract: In recent years, remotely operated astronomical observatories have played a key role in modern astronomical research by providing access to high-quality observations for both professional astronomers and citizen scientists. The development of such observatories expands the possibilities for scientific research and the popularization of astronomy, bringing together the efforts of professionals and enthusiasts in joint scientific projects. The presentation includes the technical specifications of the observatory, methods for remote control and automation, and its integration into research networks and initiatives with other observatories and telescopes. Specific examples of successful observational tasks will be demonstrated, such as monitoring variable stars and exoplanets, along with the observatory's participation in international citizen science initiatives.

Spectroscopic and archival studies of ultracool dwarf candidates

Antoaneta Antonova

Institute of Astronomy and NAO, Bulgarian Academy of Sciences, Bulgaria

Co-authors: Pessev, P., Golev, V., Dimitrov, D. Abstract: We present a comprehensive spectroscopic study of a sample of poorly studied ultracool/brown dwarf candidates, selected by high proper motion criteria. The original data selection predates GAIA and is based on proper motion determinations utilizing the combined 2MASS and WISE data sets. For the majority of the targets, this is the first spectral classification based on wide wavelength coverage low resolution optical spectra. All of the dwarfs from the sample are also lacking determined stellar parameters in the most recent GAIA DR3. H-alpha emission is detected in a significant fraction of the sample objects, including the first detection of such emission from a previously classified dwarf carbon star. We utilize the existing and newly available archival data to gain deeper insight on the overall sample and the ultracool/brown dwarf stars in general.

Investigating Flares and Chromospheric Activity in Dwarf Strars with Spectroscopy and TESS Data

Antoaneta Avramova-Boncheva

Institute of Astronomy and National Astronomical Observatory, BAS

Co-authors: H. Korhonen, A. Antonova and I. Stateva Abstract: Stellar activity plays a critical role in the evolution, habitability, and detectability of exoplanets, especially around low-mass stars. In this study, we investigate chromospheric and flare activity in a sample of M and K dwarfs, as well as solar-like (G-type) stars using a combination of space-based photometry from the Transiting Exoplanet Survey Satellite (TESS) and ground-based spectroscopic observations from the 2m RCC telescope at the Rozhen National Astronomical Observatory (NAO), operated by the IA and NAO, BAS and the New Technology Telescope (NTT) at La Silla Observatory. We focus on detecting and characterizing stellar flares and chromospheric variability, primarily through the H-alpha line as an activity indicator in our spectra, complemented by time-domain photometric variability from TESS. Our targets were selected based on their brightness, spectral type, and known or suspected variability. The spectroscopic data allow us to probe chromospheric conditions and search for signs of activity cycles or transient events, while the TESS data provide high-cadence, long-baseline light curves to identify and characterize flare frequency, energy distribution, and possible periodic modulations related to rotation or active regions. Several flare events have already been registered in the spectroscopic data through enhancements in the H-alpha line profile. Data reduction is ongoing, and further analysis is in progress to characterize these events and correlate them with TESS photometry, which is currently under examination.

Design and Experimental Investigation of a Solid Propellant Rocket Motor

Ana-Maria Bogdanova

Sofia University 'St. Kliment Ohridski', Bulgaria

Abstract: This thesis presents the design, theoretical modeling, and experimental evaluation of a solid propellant rocket motor named AMC-1. It examines the key components of the motor-combustion chamber, insulation, ignition system, propellant, and nozzle - along with the principles of flow dynamics and thrust generation. The motor uses a potassium nitrate-sorbitol (KNSB) propellant for its safety and suitability in amateur applications. All components are custom-fabricated. Experimental thrust data is presented and compared with theoretical predictions. The study confirms the feasibility of building and testing a functional rocket motor in an academic context.

Emerging Paradigms in Solar Energy Harvesting for Space Applications

Francesca Brunetti

Tor Vergata University of Rome - CHOSE, Centre for Hybrid and Organic Solar Energy, Italy

Co-authors: F. De Rossi, M. Stefanelli, E. Leonardi, M. Di Donato, G. Detrell, E. Barrigon Montanes, M. T. Borgstroem, D. Dancila, A. Ziaei, S. Tkatchova Abstract: As space missions evolve toward longer durations and higher energy demands, the need for lightweight, high-efficiency, and radiation-hard energy solutions becomes critical. This contribution presents an overview of frontier technologies for solar energy harvesting, specifically geared for space applications, emphasizing innovations beyond traditional III-V triple-junction photovoltaics (PV). Tandem solar cell architectures are leading contenders. Among them, all-perovskite tandem cells have achieved power conversion efficiencies (PCE) of over 30 percents on rigid glass and 24.7 percents on flexible substrates, showing exceptional promise due to their high power-to-weight ratios, radiation tolerance and mechanical flexibility. Perovskite/CIGS tandems represent another promising avenue, combining the advantages of both absorbers, with efficiencies of 24.2 percents and 21.2 percents for rigid and flexible substrates, respectively. In parallel, nanowire-based solar cells offer an inherently radiation-hard design, due to their hollow-like geometry and enhanced light-trapping capabilities. These III-V nanostructured devices have shown strong potential in both single- and multi-junction formats, with models projecting up to 47 percents PCE using just 1 g of active material per square meter - a revolutionary step for ultra-lightweight space PV. In addition, conventional solar panels predominantly capture energy from the visible range of the solar spectrum, leaving nearly 55 percents of the incident solar energy-corresponding to frequencies between 1 and 1000 THz - unexploited. Bridging this spectral gap and advancing rectification mechanisms at THz frequencies is essential for increasing energy harvesting yield. Finally, an emerging disruptive concept is the sunlight-pumped laser (SPL), converting non-concentrated solar radiation into coherent laser beams via biomimetic or supramolecular gain media. This approach could enable direct in situ energy conversion and wireless transmission, opening new avenues for space-based power systems. Together, these technologies redefine the landscape of space PV by combining high performance, low mass, and superior radiation resistance. Their development and deployment could significantly enhance the autonomy and sustainability of future space infrastructure.

Challenges for SiPM sensors in space

Valentin Buchakchiev

Sofia University 'St. Kliment Ohridski', Bulgaria

Co-authors: Venelin Kozhuharov Abstract: Silicon Photomultipliers (SiPM) are a good candidate when designing the readout for modern scintillator detectors for ionizing particles, both for space-borne and Earth-based devices, due to their lower operating voltage and power consumption. A major issue, however, is that high radiation environments may degrade SiPM performance due to defects accumulating within the silicon crystal lattice. For this study, several SiPMs were irradiated at the CHARM mixed-field facility at CERN. Two sets of SiPMs containing FBK ASD-RGB3S-P-40 and ASD-RGB4S-P-40 SiPMs, and OnSemi MICROFJ-30035-TSV SiPMs were exposed to different levels of total dose, reaching up to O(10 12) 1 MeV n eq/cm 2. In each set, half of the SiPMs were continuously powered to nominal voltage while others were kept in an off state during the irradiation. The dark current of all SiPMs was continuously monitored and I-V curve measurements were taken at different irradiation levels to allow the determination of the SiPM breakdown voltage and its dependence on the absorbed dose. In addition short LED pulses were used to record SiPMs signal shapes throughout the irradiation to follow the signal parameters degradation. Preliminary results from the described test irradiation campaign will be presented and discussed.

