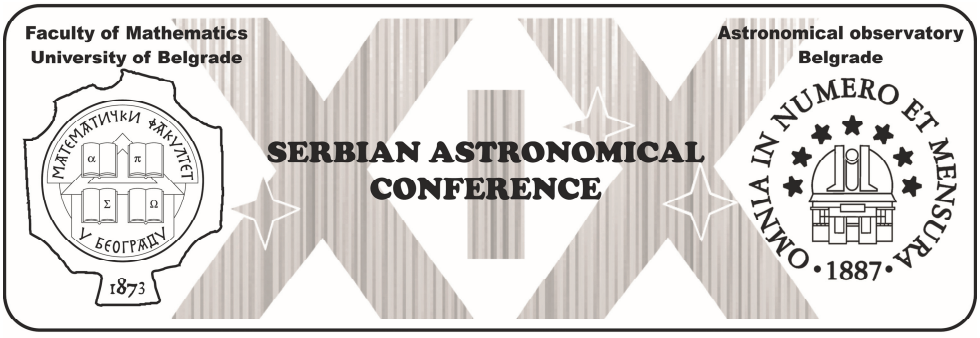
XIX SERBIAN ASTRONOMICAL CONFERENCE

October 13 - 17, 2020, Belgrade, Serbia

BOOK OF ABSTRACTS

Eds. Anđelka Kovačević, Jelena Kovačević Dojčinović, Dušan Marčeta and Dušan Onić



Belgrade 2020

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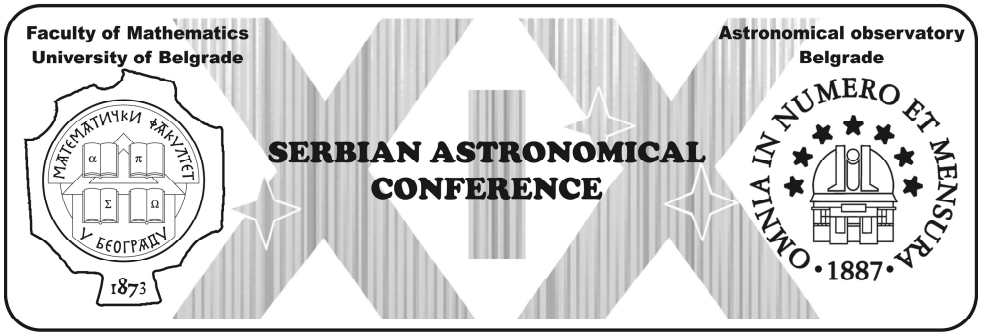

Belgrade 2020

CONTENTS

INVITED REVIEWS

INVITED LECTURES

Invited Reviews

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
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Invited Review

ALTERNATIVE STRATEGIES TO SOLVE STELLAR ATMOSPHERE PROBLEM

Lucio Crivellari

Instituto de Astrofısica de Canarias, Spain
INAF – Osservatorio Astronomico di Trieste, Italy
INFN – Sezione di Perugia, Italy
E-mail: luc_ext@iac.es

At the heart of the computation of model atmospheres is the so-called *Stellar Atmosphere Problem*, which consists of the self-consistent solution of the radiative transfer equations under the constraints of hydrostatic and radiative equilibrium, as well as that of the statistical equilibrium of the atomic populations. The amazing progresses achieved in the field since the 1970s are due to both the dramatic increase of the computational facilities and the development of effective numerical algorithms. The latter is the result of a careful analysis of the underlying physical problems. The purpose of this review is to call attention to some numerical algorithms, alternative to the ones that are mostly used nowadays like, *e.g.*, the ALI methods. More than a detailed presentation of the former, out of place here, the prime aim is to stress that the physics itself dictated the most effective algorithm.

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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Review

SURVEY OF THE POSITIONS OF SECULAR RESONANCES IN THE ASTEROID BELT

Zoran Knežević

Serbian Academy of Sciences and Arts, Kneza Mihaila 35, 11000 Belgrade, Serbia
E-mail: zoran@aob.rs

Using a recently introduced synthetic method to compute the asteroid secular frequencies (Knežević and Milani, 2019), in this review we survey the locations of secular resonances in the 9 dynamically distinct zones of the asteroid belt. Positions of all resonances up to degree 4 in orbital eccentricity and (sine of) inclination are determined, presented in the space of proper elements, and discussed in relation to the local dynamics and to the structure of the nearby asteroid collisional families. Several new insights are considered and briefly explained. Accuracy of the polynomial fit to determine the frequencies, and the resulting reliability of the resonant positions, are compared from one zone to another. The resonant maps in the space of frequencies are shown too.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Review

SUPERMASSIVE BINARY BLACK HOLES

Stefanie Komossa

Max-Planck-Institut fuer Radioastronomie, Auf dem Huegel 69, 53111 Bonn, Germany

E-mail: astrokomossa@gmx.de

Supermassive binary black holes (SMBBHs) are laboratories par excellence for relativistic effects, including precession effects and the emission of gravitational waves. Binaries form in the course of galaxy mergers, and are a key component in galaxy evolution. Dedicated searches for SMBBHs in all stages of their evolution are therefore ongoing. Many systems have been discovered in recent years. This talk provides a review of the status of observations and the astrophysical implications.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Review

SUPERMASSIVE BLACK HOLES IN ALL THEIR GUISES

Debora Sijacki

Institute of Astronomy and Kavli Institute for Cosmology,
University of Cambridge, UK

E-mail: deboras@ast.cam.ac.uk

In this talk I will review current theoretical efforts in understanding supermassive black hole formation, accretion and feedback throughout cosmic time. Specifically, I will discuss possible links between large scale cosmological environment and supermassive black hole assembly and outline several possible interaction channels between active black holes and their host galaxies. In the second part of the talk I will focus on novel computational methods that allow us to follow black hole physics on much smaller scales in full galaxy formation simulations to unravel how black hole mass and spin evolve during the binary hardening stages or during launching of powerful jets.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Review

OBSERVATIONAL SIGNATURES OF CLOSE BINARIES OF SUPERMASSIVE BLACK HOLES IN ACTIVE GALACTIC NUCLEI

Jian-Min Wang

Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China
E-mail: wangjm@ihep.ac.cn

Inspired by the General Relativity for many decades, experimental physicists and astronomers have a solid dream to detect gravitational waves (GWs) from mergers of black holes, which came true until the excellent performance of the Laser Interferometer Gravitational-Wave Observatory (LIGO) at hundreds Hz. Nano-Hz GWs are expected to be radiated by close-binaries of supermassive black holes (CB- SMBHs; defined as those with separations less than ~ 0.1 pc) formed during galaxy mergers and detected through the Pulsar Timing Array (PTA) technique. As of the writing, there remains no nano-Hz GWs detection. Searching for CB-SMBHs are also observationally elusive though there exist a number of possible candidates. In this review, we focus on observational signatures of CB-SMBHs from theoretic expectations, simulations and observations. These signatures appears in energy distributions of multiwavelength continuum, long term variations of continuum, jet morphology, reverberation delay maps and spectroastrometry of broad emission lines, AGN type transitions between type-1 and type-2 (changing-look), and gaseous dynamics of circumbinary disks, etc. Unlike hundred-Hz GWs from stellar mass black hole binaries, the waveform chirping of nano-Hz GWs is too slow to detect in a reasonable human timescale. We have to resort to electromagnetic observations to measure orbital parameters of CB-SMBHs in order to test nano-Hz GW properties. Reverberation mapping is a powerful tool for probing kinematics and geometry of ionized gas in the gravitational well of SMBHs (single or binary) and therefore provides a potential way to determine orbital parameters of CB-SMBHs. In particular, a combination of reverberation mapping with spectroastrometry (realized at the Very Large Telescope Interferometer) will further reinforce this capability. The Atacama Large Millimeter/submillimeter Array (ALMA) as well as the forthcoming Square Kilometer Array (SKA) are suggested to reveal dynamics of circumbinray disks through molecular emission lines.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Review

TESTS OF GRAVITY THEORIES WITH BLACK HOLE OBSERVATIONS

Alexander F. Zakharov

Institute of Theoretical and Experimental Physics, 117218, Moscow, Russia
E-mail zakharov@itep.ru

Black holes with different masses are observed in a wide range of electromagnetic radiation frequencies. Astronomers believe that they have detected neutrinos whose sources are associated with black holes. The first detection of gravitational radiation from merging binary black holes occurred using the LIGO–Virgo gravitational wave detectors just a few years ago. After that, researchers began to talk about the fruitfulness of multi-messenger astronomy. At present, we can say that the general relativity is the best theory of gravity, however, in recent years, many alternative theories of gravity have emerged and the emergence of at least part of these theories has been associated with attempts to explain the problems of dark matter and dark energy by changes in the law of gravity. We discuss the possibilities of using black hole observations to test the predictions of general relativity and obtain constraints on the parameters of alternative theories of gravity. In particular, we discuss constraints on the theory of gravity from observations of the supermassive black holes at the Galactic Center and at the center of the galaxy M87.

Invited Lectures

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

DYNAMICAL FORMATION OF GRAVITATIONAL WAVE SOURCES

Abbas Askar

Lund Observatory, Department of Astronomy, and Theoretical Physics, Lund University, Box 43, SE-221 00 Lund, Sweden

E-mail: askar@astro.lu.se

Over the past five years, several tens of merging compact object binary systems have been detected through gravitational waves by the LIGO/Virgo detectors. While these observations provide a new window to observe the universe, they also raise important questions about the astrophysical origin and formation of these elusive binary systems. In this talk, I will discuss the various processes by which gravitational wave sources can form in dense stellar clusters. The retention and long-term evolution of compact objects in stellar clusters depends on a variety of physical processes that are not fully understood. I will give an overview of these processes and explain how they shape the properties and merger rates of binary black holes and neutron stars that originate in dense environments. Additionally, I will also discuss how mergers between stellar clusters in galactic nuclei may play a role in forming a nuclear star cluster and seeding the formation of super-massive black holes.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

SEARCHING FOR EXTREMELY ACCRETING QUASARS

N. Bon, P. Marziani and E. Bon

Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
E-mail: nbon@aob.bg.ac.rs

Quasars are most luminous objects and therefore can be detected as far as the edge of the known Universe (so far, up to redshift $\sim$7). As such they could be useful for measuring cosmological distances. The problem is that quasars show large diversity in their properties – their luminosity is spread over six orders of magnitudes, that makes them adverse to conventional standard candles. A sub-group of quasars, called highly or extremely accreting quasars (xA quasars) radiate close, or even above Eddington luminosity. They are extreme in many aspects – xA quasars are among quasars with highest accretion rates, and their emitting line regions show the lowest ionization parameter and the highest electron density. They have very strong FeII emission lines in their spectra, with blue shifted and weak CIV λ1549 emission line. They share several other multi-frequency properties which can be used for their identification. Our ability to distinguish xA quasars as sources whose Eddington ratio is extreme and ideally scattering little around a well-defined value opens up the possibility to use these quasars as potential cosmological probes.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

A MODEL OF QUANTUM COSMOLOGY: FUZZY DE SITTER SPACE

Maja Burić

University of Belgrade, Faculty of Physics
Studentski trg 12, 11000 Belgrade, Serbia
E-mail: majab@ipb.ac.rs

Quantization of gravity is probably the most important unsolved problem of theoretical physics today. For many years it has been approached only theoretically, but in the last decades there is a growing amount of astrophysical and cosmological data that could and will guide theoretical investigations. Theories of quantum gravity are formulated both as fundamental and effective, and have diverse basic ideas or starting points (string theory, loop quantum gravity, noncommutative geometry). We here describe a model of fuzzy de Sitter space obtained in the context of noncommutative geometry, and discuss some of its implications on cosmology.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

DYNAMICS AND ORIGIN OF MARTIAN SATELLITES

Matija Ćuk

SETI Institute, 189 N. Bernardo Ave, Mountain View, CA 94043, USA
E-mail: mcuk@seti.rg

The two moons of Mars, Phobos and Deimos, have long been a mystery to astronomers. Small and irregular in shape, they have long been considered to be captured asteroids. However, their near-equatorial orbits point to their likely origin in an accretion disk around Mars (Burns, 1992). It is still not clear if these satellites accreted from Martian debris excavated by impacts, or from material derived from captured small bodies. The Martian moons' dynamics over the age of the solar system is becoming better understood now. Phobos is interior to the synchronous orbit and its orbit is decaying; it is expected that Phobos will be disrupted into a ring by the action of Martian tidal forces in the next few tens of Myr. A crucial question about the past orbital evolution of Phobos is whether it formed close to the synchronous orbit and always migrated inward (e.g. Yoder, 1982). An alternative view is that Phobos is a product of an ongoing ring-moon cycle arond Mars, with past generations of inner moons being significantly more massive (Hesselbrock and Minton, 2017). I will present my recent work on the orbit of Deimos (Ćuk et al., 2020) which strongly supports the view that Mars had past rings and much larger inner moons. I will also discuss the implications for the ultimate origin of Phobos and Deimos.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

TOWARDS GAIA DR3 AND SOME RESULTS OF COMPARISON BETWEEN GAIA DR2 AND GROUND-BASED DATA

Goran Damljanović

Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
E-mail: gdamljanovic@aob.rs

Gaia satellite of European Space Agency (ESA) was launched at the end of 2013, and the astronomical observations started in mid-2014. The first Gaia data release (Gaia DR1) appeared at 14^{th} September 2016, and the second one (Gaia DR2) at 25^{th} April 2018. Next results, the third Gaia release is going to split into an early Gaia EDR3 (at the end of 2020) and Gaia DR3 (second part of 2021). The main information about Gaia DR3, and some results of comparison between the Gaia DR2 and independent ground-based data of common stars are presented, here.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

THE NEW MODEL OF NONLOCAL MODIFIED GRAVITY

Ivan Dimitrijević

Faculty of Mathematics, University of Belgrade, Studentski trg 16, Belgrade, Serbia
E-mail: ivand@matf.bg.ac.rs

Despite of numerous significant phenomenological confirmations and many nice theoretical properties, General Relativity (GR) is not final theory of gravity. Problems mainly come from quantum gravity, cosmology and astrophysics. For example, if GR is applicable to the universe as a whole and the universe is homogeneous and isotropic, then it follows that the universe contains about 68% of dark energy, 27% of dark matter and only about 5% of visible matter. However, validity of GR at the very large cosmic scale is not verified, as well as dark matter and dark energy are not yet observed in laboratory experiments. Also, GR contains cosmological singularity. These and some other problems give rise to investigate extensions of GR.

In this talk, we present modification of GR extending $R - 2\Lambda$ by nonlocal term $\sqrt{R - 2\Lambda}\mathcal{F}(\Box)\sqrt{R - 2\Lambda}$, where $\mathcal{F}(\Box)$ is an analytic function of the d' Alembert operator $\Box$. The choice of $\mathcal{F}(\Box)$ in the analytic form is motivated by existence of analytic expressions with $\Box$ in string field theory and p-adic string theory.

We have found some exact cosmological solutions of the corresponding equations of motion without matter and with $\Lambda \neq 0$. One of these solutions contains properties similar to an interplay of the dark matter and the dark energy. For this solution we computed some cosmological parameters which are in good agreement with their values in the standard ΛCDM model. Also, constraints on function $\mathcal{F}(\Box)$ are obtained.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

THE INFLUENCE OF STARK BROADENING ON WHITE DWARF SPECTRA

Milan S. Dimitrijević[1,2]

[1]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
[2]*Sorbonne Université, Observatoire de Paris, Université PSL, CNRS, LERMA, F-92190 Meudon, France*

E-mail: mdimitrijevic@aob.rs

First, I will explain what is Stark broadening and where in Astrophysics it is important. Additionally, I will speak about other applications of Stark broadening results in laboratory, laser produced, and technological plasmas, as well as in analysis and investigation of fusion plasma. Then, I will talk about history of ivestigations of white dwarfs and about various types of these degenerate stars, since in such objects Stark broadening is usually the dominant line broadening mechanism. After, I will speak about our investigations of the influence of Stark broadening on spectral lines originated in white dwarf atmospheres. In the next part theoretical methods for determination of Strak broadening parameters, line widths and shifts will be briefly presented: strong coupling quantum mechanical approach (see e.g. Dimitrijević et al. 1981), semiclassical perturbation approach (see Sahal-Bréchot, Dimitrijević and Ben Nessib, 2014, and references therein) the modified semiempirical approach, formulated in Belgrade (Dimitrijević and Konjević, 1980) and its symplified variant, convenient for large scale calculations in astrophysics (opacity for example) and for complex atoms when more sophysticated methods are not convenient (Dimitrijević and Konjević, 1980). In final part of the talk I will briefly speak about organization of Stark broadening data needed for analysis and investgation of white dwarf spectra in STARK-B database (Sahal-Bréchot, Dimitrijević and Moreau, 2020).

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XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

COSMOLOGY OF NONLOCAL GRAVITY

Branko Dragovich

Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

E-mail: dragovich@ipb.ac.rs

Despite of numerous significant phenomenological confirmations and many nice theoretical properties, General Relativity (GR) is not final theory of gravity. Problems mainly come from quantum gravity, cosmology and astrophysics. In this talk, we consider some models of nonlocal modificed GR, where nonlocality is presented by an analytic function of the d'Alembert-Beltrami operator. We obtained some exact vacuum cosmological solutions of the corresponding equations of motion. We pay special attention to the model which exact cosmological solutions contain effects that mimic dark matter, dark energy and radiation. Here, dark energy is produced by the cosmological constant Λ. For this solution, computed cosmological parameters are in good agreement with cosmological observations. Details can be found in our recent papers, see references.

This is joint work with I. Dimitrijevic, A. S. Koshelev, Z. Rakic and J. Stankovic.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

DARK MATTER THROUGHOUT COSMIC HISTORY

Vera Gluščević

University of Southern California Los Angeles, CA 90089-0484, USA
E-mail: vera.gluscevic@gmail.com

Dark matter constitutes 85 percent of matter content in the Universe, but its physical nature remains unknown and requires new physics to explain. I will review the status of cosmological searches for dark matter interactions, summarizing the best current limits on scattering of light particle candidates with protons derived from the cosmic-microwave-background anisotropy measurements. I will then present stringent new bounds on the same physics, inferred recently from the observed abundances of the Milky Way satellite galaxies. I will highlight complementarities between different observations and laboratory searches for dark matter, and discuss the prospects for unveiling the physics of dark matter in the coming decade.

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Invited Lecture

NONCOMMUTAIVE $SO(2,3)_\star$ MODEL OF GRAVITY

Dragoljub Gočanin[1] and Voja Radovanović[2]

[1] *Faculty of Physics, University of Belgrade*
[2] *Faculty of Physics, University of Belgrade*

E-mail: dgocanin@ipb.ac.rs, rvoja@ipb.ac.rs

This talk is devoted to Noncommutative (NC) Field Theory. It is based on the method of *quantization by deformation* via NC $\star$-product first developed in the context of phase-space quantum mechanics. To deform the classical structure of spacetime, we introduce an abstract algebra of NC coordinates. These NC coordinates, denoted by $\hat{x}^m$, satisfy some non-trivial commutation relations. The simplest case of noncommutativity is the so-called *canonical noncommutativity*, $[\hat{x}^m, \hat{x}^n] = i\theta^{mn}$ where θ^{mn} are components of a *constant* antisymmetric matrix. The quantity $\theta^{\mu\nu}$ is a, presumably small, deformation parameter that has dimensions of $(length)^2$. It is a fundamental constant, like the Planck length or the speed of light.

In this setting, NC gravity can be obtained by canonical NC deformation of the AdS gauge theory of gravity in which spin-connection and vierbein are unified, being the components of a general $SO(2,3)$ connection. We present a classical (undeformed) action invariant under $SO(2,3)$ gauge transformations, that reduces to the standard Einstein-Hilbert action with cosmological constant after gauge fixing, for which we use a constrained auxiliary field. NC correction is obtained perturbatively, by expanding the NC action invariant under $SO(2,3)_\star$ deformed gauge transformations, in powers of deformation parameter θ^{ab}, and they are quadratic in θ^{ab}. For this, we employ the enveloping algebra approach and the Seiberg-Witten map. A deformation of Minkowski metric is derived, and we explain the breaking of diffeomorphism invariance in NC theory. After that, we introduce matter fields into the framework, in particular, Dirac spinor field and $U(1)$ gauge field. NC corrections are now *linear* in θ^{ab}. Phenomenological consequences are most significantly reflected through the NC-deformed Dirac equation in flat spacetime. We discuss how spacetime noncommutativity modifies Landau levels of an electron in a background magnetic field.