Landing with Intelligence: Deep Reinforcement Learning for Thrust Vector-Controlled Rocket Descent

Michael Tsanev

Sofia University 'St. Kliment Ohridski', Bulgaria

Abstract: I explore the application of deep reinforcement learning (DRL) to the autonomous landing of a thrust vector-controlled rocket. Traditional model-based control systems, such as PID control or 'G-FOLD' (Guidance For Optimal Large Diverts) algorithm [1], which require extensive tuning and may struggle with highly nonlinear dynamics and real-time uncertainty. In contrast, DRL offers a data-driven approach that can learn optimal control strategies directly through interaction with a simulated environment. I present a custom rocket dynamics model built in MATLAB and Simulink, capturing 6-DOF motion under atmospheric drag and gimbaled thrust. A neural network agent, trained via proximal policy optimization (PPO), learns to perform stable vertical landings from randomized initial conditions. The system demonstrates precise attitude control, terminal velocity minimization, and landing zone targeting without explicit trajectory programming. This work highlights the potential of combining control theory with machine learning to enable agile, adaptive, and scalable rocket guidance systems. [1] Lossless Convexification of Non-Convex Control Bound and Pointing Constraints of the Soft Landing Optimal Control.

Leveraging Slooh's Global Robotic Telescopes Network for Fast-Response Precision Astrometry of Newly Discovered NEA and Comets

Kolyo Dankov

Sofia University 'St. Kliment Ohridski', Bulgaria

Abstract: Near-Earth Asteroids (NEAs) and Comets, particularly newly discovered and potentially hazardous objects (PHOs), demand rapid, precise astrometric follow-up to accurately determine their orbits and assess impact risks. Ground-based observatories face challenges in providing immediate, global coverage due to weather, daylight, and scheduling constraints. This work highlights the significant contribution of the remote-controlled, globally distributed Slooh Observatories in addressing this critical need. Slooh operates a network of seven fully robotic telescopes situated at premier astronomical sites in the Canary Islands (Spain), Chile and Australia. This strategic geographic distribution enables 24/7 coverage of the sky, crucial for observing newly discovered NEOs during their often brief optimal visibility windows. The platform's innovative reservation system and full automation allow for exceptionally fast response times. Upon receiving alerts for new discoveries or objects requiring urgent follow-up on the NEOCP page of the Minor Planet Center, observations can be scheduled and executed within minutes to hours, far outpacing many traditional facilities. The telescopes deliver precise astrometry essential for refining orbital calculations. The significance of Slooh's infrastructure lies in its ability to provide reliable, rapid, and precise data during the critical initial tracking phase of NEOs. Early, high-quality astrometry significantly reduces orbital uncertainties, enabling more accurate predictions of an object's future path and improving the assessment of potential Earth impact probabilities for PHOs. By filling observational gaps and offering immediate access, Slooh's robotic network acts as a vital component in the global planetary defense observational pipeline. While primarily an educational platform enabling unprecedented student access to professional-grade telescopes, Slooh's operational model demonstrably contributes valuable scientific data. It exemplifies how scalable, remote-controlled observatory networks can enhance our capability to monitor and characterize hazardous celestial objects, directly supporting efforts to safeguard our planet. The speed, precision, and accessibility offered by such systems are increasingly indispensable for NEO tracking and risk mitigation.

Results from the Bulgarian-Austrian Project on Solar and Coronal Activity

Momchil Dechev

Institute of Astronomy with NAO - BAS, Bulgaria

Co-authors: Rositsa Miteva, Werner Poetzi, Kamen Kozarev, Oleg Stepanyuk, Pencho Markishki, Georgi Latev Abstract: An overview of the activities under all three work packages of the project is shown. Apart from the solar telescope installation, test observations and dissemination, the focus of this report is on the science results. Various research tasks using chromospheric solar data have been completed. Among these are the statistical results on active region morphology and size, both for eruptive and confined flares, and machine learning approach on solar filament recognition. Future plans for the development of solar observations in Bulgaria are presented.

Defining a space exploration mission in search for shelter on Mars (e-poster)

Nikola Dekovski

Faculty of Physics, Sofia University 'St. Kliment Ohridski', Bulgaria

The Orbiting Mars Cave Observatory (OMCO) mission aims to contribute to the study of submartian lava tubes by providing orbital images or orbital radar wave reflection data. Such data may be used to aid in the location of those formations. Underground lava tubes, effectively caves, in the shallow parts of Mars' or the Moon's crust provide shelter from solar and galactic background radiation. These subsurface spaces can offer suitable base sites for future long-term Lunar and Martian crewed missions due to their large volume. The comparatively low gravitational acceleration near the surface of Mars allows for the formation of very large underground chambers, on the order of tens to hundreds of meters in diameter. These massive hollow spaces can shelter entire communities of researchers and settlers in future endeavors of exploration.

Searching for Dark Photons with PADME

Katerina Kostova

Sofia University 'St. Kliment Ohridski', Bulgaria

Co-authors: PADME Collaboration Abstract: The PADME Experiment in Laboratori Nationali di Frascati, Italy, is designed to search for new light particles in the process of annihilation of beam positrons with the electrons in a fixed target. One such particle is the hypothetical Dark Photon, a vector boson acting as mediator between the visible and the hidden sector, providing a possible explanation for the Dark Matter phenomenon. The original setup of PADME is designed to search for associate production of a Dark Photon together with an ordinary photon, the latter being registered by the experiment's electromagnetic calorimeter. We present the current status of the PADME Run II data analysis, aimed at identifying possible Dark Photon events: the event selection methods, background reduction techniques and future prospects.

Comparative evaluation of next-generation aluminium alloys for lightweight aerospace structures (e-poster)

Margarita Dimitrova

Space Research and Technology Institute - Bulgarian Academy of Sciences, Bulgaria

Co-authors: Adelina Miteva Abstract: Next-generation aluminium alloys have become increasingly significant in aerospace engineering due to the ongoing demand for lightweight, high-strength materials that enhance structural efficiency and reduce operational costs. This study provides a comprehensive comparative evaluation of several novel aluminium alloys specifically developed for lightweight aerospace structures. The investigation focuses on alloys from the advanced 2xxx, 6xxx, and 7xxx series, assessing critical properties such as tensile strength, yield strength, fatigue resistance, corrosion resistance, fracture toughness, and weldability. Experimental methodologies including mechanical testing, microstructural characterization via microscopy, and corrosion resistance analysis were employed to systematically evaluate each alloy. Findings reveal distinct performance advantages among the alloys, highlighting particular suitability depending on structural application requirements. The 7xxx series alloys exhibited superior tensile strength and fatigue resistance, making them ideal for primary load-bearing structures, whereas certain 2xxx series alloys demonstrated enhanced fracture toughness and improved corrosion resistance, proving beneficial in damage-tolerant designs. Additionally, the evaluation includes the analysis of processing techniques, such as heat treatments and additive manufacturing compatibility, further emphasizing the practical aspects of implementing these alloys in aerospace manufacturing processes. The outcomes of this research serve as a guideline for aerospace engineers and designers, facilitating informed material selection decisions based on structural performance requirements, weight reduction goals, and manufacturing considerations. The paper concludes by identifying future research directions aimed at optimizing alloy compositions and developing advanced fabrication processes to fully harness the potential of next-generation aluminium alloys for the aerospace industry.

Neutrino Interactions and Hidden Particle Searches with SND LHC

Ivaylo Dionisov

Sofia University 'St. Kliment Ohridski'

Abstract: The nature of dark matter and the possible existence of hidden sector particles remain fundamental open questions in modern astrophysics. While astronomical observations point to their presence, accelerator experiments offer a complementary approach to explore their underlying particle nature. The SND LHC experiment extends this search frontier by providing sensitivity to light, feebly interacting particles (FIPs) produced in the far-forward region of the LHC, with the potential to test and constrain models predicting leptophobic mediators.

The new Master's Program in Astrobiology - Goals and Perspectives in Search of an Intersection between Space and Life Sciences

Petar Eftimov

Sofia University 'St. Kliment Ohridski', Bulgaria

Co-authors: Nadezhda Stefanova, Vladimir Bozhilov Abstract: The new master's Program in Astrobiology is a joint project of the Faculty of Biology, the Faculty of Physics, the Faculty of Chemistry and Pharmacy, the Faculty of Geology and Geography, and the Faculty of Philosophy of Sofia University 'St. Kliment Ohridski' and the Institute of Molecular Biology (IMB) of the Bulgarian Academy of Sciences. It was found in 2024 after considerable research done on several master's programs and courses in Astrobiology curricula with the aim of covering the main topics in the field, i.e. understanding how life begins and evolves, searching for life beyond Earth, and exploring the future of life on Earth and beyond. The program consists of 18 compulsory and 12 elective subjects distributed in 4 semesters. The courses' emphasis is on the theoretical understanding of the complexity of the main geologic, biologic and astrophysics foundations of life, with broad practical involvement and hands-on work in real projects between the involved institutions. Our master students are encouraged to collaborate and to form teams in order to solve actual problems ranging from the origin of life to the effects of xenoenvironments on living systems (animals, plants, protists and prokaryotes). The program is open for admission to all professionals with a bachelor's degree in any of the aforementioned fields (biology, physics, geology, chemistry), thus fulfilling the idea of our team that only interdisciplinary research can encompass the vast perspectives in a scientific field of over 110 disciplines. Here, we try to summarize the programs goals, scientific potential and possible impact on the cooperation between involved institutions, along with ongoing and planned international projects.

Quantum Space Science in Museums: A New Way to Inspire the Future Workforce (e-poster)

Mariana Filipova

ULSIT, Bulgaria

Co-authors: Yancho Yordanov, Genadiy Gospodinov, Rosalina Gramatikov, Tamara Ristovska

Abstract: Quantum space science and technology are opening new possibilities for space exploration and human progress. However, many people still know little about quantum technologies, and their potential remains largely unexplored. Interactive and engaging education plays a key role in this process, and modern methods of attracting people to learn about quantum science and its importance for the growth of space research are essential. STEM education is highly valuable today, and approaches for outreach and development are a major focus. Introducing young people and society to new technological and scientific discoveries helps attract them for STEM careers. Inspiring people to study space and Astro-sciences creates the workforce that can change our understanding of the universe, supported by quantum technology advancements. STEM museums, especially Space Museums, provide an environment that combines knowledge, interactivity, and the opportunity for learning by doing. Creating educational programs that foster curiosity and encourage new professionals and researchers in the field would greatly benefit both individual growth and scientific progress. This paper aims to explore the potential for developing educational and informational programs for students, professionals, and the general public, helping to spread knowledge about quantum space technologies and inspire future STEM experts.

Current Development of VLEO Activities at the University of the Bundeswehr Munich

Nikola Ganchev

University of the Bundeswehr Munich

Co-author: Jochen Schein Abstract: Very Low Earth Orbit (VLEO, altitudes below 450 km) offers unique opportunities for Earth observation, telecommunication, and defense applications due to increased spatial resolution and reduced latency. However, the residual atmospheric drag at these altitudes imposes stringent requirements on propulsion systems to maintain orbital stability and mission lifetime. At the University of the Bundeswehr, we are currently developing a comprehensive technology suite for VLEO operations, focusing on two key areas: an atmospheric-breathing electric propulsion (ABEP) system based on an Electron Cyclotron Resonance (ECR) plasma source and a VLEO particle accelerator for environmental characterization. The main objective is to develop, test, and characterize ABEP under conditions representative of the VLEO environment while advancing our understanding of particle dynamics in rarefied atmospheres. Our approach integrates experimental campaigns for the ABEP thruster and the VLEO particle accelerator with numerical simulations and laboratory experiments dedicated to the atmospheric intake system. This combined methodology allows for iterative optimization of intake efficiency, plasma generation, and thrust performance under realistic flow conditions. The ongoing work aims to deliver validated performance data for ABEP operation in VLEO and pave the way toward future in-orbit demonstrations. By addressing key challenges in plasma coupling, intake design, and system integration, this research contributes to enabling sustainable long-term operations in very low Earth orbits.

Radio and optical observation of flares and coronal mass ejections in the Hyades open cluster

Anna Görgei

Konkoly Observatory / Eötvös University, Hungary

Co-authors: Antoaneta Antonova, Krisztian Vida Abstract: Flares and coronal mass ejections (CMEs) are powerful events that occur on the surface of stars, including our own Sun. They are sudden, explosive releases of energy that emerge when magnetic fields on the star's surface become twisted and reconnected, releasing a burst of radiation across a wide range of wavelengths, from radio waves to X-rays. On our Sun most large flares are associated with massive eruptions of plasma - CMEs. These events can have a significant impact on the space environment around the star, including the production of energetic particles, the acceleration of charged particles to high speeds, and the disruption of the interplanetary magnetic field: CMEs could render planets uninhabitable. On the Sun, both flares and CMEs are well investigated by dedicated monitoring. On other stars, flares are much better characterized than CMEs, since the latter are challenging to observe: most of the known stellar CMEs were detected indirectly using optical spectroscopy. On the Sun, Type II radio bursts are associated with CMEs and shock waves, and can be used to probe the properties of both CMEs and the solar wind. With low-frequency radio arrays, including LOFAR, the possibility to detect the stellar analogs of Type II bursts - as a proxy for CMEs - is open. We observed Hyades, an open cluster with a large number of stars having different spectral types, but the same age with the aim of estimating the CME frequency as a function of mass. With the aim of a better understanding on the connection between flaring in the photosphere and CMEs in the higher stellar atmosphere,we coordinated the observation with the TESS satellite and LOFAR. Optical observations were essential to determine the times of the optical flaring events of the targets, and to correlate any detected radio emission with the stellar activity.

Testing and Calibration of Particle Detector Modules

Simeon Ivanov

Sofia University 'St. Kliment Ohridski' and National Centre for Mechatronics and Clean Technologies

Abstract: Robustness and reliability are of paramount importance for space equipment. An approach for modeling and comprehensive testing of a set of modular components for ionizing radiation measurements in space will be described. The tests include time resolution, energy resolution, dynamic ranges and flux rates for relevant environments, as well as tests of the on-board analysis software for event reconstruction, particle identification, spectra and flux directionality.

Evaluation of Timepix3 sensor operating in nanosecond data-streaming mode for space research

Svetoslav Ivanov

Sofia University 'St. Kliment Ohridski' and National Centre for Mechatronics and Clean Technologies

Abstract: The Timepix3 sensor is a square matrix of 256 x 256 pixels capable to operate in two different modes: a frame mode providing information for all of the recorded events in a predefined time interval, and a data-streaming mode providing continuous readout for every pixel in 1.56 ns. In the present work, an array of 2x6 Timepix3 sensors are investigated for future space research in nuclear and high-energy physics. Calibration and evaluation of the response of the individual chips for bias and threshold voltage are performed with respect to different multiplicity, energy and duration of charged particle bunches in the Beam Test Facility of LNF, INFN.