The above procedure is generalized to extended $N = 2$ anti-de Sitter (AdS) Supergravity (SUGRA) in $D = 4$, by gauging orthosymplectic graded Lie group $OSp(4|2)$. The noncommutative corrections of this model are obtained.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

QUASARS RESEARCH IN TIME-DOMAIN ERA

D. Ilić[1], A. Kovačević[1] and L. Č. Popović[1,2]

[1]*Department of Astronomy, Faculty of Mathematics, University of Belgrade, Studentski trg 16, Belgrade, Serbia*
[2]*Astronomical Observatory, Volgina 7, Belgrade, Serbia*
E-mail: dilic@matf.bg.ac.rs, andjelka@matf.bg.ac.rs, lpopovic@aob.bg.ac.rs

The perfect case for the time-domain investigations are quasars (i.e., active galactic nuclei) since they are luminous objects that show strong variability. Key results of quasar variability investigations are estimated properties of a supermassive black hole (SMBH), which resides in the center of a quasar, and how they connect with the host galaxy. These give an essential link to the studies of galaxy evolution and cosmology.

With the advances of technology and robotization of telescopes, we have entered the era of massive time-domain observations, with several missions already running and producing amazing results. The Sloan Digital Sky Survey (SDSS) is, for sure, the most famous and successful example. In the next decade, we expect to have comprehensive monitoring campaigns, out of which the Vera Rubin Observatory Legacy Survey of Space and Time (LSST) with its very high cadence 10-year photometric survey seems to be very promising for the quasar investigations. LSST will provide millions of quasar photometric light curves, which will facilitate better understanding of the physical processes that power quasars and their variability (Brandt et al. 2018). One particular class of objects are so-called changing-look quasars, which show extreme variability and may reveal the answers to these questions (Ilić et al. 2020). So far, surveys have discovered only a small fraction of changing-look candidates, but LSST will be able to discover many or even show that this phase is not so rare. LSST will be complemented with several spectral surveys, such as the Maunakea Spectroscopic Explorer (MSE, MSE Science Team 2019). This survey will cover both the time and spectral domain, including also the infrared band, which is important for the high-redshift quasar studies. The MSE will, with its multi-object spectrographs, provide spectral light curves of a large number of quasars.

In this talk, we review the current status of quasars variability investigations in Serbia, in the perspectives of the present and future monitoring campaigns (Kovačević et al. 2020a,b). Special focus will be on our participation in the future two big projects LSST and MSE.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

ADAPTING IMAGE CENTROIDING TO ASTROMETRIC DIFFERENTIAL REDUCTION

Anatoliy Ivantsov

Space Sciences & Technologies Department,
Science Faculty, Akdeniz University, Dumlupınar Bulvarı Campus,
07058 Antalya, Turkey

E-mail: ivantsov@akdeniz.edu.tr

Highly accurate ground-based astrometric measurements of asteroids are still a rare case today while the number of them is growing exponentially with time. Limited time-space missions can not satisfy our requirements for keeping orbits of asteroids updated for many years after the missions are finished. Following astrometry statistics of the IAU Minor Planet Center (MPC), one can easily discover that the number of highly accurate astrometric measurements with precision less or equal $0.1''$ at least in both coordinates are very rare even using the Gaia Data Releases. There are only 13 of 2210 observatories in the whole world which provided more than 50 of such observations after 2013 to the MPC as of June 2020. The Gaia Data Releases removes much of systematic errors present in the past reference catalogs used, the differential astrometric reduction is done mostly automatically through using different software, so we expect that today the greater contributors to the astrometry error budget are the instrumental errors (large scales, lack of distortion correction) and image centroiding deficiencies. We emphasise the latter problem using the observations done in 2018-2020 at the UBT60 telescope (D=0.61 m, F/6.5) of the Akdeniz University in Antalya, the telescopes T100 (D=1.0 m, F/10) and RTT150 (D=1.5 m, F/7.7) of the TÜBİTAK National Observatory. We propose a special adapting technique that is free of the reference catalog used for adapting the image centroiding algorithm to the astrometric reduction used. The efficiency of this approach is demonstrated by a comparison of astrometric measurements of asteroids observed at the telescopes mentioned. The proposed technique can be introduced to the astrometric reduction software used for the measurements made with any telescope.

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Invited Lecture

ASTROCHEMISTRY: SYNTHESIS OF THE BASIC 'BUILDING BLOCKS' OF LIFE

Sohan Jheeta

NoR CEL, Leeds, UK
E-mail: sohan@sohanjheeta.com

It is believed that some of the necessary organic molecules may have been formed in specific areas of space (namely dark molecular clouds, eg Horsehead nebula) and delivered on to the Earth during the early heavy bombardment period of its history, approximately 4.3-4.0 billion years ago. These organic molecules may have played a pivotal role in the formation of life on Earth. In addition, it is believed that life on Earth was formed within a very short geological time frame of only 200-300 million years. So, it is not unreasonable to suppose that these molecules were initially made in space which in effect could be, metaphorically speaking, a huge chemical laboratory.

The research (drawn from my own experimental astrochemistry) highlighted during this oral presentation focuses on the formation of molecules under a variety of simulated space conditions (eg different temperatures, levels of radiation energies and types of impinging radiations). There are two sorts of chemistry that take place in space, solid and gas phase, and although only 25the solid phase, this will be the focus of my oral presentation.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

GALAXY EVOLUTION WITH STELLAR FEEDBACK AND COSMIC RAYS

Dušan Kereš

Center for Astrophysics and Space Sciences, University of California San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0424, USA

E-mail: dkeres@physics.ucsd.edu

Stellar feedback plays an important role in regulation of star formation within galaxies and regulation of stellar mass growth on cosmological timescales. Direct inclusion of this feedback in cosmological simulations has proven difficult but a new generation of cosmological zoom-in simulations shows significant promise. These simulations can now model stellar feedback on spatial scales of molecular clouds and achieve local self-regulation of star formation and self-consistent driving of galactic outflows. An example are simulations from the FIRE project that include careful treatment of the supernova momentum and energy injected to the surrounding ISM along with stellar winds, radiation pressure, photoionization and photoelectric heating. A prominent feature of these simulations is bursty star formation and spatial clustering of supernovae that drive significant outflows from galaxies, especially in low mass objects. Star formation-driven galactic outflows become inefficient for galaxy masses similar to the Milky Way, which leads to significant buildup of galactic stellar mass. Interestingly, if only a moderate fraction of supernova energy is imparted to the surrounding gas in the form of cosmic rays, this can significantly modify the structure and properties of the circum-galactic medium (CGM), drive large scale winds, and slow down the growth of L* galaxies. The magnitude of these effects is sensitive to the detailed transport of cosmic rays. Fortunately, the effective transport speed can be constrained from the gamma ray emission of galaxies and observations of the CGM.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

MASS-LOSS RATES AND NLTE WIND MODELS OF MASSIVE STARS

Jiří Kubát

Astronomický ústav AV ČR, Fričova 298, 25165 Ondřejov, Czech Republic
E-mail: kubat@sunstel.asu.cas.cz

Determination of mass-loss rates of massive stars is an important output of massive star analysis, which influences our understanding of stellar evolution. Stellar mass-loss rates are usually determined using wind models with a different level of sophistication. Commonly used models are based on an assumption of spherical symmetry and solve the NLTE radiative transfer consistently for a given density and velocity structure, which means that the hydrodynamic structure is held fixed. Usually, an approximate dependence of velocity on radius is being assumed (the so-called β-velocity law). Using a different approach, mass-loss rates can be predicted by hydrodynamic models, which do not solve the radiative transfer, but they describe the radiation force in a parametric way (using force multipliers). The most sophisticated wind models do not use the simplifications of the β-velocity law and the force multlipliers. Consistent NLTE wind models including both the wind dynamics and NLTE radiative transfer can be calculated.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

THE DISTRIBUTION OF EXPLOSION ENERGIES AND ISM DENSITIES FOR SUPERNOVA REMNANTS IN THE GALAXY

Denis Leahy

University of Calgary, 2500 University Dr.NW, Calgary, Alberta, Canada T2N 1N4
E-mail: leahy@ucalgary.ca

Supernova remnant (SNR) models have been developed to explain the observed characteristics of SNRs, and thus to deduce their physical properties. One important part of modelling is use of hot plasma (X-ray) emission models to derive temperature and amount of shocked plasma and the SNR shock velocity. Coupled with a SNR evolution model, one can use the current state of a SNR to deduce fundamental properties of the supernova (SN) explosion. The general phases of SNR evolution are the ejecta-dominated phase, the adiabatic phase and the radiative phase. The transition phases between these are less-appreciated but at least as important, because the transition phases account for much of the total lifetime of a SNR. Progress in X-ray observations of SNRs has resulted in a significant sample of Galactic SNRs with measured X-ray spectra. We have developed spherically symmetric models over the past few years (Leahy and Williams 2017, Leahy et al. 2019) which allow inference of SNR explosion energy, circumstellar medium density and age. With detailed enough X-ray spectra, ejecta mass and whether the SN occurs in a uniform or stellar wind environment. We have applied the models to observations of LMC SNRs (Leahy 2018) and of Galactic SNRs (Leahy and Ranasinghe 2018, Leahy et al. 2020). We find that the energy and density distributions can be well fit with log-normal distributions and that SNR birth-rates are consistent with SN rates.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

INTERGALACTIC MEDIUM AS A PROBE OF REIONIZATION, PHYSICS, AND COSMOLOGY

Zarija Lukić

Berkeley Lab, 1 Cyclotron Road, Berkeley CA 94720, USA
E-mail: zarija@lbl.gov

The intergalactic medium (IGM) is the rarefied gas that fills the vast volumes between the galaxies in the universe. Physical effects, ranging from the nature of dark matter to the radiation from star-forming galaxies and quasars, set the observable properties of the IGM, making the IGM a powerful probe of both fundamental physics and astrophysics. As the dominant reservoir of baryons ("the ordinary matter") in the Universe, the history of the intergalactic medium (IGM) is tightly coupled to the evolution of cosmic structure. Baryons in the IGM trace dark matter fluctuations on Mpc scales, while on smaller scales ($\lesssim$100 kpc) the $T \sim 10^4$ K gas is pressure supported against gravitational collapse. Analogous to the classic Jeans argument, baryonic fluctuations are suppressed relative to the pressureless dark matter as gas is pressure-smoothed or "filtered" on small scales. At any given redshift, the pressure smoothing scale depends not only on the prevailing pressure/temperature at that epoch, but also on the temperature of the IGM in the past. Therefore the IGM is very sensitive to the timing and heat injection of the Epoch of Reionization. Understanding this reionization means answering three specific questions: 1) When did the hydrogen phase transition occur? 2) How extended is was? 3) Which sources reionized the universe? Similarly, the density distribution of the IGM is sensitive to the nature of dark matter. The free-streaming horizon of dark matter particles lead to a 3D smoothing at high redshift that keeps decreasing as non-linearities increase. Therefore, the small-scale suppression in non-CDM dark matter models moves from very large scales to smaller scales at progressively lower redshifts. To extract scientific insights, confronting observations of the IGM with precise numerical simulations is a necessity. Because complex and poorly understood physical processes related to galaxy formation only play a minor influence, predicting the thermodynamical structure of the IGM is theoretically well-posed problem, albeit requiring expensive hydrodynamical simulations. Here, I will present a short overview and main results of our investigations of the intergalactic medium, focusing on the simulations and modeling.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

COMPARISON AND COMBINATION OF RADIO SOURCE POSITION CATALOGS

Zinovy Malkin

Pulkovo Observatory, Pulkovskoe Sh. 65, St. Petersburg, 196140, Russia
E-mail: malkin@gaoran.ru

Comparison of the astrometric source position catalogs is an important and necessary step in solving various problems of fundamental astrometry, such as comparison of different VLBI-based celestial reference frames (CRF) realizations, mutual alignment of radio and optical reference frames, and constructing combined catalogs. In this work, an analysis is performed of several factors that may affect the accuracy of computation of the orientation parameters between astrometric position catalogs. Among these factors are different representations of the systematic differences, the impact of correlations between source positions, and mitigation of influence of outliers, and others. Mostly classical comparison and combination techniques historically developed in optical astrometry for creating fundamental and combined catalogs are considered. In particular, the experience of the Pulkovo Observatory in this field and recent obtained results are described. Other methods for computing radio source position combined catalogs based on global VLBI solutions are also discussed.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

CIRCUMSTELLAR MATTER AND DISKS IN BETA LYRAE-TYPE BINARIES

Ronald E. Mennickent

Universidad de Concepción, Departamento de Astronomía, Casilla 160-C, Concepción, Chile

E-mail: rmennick@udec.cl

We review the observational evidence of circumstellar matter and disks in beta Lyrae-type binaries. Multi-wavelength spectroscopic and photometric observations are summarized along with published numerical simulations and theoretical work, and presented in the context of interacting close binaries in a stage of mass transfer. We put emphasis in some interesting targets showing peculiar behaviors and also in recent challenging results, some of them related to disk evolution, mass exchange between stellar components and systemic mass loss.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

SMBH GROWTH AND GRAVITATIONAL WAVE RADIATION

Miroslav Micic

Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
E-mail: micic@aob.rs

Supermassive black holes (SMBH) with masses $10^6 - 10^{10} M_\odot$ exist at the centres of all massive galaxies (both late and early type). They form through mergers and gas accretion very early. Mostly at redshift z $\sim$ 2 - 3. But some of them form short after the formation of the first galaxies as early as z $\sim$ 7. The time available for their formation is so short that we still do not know about the properties of the seed black holes from which SMBH forms. Two competing theories are: formation from the mergers of POP III remnants, $\sim 10^2 - 10^3 M_\odot$ BHs, or, formation of the massive BHs directly collapsed from the gas cloud into $\sim 10^4 - 10^5 M_\odot$ BHs. Both theories assume gas accretion episodes between and after BH mergers. While POP III seeds model struggles to find mechanism behind the necessary super Eddington accretion, collapse model has a problem with explaining accretion at Eddington ratio for hundreds of millions of years. Since merger histories of black holes in these two models are very different, gravitational wave radiation from BHs mergers will be a powerful method for distinguishing between these two SMBH formation models. Here we review the latest results from the works on both theories and the results on the gravitational wave radiation from BH mergers expected to be detected by Laser Interferometer Space Antenna (LISA).

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

IMPACT BOMBARDMENT OF MARS: LESSONS LEARNT FROM THE INSIGHT MISSION

Katarina Miljković

Space Science and Technology Centre, School of Earth and Planetary Science, Curtin University, Australia

E-mail: katarina.miljkovic@curtin.edu.au

NASA InSight mission has been operating on Mars since November 2018. During the first year of operations, lnSight has confirmed the existence of seismic activity on Mars. InSight's observations provide a starting point, and the work on defining the interior model for Mars has just begun. Impact bombardment is a geologic process that can help understand the structure of the Martian crust, via small bombardment expected to cause quakes and large old craters.

INTRODUCTION

The crust on Mars has been structurally affected by impacts, volcanism, mantle flow and erosion. Previous observations and modelling point to a dynamically active interior in early Martian history, that for some reason was followed by a rapid drop in heat transport. Such a change has significantly influenced the geological, geophysical and geochemical evolution of the planet, including the history of water and climate.

NASA's InSight mission (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) landed on Mars' surface on 26th November 2018 (Banerdt et al., 2020). This geophysical laboratory now sits on Elysium Planitia, a smooth, flat plain close to Mars' equator where InSight placed the first seismometer on the Martian surface. The InSight mission aims to study the planet's interior. One of its scientific payloads is the SEIS (Seismic Experiment for Interior Structure) has been measuring seismic activity on Mars (Lognonné et al., 2020). In the first year of operations, about a year and it has recorded over 300 Marsquakes (Giardini et al., 2020).

Impacts as a tool to probe interior structure

Geologic activity, such as impact bombardment can help further constrain Mars' evolution and interior structure. Present-day impact bombardment is limited to small strikes (in atmosphere and ground), and those count toward possible natural seismic sources on Mars (Daubar et al., 2020). A small number of detectable impacts is expected during the lifetime of the InSight mission, which will further understanding of the geologic structure of the Mars' upper crust.

To look further back in time, planetary crusts are long-surviving witnesses of asteroid impact bombardment. The outcome of an impact is dependent on the target

properties (conditions in the planetary crust and interior) at the time of crater formation, therefore, we can use simulations of impact cratering mechanics as a tool to probe the interior properties of a planet. Impact simulations, in tandem with InSight observations, help understand the crustal properties over the course of Mars' evolution, including the state of Mars' crust today.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

PARTIAL QUASI-MORPHISMS AND PARTIAL SYMPLECTIC QUASI-STATES IN THE AMBIENT OF COTANGENT BUNDLES

Jovana Nikolić

Faculty of Matehmatics, Studentski trg 16, 11158 Belgrade, Serbia
E-mail: jovanadj@matf.bg.ac.rs

In this lecture we will explain how one can define conormal spectral invariants in the ambient of cotangent bundles. Our main tool is Floer homology for Lagrangian intersections. Using aforementioned spectral invariants we can construct partial quasi-morphisms on the group of Hamiltonian diffeomorphisms of cotangents bundles and partial symplectic quasi-states on the space of smooth functions with compact support on cotangent bundles. This is joint work with Jelena Katić and Darko Milinković.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

MONITORING OF LOWER IONOSPHERE: POSSIBLE EARTHQUAKE PRECURSORS AND APPLICATION IN EARTH OBSERVATIONS BY SATELLITE

Aleksandra Nina

Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

E-mail: sandrast@ipb.ac.rs

Ionospheric observations can be used for indirect detection of various processes in the outer space and Earth. In addition, the ionosphere affects the propagation of electromagnetic signals used in numerous practical applications. Here, we present the latest research based on the observation of the low ionosphere by very low frequency radio signals recorded in Belgrade related to a possible new type of earthquake precursor, and the impact of the perturbed ionospheric D-region on the propagation of satellite signals used in Earth's observations.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

WATER CONTENT IN COMPOSITIONALLY PRIMITIVE ASTEROID FAMILIES: INSIGHTS FROM THE MAIN BELT COMETS

Bojan Novaković

Faculty of Mathematics, University of Belgrade, Studentski trg 16, 11000 Belgrade, Serbia

E-mail: bojan@matf.bg.ac.rs

Active asteroids are a relatively new class of objects in the asteroid belt. These intriguing objects have both, the orbital characteristics of asteroids and the physical characteristics of comets. Main belt comets (MBCs) are a subgroup of active asteroids for which it is believed that observed activity is driven by the sublimation of volatile ices. Our recent work has demonstrated that all MBCs associated to collisional families belong to families with primitive taxonomic classifications. Some of these families are located close to the main transport routes from the main belt to the near-Earth region, and therefore may supply some members to these routes. We have found that an object escaping from the Themis family, may preserve its polar ice all the way to the near-Earth region. These results collectively imply that ice may be present in some near-Earth asteroids, while the number of such objects and the total amount of water depend on the water content in their source asteroid families. In this talk we will briefly review the obtained results, and discuss future research agendas along these lines.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

SPECTROSCOPIC AND HYDRODYNAMIC ANALYSES OF THE NORTHWESTERN RIM OF THE GALACTIC SUPERNOVA REMNANT G156.2+5.7

Thomas G. Pannuti[1], Glenn E. Allen[2], Allana Iwanicki[3] and Evan van Daniker[4]