Machine-learning methods to study the dynamics and dark matter of nearby galaxies

Veselina Kalinova

Max Planck Institute for Radioastronomy, Germany

Abstract: In this talk, I will present our work on the mass distribution of nearby galaxies using several machine learning methods - Markov Chain Monte Carlo (MCMC), Principal Component Analysis (PCA), clustering and Jack-knife techniques. We use these methods to objectively categorise the galaxies based on the shape and amplitude of their circular velocity curves (CVC), derived from stellar kinematics via Jeans Axisymmetric models. We found a key clue from the PCA-CVC reconstruction that can serve as a guide in studying dark matter distribution in galaxies. Additionally, using multi-wavelength observations (i.e. HI, CO, photometry, and optical spectroscopy) and observationally-derived variable stellar mass-to-light ratio profiles provides a new and advanced technique to study dark matter in galaxies.

Intelligent Road Infrastructure - ML for detecting road features using high resolution satellite imagery

Vasilena Krazheva

Wiser Technology, Bulgaria

Co-authors: Nevena Pavlovska Abstract: Traditional road network monitoring is often costly and inefficient. This presentation details a machine learning (ML) framework using high-resolution satellite imagery for automated road feature extraction and quality assessment. We developed a robust segmentation model, experimenting with architectures including U-Net with an EfficientNet-B7 backbone and MTP, to accurately delineate roads, bridges, and parking areas from a custom-annotated dataset. A novel algorithm subsequently calculates precise road widths from these segmentations. Furthermore, MobileNet-based classifiers were trained to determine lane count and assess lane marking visibility. These diverse indicators are consolidated into a comprehensive road quality index, enabling efficient, data-driven decision-making for infrastructure management and contributing to safer, more reliable transportation networks.

Magnetic shielding for space re-entry: from science fiction to science fact!

Andrea Lani

KU Leuven, Belgium

Co-authors: Vatsalya Sharma, Vincent Giangaspero, Alan Viladegut, Diana Luis, Johannes Oswald, Georg Herdrich, Minkwan Kim, Jan Thoemel, Johannes S. Laur, Sonja I. Schlachter, Penelope Leyland, Manuel La Rosa, Anis Smara, Matthieu Dalban-Canassy Abstract: (Re-)entry represents one of the most critical phases for space exploration missions. The safety of the expensive payload and/or human crew strongly depends on the spacecraft survival to the harsh conditions which are experienced during the hypersonic descent into the target planetary atmosphere, involving high thermal loads on the vehicle surface. In addition, at the highest speeds, the surrounding gas ionizes forming a plasma sheath which can prevent radio signals to pass through, leading to communication blackout which can last for minutes, as in the case of the 4.5 minutes during the famous Apollo 13 re-entry. While previously confined solely to Sci-Fi movies, magnetic shielding can now be seriously proposed and technologically pursued as a potential game-changer for tackling all these issues and for contributing to establish a safer and possibly more cost-effective era for space flight. To this end, this presentation introduces MEESST (MHD Enhanced Entry System for Space Transportation), an international project that has developed and demonstrated the first magnetic shielding prototype for re-entry based on high-temperature superconductors (HTS), aiming at actively mitigating both high surface heating and communication blackouts. MEESST has been funded under the Pathfinder program of the European Innovation Council (EIC) and has involved 30+ scientists/engineer from 10 organizations (of which 4 SMEs) in 6 countries. The project has involved a combination of numerical modelling of plasma flows and radio communication blackout, design/assembly/testing of a cryocooled probe integrating a HTS magnet, and experimental measurements in high-enthalpy plasma wind-tunnels (i.e. the PWK1 arc-jet facility at the Institute for Space Systems in Stuttgart and the Plasmatron at the Von Karman Institute for Fluid Dynamics in Belgium). The vision, methodology, main results and achievements of MEESST will be presented, together with a roadmap towards consolidating and establishing this technology as a disruptive solution to empower future space missions.

Bulgarian Astronomical Society - mission and outlook (e-poster)

Rositsa Miteva

Institute of Astronomy and National Astronomical Observatory - Bulgarian Academy of Sciences, Bulgaria

Co-authors: Rositsa Miteva, Dragomir Marchev, Antonia Valcheva, Stefan Stefanov, Momchil Dechev, Tsvetelina Gencheva, Nikola Antonov, Pencho Markishki Abstract: The goal and main activities of the Bulgarian Astronomical Society are presented. It is a non-governmental organization founded in 2000, which has organized 18 national astronomical meetings in different cities. The membership of the society includes professional and amateur astronomers. The initiative aims to coordinate various educational and popularization activities from the observatories and planetariums, astronomy clubs, academic achievements, and projects in the field of astronomy, astrophysics, and space sciences.

In-Space Green Propulsion Innovations in the EIC Portfolio on In-Space Solar Energy Harvesting for Innovative Space Applications

Tomas Mrazek

Technical University of Munich

Co-authors: Tomas Mrazek, Chiara Manfletti, Alberto Sarritzu, Lily Blondel-Canepari, Angelo Pasini, Lorenzo Tarabini Castellani, Gonzalo Sanchez-Arriaga Abstract: Within the EIC Pathfinder Portfolio on In-Space Solar Energy Harvesting for Innovative Space Applications, GreenSWaP, Ice2Thrust, and E.T.COMPACT focus on in-space green propulsion, seeking to develop systems competitive with conventional solutions on both price and performance. The current in-space propulsion landscape relies heavily on toxic propellants, which complicates operations both on ground and in orbit. Water as a propellant offers a non-toxic, high-performing alternative that simultaneously promotes European strategic autonomy. GreenSWaP proposes a solution allowing satellites to launch with only water onboard and harness solar energy to produce hydrogen peroxide (H2O2) and hydrogen (H2), directly in space. The system then offers bimodal propulsion combining a 200N main engine (H2O2/H2) with a 1N solar-thermal thruster powered by hydrogen. To support this, two production methods, photo/electrochemical and plasma-assisted synthesis, are being developed to determine the most efficient and mission-compatible solution. Ice2Thrust is developing a Water Electrolysis Propulsion (WEP) system featuring a 1N hot-gas thruster (Isp > 370s) and cold-gas attitude control, as well as autonomous spacecraft docking and refilling capability. In-space water extraction and utilisation are also investigated, targeting a world-first end-to-end ISRU lab demonstration. With these efforts, Ice2Thrust aims to promote the development of a self-sustaining space economy based on solar energy harvesting. The propellant-less character of Electrodynamic Tethers (EDTs) can contribute to efficient in-orbit mobility for in-orbit servicing and deorbiting scenarios. With this aim, the E.T.COMPACT project is exploring the miniaturization limits of EDT technologies by preparing a green mobility module within a stringent volume envelope of only 3U. It includes the EDT, its deployment mechanism, and an expellant-less cathode. The project also carries out research and development activities on the bare-photovoltaic tether concept, which integrates PVK/CIGS thin film solar cells in the EDT to achieve in a single and compact device propellant-less propulsion and power harvesting capabilities.

Nanotechnology in the aerospace industry

Adelina Miteva

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Co-authors: Margarita Dimitrova, Gyunver Hodjaoglu Abstract: Nanotechnology has emerged as a transformative force in the aerospace industry, offering innovative solutions to longstanding challenges in material science, structural design, and operational efficiency. By manipulating materials at the atomic or molecular scale, nanotechnology enables the development of advanced composites, coatings, and sensors with unparalleled mechanical, thermal, and electrical properties. Key nanomaterials such as carbon nanotubes (CNTs), graphene, and nanoparticles are revolutionizing aerospace applications by enhancing strength-to-weight ratios, improving fuel efficiency, and increasing resistance to extreme environments. For instance, carbon nanotube-reinforced composites reduce aircraft weight while maintaining structural integrity, directly contributing to lower fuel consumption and emissions. Similarly, graphene-based coatings protect against lightning strikes and oxidative damage, extending component lifespans. The integration of nanotechnology extends to additive manufacturing, where nanomaterials enable 3D-printed components with enhanced durability and precision, critical for both commercial aviation and space exploration. Nanosensors embedded in aerospace systems provide real-time monitoring of structural health, detecting stress, corrosion, and temperature fluctuations to prevent failures. Additionally, nanotechnology addresses thermal management challenges through materials like aerogels and nanoporous ceramics, which offer superior insulation for high-speed travel and re-entry conditions. Despite these advancements, challenges remain, including scalability, cost-effectiveness, and safety concerns related to nanomaterial toxicity and environmental impact. The paper concludes by identifying critical future directions, highlighting the importance of interdisciplinary collaboration, regulatory considerations, and continued research investments. Overall, nanotechnology promises to significantly change the aerospace industry by stimulating innovation, improving operational efficiency, safety and sustainability, ultimately paving the way for next-generation aerospace vehicles and systems.

Geomagnetic storm effects on satellite orbits

Rositsa Miteva

Institute of Astronomy and NAO - BAS, Bulgaria

Co-authors: Adrian Sonka, Nikola Antonov, Stela Tkatchova, Susan Samwel Abstract: This paper summarized selected results on the variation of the orbital parameters of satellites (space debris) during geomagnetic storms (GSs), presenting an analysis and classification of the impacts of geomagnetic storms on satellites and their payloads and on space debris. The Dst index is used to quantify the intensity of the GSs. Objects at various orbits (LEO, MEO and GEO) have been pre-selected for this study, and their orbits have been tracked during the strongest geomagnetic disturbances in the last solar cycles. The results are discussed in the framework of space weather research.

Assessing Forest Conservation Effectiveness of Natura 2000 Zones in Bulgaria, Including Vitosha and Vrachanski Balkan Nature Parks: A Remote Sensing and GIS Approach (e-poster)

Eleonora Mitkova

Birkbeck University, London

Abstract: Assessing Forest Conservation Effectiveness of Natura 2000 Zones in Bulgaria Using Remote Sensing and GIS Forest conservation is essential for biodiversity protection and climate resilience. This study evaluates the effectiveness of Natura 2000 zones in Bulgaria, focusing on Vitosha and Vrachanski Balkan Nature Parks, by analysing forest cover dynamics compared to non-protected areas (non-PAs) and examining the influence of road networks on forest change. Although Natura 2000 is the world's largest PA network, its effectiveness in reducing deforestation at regional scales remains underexplored. This research addresses three questions: how forest cover has changed in PAs and non-PAs between 1986 and 2023, how road proximity influences forest loss and gain, and whether Natura 2000 zones achieve stronger conservation outcomes than adjacent non-PAs. Satellite data from Landsat TM (1986, 2003, 2006) and Sentinel-2 MSI (2023) were processed in ArcGIS Pro. Processing included band compositing, segmentation, and NDVI analysis. Supervised object-based classification was performed and validated with accuracy assessments. Change detection quantified transitions between forest and non-forest, while road networks and 200 m buffer zones were mapped to evaluate accessibility effects. Spatial overlays enabled comparisons between PAs and non-PAs. Results show that forest cover increased from 32 in 1986 to 48 percent in 2023. Gains were stronger in PAs, rising from 45 to 62 percent, with Vitosha reaching 72 percent forest cover and Vrachanski Balkan recording the highest proportional increase (+17 percent). Non-PAs recovered more slowly, from 25 to 41 percent, with deforestation linked to agricultural expansion and urban growth. Unexpectedly, non-PAs near roads recorded forest gains, suggesting afforestation or management initiatives. Road-buffer dynamics point to complex socio-ecological interactions, challenging assumptions of uniform road-driven deforestation and instead showing the positive impact of afforestation. The study underscores the need for further research, including ground truth validation and higher-resolution optical and radar data (e.g. Sentinel-1 SAR). Expanding to additional Natura 2000 sites would also help better understand forest disturbances and road proximity.

Impact of solar activity on ionospheric dynamics and high-energy particle fluxes over Antarctica

Ivaylo Nachev

Technical University of Sofia

Abstract: This study presents a comprehensive investigation into the effects of solar flares on the Earth's ionosphere, conducted during the maritime expedition of vessel NIC421 from Varna Port to Livingston Island and back. Using Very Low Frequency (VLF) radio wave propagation analysis, the project monitored ionospheric disturbances in the region referred to as "Ionosphoretta" to assess the impact of solar activity in real-time. The study focuses particularly on the response of the lower ionosphere to solar flare events, with an emphasis on Type II and Type III flares directly recorded using a solar spectrometer. Additionally, magnetic field variations were measured throughout the journey using a high-resolution triaxial magnetometer, enabling correlation between solar flare events and geomagnetic fluctuations. The combination of VLF diagnostics, direct solar flare observations, and geomagnetic monitoring provides a multi-modal approach to understanding space weather phenomena and their terrestrial effects over maritime and polar regions.

Band-gap PV material investigation for High-Power Optical Transmission in Planets and Satellites of the Solar System

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University of Jaen, Spain

Co-authors: Manuel Peralta-Fuentes, Pablo Sanmartín, Álvaro Valera, Elvira Castillo-Garcia, Jose Luis Lombardo-Garcia, Jesus Montes-Romero, Florencia Almonacid and Eduardo F. Fernandez
Abstract: High-Power Optical Transmission (HPOT) is one of the ground-breaking technologies that are expected to revolutionize the energy paradigm in the 21st century. It uses monochromatic light sources, notably lasers, to transfer power to a remote system via a photovoltaic (PV) cell or optical PV converter (OPC). Some promising applications of HPOT technology include atmospheric, underwater and in-space power transmission. In particular, one of the main advantages of the technology is the capacity to enable uninterrupted energy availability on Earth and other celestial bodies, opening new horizons for space and planetary exploration. In order to study HPOT as the key to explore the Solar System and enhance the capabilities of planetary exploration, the atmospheres of celestial bodies and their optical properties have been analysed. As discussed by the research team in previous work, PV materials need to be carefully selected to ensure the maximum potential efficiency of global HPOT systems. Atmospheres data have been obtained using NASA's tool 'Planetary Spectrum Generator' (PSG) and the Shockley-Queisser radiative method has been employed for modelling the OPCs. Transmittance spectra have been retrieved from NASA's PSG for Mars, Earth, and Venus, allowing the identification of wavelength ranges with maximal transmittance. These spectral windows define the optimal regions for HPOT, and materials matching these gaps must be identified and studied, as they are key for efficient energy transfer on each planet. Furthermore, as part of the RePowerSiC European project, silicon carbide (SiC) polytypes have been proposed and studied as potential devices for laser power conversion of HPOT systems on Mars. Their wavelengths are in the optimal efficiencies range, showing their potential in terms of HPOT systems. Further considerations and other celestial bodies, simulations and radiative efficiency calculations are also included in the work. Acknowledgements: This work is funded by the EU under grant agreement N 101160868.