[1]*Department of Physics, Earth Science and Space Systems Engineering, Morehead State University, 235 Martindale Drive, Morehead, KY 40351, USA*
[2]*Lexington High School, 251 Waltham Street, Lexington, MA 02421, USA*
[3]*Princeton University, Princeton, NJ 08544, USA*
[4]*Craft Academy for Excellence in Science and Mathematics, 150 University Boulevard, Box 746, Morehead State University, Morehead, KY 40351, USA*

E-mail: t.pannuti@moreheadstate.edu, gallen@lexingtonma.org, iwanicki@princeton.edu, evandaniker@moreheadstate.edu

We present a broadband X-ray study (0.2-12.0 keV) of the Galactic supernova remnant (SNR) G156.2+5.7 (RX J04591+5147). Our primary goals are to search for evidence of synchrotron emission and to characterize the shape of the electron spectrum. The analysis is based on observations made of this source using the *ROSAT* PSPC, *XMM-Newton* EPIC MOS and pn-CCD cameras and the *RXTE* PCA. We derive statistically acceptable fits to the extracted spectra using models with two VPSHOCK components or with one VPSHOCK component and one SRCUT component. We argue that the results favor the model with two thermal components (i.e. that there is no evidence of X-ray synchrotron emission) and suggest that these components represent a single κ-like distribution of electrons associated with shock-heated circumstellar material. Furthermore, the results for two small regions, one at the forward shock and another just downstream of the forward shock indicate that the electron spectral shape changes as the forward-shocked gas propogates downstream.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

SUN AND SOLAR ACTIVITY: OPPORTUNITIES FOR OBSERVATIONS AND DEVELOPMENT

Nikola Petrov

Institute of Astronomy and National Astronomical Observatory,
Bulgarian Academy of Sciences
72 Tsarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria
E-mail: nip.sob@gmail.com

The fast technological development and the new possibilities for observations allowed solving some of the theoretical issues in modern heliophysics and astronomy in general. But there are still unresolved questions regarding the physical processes of solar activity and space weather. We use the potential of both ground-based and space-based astronomical observatories to analyze the present results and understandings in the field of heliophysics. We show the current observational possibilities and perspectives for development in the research of the solar activity in Bulgaria.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

MASSIVE CLOSE BINARY EVOLUTION - PROGENITORS OF GRAVITATIONAL WAVE SOURCES

Jelena Petrović

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
E-mail: jpetrovic@aob.rs

Massive close binary systems are thought to be sites of many exciting cosmic phenomena, such as for example, x-ray binaries, supernovae Ib, Ic and gamma-ray bursts. Most recently, sources of gravitational waves observed by the LIGO and Virgo telescopes were associated with binary systems containing compact objects, relics of massive stars - black holes and neutron stars. In this contribution, examples of detailed evolutionary models of massive close binary systems, possible progenitors of gravitational wave sources, are presented. The MESA (Modules for Experiments in Stellar Astrophysics) numerical code is used for the evolutionary calculations.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

SPECTO-POLARIZATION OF ACTIVE GALACTIC NUCLEI: CENTRAL SUPER-MASSIVE BLACK HOLE AND DUST SUBLIMATION REGION

L. Č. Popović[1], V. L. Afanasiev[2] and E. S. Shablovinskaya[2]

[1]*Astronomical Observatory, Volgina 7, 11160 Belgrade, Serbia*
[2]*Special Astrophysical Observatory of the Russian Academy of Science, Nizhnij Arkhyz, Karachaevo-Cherkesia 369167, Russia*

E-mail: lpopovic@aob.rs, vafan@sao.ru

Active galactic nuclei (AGNs) are one of the most powerful sources in the Universe that can be detected at high cosmological redshift. The produced AGN energy is coming from the matter accretion in the central super-massive black hole (SMBH). Different types (Type 1, and 2 with and without broad lines) of AGNs can be explained by orientation of an AGN, but also by the dust distribution around the active nuclei. Therefore, the amount of observed AGN energy depends on the AGN central part characteristics.

In this talk we are going to present our recent work where spectropolarimetry has been used to probe the nature of central part in the case of several AGNs, especially the mass of central SMBHs (Afanasiev & Popović 2015), and broad line emiting region geometry-dimension (Afanasiev, Popović & Shapovalova 2019). Also, we investigate some spectral and polarization characteristics of gravitational lenses (Popović et al. 2020a,b) in order to explore the inner structure of lensed quasars. Additonally we propose to use reverberation in polarization to find the place of the dust sublimation region in AGN structure (Shablovinskaya, Afanasiev & Popović 2020). Finally, we will discuss the advances of using spectral and polarization observations for investigation of the AGN and perspective for small telescopes (1-4m) to perform polarimetric observations.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

GREEN VALLEY GALAXIES AND THE ROLE OF AGN IN GALAXY EVOLUTION

Mirjana Pović

Ethiopian Space Science and Technology Institute, Entoto Observatory and Research Centre, Addis Ababa, Ethiopia
Instituto de Astrofísica de Andalucía (CSIC), Granada, Spain
E-mail: mpovic@iaa.es

Green valley galaxies showed to be very important for better understanding of star formation quenching mechanisms, morphological transformation in galaxies, and galaxy evolution across cosmic time. Many X-ray detected AGN have been found in the green valley suggesting that AGN might be responsible for stopping the star formation in galaxies. This is however in contrast with FIR studies where recently it has been seen that active galaxies in the green valley have enhanced star formation rates in comparison to inactive ones. This talk will give an overview of properties of green valley galaxies and the role that AGN could have in galaxy evolution.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

HUMAN CAPACITY BUILDING AND DEVELOPMENT OF ASTRONOMY IN AFRICA

Mirjana Pović

Ethiopian Space Science and Technology Institute, Entoto Observatory and Research Centre, Addis Ababa, Ethiopia
Instituto de Astrofísica de Andalucía (CSIC), Granada, Spain
E-mail: mpovic@iaa.es

Development of astronomy in Africa has grown significantly over the past years, through strong human capacity building and institutional, scientific, and technological developments. Local initiatives, creation of strong networks on continental level and international collaborations contributed significantly to that. This talk will summarise the current status of astronomy in Ethiopia, using it as an example, and Africa in general, summarising some of the main initiatives that have been taken over the last years. It will be highlighted how through astronomy we can contribute to development of science for the benefit of our societies.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
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Invited Lecture

THE CENTENARY OF THE JEANS EQUATIONS: DARK MATTER IN MASSIVE EARLY-TYPE GALAXIES

Srdjan Samurović

Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
E-mail: srdjan@aob.bg.ac.rs

The year 2019 marked the centenary of the publication of the book *Problems of Cosmogony and Stellar Dynamics* by James Jeans in which he summarized the work on dynamics of stellar systems based on his works published from 1915 onwards. We discuss one important application of his work relevant for contemporary galactic research: we analyze the problem of dark matter in massive early-type galaxies (ellipticals and lenticulars) using various available observational data. We show that in these galaxies dark matter does not dominate in the inner regions, but becomes more important beyond three effective radii.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

COSMOLOGY FROM CURRENT AND FUTURE SPECTROSCOPIC GALAXY SURVEYS

Marko Simonović

CERN, Switzerland
E-mail: marko.simonovic@cern.ch

Mapping of galaxy density fluctuations on large scales is one of the most important goals of observational cosmology in this decade. These observations can significantly improve our knowledge of the universe, its origin and composition. In combination with the CMB observations, the galaxy clustering data can lead to much tighter constraints on cosmological parameters and lead to potential discoveries of new physics. In this talk I will review some of the science goals of ongoing and future spectroscopic galaxy surveys and explain how these goals can be met. In particular, I will focus on some recent progress in theoretical modelling of the nonlinear structure formation and show how it can be used to extract cosmology from observations of the cosmic web. As an example, I will present several analyses from the publicly available Baryon Oscillation Spectroscopic Survey (BOSS) data and results for the standard ΛCDM model as well as several relevant extensions.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

NEW PERSPECTIVES ON THE DIFFUSE INTERSTELLAR MEDIUM: FROM THE MILKY WAY TO NEARBY GALAXIES

Snežana Stanimirović

Astronomy Department, University of Wisconsin - Madison, 475 North Charter Street, Madison, WI, 53706-1582 USA

E-mail: sstanimi@stro.wisc.edu

The diffuse interstellar medium (ISM) – gas and dust – is a vital player in the star formation process, based on its major contribution to the ISM's mass, and bears the brunt of the stellar feedback. In particular, the diffuse ISM is not only the key for building seeds for star formation – interstellar molecules – it also shields molecules from the harsh effects of stellar feedback and therefore determines the duration of their survival. As numerical simulations of galaxy evolution continue to include more complex ISM physics, detailed understanding and inclusion of key sources of stellar feedback and the exact effects they have on the diffuse ISM are essential.

In this talk, I will summarize the current status of our understanding of the neutral ISM and its connection with molecular gas, as the first step in the process of star formation. I will highlight key results from recent neutral hydrogen (HI) surveys of the Milky Way and nearby galaxies, specifically focusing on the neutral gas thermodynamics, transition from atomic to molecular medium, and interstellar turbulence. Current and upcoming observations of the diffuse ISM with new telescopes, such as ASKAP, MeerKAT, ngVLA, SKA, promise great observational advances and the ability to guide numerical simulations of star formation and galaxy evolution.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

ZAŠTO JE VAŽNO IZUČAVANJE ASTRONOMIJE U TOKU SREDNJOŠKOLSKOG OBRAZOVANJA?

Biljana Stojičić

Zemunska gimnazija, Gradski park 1, 11080 Zemun, Beograd, Srbija
E-mail: biljanastojicic963@gmail.com

Astronomija se u našim školama od 1991. godine izučava na prirodno-matematičkom smeru u četvrtom razredu gimnazije. Zanimljivo je da to nije poseban predmet već se izučava u okviru fizike. Izuzetatak su matematička gimnazija i gimnazija za učenike sa posebnim sposobnostima za fiziku. Nastavu astronomije u našim školama realizuju, pored astronoma, astrofizičara i fizičari. Iskustvo stečeno tokom poslednje tri decenije je dragoceno i može poslužiti za kreiranje nastave astronomije u budućem periodu. Svaki nastavnik koji je realizovao program astronomije u gimnaziji je uočio da je ona izuzetno zanimljiva učenicima, a razlog tome treba tražiti u samom polju istraživanja astronomije. Upravo je ta zainteresovanost nešto što može biti dobro polazište za ono što se želi postići kroz nastavu astronomije. Program je tako koncipiran da je moguće, kroz njegovo izučavanje ponoviti celokupno gradivo fizike. Ne bi trebalo izgubiti iz vida da se astronomija izučava u četvrtom razredu gimnazije, kada su učenici stekli značajna znanja iz matematike i kada su mnogo zreliji i sa usvojenim raznim tehnikama učenja. Astronomija pruža široko polje primene znanja iz geometrije, stereometrije, trigonometrije, sferne trigonometrije. Sve navedeno omogućava da kroz izučavanje sadržaja iz astronomije razviju i usvoje osnovne koncepte u fizici i primene znanja iz matematike. Na taj način ponavljanje gradiva nije prosta reprodukcije, već se postiže viši kvalitet tog znanja. Opčinjenost nebeskim svodom prekrivenog zvezdama pokretala je stare narode da posmatraju astronomske pojave i tragaju za njihovim objašnjenjima, što je u novije vreme dovelo do formiranja nove oblasti-arheoastrnomije. Upravo ta otkrića, učenicima naviknutim na veliku podršku tehničkih sredstava, često deluju neverovatna. Sa druge strane, ona su izvanredni primeri na kojima se demonstrira potreba za pažljivim posmatranjem pojava i njihovog analiziranja, što je duboko vezano za prirodu istraživanja u astronomiji. Često se može uočiti insistiranje na integrativnoj nastavi u našem obrazovnom sistemu. O važnosti tog pristupa se ne polemiše, ali ono što jeste problem je realizacija. Upravo interdisciplinarnost astronomije daje mogućnost i za ovakav pristup u nastavi. Nastava astronomije otvara još jednu mogućnost, a to je projektna nastava. U radu će biti opisane neke od ideja za projektnu nastavu, kao što su Eratostenov eksperiment, odredjivanje lokalnog meridijana, unutrašnji meridijan i posmatranje prelaska Sunčevog diska preko lokalnog meridijana, simulacija petlji planeta u školskom dvorištu kao što su predložili Bennett et al. (2004). Iskustvo pokazuje da su za učenje i razumevanje osnovnih pojmova u astronomiji veoma korisni modeli

u realnom prostoru koji omogućuju njihovu vizuelizaciju. Dan Noć i Godina Globus (DING), koji se naziva i Paralelni globus (Rossi et al. 2015), omogućuje da posmatrač na Zemlji "vidi" trenutno osunčenje Zemlje onako kako to vidi astronaut iz svog vasionskog broda. Ovo zato što je osa Paralelnog globusa paralelna Zemljinoj osi, a položaj grada u kome je globus je na vrhu globusa. Posmatrač može tokom dana, ali i godine pratiti niz različitih fenomena vezanih za kretanje Zemlje.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

SHORT TERM CHAOS IN THE SOLAR SYSTEM

Nataša Todorović

Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia
E-mail: ntodorovic@aob.rs

Despite the enormous time spans of cosmic processes, which are often beyond human comprehension, there are some space events that could be perceived in its entirety; flybys of near-Earth objects (NEOs), meteorite impacts, comet passages, star explosions. In this regard, we will focus on dynamical mechanisms in our Solar system, acting in times that are extremely short - measurable with the lifetime of a human. Using sensitive numerical methods, that have been developed in recent decades, and using a realistic model of the Solar system, we were able to observe intricate phase-space structures, traces of the so-called *space manifolds*. Space manifolds have been considered in the literature as sources of natural flows, mostly in the context of individual trajectories. Here we will present their global architecture, and illustrate how it could be related to the orbital evolution of asteroids and comets. In the end, we will address some questions related to their role in the human exploration of space.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

NEWS AND FUTURE PLANS IN THE DEVELOPMENT OF THE ASTRONOMICAL STATION VIDOJEVICA

Oliver Vince

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
E-mail: ovince@aob.rs

Due to the new health situation that affected the whole world, the rhythm of work of the Astronomical Station Vidojevica was disturbed. However, despite this, a lot has been done for the development of the station and they will be presented in this lecture. In the first place, it is the construction of the pavilion for the 40cm Meade telescope and its installation and calibration that are still in progress at the time of submission of the Abstract. With a little luck and skill, we hope that the first images with this telescope as well as its characteristics will be presented. In addition to the infrastructure for the 40 cm telescope, we will also talk about the news related to the other two telescopes - the 60 cm telescope "Nedeljković" and the 140 cm telescope "Milanković".

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

COSMOLOGICAL CONSTANT PROBLEM IN DISCRETIZED QUANTUM GRAVITY

Marko Vojinović

Institute of Physics, Pregrevica 118, 11080 Belgrade, Serbia
E-mail: vmarko@ipb.ac.rs

The cosmological constant (CC) problem is one of the main unsolved problems in quantum field theory, and it is expected to be somehow resolved within the context of some theory of quanutm gravity (QG).

One of the recently proposed models is the so-called *spincube model* of QG (Miković and Vojinović 2012), a categorical generalization of spinfoam models developed within the framework of Loop Quantum Gravity. The main advantage of the spincube model over previous models is the ability to couple matter fields to gravity. This opens up the possibility to discuss the CC problem. As it turns out, the spincube model indeed does offer a plausible resolution of the CC problem (Miković and Vojinović 2015).

Using the effective action framework, one can compute the effective value of the CC in the model. It is given as a sum of three terms: the classical CC, the quantum gravity CC and the matter CC. Since the observations can only measure the sum of these three terms, we can choose the classical CC to cancel the matter CC. Hence the effective CC is given only by the quantum gravity contribution, which is determined by the path-integral measure, and must necessarily be much smaller than one, as a consequence of the analyticity requirement for the model. Finally, since the path-integral measure depends on a free parameter, this parameter can be chosen such that the effective CC gives the observed value.

We will discuss the obtained results, as well as some issues that require further research.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Invited Lecture

TESTING PERFORMANCE OF THE MILANKOVIĆ TELESCOPE

A. Vudragović[1], M. Bílek[2], S. Samurović[1] and M. Jovanović[1]

[1]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
[2]*Astronomical Institute of the Czech Academy of Sciences, Boční II 1401/1a, 141 00 Praha 4, Czech Republic*

E-mail: ana@aob.rs

We have undertaken multi-band imaging campaign of several galaxies, that are challenging due to the presence of low surface brightness features such as shells and mostly lie in the unfavorable environment. Using 1.4-m Milankovic telescope, we have measured the surface brightness limits in various bands dependent on the exposure time, and the change of the point spread function across the whole field-of-view. In three to four hours of observations with L-filter, the surface brightness limit of 28.5-29 mag/arcsec^{-2} was reached, when converted to the g-band. We have imaged single knee-shaped stellar stream around NGC 5907 galaxy, where double-loop was previously reported and published our findings. The comparison to other deep photometric surveys has shown that within few hours of observations we can make competitive results.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Invited Lecture

GALACTIC HABITABILITY AND STELLAR MOTION

Branislav Vukotić

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
E-mail: bvukotic@aob.rs

One of the key factors of Galactic habitability is the movement of stars. The stellar flybys can influence the stability of planetary systems and possible matter exchange between the individual stellar systems. The recent detection of interstellar objects, Oumuamua asteroid and comet 2I/Borisov lead to estimates that about ten such objects are present in the Solar system at any instant. In addition, the indications of stellar migrations within the Galactic disk imply that individual stellar systems may experience different Galactic environments during their lifetimes. Advanced models of Galactic habitability should appreciate these factors. We consider the potential for capturing the interstellar objects and stellar migrations, given the overall distribution of stars in the Galactic disk and re-assess the recent findings on Galactic habitability.

Contributed Talks

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

THE FIRST YUGOSLAV NATIONAL COMMITTEE FOR ASTRONOMY

Bojan Arbutina

Department of Astronomy, Faculty of Mathematics, University of Belgrade, Studentski trg 16, 11000 Belgrade, Serbia

E-mail: arbo@matf.bg.ac.rs

Although Serbia, as a member of the Allied Powers and a WWI winner, was one of the founding members of the International Research Council in the context of which the International Astronomical Union (IAU) was established, in Brussels in the summer of 1919, it joined IAU, within the Kingdom of Yugoslavia, only in 1935. The formal representative of Yugoslavia at this assembly was Prof. Vojislav Mišković, a member of the Serbian Royal Academy and Director of the Astronomical Observatory of Belgrade. Shortly after the assembly, the first Yugoslav National Committee for Astronomy was established, the president of which was Prof. Milutin Milanković, a member of the Serbian Royal Academy and one of the greatest Serbian scientists.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

DEPARTMENT OF ASTRONOMY AT THE FACULTY OF MATHEMATICS UNIVERSITY OF BELGRADE IN THE PERIOD 1999-2020

Bojan Arbutina, Olga Atanacković and Andjelka Kovačević

Department of Astronomy, Faculty of Mathematics, University of Belgrade, Studentski trg 16, 11000 Belgrade, Serbia

E-mail: arbo@matf.bg.ac.rs

This contribution represents an attempt to give a brief overview of the development of the Department of Astronomy, Faculty of Mathematics, University of Belgrade in the period 1999-2020. It is primarily based on the paper in Serbian by Atanacković, Arbutina and Kovačević (2019) that chronologically covered in much more detail the period 1999-2018, and, in a sense, it is also a sequel to a paper by Milogradov-Turin (2003) that covered the history of the teaching of astronomy and Astronomy group at the University of Belgrade, from the beginnings until 2002. We hope that this contribution will serve as a valuable historical source to the future generations of Serbian astronomers.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Contributed Talk

ASTRONOMY EDUCATION IN SERBIA 2017-2020

O. Atanacković and B. Arbutina

Department of Astronomy, Faculty of Mathematics, University of Belgrade, Studentski Trg 16, 11000 Belgrade, P.O.Box 550, Serbia

E-mail: olga@matf.bg.ac.rs, arbo@matf.bg.ac.rs

A review of triennial activities in astronomy education in Serbia at all levels is given with an emphasis put on considerable changes introduced within the reform of the primary and secondary school education, especially regarding the representation of Physics in high school teaching. Numerous activities of the Department of Astronomy will be considered too.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Contributed Talk

HERMES – POSSIBLE ASTRONOMICAL ASPECTS

Aleksandra Bajić[1] and Milan S. Dimitrijević[1,2]

[1]*Society for Archaeoastronomy and Ethnoastronomy, "Vlašići", Belgrade, Serbia*
[2]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
E-mail:aleksandra.bajic@gmail.com, mdimitrijevic@aob.rs

Cosmological significance of a Greek deity can be examined in several ways: **1)** Mythological sources could offer some attributes and the symbolism associated with the deity, which could be connected to some celestial bodies; **2)** Reviewing the visual representations of the deity, one could also look for attributes and symbols, as well as the (direct or indirect) connection of these with the sky; **3)** Historical sources on the worship of the deity, sometimes describe festivals and rituals along with the position these in the Greek calendar(s); **1)** Analyzing the shadow of the gnomon at the site of the temple or in its vicinity could help us to understand the criteria for choosing the location; **5)** By analyzing the orientation of the temples dedicated to the deity and comparing it with the position of the celestial bodies some conclusions can be reached. These conclusions then could be corroborated by the data from mythological sources or by archaeological data from the site, which can provide additional insights.