Reflector Antennas for Radioastronomical purposes

Peter Petkov

Technical University of Sofia, Bulgaria

Abstract: One of the key players in Radioastronomy is the Reflector antenna. The presentation demonstrates the fetures and repurposing of a 3.7m Telecom Satellite antenna for radiastronomical purposes. The antenna was recently donated to the Technical University of Sofia and expected to comence operations by the Summer of 2025.

Evaluation of spent fuel as a possible energy source of long term space missions (e-poster)

Nikolay Petrov

Sofia University 'St. Kliment Ohridski'

Abstract: Plutonium-238 is critically important for deep space missions because it serves as a long-lasting, reliable power source where solar energy is insufficient. This isotope is an artificial one and not easily accessible to produce or get. Currently, the most efficient way to make Pu238 is to convert Np237 using high density neutron fluxes. In the most widely used power light water reactors (PWR) part of the fuel is activated due to neutrons. Then, a variety of heavy isotopes are present at the end of fuel burnup. This study investigates the potential of spent nuclear fuel (SNF) as an alternative heat source for Radioisotope Power Systems (RPS) applications. It estimates amount of Pu and Np that can be found in two commonly used fuel assemblies - low enriched uranium (LEU) and mixed-oxide (MOX) fuel.

Observations of the Sun from the Astronomical Center of the University of Shumen (e-poster)

Samuil Petrov

Astronomical Observatory at the Astronomical Center of Shumen University 'Bishop Konstantin Preslavski', Bulgaria

Co-authors: Dragomir Marchev, Sunay Ibryamov, Rositsa Miteva Abstract: We present the Shumen Astronomical Center, as well as the first test observations of the Sun. The observatory has two observation bases, one located on the Shumen plateau (the Astronomical Observatory) and the other located on the roof of Building 3 of the university (the Teaching Observatory). Observations of the Sun from the Astronomical Observatory are carried out with a 40 mm Coronado solar telescope with an H-alpha filter. A CCD camera is used as a receiver. In the teaching observatory, observations are carried out with a 25 cm Schmidt-Cassegrain telescope MEADE 10" LX80 SC equipped with a SBIG ST-10XME CCD camera. In the year of maximum Solar activity, each endo observation is a contribution to observational astronomy. By including the Astronomical Center in the Solar Observation Network, we hope to contribute to the registration and explanation of a number of observational phenomena of the Sun.

Integrating Rotating Detonation Engines in Orbital Transfer Vehicles: Redefining Propulsion for Efficient Space Logistics

Emil Raychev

Naval Academy 'Nikola Vaptsarov', Bulgaria

Abstract: This thesis explores the use of Rotating Detonation Engines (RDEs) in orbital transfer vehicles (OTVs) to improve propulsion performance while reducing system complexity and cost.

Combatting Stellar Granulation via Individual Spectral Line Investigation

Djema Russeva

University of St. Andrews

Abstract: In the last 15 years, the presence of stellar activity has limited the detection of low mass exoplanets using radial velocity (RV) techniques. Among the various sources of activity-induced noise, granulation has emerged as a major obstacle to reaching the precision required for detecting Earth-like planets. In this work, we retrieve the velocities using the line-by-line (LBL) method, instead of the standard Data Reduction System (DRS) of HARPS-N, to isolate and mitigate granulation effects on individual spectral lines. We incorporate magnetohydrodynamical (MHD) models to construct decorrelation vectors sensitive to granulation structure and apply them to the multi planet systems HD 48948 and HD 99492. We find that models including granulation corrections improve the Bayesian evidence for the two systems and significantly reduce the scatter in the residuals of the model and the data. These results emphasise the critical role of granulation modelling in precise RV studies and demonstrate that combining theoretical models with observational techniques offers a promising path toward the detection of Earth-mass planets.

Status and Development Roadmap of a Deorbit Device Based on Electrodynamic Tethers

Gonzalo Sanchez-Arriaga

Universidad Carlos III de Madrid, Spain

Co-authors: Ghasem Sharifi, M. Tajmar, J. P. Wulfkuehler, A. Valmorbida, A. Brunello, A. Velasco, D. Cruces, and J.M Muñoz Tejeda Abstract: The goal of the EIC Transition E.T.PACK-F project is to prepare a flight-ready deorbit device based on electrodynamic tether technology. This work presents the status and main technological achievements of the project, including the results of the qualification campaign of the engineering qualification model and the status of the flight model and its acceptance test campaign. Led by PERSEI Space, the in-orbit demonstration of the deorbit device of E.T.PACK-F is scheduled in Q2 2026. It will be launched in a Vega-C rocket to an orbit of about 550 km of altitude and 50ž of inclination. The mission will validate the technology and generate key data on the performance of electrodynamic tethers in deorbiting scenarios. The roadmap and most important milestones towards the commercialization of the deorbit device are summarized.

European Radioisotope Dynamic Generator (RDG) for Deep Space Exploration and Power Resilience for Strategic Satellites

Mihalis Scepankis

Deep Space Energy

Abstract: Deep Space Energy (DSE) develops a new concept of the European Radioisotope Dynamic Generator (RDG) - Radioisotope Thermoacoustic Linear Induction Generator (RTALIG), aiming to become a commercial supplier of radioisotope (nuclear) electricity for the needs of science surface missions on the Moon and Mars, commercial Lunar market for in-space resource utilization and interplanetary transportation, deep space science missions, and power resilience for strategic dual-use satellites against possible laser attack. Nuclear energy is the only reliable and resilient energy source in deep space. In early days of space exploration, Radioisotope Power Systems (RPS) has been chosen as a solar-independent energy source - radioisotope produces heat as the result of self-decay of nuclear material, absolutely autonomously, then heat is converted into electricity. RPS powered all science missions beyond Earth orbit, from Apollo to Voyagers, Cassini, Mars rovers and others. Radioisotope fuel used to be cheap during the Cold-War-era as the byproduct of nuclear weapon production. Now, it is prohibitively expensive while the demand is expected to skyrocket due to the new era of Moon and Mars exploration and resource utilization. Thus, DSE re-invents the heat-to-electricity converter to scale the energy supply capability in deep space. RTALIG works at 25 percent conversion efficiency, which is 5 times more efficient than Radioisotope Thermoelectric Generator (RTG), which is in current use by NASA. That means RTALIG requires 5 times less radioisotope material per watt-electric while having enhanced long-term reliability by design. Compared to the free-piston Stirling design, with no displacer piston, RTALIG has less moving parts, thus considered to be more reliable. At the end of 2024, DSE finished the design contract with the European Space Energy (ESA).

A Conceptual Approach to Deploying Laser Power Transmission Technologies in Space Infrastructure

Amirmohammad Shahriyari

University of Santiago de Compostela

Co-authors: J. F. Lozano, E. Comesana, N. Seoane, Eduardo F. Fernandez, Florencia Almonacid and A. Garcia-Loureiro Abstract: Wireless Power Transmission (WPT) is an innovative technology that allows energy transfer without physical wires, utilizing methods like radio waves, electromagnetic fields, lasers, and microwaves. This technology has attracted considerable interest for its ability to surpass the constraints of conventional power systems, especially in demanding settings such as space, underwater, and military uses, especially where standard energy sources are unavailable. Recent developments in Laser Power Transmission (LPT), showcase its capability to transfer power efficiently over long distances. This innovation minimizes dependence on physical infrastructure and facilitates a continuous energy supply in space and remote locations. Today, it is gaining traction due to the rising demand for contactless energy solutions in space exploration, lunar bases, and deep-space missions. A critical element of LPT systems is the Optical Power Converter (OPC), which converts laser energy transmitted through space into electrical power (see the schematic of the basic OPC structure). The ongoing European Project rePowerSiC focuses on developing SiC-based laser beaming systems to enhance efficiency, precision, and durability for in-space applications. This work reviews the latest advancements in laser power technology, showcasing the progress made by organizations like NASA, JAXA, and the private sector. It also discusses challenges such as beam alignment, thermal management, and scalability. Current research in LPT, particularly with SiC-based systems, aims to transform space energy infrastructures, improve deep-space missions, and possibly offer sustainable energy solutions for Earth.

Modeling of trajectory of reentry vehicles from low Earth orbit

Valentyn Shopov

Sofia University 'St. Kliment Ohridski', Bulgaria

Co-authors: Stoil Ivanov Abstract: The study considers a small orbit vehicle equipped with propulsion subsystem and ground targeting capabilities. The model considers the aerodynamic properties of the vehicle, different propulsion technologies and burn programs together with atmospheric and gravitational Earth environment.

OLFAR implementation on picosatellite swarm

Valentin Stavrev

Visign Ltd

Co-author: Angela Nedyalkova Abstract: A concert and a feasibility study of OLFAR (Orbiting Low-Frequency Antennas for Radio Astronomy) by a picoisatellite swarm will be presented. The idea, known as OLFAR, is not entirely new. It was theorised for more than a decade. The essence is to equip a swarm of nanosatellites with low-frequency antennas and receivers and connect them to act as a single large antenna, similar to the LOFAR system. The practical problem is the substitution oc coaxial cables of terrestrial with an intersatellite radio link. To date, very few implementations have taken place. Maintaining coherence through the communication channel is a challenging task. The presented concept takes a slightly different approach. The received signals are digitised and timestamped with a precise CNSS disciplined clock. The record signal is sent via downlink to the ground station, where the processing is done, such as intercometry. This approach is routinely employed in terrestrial radio astronomy, particularly in ultra-long baseline interferometry. We propose an implementation to utilise a new platform specifically designed for deploying nanosatellite formations. A block diagram with off-the-shelf components is shown. The project's goal is to demonstrate that large telescopes can be constructed on a small budget.

A Warm Jovian Exoplanet Exhibiting Transit Timing Variations Indicating a Nearby Companion, and Evidence for a Cold Jupiter from HARPS and FEROS Observations

Stefan Stefanov

Institute of Astronomy and NAO - BAS; Sofia University 'St. Kliment Ohridski'

Co-authors: Trifonov T., Stoeva D., Antonova D., Bozhilov V., Zaharieva E., Mihaylov D., Vchkova E. Abstract: TOI-2361 is a solar-type G-dwarf star with a mass of 0.996 +/- 0.04 MSun and a radius of 0.988 +/- 0.02 RSun. It hosts a transiting warm Jovian-mass planet, TOI-2361 b, with an orbital period of approximately Pb = 8.7 days, identified by TESS observations in Sectors 10, 37, and 63. The TESS transit measurements of TOI-2361 b exhibit strong transit timing variations (TTVs) with an amplitude of about five hours, suggesting a close massive planet perturber. As part of the WINE collaboration, we performed radial velocity follow-up observations with the FEROS and HARPS spectrographs, confirming the transiting candidate's planetary nature. A self-consistent N-body analysis of the radial velocities and TTVs revealed the presence of a second, outer Saturn-mass companion, TOI-2361 c, with a period Pc 18 days, near but outside the 2:1 mean-motion resonance (MMR) commensurability. Additionally, the long observational baseline of the FEROS radial velocities suggests the existence of a third, long-period super-Jovian-mass companion in a colder orbit around 3.5 au. The TOI-2361 system is particularly intriguing due to two massive planets in warm orbits and a Jovian-mass planet in a colder orbit. Hence, TOI-2361 represents an important multi-planet system whose dynamical architecture and exoplanet compositions provide valuable insights into the formation and evolution of gas giants around solar-type stars.

Long-Period Magnetic Activity in the K-Dwarf GJ 1137 and a new Super Earth on a 9-day orbit

Denitza Stoeva

Sofia University 'St. Kliment Ohridski'

Co-authors: Abstract: EXO-RESTART Project Findings Our study explores the long-term variations in Radial Velocity (RV) of the K-dwarf star GJ 1137, a confirmed host of a Jovian-mass exoplanet. We specifically examine how stellar activity influences these observed signals. Methods: We analyzed high-precision spectroscopic data collected over approximately 15 years using the HARPS spectrograph. A comprehensive spectroscopic investigation was conducted, assessing stellar activity indicators. Our RV modeling approach integrated Keplerian fits, Gaussian process regression (as a tool for characterizing stellar activity), and additional diagnostic measures. Furthermore, we refined the orbital parameters and minimum mass of the known exoplanet GJ 1137 b while searching for potential additional planetary candidates. Results: A detected long-period RV signal, if interpreted as planetary in origin, suggests a Jovian-mass companion. However, our spectroscopic activity analysis strongly indicates that this variability stems from the star's magnetic cycle rather than an orbiting planet. Additionally, we constrained the stellar rotation period and identified activity cycle properties likely linked to the star's rotation. Moreover, within the residuals of our refined RV model, we uncovered a notable short-period planetary candidate with a 9.64-day orbit and a minimum mass of 4.9 Earth masses - revealing GJ 1137 as a complex and important multi-planet system.

Structure Dependence of W Diffusion in TiN-TiCN Protective Coatings for Space Applications

Petya Tabakova

Space Research and Technology Institute - BAS

Co-authors: S. Atanasova, A. Petrova, I. Zahariev, K. Grigorov Abstract: Titanium carbonitrides (TiN, TiCN) are wear resistant hard coatings used at spacecraft and aerospace industry to protect surfaces of strategical meaning at extreme conditions, such as temperatures with vast gradients, intensive radiation, vacuum and in some rare case - high-temperature plasma. They combine high hardness at low friction of the TiC-phases and high toughness, absorb energy and deform plastically of the TiN phases. Ti-based coatings deposited on Tungsten carbide (with Co as a binder) by means of Physical Vapor Deposition (PVD), namely by CAD (Cathodic Arc) grows dense structures which inhibit the subsequent elements diffusion. The latter lead compromises its mechanical properties. To trace the elemental depth distribution, Glow-Discharge-Optical-Spectroscopy (GDOES) was used in order to quantified the W diffusion in both, TiN and TiCN coatings under specific temperatures.