This last method (no 5) is by far the most popular among the researchers interested in the role of astronomy in the culture of ancient Greece: it is based on astrogeodetic survey of the horizon as seen from the temple and the positional astronomy. It happens that a temple is well preserved and easier to analize. Sometimes archaeologists find that a part of the temple (usually adyton) was roofless (hypaethral), so that the view from it was open to the zenith. At a certain geographical latitude only certain stars can reach the zenith. This kind of research is facilitated in present times by good astronomical software, such as Stellarium 19 or RedShift 7. The knowledge thus obtained is then compared with mythological and historical sources, visual representations of the examined deity.

That's why Hermes was a challenge for the authors of this paper. The most popular method is impossible. None of the temples dedicated to the God have been preserved, not even archaeologicaly identified, although the cities in which these were located are known. Due to that fact, the axial directions of the temples are unknown, as well as the horizon altitude which cannot be surveyed. positional astronomy, therefore, is of no use in this case.

Mythological sources and visual representations of Hermes offer a range of symbols some of which can be associated with stars and constellations, representing astronomical lore. Several rods appear in his mythology, one of which is golden and is the gift of Apollo, the solar deity; Hermai, the pillar-shaped statues of the deity,

which were widespread in ancient Greece, could be easily imagined to have the function of gnomons, which lead to the hypothesis that Hermes represents (among other things) the divine personification of a gnomon. None of the Temples of Hermes is preserved, not even archaeologically identified but the locations of these are known. Therefore, the archaeoastronomical analysis has to be limited. It is possible to analyse the gnomon's shadow at these locations, on solstices and equinoxes together with the zenith position of some stars and constellations during the morning (or evening) dusk.

In this work we analyzed the gnomon shadow and positions of constelations on solstices and equinoxes in Pheneos in Arcadia, because it is close to the Mount Kyllene, the center of the Hermes' cult and Pausanias writes (8. 14. 10) about a temple, dedicated to this deity, there. The archaeoastronomical analysis has been performed with the astronomical software Stellarium.

The obtained results are consistent with the symbols tied to the deity. It is possible to demonstrate that Hermes had an important role in the cosmology of the ancient Greeks and it is very likely that (among his other competences) he was the divine personification of gnomons.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Contributed Talk

THE MATLAS SURVEY OF FAINT OUTSKIRTS OF BRIGHT GALAXIES

Michal Bílek

Université de Strasbourg, CNRS, Observatoire astronomique de Strasbourg (ObAS), UMR 7550, 67000 Strasbourg, France

E-mail: bilek@astro.unistra.fr

Deep imaging, i.e. imaging capable of capturing very faint objects, is a quickly growing field of extragalactic astronomy. Not only new types of faint objects can be discovered, but deep images of bright galaxies are very valuable, too, since they reveal faint signs of past galaxy collisions, the tidal features. Such "archeological" record can be exploited for investigating how galaxies formed. In the MATLAS survey, we obtained extremely deep images of 177 nearby massive elliptical and lenticular galaxies using the 3.5m Canada-France-Hawaii Telescope. In my contribution, I will present the various types of objects and features seen in our images, e.g. the tidal features, the faint star-forming regions in otherwise quenched galaxies, or the faint dust clouds in our own Galaxy. I will present our first conclusions about the formation of galaxies. Finally, I will introduce our deep-imaging efforts with the Milanković Telescope.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

STATISTICS OF THE LARGEST SAMPLE OF LATE-TYPE CONTACT BINARIES STUDIED SO FAR

A. Čeki, O. Latković and S. Lazarević

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
E-mail: atila@aob.rs, olivia@aob.rs, sanja@aob.rs

Late-type contact binaries, also known as W UMa stars, are intriguing objects whose present-day properties, evolutionary history and membership in multiple stellar systems are still not fully understood despite decades of dedicated research. At the same time, they are a favorite target for observations with relatively small, ground-based telescopes because of their short periods, so an entire light curve can often be recorded in a few nights. The last decade has seen a considerable rise in both the number and quality of studies of W UMa stars, and the establishment of de-facto standards in their analysis that help aggregate the results. We have collected new and updated solutions of light curves for almost 700 W UMa stars, more than half of which have been studied for the first time in the last few years. This is the largest catalog of its sort published to date and it provides ample material for various statistics. We showcase and discuss the most interesting findings.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

DETERMINATION OF STELLAR RADII BY OBSERVING ASTEROID OCCULTATIONS

Stefan Cikota

University of Zagreb, Faculty of Electrical Engineering and Computing, Unska 3, 10000 Zagreb, Croatia
E-mail: scikota@fer.hr

A stellar occultation occurs when the light from a star is blocked by an intervening body (such as an asteroid), from reaching an observer. They are in general short duration events, taking between a few seconds, up to ∼100 seconds for distant and large objects. Stellar occultations have been used as a powerful tool to determine physical characteristics (Sicardy et al. 2011; Ortiz et al. 2012) of the objects - the size, shape, atmosphere, and other physical features like the presence of rings or satellites (e.g. Ortiz et al. 2017). Just by measuring the time of occultation at different points along the path of the asteroid's shadow gliding over the Earth's ground, resolutions of several orders of magnitude better than the resolution of any other Earth-based method can be reached.

When an intervening asteroid is passing in front of a star, the brightness drop is not completely sharp. In a similar way as in the experiments in the introductory physics classes monochromatic point-like light source passing through a narrow slit creates a fringe pattern of light on the distant screen (phenomenon of diffraction), so is an intervening body passing in front of a star producing a diffraction pattern, like through a "slit" which has only one single edge.

An extended disc of a star will modify and reduce the intensity of the diffraction patterns. Analysing the observed diffraction patterns enables direct measurements of the angular sizes of the stars, even though they may be far below the optical resolution of the telescope.

Stellar angular diameters are critical in order to determine basic properties of the stars, as well as to compare stellar evolution models with observations, or for example, in determining the physical properties of Earth-mass exoplanets in the habitable zones around M-stars.

Most of the stellar diameter measurements available so far have been obtained through interferometry or using lunar stellar occultations. Obtaining stellar radii measurements through asteroidal stellar occultations has largely remained unexploited in the past because of instrumental limitations, whereas the precision is around a factor 10 better than with lunar occultations and at least a factor 2 better than using interferometry (Mozurkewich et al., 2003).

Today's instruments allow observing stellar occultations already by using mid-sized telescopes. By limiting the region of interests and using binned images on

fast imaging cameras, temporal resolutions of 0.01 s, or even below the millisecond can be achieved, which is enough to detect the diffraction patterns occurring during occultation events that allow measuring the stellar diameters.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
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Contributed Talk

ARCHAEOASTRONOMY AND EXAMPLES OF RESEARCH IN SERBIA

Milan S. Dimitrijević

Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
E-mail: mdimitrijevic@aob.rs

Archaeoastronomy is an interdisciplinary science that investigates and considers how in the past humans observed sky and celestial bodies, understood and recorded what they saw on it and what it meant in their culture, religion, and worldviews. Aveni defines it as "the study of the practice and use of astronomy among the ancient world cultures based on all accessible forms of evidence, written and unwritten." Ruggles considers that the word "old" can be freely omitted, from Aveni's definition, to include ethnoastronomy.

Close relations exist between Archaeoastronomy and ethnoastronomy, anthropological studies the sky observations in both earlier and present societies, as well as the history of astronomy, which uses available records to consider the development of astronomy, understanding of the universe and its phenomena and astronomical practice throughout history. It is a relatively new science, developed as a result of exploring the possible astronomical significance of the directions that connect an object, a marker on the horizon and some astronomical phenomenon (sunrise or sunset on solstice, star or constellation raising or setting). Largely contributed to its developpment and the study of astronomical aspects of the Stonehenge Megalithic Monument in England and astronomical alignments in the architecture of the ancient inhabitants of South America.

Archaeoastronomy uses a number of different methods that include archaeological, anthropological, astronomical, statistical, probabilistic, historical and geodetic ones. It has particularly developed over the last fifty years.

The basic sources that provide us with information about how humans interacted with the sky and celestial phenomena are the significant directions and orientations of particular constructions, objects, ethnographic research, calendars, written sources, myths and cosmologies.

Although particular works that could be classified in this field, existed earlier, the first conference dedicated entirely to the history of astronomy, with a number of contributions that could be included in archaeoastronomy, was the VII National Conference of Astronomers of Yugoslavia, held in 1984, on the 50^{th} anniversary of the founding of the Astronomical Society "Rudjer Bošković". The next was the session "Astronomy in Archaeology, History and Culture", dedicated to archaeoastronomy, organized for the first time on the 4^{th} Yugoslav-Romanian Astronomical Conference in Belgrade (May 5-8, 1998). The study about the astronomical orientations of graves and skeletons

in Gomolava and Mokrin, presented at the XI National Conference of Astronomers of Yugoslavia 1996 in Belgrade, by A. Vince, B. Jovanović, I. Vince and O. Vince, was the first archaeoastronomical investigation in Serbia, by a joint team of archaeologists and astronomers. That year, at a meeting held on June 12^{th}, astronomers (M. S. Dimitrijević and Ištvan Vince) and archaeologists (Borislav Jovanović, Milorad Stojić, Andor Vince and Živko Mikić) formed a Group for archaeoastronomy that had been active for about a year. In 2009, at the Faculty of Mathematics in Belgrade, at the Department of Astronomy, the course of Archaeoastronomy was introduced as an optional course in doctoral studies, which existed until 2014/2015. The first archaeoastronomical study of how the movement of the Sun and the appearances in the sky could be observed and monitored during the year from an archaeological site in order to determine the beginning of the seasons and to correct the calendar, started by Aleksandra Bajić and Hristivoje Pavlović, in 2014, at Lepenski Vir. That year, the Society for Archaeoastronomical and Ethnoastronomical Research "Vlašići" (http://www.vlasici.org.rs/) was founded in Belgrade.

Archaeoastronomy in Serbia has achieved a number of original and interesting results, but it is not developed like in some of the surrounding countries, such as Greece and Bulgaria in particular.

In this contribution, the significance, development and importance of archaeoastronomy will be discussed, some examples of research and objects of importance for this topic will be presented and the history and development of archaeoastronomy in Serbia will be briefly reviewed.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
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Contributed Talk

RADIO WATCHING DRACONIDS FROM 2005-2015

Žan Disterlo

Radio-astronomski klub-DMI Bor
https://radioastronomijasrbija.blogspot.com

Draconins are known as sporadic swarws or periodic swarws, accasionally having surprisingly extraordinary activity. Sudden events are directly related to the trajectories of the parent comets (the parent periodic comet is 21P Giacobini-Ginner), the famous Draconids meteor storms were in 1933. 1946- There were two stroms betveen 2005 and 2015. Draconids, 2011- (ZHR=846), 2012- (ZHR=236), in a short time of a few hours. Increased radio-observation activity was observed in 2006- (ZHR=293), 2011- (ZHR=846), 2012- (ZHR=236), 2014- (ZHR=218).

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

ELECTRON TRANSPORT, STREAMER PROPAGATION AND LIGHTNING IN THE ATMOSPHERE OF TITAN

S. Dujko[1], D. Bošnjaković[1], I. Simonović[1] and C. Köhn[2]

[1] *Institute of Physics, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia*
[2] *Technical University of Denmark, National Space Institute (DTU Space), Elektrovej 328, DK-2800 Kgs Lyngby, Denmark*

E-mail: sasa.dujko@ipb.ac.rs

In this work we investigate the electron transport, streamer propagation and the possibility for the occurrence of lightning in the atmosphere of Titan. Titan is the largest satellite of Saturn, and its atmosphere is mostly composed of N_2 and CH_4 and trace amounts of H_2 and HCN, including many hydrocarbons and nitriles. The modeling studies of Titan's atmospheric chemistry suggest the existence of lightning since the amount of HCN and C_2H_2 in the atmosphere cannot be explained as the results of photo-chemistry or charged-particle chemistry in the upper atmosphere. We approach the problem at three stages. Firstly, using a multi term solution of the Boltzmann equation, we calculate transport coefficients of electrons in the mixtures of N_2 and CH_4 under the influence of various electric field strengths. In addition, transport coefficients in C_2H_2, C_2H_4 and C_2H_6 are measured with a scanning drift tube apparatus and calculated using the Boltzmann equation and Monte Carlo simulations. Calculated transport coefficients are then used as an input into discharge models, based on the fluid equations, to investigate the development of an electron avalanche and its transition into a negative streamer in N_2-CH_4 mixtures. Finally, we use a 2.5 dimensional Particle in cell Monte Carlo code with cylindrical symmetry and photo-ionization to simulate the development of both positive and negative streamers in the atmosphere of Titan. The results of simulations will be discussed using physical arguments and will be placed in a broader context of astrobiological studies of Titan's atmosphere.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
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Contributed Talk

MANIFOLD LEARNING IN THE CONTEXT OF QUASAR SPECTRAL DIVERSITY

I. Jankov, D. Ilić and A. Kovačević

Department of Astronomy, Faculty of Mathematics, University of Belgrade
Studentski trg 16, 11000 Belgrade, Serbia
E-mail: isidora_jankov@matf.bg.ac.rs, dilic@matf.bg.ac.rs, andjelka@matf.bg.ac.rs

Application of dimensionality reduction techniques (mainly principal component analysis - PCA) to astronomical data proved to be a powerful tool in exploratory data analysis and identification of meaningful correlations between parameters, as well as in spectral analysis. When applied to spectral parameters of type 1 quasars, PCA revealed that they occupy a specific parameter space, the so-called Eigenvector 1 (E1), an analogue to the H-R diagram for stars. This parameter space has four dimensions, two of which are described by spectral parameters derived from the optical part of the spectrum. Sulentic, et al. (2000) have shown that E1 parameter space could be used to distinguish between different spectral populations of type 1 quasars, namely population A and B, based on the Hβ line width and the strength of the iron line. The authors suggest that the principal driving mechanism behind this classification scheme might be the Eddington ratio.

We propose an improvement to the interpretation of quasar spectral diversity by subjecting quasars to non-linear treatment using a manifold learning technique called locally linear embedding (LLE). In the context of E1 parameters, we apply LLE analysis to a sample of type 1 quasars, for which the spectral features are taken from a Sloan Digital Sky Survey data catalog which counts a total of $\sim$100,000 objects. In the case when we have a large number of parameters describing objects in question, LLE can be useful because it aims to find a low-dimensional representation of the original data set while preserving the geometry of the local neighborhoods within the data. In this analysis, we have shown that LLE can be used as a contextual tool, in addition to PCA, in the search for important correlations in astronomical data sets. We also have indications that LLE may perform even better than PCA in the identification of different spectral populations and their visual, as well as functional representation (Jankov et al., 2020).

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

DYNAMICAL MODELING OF NEARBY GALAXIES

Milena Jovanović

Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
E-mail: milena@aob.rs

Here we present detailed dynamical models for a sample of galaxies based on THINGS (The HI Nearby Galaxy Survey). Stellar mass is derived for all galaxies using a free mass-to-light ratio. Where possible, a modeling procedure is also done for a fixed M/L^* based on modern stellar population models. Finally we give the outline of the ongoing work, which is determining the baryon distribution of the Milky Way environment reflected by the Baryonic Mass Function based on the same sample of galaxies.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

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

Miljana D. Jovanović[1], Goran Damljanović[1] and François Taris[2]

[1]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
[2]*Observatoire de Paris - SYRTE, 61 av. de l'Observatoire, 75014 Paris, France*
E-mail: miljana@aob.rs, gdamljanovic@aob.rs, francois.taris@obspm.fr

Some of quasars (QSOs) which were observed by Gaia satellite in optical and by very long baseline interferometry (VLBI) in radio wavelength will be used to link two reference frames (Gaia CRF and ICRF). Monitoring photometry stability of candidate QSOs is of importance for this link. During six years we observed these objects in V and R bands. Their brightness was obtained by using differential photometry with two comparison stars. In the same manner the brightness of several control stars around each QSO was obtained. We tested their brightness and color variability. The tests show that most of these stars are suitable for photometry and could be used as comparison stars. The results and finding charts are presented here.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

TYPE II AND ANOMALOUS CEPHEIDS

Monika Jurkovic

Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
E-mail: mojur@aob.rs

Type II Cepheids are old (> 10 Gyrs) pulsating stars with masses of around 0.5 M⊙, while anomalous Cepheids are between 1 and 5 Gyrs with masses around 1.2 M⊙. Anomalous Cepheids pulsate in the fundamental mode and first overtone. Type II Cepheids pulsate mainly in the fundamental mode. The number of new discoveries about these variable stars has been significant in the past years. The physical parameters (luminosities, effective temperature, radii and masses) were determined using the Spectral Energy Distribution fitting, resulting in the bolometric period-luminosity relation for them. New behavior in the pulsation was discovered: the phenomena of period-doubling was observed, double mode pulsators were discovered among Type II Cepheids (meaning that the first overtone and fundamental mode are both present in the star), and in the longer period Type II Cepheids, the W Virginis sub-types (4 <P [days] < 20), a newly discovered behavior in the light curves, the *shape-shifting* was seen for the first time. These discoveries contribute to our understanding of stellar pulsation. Pulsating stars are important, because they form a period-luminosity relation, which is the stepping stone of the cosmic distance ladder. They are the link between our own galaxy and the nearby galaxies. Here we are going to take a closer look at all of these new discoveries.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

SFC BARYOGENESIS MODEL, INFLATIONARY SCENARIOS AND REHEATING IN THE UNIVERSE

D. Kirilova and M. Panayotova

Institute of Astronomy and NAO, Bulgarian Academy of Sciences, Sofia, Bulgaria
E-mail: dani@astro.bas.bg

We discuss Scalar Field Baryogenesis Model and its capability to produce the observed baryon asymmetry of the Universe in different inflationary scenarios and for different types of reheating. Interestingly enough among the preferred by SFC baryogenesis model is the Starobinsky inflation model, which is the preferred one also by the recent CMB data analysis.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

USING BALMER LINES TO UNVEIL THE PRESENCE OF COSMIC RAYS IN THE SUPERNOVA REMNANT SNR 0509-67.5

S. Knežević[1], G. Morlino[2], R. Bandiera[2], S. Schulze[3], G. van de Ven[4] and J. C. Raymond[5]

[1]*Astronomical Observatory of Belgrade, Volgina 7, 11060 Belgrade, Serbia*
[2]*INAF – Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy*
[3]*Department of Particle Physics and Astrophysics, Weizmann Institute of Science, 234 Herzl St, 76100 Rehovot, Israel*
[4]*Department of Astrophysics, University of Vienna, Türkenschanzstrasse 17, 1180 Vienna, Austria*
[5]*Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA, 02138, USA*