Future 'Game-changing' concepts, technologies and 'use cases' for in space solar energy harvesting

Stella Tkatchova

European Innovation Council (EIC) and SMEs Executive Agency (EISMEA), Belgium

Co-authors: Francesca Brunetti, Garcia Antonio Jesus, Chiara Manfletti, Gonzalo Sanchez, John C Mankins, Thomas Parry, Antonio Pedivellano Abstract: The EIC Space Pathfinder Portfolio of WP23: In-Space Solar Energy Harvesting for innovative space applications includes 9 projects performing scientific research to enable collection, conversion and transmission of in-space solar energy and its use for in-space green propulsion. The projects involved in identifying common 'use cases' for in-space solar energy harvesting. The selected projects have already identified common synergies to achieve the portfolio objectives, which are to advance in-space solar energy harvesting technologies for collection (perovskite cells, new types of antennas, rectennas, solar concentrators, etc.), solar energy conversion, wireless power transmission (e.g. laser, microwave) and in-space green propulsion (e.g. solar electric propulsion and electrodynamic tethers). The projects proposed innovative concepts that address end-to-end energy (E2E) efficiency conversion or transmission, demonstrate interoperability, high efficiency conversion and address lightweight aspects. They work together under four working groups on solar cells (WG1), wireless power transmission (WG 2), in-space green propulsion (WG3) and system engineering (WG4). A number of interesting 'use-cases' have emerged from the ongoing projects such as space-based solar power (SBSP), active debris removal (ADR), In-Space Assembly and Manufacturing (ISAM), In-Situ Resource Utilization (ISRU), Cis-lunar exploration, Asteroid mining, etc. However, the diversity of the concepts and technologies researched under each WG will require common criteria for selecting 'use cases' under which the projects can identify synergies and be complementary in their research objectives. This paper will discuss the several EIC In-Space Solar Harvesting use cases, including a description of each, and explanation of how they were identified, and directions for future research. Disclaimer: The views expressed in this publication are the responsibility of the authors and do not necessarily reflect the views of the EC nor of the EIC and SMEs Executive Agency. The EC or the EIC and SMEs Executive Agency are not liable for any consequence stemming from the reuse of this publication.

Development and Characterization of a High-Power Optical Transmission (HPOT) System

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Co-authors: Elvira Castillo-Garcia, Manuel Peralta-Fuentes, Pablo Sanmartin, Jose Luis Lombardo-Garcia, Jesus Montes-Romero, Florencia Almonacid and Eduardo F. Fernandez Abstract: High-Power Optical Transmission (HPOT) uses a monochromatic light source, typically a collimated laser, to wirelessly deliver energy over long distances via an Optical Photovoltaic Converter (OPC). This system enables efficient transfer of kilowatts of power through small apertures in different media (e.g., air, water, or space). HPOT is a promising solution for clean energy and green mobility applications. Critical challenges in the development of HPTO systems include selecting and collimating the emitting source to reduce divergence and minimize transmission losses. Additionally, the receiver must ensure uniform light distribution, minimize electrical mismatch, and manage heat effectively. Within the framework of the RePowerSiC Pathfinder European project, this study presents the theoretical design of a collimation system to deliver a laser beam to a target 100 m away. Reducing the fiber core diameter from 400 micro-m to 100 micro-m decreases the spot size from 20.07 mm to 5.51 mm, while maintaining a high optical efficiency of approximately 83.7 percents, providing a compact and effective solution for long-range laser transmission. The optical model employed for a fiber-coupled laser system was previously validated by beam profiling through a CCD camera with a good agreement between simulated and measured beam diameters and divergence results. As a proof of concept, an indoor HPOT system was developed to enable full-system evaluation. To further optimize performance, multiple designs of low-concentration optical concentrator arrays for solar cells were proposed. Preliminary experimental results demonstrated a 2.1-fold enhancement in the current density of the solar cells when employing optical concentrators, along with an estimated 60 percents reduction in semiconductor material requirements. Further analysis of the full-system including optical performance, mismatch analysis of the photovoltaic receiver array and power conversion efficiency in the overall HPOT system will be presented at the conference. This work has been supported by the European Union's Horizon Europe programme under Grant Agreement No. 101160868.

Searching for Dark Matter with the AMS-02 Detector

Georgi Vasilev

Sofia University 'St. Kliment Ohridski'

Abstract: The Alpha Magnetic Spectrometer (AMS) is a general-purpose high-energy particle detector located onboard the ISS. Its long-term mission is to study the fluxes of charged cosmic rays from various cosmic sources in order to gain understanding of their origin and to seek answers to fundamental scientific questions such as the baryon-antibaryon asymmetry, the nature and origin of dark matter, and to discover new cosmic phenomena. Active since 2011, AMS is currently the only detector capable of determining the characteristics of the particles it detects with 1 percent precision over an energy range of 1 GeV to 1 TeV. The Bulgarian group participating in the AMS collaboration studies the production mechanisms of light antimatter in the Galaxy. One of its main objectives is the search for cosmic antideuterons, whose hypothetical source could be the annihilation of supersymmetric neutralinos. In the course of its work, the group has developed a method for antideuteron selection optimization, using machine-learning techniques. Data taking and analysis are currently ongoing.

Experimental investigation of an arc discharge for in-situ oxygen production on Mars

Veselin Vasilev

Sofia University 'St. Kliment Ohridski', Bulgaria

Co-authors: S. Lazarova, Ts. Paunska, St. Kolev Abstract: In-situ oxygen production on Mars is critical for sustaining human life and providing an oxidizer for rocket fuel during future crewed missions. Among the various technologies under investigation, plasma-based methods have shown significant promise. Mars' atmosphere, composed of approximately 96 percents carbon dioxide (CO2), can be dissociated into carbon monoxide (CO) and oxygen (O2), making it an ideal candidate for such approaches. In this study, we present experimental results on CO2 conversion using an arc discharge operating under low-pressure conditions (200-600 mbar), representing a preliminary step toward the development of a full-scale oxygen generation system.

Constraints on Exotic Early-Universe Physics from the CMB

Luca Visinelli

Universita degli Studi di Salerno; INFN

The epoch of reionization marks a key phase transition in the Universe's history, typically attributed to the formation of the first stars and galaxies. However, a range of exotic early-Universe physics (decaying particles, low-temperature reheating, and axion-like fields) could introduce additional high-redshift ionization, leaving imprints on the cosmic microwave background (CMB) polarization. In this talk, I will present recent work using Gaussian process reconstruction to extract a model-independent reionization history from Planck data. This approach places robust bounds on high-redshift optical depth, and provides a powerful discriminator against nonstandard reionization scenarios. I will then apply this framework to constrain classes of axion-based models that alter the thermal and ionization history of the early Universe. These results highlight the constraining power of the CMB in testing fundamental physics beyond the standard model, without relying on detailed assumptions about astrophysical sources.

Integrating quantum layers into neural networks for analysis and classification of Earth observation satellite images (e-poster)

Yancho Yordanov

Sofia University, Bulgaria

Co-authors: Doncho Filipov, Mariana Filipova, Todor Tsvetkov Abstract: Real-time satellite image classification is emerging as a key tool in climate monitoring. It provides crucial information for assessing the state of the Earth's environment, validating scientific models, and guiding climate policy. Remote sensing technology enables high-time resolution and large-scale observations of terrestrial and atmospheric processes, such as deforestation, agriculture, and extreme weather. Nowadays, the global satellite network provides a huge amount of visual Earth observation data, about 150 terabytes per day. Integrating quantum information processing into classical neural networks promises a potential solution. This study examines hybrid quantum neural network classifiers, demonstrating the possibility of improving image classification despite current limitations in quantum hardware. By incorporating quantum layers into conventional architectures, the researchers aim to overcome the limitations of data processing, paving the way for scalable and cost-effective Earth observation systems in the era of big data.

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