E-mail: sknezevic@aob.rs

We present spectroscopic observations of the supernova remnant SNR 0509-67.5 in the Large Magelanic Cloud. We used MUSE instrument on the Very Large Telescope to spectrally and spatially resolve the fast Balmer shocks around the remnant. We show the preliminary results of the resolved broad Hα-line component, whose width indirectly provides the temperature of the shocked plasma. Coupling this information with the shock speed recently determined by proper motion measurements, we infer the total amount of energy channelled into cosmic rays. In addition, by comparing monochromatic images of the observed field at various wavelengths we report a discovery of new objects located in the direction of SNR 0509-67.5 that were not observed/reported before.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
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Contributed Talk

COMPUTER VISION AS A TOOL FOR STUDYING CLOSE BINARY STARS

O. Latković and A. Čeki

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
E-mail: olivia@aob.rs, atila@aob.rs

Computer vision is a subfield of artificial intelligence that deals with automated detection and classification of objects from images, used in a variety of advanced applications, from facial recognition to self-driving cars. While other machine learning methods have gained a strong footing in astronomy over the last several years, computer vision is still a relatively rare and novel approach. We have been experimenting with this technique in the context of eclipsing binary stars, with the aim to automate the analysis of photometric time-series data from ground-based and space surveys. The current and future deluge of such data requires the automation of as many tasks as possible, otherwise much of it will remain unutilized. Computer vision might be used to estimate the stellar and orbital parameters of eclipsing binaries based on the images of their light curves. As proof-of-concept, we have already developed a computer vision system for automated recognition of light curves with total eclipses, and demonstrated that a computer can perform this task as well or better than humans.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Contributed Talk

COSMIC RAY PRODUCTION SITES: SUPERNOVA REMNANTS INTERACTION WITH MOLECULAR CLOUDS

Jasmina Lazendić-Galloway

School of Physics and Astronomy, Monash University, Australia
E-mail: jasmina.lg@monash.edu

Powerful shock fronts of young supernova remnants (SNRs) are very likely the powerhouses where particles can be accelerated to become cosmic rays. Interestingly, we observe many older SNRs being very bright in γ-rays, although their shocks have slowed down. These SNRs tend to interact with nearby molecular clouds (MCs), and these interactions have therefore been recognised as an important condition for cosmic ray production. However, looking for a firm evidence of supernova remnant interaction with ambient molecular clouds is not easy. The 1720 MHz OH maser line has been found in only 10% of the SNRs and can be used as a signpost of the interaction. Otherwise, a spatial correlation between SNRs and MCs is used to assess the physical interaction, but this is a very ambiguous association. Both the SNRs and the MCs are shell-like objects and chances of random alignment along-the-line of sight are high. However, finding shock-broadened lines in molecular gas is a strong signature of a SNR shock interaction with an MC. I will present a summary of findings on a very interesting SNR, RX J1713.7–3946 (G347.3–0.5), which emits only non-thermal X-rays emission and it's very bright in γ-rays, making it a favourite candidate when searching for SNR shock connections with cosmic ray production. This remnant has been studied in detail with many telescopes across X-ray and γ-ray bands, but we still don't have definitive proof that cosmic ray protons are accelerated in shocks of this SNR.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Contributed Talk

COMPARISON OF TWO MODELS OF INTERSTELLAR TRAVEL USING LASER-PUSHED LIGHTSAIL

Dragan V. Lukić

Institute of Physics, Pregerevica 118, 11080 Belgrade, Serbia
E-mail: lukic@ipb.ac.rs

We are describing the current state of the research, two recent projects from Harward University and Max Planck Institute for Astrophysics and presenting our model for light propulsion based on non diverging beam powered by Solar radiation. In this presentation we will focus on power infrastructure.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

THE INTERMITTENT EXTREME BEHAVIOR OF BL Lac 1ES 2344+514

M. Manganaro[1], A. Arbet Engels[2], D. Dorner[3], M. Cerruti[4], A. V. Filippenko[5], T. Hovatta[6], V. M. Larionov[7], J. A. Acosta-Pulido[8], C. M. Raiteri[9], V. F. Ramazani[10], V. Sliusar[11], M. Šegon[1], M. Villata[9], W. Zheng[5] on behalf of MAGIC and FACT collaborations

[1]*Department of Physics, Univeristy of Rijeka, Croatia*
[2]*ETH Zurich, Institute for Particle Physics, Zurich, Switzerland*
[3]*Institut für Theoretische Physik und Astrophysik - Fakultät für Physik und Astronomie - Universität Würzburg, Würzburg, Germany*
[4]*Universitat de Barcelona, Barcelona, Spain*
[5]*Department of Astronomy, University of California, Berkeley, CA, USA*
[6]*Finnish Centre for Astronomy with ESO (FINCA), University of Turku, Turku, Finland and Aalto University Metsähovi Radio Observatory, Kylmälä, Finland*
[7]*Astronomical Institute, St. Petersburg State University, St. Petersburg, Russia, and Main (Pulkovo) Astronomical Observatory of RAS, Pulkovskoye shosse 60, St. Petersburg 196149, Russia*
[8]*Instituto de Astrofisica de Canarias, La Laguna (Tenerife)*
[9]*INAF, Osservatorio Astrofisico di Torino, Italy*
[10]*Finnish MAGIC Consortium, Turku, Finland*
[11]*University of Geneva, Department of Astronomy, Versoix, Switzerland*
E-mail: marina.manganaro@phy.uniri.hr

The BL Lac object 1ES 2344+514 was one of the first sources to be included in the extreme high-peaked BL Lac (EHBL) family. EHBLs are characterised by a broadband spectral energy distribution featuring the synchrotron peak above ~ 1 keV. 1ES 2344+514 was detected in VHE gamma rays for the first time by the Whipple telescope in 1995. The extreme nature of 1ES 2344+514 in the X-ray band was observed in 1996, when Beppo-SAX detected a large 0.1-10 keV flux variability on timescales of a few hours, during another bright outburst in the X-ray band. This extreme behavior of the source triggered several multi-wavelength campaigns in the following years, in which the source appeared to be in a low state. In August 2016, FACT detected the source in a high state, triggering multi-wavelength observations. The combination of MAGIC, FACT and Fermi-LAT spectra provides an unprecedented characterisation of the inverse Compton peak for this object during a flaring episode. We collected multi-wavelength data, and modeled the broadband emission during this peculiar flaring episode using a leptonic and a hadronic model. The source was in an extreme synchrotron state. The peak frequency obtained from the leptonic model corresponds to a synchrotron peak ν_s at 18 keV. The shift of peak frequency with respect

to previous observations is of about two orders of magnitude. A harder than usual intrinsic VHE gamma-ray spectrum is observed, with $\Gamma = 2.04 \pm 0.12_{stat} \pm 0.15_{sys}$. The leptonic and hadronic models both describe successfully the data, but require a significantly different magnetization of the emitting zone. Our conclusion is that 1ES 2344+514 belongs to a subcategory of EHBLs, which reveal to be extreme only in some circumstances.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

A 'NEW' RADIUS-LUMINOSITY RELATION: USING THE NEAR-INFRARED CaII TRIPLET

M. L. Martínez–Aldama[1], S. Panda[1,2], M. Marinello[3], B. Czerny[1], P. Marziani[4] and D. Dultzin[5]

[1] *Center for Theoretical Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland*
[2] *Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, ul. Bartycka 18, 00-716 Warsaw, Poland*
[3] *Laboratório Nacional de Astrofísica, R. dos Estados Unidos, 154 - Nações, Itajubá - MG, 37504-364, Brazil*
[4] *INAF-Astronomical Observatory of Padova, Vicolo dell'Osservatorio, 5, 35122 Padova PD, Italy*
[5] *Universidad Nacional Autonóma de México Instituto de Astronomía: Ciudad de Mexico, Distrito Federal, MX 04510, Mexico*
E-mail: mmary@cft.edu.pl

The Radius-Luminosity (R–L) relation has been an excellent option to estimate the black hole mass for single-epoch objects. However, with the inclusion of new sources, particularly those radiating close to the Eddington limit, has increased the scatter in the R–L relation bringing into discussion the validity of the R–L relation for the general AGN population. Since the accretion rate intensity seems to be the main driver behind this scatter, corrections based on it have been suggested to recover the low scatter in the R–L relation. However, a self-correlation in the determination of this parameter, makes it less reliable. Thus there is a need to search for other observables which, when incorporated as a correction, can streamline the R-L relation. Particularly, the Eigenvector 1 scheme has found that the intensity of the very low–ionization lines such as optical FeII and the Near–Infrared (NIR) CaII triplet are driven by the accretion rate. Both lines have ionization potentials very similar and according to the photoionization results, they are emitted under the same physical conditions. Recently, a correction based on the optical FeII has been proposed, recovering a low-scatter in the R–L relation. Combining the aforementioned deductions, we present a correction based on the NIR CaII triplet considering a sample of 58 sources with $42.5 < \log L_{\rm opt} < 46.8$ at $0.01 < z < 1.68$. The CaII shows a better correlation with the accretion rate than FeII. The corrections are done in two ways: (1) throughout the linear relation between FeII and CaII, and (2) considering the measured time delay of Hβ (for only 15 sources). The first case provides better results and a scatter similar to one obtained with FeII. In the second case, the limited sample affects the recovery of a good correction. These results show the relevance and the potential use of the CaII ion, which should be considered for future observational programs.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

ALGEBRAIC DEPENDENCIES AND REPRESENTATIONS OF COSMOLOGICAL PARAMETERS

Ž. Mijajlović[1] and D. Branković[2]

[1]*Faculty of Mathematics, Studentski trg 16, 11000 Belgrade, Serbia*
[2]*School of Electrical Engineering, Bulevar kralja Aleksandra 73, 11000 Belgrade, Serbia*

E-mail: zarkom@matf.bg.ac.rs, danijela@etf.bg.ac.rs

Accurate determination of cosmological parameters is one of the main tasks of modern cosmology as they may provide a unique probe of the physics of the early universe, as well as computing of the main events in the past time-line and prediction of the future evolution of the universe. Cosmological parameters are considered mostly as functions of time, but their dependence on time in general is transcendental. Moreover, they cannot be represented in the closed form by elementary functions using time variable, particularly in the presence of the cosmological constant Λ, due to the elliptic integral (which comes as a solution of the Friedmann equations) used in the representation:

$$\tau = \frac{1}{H_\tau} \int_0^1 \frac{s\, ds}{\sqrt{\Omega_{r\tau} + \Omega_{m\tau} s + \Omega_{k\tau} s^2 + \Omega_{\Lambda\tau} s^4}}.$$

However, if the time variable τ is excluded, there are algebraic dependencies between the main cosmological parameters such as the scale factor a_τ, Hubble parameter H_τ, redshift and density parameters $\Omega_{i\tau}$ at time τ related to Λ, space curve κ, radiation r and baryonic matter m. In this article we discuss these mutual dependencies at a certain time τ but also at some particular time τ_0, which may correspond to the contemporary measurements. Two possible applications are presented. The first one is the representation of cosmological parameters in respect to some chosen parameter, while the second one considers the computation of values of all cosmological parameters at particular points in the evolution of the universe, such as the transition point from radiation dominated to matter dominated era, recombination or the starting point of the accelerated expansion of the universe.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

SATURN - A SERBIAN JOURNAL ON ASTRONOMY FROM THE PAST

Ž. Mijajlović and N. Pejović

Faculty of Mathematics, Studentski trg 16, 11000 Belgrade, Serbia
E-mail: zarkom@matf.bg.ac.rs, nada@matf.bg.ac.rs

The publication of the astronomical journal "Saturn" started in 1935 as a messenger of the Yugoslavian "Astronomical Society", founded in Belgrade a year before. This monthly periodical was conceived as a semiprofessional journal with many popular articles intended to astronomy lovers. At the same time the journal was planned to be useful to professional astronomers, surveyors, meteorologists and seismologists, because there were published also scientific articles. Popular and professional articles were separated into different sections, and there also was a section with short notes and news for people interested in astronomy. The members of the Editorial board were a general and academician Stevan Bošković, known for his very extensive geodetic measurements in Serbia in the first decade of XX century and his translation of famous Tsinger's three volume books on astronomy, and Vojislav Grujić who was holding two doctoral dissertations in mathematics related to astronomy, obtained at Strasbourg University in 1933. Articles were published in Cyrillic and Latin, reflecting in this way both variants of Serbo-Croation. Slovenian authors published in Slovenian. Some of the leading Yugoslavian astronomers and physicists published there, e.g. Serbian Milutin Milanković, Croat Andrej Mohorovičić and Slovenian Lavo Čermelj. The journal was published for the period of six year, 1935-1940. All 60 volumes were recently digitized and deposited in the Virtual Library of the Faculty of Mathematics in Belgrade.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
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Contributed Talk

KOMPLEKS ASTRONOMSKE OPSERVATORIJE U BEOGRADU I ASTRONOMSKA STANICA VIDOJEVICA

Vesna Mijatović, Zorica Cvetković and Gojko Djurašević

Astronomska opservatorija, Volgina 7, 11060 Beograd 38, Srbija
E-mail: vesna@aob.rs, zorica@aob.rs, gdjurasevic@aob.rs

Astronomska opservatorija u Beogradu je gradjevinski kompleks koji je zbog svojih izuzetnih arhitektonskih vrednosti 2001. godine proglašen za spomenik kulture. Osim jedinstvenih arhitektonskih objekata, Opservatorija poseduje veoma značajnu i vrednu Zbirku astronomskih instrumenata. Usled hroničnog nedostatka sredstava za redovno održavanje svi objekti Astronomske opservatorije su bili ugroženi i izloženi ubrzanom propadanju. Od 2015. godine Astronomska opservatorija počinje integralnu zaštitu, čuvanje i prezentovanje svog, kako kulturno–spomeničkog, tako i naučno–tehničkog nasledja. Konzervatorsko–restauratorski radovi na nekim objekatima kompleksa Opservatorije su završeni, a na ostalim su u toku ili tek predstoje. Istovremeno Opservatorija proširuje infrastrukturu na Astronomskoj stanici Vidojevica. U poslednjih pet godina izgradjena su tri nova paviljona, montažni paviljon sa pokretnim krovom, paviljon sa obrtnom kupolom u kome je instaliran 1.4 m teleskop i paviljon za smeštaj 40 cm teleskopa MEADE. Nabavljeni su savremeni detektori zračenja i radi se na robotizaciji posmatračkog procesa.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

FUNCTIONAL RELATIONS BETWEEN TIME, RESONANCE STRENGHTS, YARKOVSKY DRIFT SPEEDS AND ECCENTRICITIES IN MOTIONS OF RESONANT ASTEROIDS

Ivana Milić Žitnik

Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia
E-mail: ivana@aob.rs

The dynamics of asteroids in the Solar System pose numerous interesting questions for celestial mechanics. Asteroid dynamics are determined by the interaction between gravitational (i.e. mean-motion resonance) and non-gravitational (i.e. Yarkovsky thermal effect) forces. The Yarkovsky effect plays an important role in asteroids drifting in the Solar System. Many asteroids are continuously pushed by the Yarkovsky effect into mean motion resonances (MMRs) and then ejected after a period of time due to the instability of MMRs. The interplay between MMR and the Yarkovsky effect in motion of asteroids is very important and very complex. Here we present our new results about the effect of 11 two-body MMRs with Jupiter (resonances with wide range of strength), on the mobility of an asteroid's semi-major axis caused by the Yarkovsky effect (semi-major axis drift speed). This study is accomplished using numerical integrations of very large number of test asteroids with higher eccentricities. The asteroids' motions becomes more complicated on higher eccentricities because of close approaches with planets and dynamically unstable regions in MMRs. Here we will present our functional relation that describes dependence of the average time lead/lag $\langle \mathrm{d}tr \rangle$ (time that asteroid spent to make successful crossing over MMR due to the Yarkovsky effect) on the strength of the resonance SR and the semi-major axis drift speed $\mathrm{d}a/\mathrm{d}t$ with eccentricities (0.1, 0.2). We compared this relation with our previous functional relation between $\langle \mathrm{d}tr \rangle$, SR, $\mathrm{d}a/\mathrm{d}t$ with eccentricities (0, 0.1) and discussed their similarities and differences. Finally, we analysed calculated $\langle \mathrm{d}tr \rangle$ from these functional relations comparing with obtained values $\langle \mathrm{d}tr \rangle$ from the numerical integrations.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

VARIOUS EFFECTS OF GALAXY FLYBYS: DEPENDENCE ON IMPACT PARAMETER

A. Mitrašinović[1], M. Mićić[1], M. Smole[1], N. Stojković[1], N. Martinović[2] and S. Milošević[3]

[1]*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*
[2]*Mathematical Institute of the Serbian Academy of Sciences and Arts, Kneza Mihaila 36, 11000 Belgrade, Serbia*
[3]*Department of Astronomy, Faculty of Mathematics, Studentski trg 16, 11000 Belgrade, Serbia*

E-mail: amitrasinovic@aob.rs, micic@aob.rs, msmole@aob.rs, nstojkovic@aob.rs, nmartinovic@turing.mi.sanu.ac.rs, stanislav@matf.bg.ac.rs

Galaxy flybys, interactions where two independent halos inter-penetrate but detach at a later time and do not merge, occur frequently at lower redshifts. Due to their violent nature, these interactions can significantly impact evolution of individual galaxies - from mass loss, and shape transformation, to emergence of tidal features, and formation of morphological disc structures (e.g. bar, spiral arms).

Based on N-body simulations of galaxy flybys, these various effects will be discussed briefly in the context of different impact parameters. While there is clear dependence on impact parameter for some effects, results suggest that secular evolution of galaxies should not be neglected.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

ON NEARLY CIRCULAR ORBITS

Slobodan Ninković

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
E-mail: sninkovic@aob.rs

Nearly circular orbits are characteristic for thin discs of spiral galaxies, the subsystem and the type of galaxies to which the Sun and the Milky Way belong. Such orbits are studied in a way different from the usual one (epicycles). Formulae wherein the total energy and the conserved angular momentum component are expressed in terms of the mean distance and eccentricity are derived. The classical results concerning the sinusoidal dependence of distance on time and the ratio of the circular period to the anomalistic one for the same mean distance are confirmed. However, it is shown that, whereas the dependence on time even for a very low eccentricity begins to deviate from the sinusoidal form noticeably, the period ratio remains practically unaffected for eccentricities almost as high as 0.5.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

THE CAFE PROJECT: CORRELATION BETWEEN Fe II AND Ca II IN ACTIVE GALAXIES

S. Panda[1,2], M. L. Martínez Aldama[1], M. Marinello[3], B. Czerny[1], P. Marziani[4] and D. Dultzin[5]

[1] *Center for Theoretical Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland*
[2] *Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, ul. Bartycka 18, 00-716 Warsaw, Poland*
[3] *Laboratório Nacional de Astrofísica, R. dos Estados Unidos, 154 - Nações, Itajubá - MG, 37504-364, Brazil*
[4] *INAF-Astronomical Observatory of Padova, Vicolo dell'Osservatorio, 5, 35122 Padova PD, Italy*
[5] *Universidad Nacional Autonóma de México Instituto de Astronomía: Ciudad de Mexico, Distrito Federal, MX 04510, Mexico*

E-mail: panda@cft.edu.pl

Resolving the complexity in Fe II species in quasar spectra has been an ongoing work for over 40 years. First identified and reported for the prototypical Narrow-line Seyfert 1 galaxy, I Zw 1 (Phillips 1978a), the study has made a niche of its own in the field of AGN research. Seminal works led by Boroson & Green (1992), Verner et al. (1999), Sigut & Pradhan (2003) and others encapsulate the 'yet to be complete' understanding of the physics of the line formation for this first-ionized state of iron (Fe II). A major part of the puzzle is lent by the sheer number of spectral lines in Fe II that spans across a wide energy range (from UV to NIR). This extended emission seen in the spectra mimics a continuum of sorts, thus the telltale term *pseudocontinuum.*

Gaining knowledge from the past studies and of our own, in this study we search for a reliable proxy to Fe II. This proxy, Ca II, is a much simpler ionic species which is characterized by its triplet in the near-infrared part of an AGN spectrum. The analogous line excitation mechanisms (dominated by the Lyα fluorescence and collisional excitation) for the production of these two species is confirmed by the tight correlation between the respective line strengths that we observe from our up-to-date collection of coincident measurements in the optical and NIR, and re-affirmed by our photoionization models. Additionally, our models constrain the physical parameters, such as the required level of ionization and the density of the medium (i.e. the broad line region) that contain these ionic species, hinting also to the cloud's composition and structure (Panda et al. 2020b; Panda 2020). This study reveals the utility of the Ca II as a proxy for Fe II in ways more than one, primarily, establishing a new radius-luminosity relation and in quasar main sequence studies.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

LUCKY IMAGING AT VIDOJEVICA

R. Pavlović, Z. Cvetković, G. Damljanović and M. D. Jovanović

Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
E-mail: rpavlovic@aob.rs

We use a Lucky Imaging technique to obtain images with much improved angular resolution on a 1.4 m telescope "Milanković" at Vidojevica. We present the very first results from a short observational campaign on the 1.4 m telescope and quantify the performance of our system in seeings not better than 1.5 arcseconds. Also, we are investigating the limits of our equipment and possible application to other programmes.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
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Contributed Talk

FULLY AUTOMATED PYTHON TOOL FOR AGN SPECTRA ANALYSIS – FANTASY

N. Rakić[1], D. Ilić[2] and L. Č. Popović[3]

[1]*Faculty of Science, University of Banjaluka, Mladena Stojanovića 2, 78000 Banjaluka, Republic of Srpska, B&H*
[2]*Faculty of Mathematics, University of Belgrade, Studentski Trg 16, 11000 Belgrade, Serbia*
[3]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
E-mail: nemanja.rakic@pmf.unibl.org, dilic@matf.bg.ac.rs, lpopovic@aob.bg.ac.rs

Here we present a python code for the analysis of the optical spectra of active galactic nuclei (AGN), named Fully Automated pythoN Tool for AGN Spectra anal-Ysis – FANTASY. Its application programming interface (API) is created to be user friendly, and it poses most of the needed tools to analyze optical spectra of AGN from pre-processing (reading spectra, correction for galactic extinction and redshift, rebinning and etc.) to the fitting of the spectra (host galaxy removal, continuum, and line modeling, and MCMC uncertainty calculation). All of the intermediate and final results of the process are displayed and ready for further analysis. Additionally, we implement a set of tools for inter-calibration of series of spectra from a single object, which is the step necessary for time-domain studies of AGN (i.e. reverberation mapping). FANTASY is an open-source code, available to the astronomical community through GitHub, and will hopefully find its application in the future large spectral surveys.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

STATISTICS OF RECOILING SUPERMASSIVE BLACK HOLES FROM COSMOLOGICAL SIMULATIONS

M. Smole[1], M. Mićić[1], A. Mitrašinović[1], N. Stojković[1], N. Martinović[2] and S. Milošević[3]

[1]*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*
[2]*Mathematical Institute of the Serbian Academy of Sciences and Arts, Kneza Mihaila 36, 11000 Belgrade, Serbia*
[3]*Department of Astronomy, Faculty of Mathematics, Studentski trg 16, 11000 Belgrade, Serbia*

E-mail: msmole@aob.rs, micic@aob.rs, amitrasinovic@aob.rs, nstojkovic@aob.rs, nmartinovic@turing.mi.sanu.ac.rs, stanislav@matf.bg.ac.rs

Mergers of supermassive black holes (SMBHs) are one of the most powerful sources of gravitational wave emission. During SMBH mergers asymmetry in the binary system will lead to the asymmetric emission of gravitational radiation and BH recoil. In this process newly formed SMBH receives a kick, whose magnitude depends on the characteristics of the SMBH binary system. Those recoiling SMBHs could be observed as spatially offset active galactic nuclei (AGN).

We compare trajectories of recoiling SMBHs in analytical and numerical models of galaxy merger remnants. Our results suggest that SMBH escape velocities in numerical major merger remnant galaxies can be up to 25 per cent lower compared to those in analytical models. Further, we use results from Illustris cosmological simulation to explore statistics of spatially offset AGN in numerical and analytical models.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

SEG ACTIVITIES IN EUROPLANET

V. A. Srećković[1], A. Nina[1], M. Radovanović[2], A. Kovačević[3], L. Č. Popović[4], A. Černok[5], B. P. Marinković[1], J. Radović[6], V. Čelebonović[1], I. Milić Žitnik[4], Z. Mijić[1], N. Veselinović[1], A. Kolarski and other members of SEG

[1]*Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia*
[2]*Geographical Institute Jovan Cvijić SASA, Belgrade, Serbia*
[3]*Department of astronomy, Faculty of Mathematics, University of Belgrade, Studentski trg 16, Serbia*
[4]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
[5]*Royal Ontario Museum, Center for the applied planetary mineralogy, Toronto, ON, Canada*
[6]*Faculty of Physics, University of Belgrade, Studentski trg 16, Serbia*
E-mail: vlada@ipb.ac.rs

In this contribution, we report on progress and activities of the Serbian Europlanet Group (SEG) within the Europlanet Society. The Europlanet Society is a scientific organization that promotes planetary science and related fields across Europe, and it operates within 10 hubs. The SEG with its 20 active scientists from different institutions is included in the Europlanet South Eastern European Hub (ESEEH). We report on two EUROPLANET meetings (see e.g., Nina et al. 2019) and other activities organized by the SEG and present further plans related to the EUROPLANET and ESEEH.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

EXAMINATION OF ELEMENTS OF GALACTOCENTRIC ORBITS OF THE THIN DISK STARS FROM THE SOLAR NEIGHBOURHOOD BY VARYING POTENTIAL OF THE GALAXY

Milan Stojanović

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
E-mail: mstojanovic@aob.rs

The goal of this dissertation is to determine values of local dynamical constants. This goal is achieved through examination of multiple samples of selected stars near the Sun. The selection is done by using planar and vertical eccentricities as sampling criteria. The solution for calculating eccentricities is given. In the next step a large sample of stars is selected by defining upper limits for eccentricities and vertical amplitude. Then nested subsamples are formed in two ways: in the first one upper eccentricity limit is subjected to decreasing, in the other one this is the case with upper amplitude of oscillations perpendicular to the plane. The values of the local dynamical constants are deduced by analysing this material.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

SOLAR NEIGHBOURHOOD KINEMATICS BASED ON THE GAIA DATA

M. Stojanović[1], R. Cubarsi[2], Z. Cvetković[1], R. Pavlović[1] and S. Ninković[1]

[1]*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*
[2]*Departament de Matemàtiques, Universitat Politècnica de Catalunya, Barcelona, Spain*

E-mail: mstojanovic@aob.rs

We have formed a sample of stars closer than 100 pc to the Sun from the Gaia catalogue. Out of them we have selected those with necessary data – direction, parallax, proper motion and line-of-sight speed. The kinematics of this sample is analyzed. The sample size is 74,339 stars. Using a model of the Milky Way the orbits of these stars around the Milky way centre are calculated.

It is shown, as can be expected, that in the Solar neighbourhood stars mostly belong to the thin disc (about 80% and more). This is followed by the thick disc which has a fraction of more than 15%, whereas the lowest fraction belongs to the halo (between 2% and 4%).

The duplicity and the kinematical similarity are also examined.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

ACTIVITIES OF THE ASTRONOMICAL SOCIETY EUREKA IN THE PERIOD 2017-2020

Z. Tomić, M. Stanković, D. Jovanović, S. Andjelković and A. Petrović

Astronomical Society Eureka, Kralja Petra Prvgo 3, 37000 Kruševac, Serbia
E-mail: eurekakutak@gmail.com

In this paper we will present all activities that were done by members of the Astronomical Society Eureka in period 2017-2020 in popularization of Astronomy iz Kruševac and Serbia. Many projects were done in Kruševac, but also were realized in other cities in Serbia. In 2020. the Society started preparing and realizing online activities that will be described in this paper as well.

Contributed Talk

SERBIA IN ASTRONOMICAL CONTESTS BETWEEN 2017 - 2020

S. Vidojević[1], V. Prokić[2], S. Ninković[3] and B. Simonović[4]

[1]*State University of Novi Pazar, Department of Mathematical Sciences, Vuka Karadžića bb, 36300 Novi Pazar, Serbia*
[2] *Gymasium "Svetozar Marković", Branka Radičevića 1, 18000 Niš, Serbia*
[3]*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*
[4]*Astronomical Society "Rudjer Bošković", Kalemegdan, Gornji grad 16, 11000 Belgrade*

E-mail: sonja@math.rs, vera.prokic@gsm-nis.edu.rs, sninkovic@aob.rs, baltazartodor@yahoo.com

The subject concerns contests in astronomy and astrophysics under the supervision of the National Astronomical Olympic Committee of Serbia, both national and international, during 2017-2020. Included are: contests in Serbia (Regional and Republican), as well as Serbian participation in contests held abroad, such as International Olympiad in Astronomy and Astrophysics, St-Petersburg Astronomical Olympiad and Estonian on-line Astronomical Olympiad.

XIX SERBIAN ASTRONOMICAL CONFERENCE
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Contributed Talk

SOME GAS-STREAM VELOCITIES IN UU Cas CLOSE BINARY STAR

Ištvan Vince

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
E-mail: ivince@aob.rs

This investigation deals with determination of terminal velocity of gas-stream in UU Cas close binary at two particular orbital phases: 0.164 and 0.826. The change of selected, accurately observed, profiles of two helium lines ($\lambda\lambda$4471.48 Å, 4921.93 Å) and one hydrogen line (λ4861.33 Å) taken with echelle spectrograph of Apache Point Observatory was analyzed. We noticed a pronounced change from red to blue asymmetry at these two phases, respectively. Supposing that spectral lines observed at orbital phase 0.826 have a P Cygni profile, some kind of terminal velocity of gas streams was evaluated. The obtained average terminal velocity amounted to 690±20 km/s. Unexpectedly, similar value of terminal velocity (650±30 km/s) was also obtained at orbital phase 0.164, but with opposite sign (inverse P Cyg profile). Moreover, from the line profiles main absorption peaks' wavelength variation with orbital phase, the semi-amplitude of the line source orbital velocity curve was estimated. The acquired average value of semi-amplitude was 188±9 km/s, indicating that this component of line profile represent gas motion inherent with donors' motion. Besides, we identified a narrow component in all three, above mentioned, line profiles which wavelength variation (in velocity units: 25±20 km/s) did not significantly depend on orbital phase. We suppose that it originates from far circum-binary gas envelope or it has interstellar origin.

The investigation we finish with a brief discussion/consideration of the possible influence of the deformation of spectral line profiles due to presence of gas-streams inside and outside the binary system on the systematic error of the radial velocity curve semi-amplitude determination.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

DEPARTMENT OF ASTRONOMY AT PETNICA SCIENCE CENTER: 2018-2020

D. Vukadinović[1], N. Milanović[2], S. Milošević[3], M. Bošković[4] and N. Božić[2]

[1]*Max-Planck-Institute für Sonnersystemforschung, Justus-von-Liebig-Weg 3, 37075 Göettingen, Germany*
[2]*Petnica Science Center, Poštanski fah 14, 14000 Valjevo, Serbia*
[3]*Faculty of Mathematics, University of Belgrade, Studentski trg 16, 11000 Belgrade, Serbia*
[4]*SISSA - International School for Advanced Studies, Via Bonomea 265, 34136 Trieste, Italy*

E-mail: vukadinovic@mps.mpg.de, nikolinamilanovicc@gmail.com, bozicn@petnica.rs, stanislav@matf.bg.ac.rs, mboskovi@sissa.it

We review the activities of the Department of Astronomy at Petnica Science Center (PSC) within the years 2018-2020. The Department of Astronomy's dominant activities are aimed at high school students. The main educational principle of PSC is "education of students by other students" as high school students are taught and mentored mostly by undergraduate students. The full educational cycle at the Department of Astronomy presumes two years during which participants are introduced to the basics of astronomy and research methodology and, as a result of that, finish a research project. We will outline the present structure of the astronomical educational activities at PSC, topics of the participants' research projects and other activities in the mentioned period and future plans.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

TeV DARK MATTER SEARCH PROGRAM WITH THE CHERENKOV TELESCOPE ARRAY: THE STRATEGY AND SYNERGIES WITH CURRENT GAMMA-RAY EXPERIMENTS

Gabrijela Zaharijas, for the CTA consortium

Center for Astrophysics and Cosmology, University of Nova Gorica, Vipavska 13, SI-5000 Nova Gorica, Slovenia

E-mail: gabrijela.zaharijas@ung.si

High-energy gamma rays are among the most promising tools to constrain or reveal the nature of dark matter, in particular the Weakly Interacting Massive Particles (WIMP) models. The Cherenkov Telescope Array (CTA) is well into its preconstruction phase and will soon probe the high-energy gamma-ray sky in the 20 GeV - 300 TeV energy range. Thanks to its improved energy and angular resolutions as well as significantly larger effective area when compared to the current generation of ground based Cherenkov telescopes, the CTA is expected to probe a parameter space of heavier dark matter (above 100 GeV), with unprecedented sensitivity, reaching the dark matter thermal annihilation rate at the TeV regime.

This talk will summarise the planned dark matter search strategies with CTA, focusing on the signal of dark matter in the centre of our Galaxy. As observed with the Fermi LAT at lower energies, this region exhibits complex gamma-ray emission and the CTA is expected to be the first ground based observatory sensitive to large scale diffuse astrophysical emission, also present in that region. In this talk we report on the collaboration effort to study the impact of extended astrophysical emission backgrounds on dark matter search, based on the astrophysical emission observed with the Fermi LAT at lower energies and to suggest the promising data analysis and observational strategies for the upcoming CTA data.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Contributed Talk

QUASI-PARALLEL COLLISIONLESS SHOCKS: REVEALING THE NATURE OF COSMIC PARTICLE ACCELERATORS

V. Zeković and B. Arbutina

Faculty of Mathematics, University of Belgrade, Studentski trg 16, 11000 Belgrade, Serbia

E-mail: vlada@matf.bg.ac.rs, arbo@matf.bg.ac.rs

The collisionless shocks are associated with the most energetic phenomena in space, such as active galactic nuclei, supernovae, black holes, pulsars, and galaxy mergers. These shocks propagate through completely or partially ionized medium which is embedded in an ambient magnetic field. They are thought to be the most common source of the highest energy particles in a cosmic plasma. We explain the nature of quasi-parallel collisionless shocks and consequential particle acceleration. The plasma particles that are stricken by the shock front, become energized and gain a chaotic-like behaviour which dissorders the plasma behind the shock. In contrast to their tendency to increase the plasma entropy, shocks are governed by highly coherent and finely tuned, self-consistent plasma processes. By the means of particle-in-cell and test particle simulations, and linear plasma theory, we enter the microworld of collisionless shocks. We explain how quasi-parallel shocks are triggered and mediated by resonant-like electromagnetic micro-instabilities. We give a short review on the shock reformation process and present a new physical model. Finally, we explain the mechanisms of ion and electron thermalization and acceleration at the nature leading-edge particle accelerators.

Posters

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

OBSERVATIONS OF SELECTED STANDARD STARS IN NARROW-BAND FILTERS FROM THE AS VIDOJEVICA

B. Arbutina[1], M. M. Vučetić[1] and P. Kostić[2]

[1]*Department of Astronomy, Faculty of Mathematics, University of Belgrade, Studentski trg 16, 11000 Belgrade, Serbia*
[2]*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*

E-mail: arbo@matf.bg.ac.rs, mandjelic@matf.bg.ac.rs, pkostic@aob.bg.ac.rs

We present the results of the observations of selected standard stars in Astrodon narrow-band Hα, [SII] and red continuum filters by the 1.4m Milanković telescope at the AS Vidojevica. The telescope time was granted through the instrumental proposal aimed at testing the narrow-band filters and the observations were carried out in August 2019. The standard stars selected were: BD+33d2642, BD+28d4211, BD+25d4655, GD248, G93-48 and LDS749B. Based on these observations, we give the estimated transformation coefficients for absolute calibration.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

DeepMerge: STUDYING DISTANT MERGING GALAXIES WITH DEEP NEURAL NETWORKS

A. Ćiprijanović[1], G. F. Snyder[4], B. Nord[1,2,3] and J. E. G. Peek[4,5]

[1]*Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510, USA*
[2]*Kavli Institute for Cosmological Physics, University of Chicago, Chicago, IL 60637, USA*
[3]*Department of Astronomy and Astrophysics, University of Chicago,IL 60637, USA*
[4]*Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA*
[5]*Department of Physics & Astronomy, Johns Hopkins University, 3400 N. Charles Street, Baltimore, MD 21218, USA*

E-mail: aleksand@fnal.gov

The hierarchical merging of galaxies is both a probe of the cosmos as a whole to test the canonical ΛCDM cosmology paradigm. A particularly interesting period is "cosmic high noon" at redshifts $z \sim 2-3$, during which star formation rates were the highest, and significant amounts of stellar mass assembled into galaxy-scale bodies. Detecting galaxy mergers in observations by conventional automated methods (which use extracted parameters of galaxy structure - asymmetry, clumpiness, concentration etc.) or by visual inspection has proven to be quite time-consuming and prone to errors. Convolutional Neural Network (CNNs) are a primary representative of deep learning algorithms which are used in computer vision tasks by training to detect features in images. Here we use CNN to learn directly from images (without the need to extract morphology parameters) of distant merging galaxies in order to distinguish between merging and non-merging objects and show that deep learning can outperform other techniques in this task.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

DEEP PHOTOMETRY OF SPIRAL GALAXY NGC 941

J. Horvat[1] **and A. Vudragović**[2]

[1]*Faculty of Mathematics, Studentski trg 16, 11000 Belgrade, Serbia*
[2]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
E-mail: jasminahorvat2705@gmail.com

We have modelled surface brightness profile of the spiral galaxy NGC 941 using SDSS Stripe82 deep images in the g- and r-bands. The depth of Stripe82 images reaches the stellar halo brightness level, which was our basic motivation to start the study. In the case of the studied galaxy, the surface brightness limit reached in the r-band was 29.9 mag arcsec$^{-}2$. There are two main pathways to model surface brightness profile - two and three dimensional decomposition. We have done both isophotal analysis inside elliptical apertures and simultaneously modelled Sersic subcomponents to find that the surface brightness profile is missclassified as Type II. The "feature" responsible for apparent downbending of the light profile is actually the spiral arm structure. This naturally rises the question whether different types of galaxy surface brightness profiles are truly bending or their behaviour is a consequence of modelling done in two, instead of three dimensions.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

CORRESPONDENCE BETWEEN MILUTIN MILANKOVIĆ AND ELSE WEGENER KÖPPEN

Natalija Janc[1], Milivoj B. Gavrilov[2], Slobodan B. Marković[2], Vojislava Protić Benišek[3], Luka Č. Popović[3] and Vladimir Benišek[3]

[1] *Baltimore, Maryland 21212, USA*
[2] *University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia*
[3] *Astronomical Observatory, Volgina 7, P.O.Box 74, 11060 Belgrade, Serbia*
E-mail: natalijanc@earthlink.net

Milutin Milanković (1879–1958) had a very close collaboration with Wladimir Köppen (1846–1940) and Alfred Wegener (1880–1930). Else Wegener (1892–1992) was the daughter of Wladimir Köppen and the wife of Alfred Wegener.

Three letters and one postcard of Else Wegener and one letter / response of Milutin Milanković, which is in the legacy of Milutin Milanković in SANU in Belgrade, have been preserved from the correspondence.

Else Wegener was interested in the natural sciences. She worked on the biographies of Carl Anton Bjerknes (1825–1903), a Norwegian mathematician and physicist, well-known for his studies in hydrodynamics, of her husband, and of her father. For the first time, as far as the authors know, in 1930 she addressed Milanković with a request to send her information about the journals she needed while translating Bjerknes' biography from Norwegian. That letter is not in SANU, but it is known indirectly from the letter of Milutin Milanković sent to Vojislav Mišković (1892–1976), the director of the Astronomical Observatory.

To supplement the biography of Wladimir Köppen, she asked Milanković in 1949 to write to her how his collaboration with Köppen began on the book *Climates of the Geological Past* and about their correspondence in general. Milanković answered that he presented his personal impressions in the German edition of the book *Through the Universe and Centuries*, and about scientific cooperation in the *Canon*. That scientific cooperation lasted from 1921 until Köppen's death. Milanković received altogether 73 letters or postcards from Köppen, but he mostly kept only the drafts of his answers. Part of those contacts were near the end of Köppen's work at the Hamburg German Naval Observatory that dealt with meteorology, oceanography, geophysics, aeronomy, Earth magnetism, time service, instrument gauging, etc.

In addition, Else Wegener informs Milutin Milanković that their family copy of the translation into German of *Through the Universe and Centuries* was sent with the legacy of Wladimir Köppen to the Geophysical Institute of the Prussian State Library in Berlin. She also asked Milanković to send her a copy of *Canon*, which Milanković

did immediately. Else received the book, thanked Milanković and forwarded the *Canon* to the Academy.

The correspondence is short, but the content of the letters is interesting and contributes to the study primarily of Wladimir Köppen, as well as the participation of other important scholars who assisted Else Wegener in the work on his biography.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

MONITORING VLF SIGNAL PERTURBATIONS INDUCED BY SOLAR ACTIVITY DURING JANUARY 2005

A. Kolarski[1] and D. Grubor[2]

[1] *Technical Faculty Mihajlo Pupin, University of Novi Sad, Djure Djakovića bb, 23000 Zrenjanin, Serbia,*
[2] *Faculty of Mining and Geology, University of Belgrade, Djušina 7, 11000 Belgrade, Serbia*

E-mail: aleksandrakolarski@gmail.com, davorka.grubor@rgf.rs

Simultaneous monitoring of VLF (3-30 kHz) radio signals, transmitted within Earth-Ionosphere waveguide, from USA (NAA/24.0 kHz), GB (GQD/22.1 kHz) and Australia (NWC/19.8 kHz) towards Serbia and registered by narrowband AbsPAL receiving system, stationed at Institute of Physics in Belgrade (44.85N, 20.38E), was carried out. Series of Solar events during January 2005 were surveyed and analysed. Modeling of related perturbed D region (50-90 km) ionospheric conditions, by means of LWPC program routine, was conducted. Based on the Wait′s model of the lower Ionosphere, electron density height profiles were estimated. Inspected Solar events revealed different effects as observed on monitored VLF signal traces. Main results are presented in this paper.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

STARK BROADENING OF Co II SPECTRAL LINES FOR STELLAR SPECTRA INVESTIGATIONS

Z. Majlinger[1], M. S. Dimitrijević[1] and V. A. Srećković[2]

[1]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
[2]*Institute of Physics Belgrade, BU, Pregrevica 118, 11080 Belgrade, Serbia*
E-mail: zlatko.majlinger@gmail.com, mdimitrijevic@aob.rs, vlada@ipb.ac.rs

In this contribution Stark Full Widths at Half Maximum for 46 Co II multiplets have been calculated (Majlinger et al., 2018) by modified semiempirical method described in Dimitrijević and Konjević (1980). The calculated results have been used to investigate the importance of Stark broadening mechanism for Co II lines in A type star and DA and DB white dwarf atmospheres (Majlinger et al., 2020). Stark broadening parameters from this paper will enter in the STARK-B database (http://stark-b.obspm.fr/).

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

COMPARISON OF GROUND-BASED AND GAIA-BASED PHOTOMETRY FOR ASTROMETRIC RADIO SOURCES

Zinovy Malkin

Pulkovo Observatory, Pulkovskoe Sh. 65, St. Petersburg, 196140, Russia
E-mail: malkin@gaoran.ru

Comparison of the positions of the same objects as determined from the VLBI observations at radio waves and optical observations of the Gaia mission plays a very important role in many studies related to both constructing celestial reference system and frame, and physics of the celestial bodies. Obviously, the accuracy of scientific conclusions derived from such studies depends on the correct cross-identification of the objects in the VLBI and Gaia catalogs. Currently, this cross-identification is based of the distance between two positions, sometimes with additional criteria, such as an analysis of the position quality. In this work, a comparison was made between the optical magnitudes provided by Gaia and obtained from ground-based observations. The OCARS catalog is used for this purpose. This comparison showed that the Gaia and ground-based measurements are not always in good agreement, which my suggest mistakes in the cross-identification as well as mistakes in the ground-based photometry data. Thus, such analysis can serve as a supplement criterium for verification of both cross-identification between the Gaia and ICRF objects and photometry data obtained form various catalogs.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

ADDITIVE MANUFACTURING OF SOLAR SAIL

Ž. Medić and D. V. Lukić

Institute of Physics, Pregrevica 118, 11080 Belgrade, Serbia
E-mail: lukic@ipb.ac.rs

Advantage of graphene for solar sail applications is the extraordinary strength. A graphene monolayers tensile strength is about 200 that of steel. On the other hand pure graphene monolayers have essentially zero refectivity. Recently some graphene nanostructures shows promising theoretical results for reflectivity. We propose additive manufacturing of graphene aerogel as method of building solar sail.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

THE RELATIONSHIP BETWEEN THE 'LIMITING' YARKOVSKY DRIFT SPEED AND ASTEROID FAMILIES' YARKOVSKY *V*-SHAPES

Ivana Milić Žitnik

Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia
E-mail: ivana@aob.rs

The Yarkovsky effect is an important force to consider in order to understand the long-term dynamics of asteroids. This non-gravitational force affects the orbital elements of objects revolving around a source of heat, especially their semi-major axes. Following the recently defined 'limiting' value of the Yarkovsky drift speed at 7×10^{-5} au/Myr in Milić Žitnik (2019) (below this value of speed asteroids typically quickly jump across the mean motion resonances), we decided to investigate a relation between asteroid family Yarkovsky V-shape and the 'limiting' Yarkovsky drift speed of asteroid's semi-major axes. We have used the known scaling formula to calculate the Yarkovsky drift speed (Spoto et al. 2015) in order to determine the inner and outer 'limiting' diameters (for inner and outer V-shape borders) from the 'limiting' Yarkovsky drift speed. The method was applied on 11 asteroid families of different taxonomic classes, origin type and age, located throughout the Main Belt. Here, we present the results of our calculation on relationship between asteroid families' V-shapes (crossed by strong and/or weak mean motion resonances) and the 'limiting' diameters in the (a, $1/D$) plane. Our main conclusion is that the 'breakpoints' in changing V-shape of the very old asteroid families, crossed by relatively strong mean motion resonances on both sides very close to the parent body, are exactly the inverse of 'limiting' diameters in the a versus $1/D$ plane. This result uncovers a novel interesting property of asteroid families' Yarkovsky V-shapes.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

ROGUE PLANETS AS MEANS OF TRANSPORT

Aleksandar B. Nedeljković

Filološko-umetnički fakultet – FILUM, Univerzitet Kragujevac
E-mail: srpsko_dnf@yahoo.com

There are probably millions of rogue planets (nomadic exo-planets) in our galaxy, and there have been studies[1] about their various aspects, but we are now proposing an actual practical use for them as a means of transport for the travel to other star systems.

A rogue planet interesting to us should be rocky, and geologically very stable, without any possibility of volcanism; with a steady axis of rotation; and, very importantly, with surface gravity of almost exactly 1 G, because that is essential for long-time human survival in good health.

To such a planet, we should send thousands of our large robotic machines, with the task of drilling many thousands of kilometers of tunnels, deep and safe from cosmic radiation, meteorites etc.; probably with a number of levels or "floors" one under another; with many nuclear power-plants, with light, air, warmth, and with strong agriculture and industrial production of many kinds of goods for human needs; a whole self-maintaining, sustainable civilization deep underground, but with its own space-ships too, and strong astronomical instruments; and then, when everything is ready, we should send several million volunteers to live there. They would never return, but, eventually, sooner or later, such a rogue planet would drift near a solar system with a habitable Goldilocks-zone planet, to which their descendants could settle and terraform it for comfortable and beautiful life on the surface.

Assuming the speed of travel of perhaps 30 km/sec, it would take ten thousand years to cover one light-year of distance. But that time will pass in any case.

Preferable direction of travel would be to the galactic rim, which is safer. The main danger would be a wandering black hole, but, that can happen to us on the Earth, too, at any time now. The second greatest danger would be a fall into a star.

Basically such a populated rogue planet would be a transportation device, already in motion, so we would just need to descend on it, industrialize it, and settle down for a very long travel; a planet-sized generation ship, slow and massive, for our migration to the stars.

[1] Viorel Badescu 2010, 2011; D. C. Abbot and E. R. Switzer 2011; Louis E. Strigari et al, 2012; T. Marshall Eubanks 2014, etc.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

SPECTRAL ENERGY DISTRIBUTION OF MRK 509

L. Slavcheva-Mihova and B. Mihov

Institute of Astronomy and NAO, Bulgarian Academy of Sciences,
72 Tsarigradsko Chaussee blvd., 1784 Sofia, Bulgaria
E-mail: lslavcheva@nao-rozhen.org, bmihov@astro.bas.bg

Mrk 509 is a Seyfert 1 nucleus/quasar hosted by an S0 galaxy with a star-forming nuclear ring. The interrelationship between star formation and accretion onto supermassive black holes is crucial to understanding galaxy formation and nuclear activity triggering. The main challenge is that nearly all observational tracers used to estimate star formation parameters in galaxies suffer from severe contamination by emission from the active galactic nucleus (AGN) itself, especially for type 1 nuclei. We address the issue of disentangling the contribution of the AGN and host galaxy of Mrk 509 in the nuclear regions by fitting its spectral energy distribution. We used the AGNfitter code accounting for the emission of the accretion disk, torus, host galaxy stellar population, and cold dust related to the star forming regions. As a result parameters of the star formation and of the AGN are acquired.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

DESTRUCTION OF DIATOMIC MOLECULAR IONS OF ASTROPHYSICAL INTEREST

V. A. Srećković[1], Lj. M. Ignjatović[1] and M. S. Dimitrijević[2]

[1]*Institute of Physics Belgrade, BU, Pregrevica 118, 11080 Belgrade, Serbia*
[2]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
E-mail: vlada@ipb.ac.rs, ljuba@ipb.ac.rs, mdimitrijevic@aob.rs

In this contribution the average cross-section for the photodissociation and the corresponding spectral absorption coefficients (see Srećković et al. 2018) of the small diatomic molecular ions are calculated for the wide region of temperatures and wavelengths. The presented results are ready for further use with a particular accent to the applications for astro plasma research and low temperature laboratory plasma research (se e.g. Marinković et al. (2017), Srećković et al. (2017)). Also, we present overview of future developments and needs in the areas of presented i.e. investigated processes.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

RYDBERG ATOMIC COMPLEXES IN ASTROPHYSICAL PLASMAS

V. A. Srećković[1], Lj. M. Ignjatović[1] and M. S. Dimitrijević[2]

[1]*Institute of Physics Belgrade, BU, Pregrevica 118, 11080 Belgrade, Serbia*
[2]*Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia*
E-mail: vlada@ipb.ac.rs, ljuba@ipb.ac.rs, mdimitrijevic@aob.rs

In this contribution, we further investigate processes which include Rydberg atomic complexes important for the different astrophysic environments (Gnedin et al. 2009, Mihajlov et al. 2016). The range of the used physical parameters covers the area important for plasma modeling from astrophysical standpoint (white dwarfs, central stars of planetary nebulae, etc). Naturally, these results can be of interest and use in investigation of different laboratory plasmas (Srećković et al. 2018). Also, we present overview of future developments and needs in the areas of Rydberg collisional processes.

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XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

RESEARCH OF THE IMPACT OF STRONG SOLAR FLARES ON THE LOWER IONOSPHERE BY VLF RADIO WAVES AND SATELLITE OBSERVATIONS

V. A. Srećković[1] and D. M. Šulić[2]

[1] *Institute of Physics Belgrade, BU, Pregrevica 118, 11080 Belgrade, Serbia*
[2] *University Union – Nikola Tesla, 11000 Belgrade, Serbia*

E-mail: vlada@ipb.ac.rs

When energy from a solar flare reaches the Earth, the ionosphere becomes suddenly ionized. The term Sudden Ionospheric Disturbance, is used to describe that kind of changes of the ionosphere. Very Low Frequency (VLF) signal perturbations were examined to study ionospheric disturbances induced by solar X-ray flares (Šulić et al. 2010). The strength of the received VLF radio signal changes according to how much ionization has occurred during event of a solar flare (Šulić et al. 2016). Observed phase and amplitude of VLF radio signal propagating is used to validate electron density parameters for the lowest edge of the D-region of the Earth's ionosphere (Šulić and Srećković 2014).

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References

Šulić, D. M., Nina, A. and Srećković, V. A.: 2010, *POBeo.* **89**, 391.
Šulić, D. M., Srećković, V. A. and Mihajlov, A. A.: 2016, *Adv. Space Res.* **57**, 4, 1029.
Šulić, D. M. and Srećković, V. A.: 2014, *Serb. Astron. J.* **188**, 45.

Poster

IASC PROJECT IN SERBIA

Zoran Tomić

Astronomical Society Eureka, Kralja Petra Prvgo 3, 37000 Krusevac, Serbia
eurekakutak@gmail.com

IASC (eng: International Astronomical Search Collaboration) is one of good examples of Citizen Science projects. It provides high quality astronomical data to citizen scientists around the world. They are able to make original astronomical discoveries and participate in hands-on astronomy. This service is provided at no cost. It is realized in many countries in the world, and since 2019 in Serbia. In this paper we will present in short activities of IASC and what projects and activities were realized in Serbia, and what are plans for future.

XIX SERBIAN ASTRONOMICAL CONFERENCE
October 13-17, 2020, Belgrade, Serbia
Book of abstracts, eds. A. Kovačević, J. Kovačević Dojčinović, D. Marčeta and D. Onić
Faculty of Mathematics and Astronomical Observatory, Belgrade, 2020

Poster

FRAGMENTI IZ ISTORIJATA IZGRADNJE ASTRONOMSKE OPSERVATORIJE NA VELIKOM VRAČARU

Veselka Trajkovska

Astronomska opservatorija, Volgina 7, 11060 Beograd 38
E-mail: vtrajkovska@aob.rs

U radu se prezentuju neke pojedinosti iz istorijata izgradnje Astronomske opservatorije na Velikom Vračaru, sa posebnim osvrtom vezano za reljefe na osmatračkim paviljonima i natpisa "OMNIA IN NUMERO ET MENSURA" na glavnoj zgradi.

Programme of the Conference

XIX SERBIAN ASTRONOMICAL CONFERENCE
PROGRAMME

IMPORTANT INFORMATION:

i) 20% of each time slot can be allocated for speaker connection and discussion with audience

Tuesday, October 13

08:30-09:00. Connection of participants
09:00-09:15 **Opening addresses:**
Andjelka Kovačević chair of 19SAC SOC
Zoran Rakić Dean of Faculty of Mathematics
Vitor Cardoso Chair of COST CA16104 Gravitational waves, black holes and fundamental physics

Special session- The gravitational-wave Universe: chair Vitor Cardoso

09:15-09:55 J. M. Wang: Close binaries of supermassive black holes in active galactic nuclei
09:55-10:35 S. Komossa: Supermassive binary black holes

10:35-11:00 Morning break

Special Session-The gravitational-wave Universe: chair Luka Č. Popović

11:00-11:40 A. F. Zakharov: Tests of gravity theories with black hole observations
11:40-12:10 A. Askar: Dynamical formation of gravitational wave sources
12:10-12:40 M. Mićić: SMBH growth and gravitational wave radiation
12:40-13:00 M. Smole et al.: Statistics of recoiling SMBHs from cosmological simulations

13:00 – 14:00 Lunch break

Stellar physics and physics of the interstellar medium: chair Olga Atanacković

14:00-14:40 L. Crivellari: Alternative strategies to solve the stellar atmosphere problem
14:40-15:10 J. Kubát: Mass loss rates and NLTE wind models of massive stars
15:10-15:30 J. Lazendić-Galloway: Cosmic ray production sites: supernova remnants interaction with molecular clouds
15:30-15:50 O. Latković, A. Čeki: Computer vision as a tool for studying close binary stars

15:50-16:15 Afternoon break

Astrophysical spectroscopy and instruments: chair Vladimir Srećković

16:15-16:45 M. Dimitrijević: The influence of Stark broadening on white dwarf spectra
16:45-17:15 Nikola Petrov: Sun and Solar activity opportunities for observations and development
17:15-17:45 O. Vince: News and future plans in the development of the Astronomical Station Vidojevica
17:45-18:05 A. Vudragović et al.: Testing performance of the Milanković telescope
18:05-18:25 R. Pavlović et al.: Lucky imaging at Vidojevica

Wednesday, October 14

Stellar physics and physics of the interstellar medium: chair Olivera Latković

09:00-09:30 J. Petrović: Massive close binary evolution - progenitors of gravitational wave sources
09:30-09:50 S, Ninković: On nearly circular orbits
09:50-10:10 M. I. Jurković: Type II and anomalous Cepheids
10:10-10:30 M. Stojanović: Examination of elements of galactocentric orbits of the thin disk stars from the Solar neighbourhood by varying potential of the Galaxy
10:30-10:50 S. Knezević et al.: Using Balmer lines to unveil the presence of cosmic rays in the supernova remnant SNR 0509-67.5

10:50-11:15 Morning Break

Stellar physics and physics of the interstellar medium: chair Jelena Petrović

11:15-11:35 V. Zeković, B. Arbutina: Quasi-parallel collisionless shocks: revealing the nature of cosmic particle accelerators
11:35-11:55 A. Čeki, O. Latković, S. Lazarević: Statistics of the largest sample of late-type contact binaries studied so far
11:55-12:15 I. Vince: Some gas-stream velocities in UU CAS close binary star

12:15-13:15 Lunch break

Interdisciplinary studies (astrobiology, astrochemistry, geophysics, atmospheric physics, and space astronomy) and simulations: chair Andjelka Kovačević

13:15-13:45 S. Jheeta: Astrochemistry: synthesis of the basic 'building blocks' of life
13:45-14:15 B. Vukotić: Galactic habitability and stellar motion
14:15-14:45 A. Nina: Monitoring of lower ionosphere: possible earthquake precursors and application in Earth observations by satellite
14:45-15:05 S. Dujko et al.: Electron transport, streamer propagation and lightning in the atmosphere of Titan
15:05-15:25 D. Lukić: Comparison of two models of interstellar travel using laser-pushed lightsail
15:25-15:45 S. Cikota: Determination of stellar radii by observing asteroid occultations
15:45-16:05 V. Srećković et al.: SEG activities in Europlanet

16:05-16:25 Afternoon Break

Stellar physics and physics of the interstellar medium: chair Bojan Arbutina

16:25-16:55 R. Mennickent: Circumstellar matter and disks in beta Lyrae-type binaries: new case studies
16:55-17:25 S. Stanimirović: New perspectives on the cool interstellar medium: from the Milky Way to nearby galaxies
17:25-17:55 T. Pannuti et al.: Spectroscopic and hydrodynamic analyses of the Northwestern Rim of the Galactic supernova remnant G156.2+5.7
17:55-18:25 D. Leahy: The distribution of explosion energies and ISM densities for supernova remnants in the Galaxy
18:25-18:55 M. Ćuk: Dynamics and origin of Martian satellites

Thursday, October 15

Extragalactic astronomy: chair Jelena Kovačević Dojčinović

09:00-09:30 D. Ilić, A. Kovačević, L. Č. Popović: Quasars research in time-domain era
09:30:10:00 N. Bon, P. Marziani, E. Bon: Searching for extremely accreting quasars
10:00-10:20 N. Rakić, D. Ilić, L. Č. Popović: Fully automated python tool for AGN spectra analysis – FANTASY
10:20-10:40 I. Jankov, D. Ilić, A. Kovačević: Manifold learning in the context of quasar spectral diversity
10:40-11:00 M. Manganaro et al.: The intermittent extreme behaviour of BL Lac 1ES~2344+514
11:00-11:20 M. Bilek: The MATLAS survey of faint outskirts of bright galaxies

11:20-11:50 Morning Break

Extragalactic astronomy: chair Dragana Ilić

11:50-12:30 D. Šijački: Supermassive black holes in all their guises
12:30-13:00 L. Č. Popović, V. L. Afanasiev, E. S. Shablovinskaya: Specto-polarization of active galactic nuclei: central super-massive black hole and dust sublimation region
13:00-13:30 M. Pović: Green valley galaxies and the role of AGN in galaxy evolution
13:30-13:50 S. Panda et al.: The CaFe project: correlation between Fe II and Ca II in active galaxies
13:50-14:10M. L. Martínez-Aldama et al.: A 'new' radius-luminosity relation: using the near-infrared CaII triplet

14:10-15:10 Lunch break

Special Session-The gravitational-wave Universe: chair Alexander F. Zakharov

15:10-15:40 M. Burić: A model of quantum cosmology: fuzzy de Sitter space
15:40-16:10 V. Radovanović, D. Gočanin: Noncommutative SO(2,3) model of gravity
16:10-16:40 B. Dragović: Cosmology of nonlocal gravity

16:40-17:00 Ž. Mijajlović, D. Branković: Algebraic dependencies and representations of cosmological parameters

17:00-17:30 Afternoon Break

Special Session-The gravitational-wave Universe: chair Žarko Mijajlović

17:30-18:00 J. Nikolić: Partial quasi-morphisms and partial symplectic quasi-states in the ambient of cotangent bundles
18:00-18:30 I. Dimitrijević: The new model of nonlocal modified gravity
18:30-19:00 M. Vojinović: Cosmological constant problem in discretized quantum gravity

Friday, October 16

Astrometry: chair Ivana Milić Žitnik

09:00-09:30 G. Damljanović: Towards Gaia DR3 and some results of comparison between Gaia DR2 and ground-based data
09:30-10:00 A. Ivantsov: Adapting image centroiding to astrometric differential reduction
10:00-10:30 Z. Malkin: Comparison and combination of radio source position catalogs
10:30-10:50 M. D. Jovanović, G. Damljanović, F. Taris: Control stars around quasars suitable for the ICRF - GAIA CRF link
10:50-11:10 M. Stojanović et al.: Solar neighbourhood kinematics based on the GAIA data

11:10-11:30 Morning break

Dynamical astronomy, and planetology: chair Srdjan Samurović

11:30-12:10 Z. Knežević: Survey of the positions of secular resonances in the Asteroid Belt.
12:10-12:40 B. Novaković: Water content in compositionally primitive asteroid families: insights from the main belt comets
12:40-13:00 I. Milić-Žitnik: Functional relations between time, resonance strengths, Yarkovsky drift speeds and eccentricities in motions of resonant asteroids
13:00-13:30 N. Todorović: Short term chaos in the Solar System
13:30-14:00 K. Miljković: Structure of Mars: lessons learnt from the InSight mission and impact modelling

14:00-15:00 Lunch break

Cosmology: chair Miroslav Mićić

15:00-15:30 S. Samurović: The centenary of the Jeans equations: dark matter in massive early-type galaxies
15:30-16:00 M. Simonović: Cosmology from current and future spectroscopic galaxy surveys
16:00-16:30 V. Gluščević: Dark matter throughout cosmic history
16:30-17:00 Z. Lukić: Intergalactic medium as a probe of reionization, physics and cosmology

17:00-17:30 Afternoon Break

Cosmology: chair Edi Bon

17:30-18:00 D. Kereš: Galaxy evolution with stellar feedback and cosmic rays
18:00 – 18:20 G. Zaharijas: TeV dark matter search program with the Cherenkov Telescope Array: the strategy and synergies with current gamma-ray experiments
18:20-18:40 M. Jovanović: Dynamical modeling of nearby galaxies
18:40-19:00 D. Kirilova, M. Panayotova: SFC baryogenesis model, inflationary scenarios and reheating in the Universe
19:00-19:20 A. Mitrašinović et al.: Various effects of galaxy flybys: dependence on impact parameter

Saturday, October 17

History, philosophy and teaching of astronomy: chair Goran Damljanović

09:00-09:20 M. S. Dimitrijević: Archaeoastronomy and the corresponding research in Serbia
09:20-09:50 B. Stojičić: Zašto je važno izučavanje astronomije u toku srednjoškolskog obrazovanja?
09:50-10:10 A. Bajić, M. S. Dimitrijević: Hermes possible astronomical aspects
10:10-10:30 S. Milošević et al.: Department of Astronomy at Petnica Science Center: 2018-2020
10:30-10:50 Ž. Mijajlović: Saturn – a Serbian journal on astronomy from the past
10:50-11:10 Ž. Disterlo: Radio watching Draconids from 2005-2015

11:10-11:30 Morning Break

History, philosophy and teaching of astronomy: chair Milan Dimitrijević

11:30-12:00 M. Pović: Development of astronomy and space science in Africa
12:00-12:20 O. Atanacković, B. Arbutina: Astronomy education in Serbia 2017-2020
12:20-12:40 B. Arbutina, O.Atanacković, A. Kovačević: Department of astronomy at the Faculty of Mathematics University of Belgrade in the period 1999-2020
12:40-13:00 B. Arbutina: The first Yugoslav National Committee for astronomy
13:00-13:20 S. Vidojević et al.: Serbia in astronomical contests between 2017 - 2020
13:20-13:40 V. Mijatović, Z. Cvetković, G. Đurašević: Kompleks astronomske opservatorije u Beogradu i Astronomska stanica Vidojevica
13:40-14:00 Z. Tomić et al.: Activities of the Astronomical Society Eureka in the period 2017-2020

14:00-15:00 Lunch break

15:00-16:15 Poster Session- 5min presentation chair Dušan Marčeta and Dušan Onić

Posters:

P01. B. Arbutina, M. M. Vučetić, P. Kostić: Observations of selected standard stars in narrow-band filters from the AS Vidojevica

P02. A. Ćiprijanović et al.: Deep merge: studying distant merging galaxies with deep neural networks

P03. J. Horvat, A. Vudragović: Deep photometry of spiral galaxy NGC 941

P04. N. Janc et al.: Correspondence between Milutin Milanković and Else Wegener Köppen

P05. A. Kolarski, D. Grubor: Monitoring VLF signal perturbations induced by Solar activity during January 2005

P06. Z. Majlinger, M. S. Dimitrijević, V. A. Srećković: Stark broadening of Co II spectral lines for stellar spectra investigations

P07. Z. Malkin: Comparison of ground-based and GAIA-based photometry for astrometric radio sources

P08. Ž. Medić, D. V. Lukić: Additive manufacturing of Solar sail

P09. I. Milić Žitnik: The relationship between the 'limiting' Yarkovsky drift speed and asteroid families' Yarkovsky V-shapes

P10. A. B. Nedeljković: Rogue planets as means of transport

P11. L. Slavcheva-Mihova, B. Mihov: Spectral energy distribution of Mrk 509

P12. V. A. Srecković, Lj. M. Ignjatović, M. S. Dimitrijević: Destruction of diatomic molecular ions of astrophysical interest

P13. V. A. Srecković, Lj. M. Ignjatović, M. S. Dimitrijević: Rydberg atomic complexes in astrophysical plasmas

P14. V. A. Srecković, D. M. Šulić: Research of the impact of strong Solar flares on the lower Ionosphere by VLF radio waves and satellite observations

P15. Z. Tomić: IASC project in Serbia

P16. V. Trajkovska: Fragmenti iz istorijata izgradnje Astronomske opservatorije na Velikom Vračaru

16:15-16.35 Closing Conference

Monday, October 19

General Assembly of Serbian Astronomical Society

List of Participants
Authors' Index

LIST OF PARTICIPANTS

Aleksić Jovan
Astronomical Observatory, Belgrade, Serbia
jaleksic@aob.rs

Arbutina Bojan
Faculty of Mathematics, University of Belgrade, Serbia

Askar Abbas
Lund University, Sweden
askar@astro.lu.se

Atanacković Olga
Faculty of Mathematics, University of Belgrade, Serbia
olga@matf.bg.ac.rs

Bajić Aleksandra
Society for Archaeoastronomical and Ethnoastronomical Research "Vlašići", Serbia
aleksandra.bajic@gmail.com

Bílek Michal
Astronomical Observatory Strasbourg, France
bilek@astro.unistra.fr

Bon Edi
Astronomical Observatory, Belgrade, Serbia

Bon Nataša
Astronomical Observatory, Belgrade, Serbia
nbon@aob.rs

Branković Danijela
School of Electrical Engineering, Serbia
danijela@etf.bg.ac.rs

Burić Maja
Faculty of Physics, University of Belgrade, Serbia
makab@ipb.ac.rs

Čeki Atila
Astronomical Observatory, Belgrade, Serbia
atila@aob.rs

Cikota Stefan
University of Zagreb – FER, Croatia
stefan.cikota@fer.hr

Ćiprijanović Aleksandra
Fermi National Accelerator Laboratory, United States
aleksand@fnal.gov

Crivellari Lucio
Instituto de Astrofisica de Canarias, Spain
luc_ext@iac.es

Ćuk Matija
SETI Institute, Mountain View, California, USA

Cvetković Zorica
Astronomical Observatory, Belgrade, Serbia
zorica@aob.rs

Dakić Vinka
Faculty of Mathematics, University of Belgrade, Serbia
dakicuma11@gmail.com

Damljanović Goran
Astronomical Observatory, Belgrade, Serbia
gdamljanovic@aob.rs

Dimitrijević Ivan
Faculty of Mathematics, University of Belgrade, Serbia
ivand@matf.bg.ac.rs

Dimitrijević Milan S.
Astronomical Observatory, Belgrade, Serbia
mdimitrijevic@aob.rs

Disterlo Žan
Društvo mladih istraživača, Bor, Serbia
raurora@ptt.rs

Djurašević Gojko
Astronomical Observatory, Belgrade, Serbia
gdjurasevic@aob.rs

Đošović Vladimir
Faculty of Mathematics, University of Belgrade, Serbia

Dragovich Branko
Institute of Physics Belgrade, University of Belgrade, Serbia
dragovich@ipb.ac.rs

Dujko Saša
Institute of Physics Belgrade, University of Belgrade, Serbia
sasa.dujko@ipb.ac.rs

Gluščević Vera
University of Southern California, United States
vera.gluscevic@usc.edu

Horvat Jasmina
Faculty of Mathematics, University of Belgrade, Serbia

Ilić Dragana
Faculty of Mathematics, University of Belgrade, Serbia
dilic@matf.bg.ac.rs

Ivantsov Anatoliy
Akdeniz University, Turkey
ivantsov@akdeniz.edu.tr

Janc Natalija
Independent scholar, United States
natalijanc@earthlink.net

Jankov Isidora
Faculty of Mathematics, University of Belgrade, Serbia
isidora_jankov@matf.bg.ac.rs

Jheeta Sohan
NorCEL, UK
sohan@sohanjheeta.com

Jovanović Bora
Astronomical Observatory, Belgrade, Serbia
bjovanovic@aob.rs

Jovanović Milena
Astronomical Observatory, Belgrade, Serbia
milena@aob.rs

Jovanović Miljana D.
Astronomical Observatory, Belgrade, Serbia
miljana@aob.rs

Jurković Monika I.
Astronomical Observatory, Belgrade, Serbia
mojur@aob.rs

Kereš Dušan
University of California San Diego, United States
dkeres@physics.ucsd.edu

Kirilova Daniela
Institute of Astronomy and NAO, Bulgarian Academy of Sciences, Bulgaria
dani@astro.bas.bg

Knežević Sladjana
Astronomical Observatory, Belgrade, Serbia
sknezevic@aob.rs

Knežević Zoran
Serbian Academy of Sciences and Arts, Serbia
zoran@aob.rs

Kolarski Aleksandra
Technical Faculty "Mihajlo Pupin", University of Novi Sad, Serbia
aleksandrakolarski@gmail.com

Komossa Stefanie
MPIfR Bonn, Germany
astrokomossa@gmx.de

Kovačević Anđelka
Faculty of Mathematics, University of Belgrade, Serbia

Kovačević-Dojčinović Jelena
Astronomical Observatory, Belgrade, Serbia

Krčo Marko
FAST, China
marko@mkastro.net

Kubát Jiří
Astronomický ústav AV ČR, Czech Republic
kubat@sunstel.asu.cas.cz

Latković Olivera
Astronomical Observatory, Belgrade, Serbia
olivia@aob.rs

Lazarević Sanja
Astronomical Observatory, Belgrade, Serbia
sanja@aob.rs

Lazendic-Galloway Jasmina
Monash University, Australia
jasmina.lg@monash.edu

Leahy Denis
University of Calgary, Canada
leahy@ucalgary.ca

Lukić Dragan V.
Institute of Physics Belgrade, University of Belgrade, Serbia
lukic@ipb.ac.rs

Lukić Zarija
Berkeley Lab, United States
zarija@lbl.gov

Majlinger Zlatko
Astronomical Observatory, Belgrade, Serbia

Malkin Zinovy
Pulkovo Observatory,
Russian Federation,
malkin@gaoran.ru,
zmalkin@zmalkin.com

Manganaro Marina
Department of Physics, University of Rijeka, Croatia
marina.manganaro@uniri.hr

Marčeta Dušan
Faculty of Mathematics, University of Belgrade, Serbia

Martınez-Aldama Mary Loli
Center for Theoretical Physics, Polish Academy of Sciences, Poland
mmary@cft.edu.pl

Martinović Nemanja
Mathematical Institute of the Serbian Academy of Sciences and Arts, Serbia
nmartinovic@turing.mi.sanu.ac.rs

Mennickent Ronald
Departamento de Astronomía, Universidad de Concepción, Chile

Mićić Miroslav
Astronomical Observatory, Belgrade, Serbia

Mihić Stefan
Faculty of Mathematics, University of Belgrade, Serbia
stefanmihic@yahoo.com

Mihov Boyko
Institute of Astronomy and NAO, Bulgarian Academy of Sciences, Bulgaria
bmihov@astro.bas.bg

Mijajlović Žarko
Faculty of Mathematics, Univerisity of Belgrade, Serbia
zarkom@matf.bg.ac.rs

Mijatović Vesna
Astronomical Observatory, Belgrade, Serbia
vesna@aob.rs

Milić Žitnik Ivana
Astronomical Observatory, Belgrade, Serbia
ivana@aob.rs

Miljković Katarina
Curtin University, Australia
katarina.miljkovic@curtin.edu.au

Milošević Stanislav
Faculty of Mathematics, University of Belgrade, Serbia
stanislav@matf.bg.ac.rs

Mitrašinović Ana
Astronomical Observatory, Belgrade, Serbia
amitrasinovic@aob.rs

Nedeljković Aleksandar B.
Filološko-umetnički fakultet, Kragujevac, Serbia
srpsko_dnf@yahoo.com

Nikolić Jovana
Faculty of Mathematics, University of Belgrade, Serbia
jovanadj@matf.bg.ac.rs

Nina Aleksandra
Institute of Physics Belgrade, University of Belgrade, Serbia
sandrast@ipb.ac.rs

Ninković Slobodan
Astronomical Observatory, Belgrade, Serbia
sninkovic@aob.rs

Novaković Bojan
Faculty of Mathematics, University of Belgrade, Serbia
bojan@matf.bg.ac.rs

Onić Dušan
Faculty of Mathematics, University of Belgrade, Serbia

Pakvor Ivan
Astronomical Observatory, Belgrade, Serbia
jipakvor@eunet.rs

Panda Swayamtrupta
Center for Theoretical Physics, Polish Academy of Sciences, Poland
panda@cft.edu.pl

Pannuti Thomas
Morehead State University, United States
t.pannuti@moreheadstate.edu

Pavlović Rade
Astronomical Observatory, Belgrade, Serbia
rpavlovic@aob.rs

Pejović Nadežda
Faculty of Mathematics, University of Belgrade, Serbia
nada@matf.bg.ac.rs

Petrov Nikola
Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences, Bulgaria
nip.sob@gmail.com

Petrović Jelena
Astronomical Observatory, Belgrade, Serbia
jpetrovic@aob.rs

Popović Luka Č.
Astronomical Observatory, Belgrade, Serbia
lpopovic@aob.rs

Pović Mirjana
Ethiopian Space Science and Technology Institute, Ethiopia; Instituto de Astrofisica de Andalucia, Spain
mpovic@iaa.es

Premović Pavle I.
Retired Professor of Chemistry, Serbia
pavleipremovic@yahoo.com

Prodanović Tijana
University of Novi Sad,
Serbia
prodanvc@df.uns.ac.rs

Prokić Vera
Gymnasium "Svetozar Marković",
Serbia
vera.prokic@gsm-nis.edu.rs

Radovanović Voja
Faculty of Physics, University of Belgrade, Serbia
rvoja@ipb.ac.rs

Radović Viktor
Faculty of Mathematics University of Belgrade, Serbia
rviktor@matf.bg.ac.rs

Rakić Nemanja
University of Banjaluka, Faculty of Natural Sciences and Mathematics, Bosnia and Herzegovina
nemanja.rakic@pmf.unibl.org

Samurović Srdjan
Astronomical Observatory, Belgrade, Serbia
srdjan@aob.bg.ac.rs

Šijački Debora
IoA University of Cambridge, United Kingdom
deboras@ast.cam.ac.uk

Simonović Marko
CERN, Switzerland
marko.simonovic@cern.ch

Slavcheva-Mihova Lyuba
Institute of Astronomy and NAO, Bulgarian Academy of Sciences, Bulgaria
lslavcheva@nao-rozhen.org

Smole Majda
Astronomical Observatory, Belgrade, Serbia
msmole@aob.rs

Srećković Vladimir A.
Institute of Physics Belgrade, University of Belgrade, Serbia
vlada@ipb.ac.rs

Stalevski Marko
Astronomical Observatory, Belgrade, Serbia
mstalevski@aob.rs

Stanimirović Snežana
Astronomy Department, University of Wisconsin, Madison, USA

Stojanović Milan
Astronomical Observatory, Belgrade, Serbia
mstojanovic@aob.rs

Stojičić Biljana
Zemunska gimnazija, Serbia
biljanastojicic963@gmail.com

Taris François
Paris Observatory, France
francois.taris@obspm.fr

Todorović Nataša
Astronomical Observatory, Belgrade, Serbia
ntodorovic@aob.rs

Tomić Zoran
Astronomical Society Eureka, Serbia
eurekakutak@gmail.com

Trajkovska Veselka
Astronomical observatory, Belgrade, Serbia
vtrajkovska@aob.rs

Urošević Dejan
Faculty of Mathematics, University of Belgrade, Serbia
dejanu@math.rs

Vidojević Sonja
Department of Mathematical Sciences, State University of Novi Pazar, Serbia
sonja@math.sr

Vince Ištvan
Astronomical Observatory, Belgrade, Serbia
ivince@aob.rs

Vince Oliver
Astronomical Observatory, Belgrade, Serbia
ovince@aob.rs

Vojinović Marko
Institute of Physics Belgrade, University of Belgrade, Serbia
vmarko@ipb.ac.rs

Vučetić Milica
Faculty of Mathematics, University of Belgrade, Serbia

Vudragović Ana
Astronomical Observatory, Belgrade, Serbia
ana@aob.rs

Vukotić Branislav
Astronomical Observatory, Belgrade, Serbia
bvukotic@aob.rs

Wang Jian-Min
Institute of High Energy Physics, Chinese Academy of Sciences, China
wangjm@ihep.ac.cn

Zaharijas Gabrijela
Center for Astrophysics and Cosmology, University of Nova Gorica, Slovenia
gabrijela.zaharijas@ung.si

Zakharov Alexander F.
Institute of Theoretical and Experimental Physics, Russian Federation
alex_f_zakharov5@mail.ru

Zeković Vladimir
Faculty of Mathematics, University of Belgrade, Serbia
vlada@matf.bg.ac.rs

AUTHORS' INDEX

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52-355.3(048)
533.92:537.228.5(048)
520/524:376(048)

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