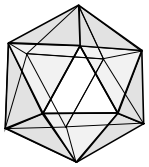


The "Prof. Dr Marko V. Jaric" Foundation
Serbian Academy of Sciences and Arts
University of Belgrade – Faculty of Physics

S Y M P O S I U M
ON LATEST ACHIEVEMENTS IN PHYSICS
ON THE OCCASION OF THE 20TH ANNIVERSARY OF
THE "PROF. Dr MARKO V. JARIC" FOUNDATION
(Symposium MJ 2018)

Programme
and
Abstracts of the lectures of the "Marko Jaric" award winners

23 and 24 March 2018
Belgrade, Serbia

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The “Prof. Dr Marko V. Jaric” Foundation
Serbian Academy of Sciences and Arts
University of Belgrade – Faculty of Physics

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SYMPOSIUM ON LATEST ACHIEVEMENTS IN PHYSICS ON THE OCCASION OF THE 20TH ANNIVERSARY OF THE "PROF. Dr MARKO V. JARIC" FOUNDATION (Symposium MJ 2018)

PROGRAMME

Friday, 23 March 2018.

Main Hall of the Serbian Academy of Scinces and Arts (SASA)
Knez Mihailova 35, II floor

09:30 – 10:00 Opening
Vladimir Kostić, President of the SASA
Petar Adžić, Governor of the Foundation

Chairman: Petar Adžić

10:05–10:50 John Ellis
Kings College London and CERN
Title of the talk: ***Particle physics, present and future***

10:55–11:25 Coffee break

11:30–13:00 Ceremony of the "Marko Jarić" prize Award for 2017
Opening: **Milivoj Belić,** Deputy president of Governing Board
Report of the Award Committe: **Zoran Radović**
The prize award to the winner
Lecture of the winner

Friday, 23 March 2018.

Faculty of Physics of University of Belgrade
Studentski trg 12–16, Block C, III floor

13:20–15:00 C O C K T A I L
(Student's library of Faculty of Physics)
Faculty of Physics of University of Belgrade
Studentski trg 12 – 16, Blok C, III floor
Physics amphitheatre – Hall 661

Chairman: Jovo Jarić

15:00–15:30 Miodrag Kulić
Institute for Theoretical Physics, Goethe University,
60 438 Frankfurt am Main, Germany
Title of the talk: ***High Temperature Superconductors – The Current State***

15:35–16:05 Zoran Lj. Petrović
Institute of Physics, University of Belgrade
Title of the talk: ***Describing the non-equilibrium processes, from plasma physics to fundamental principles and back to practical applications***

16:10 –16:40 Milan Damnjanović
NanoLab, Faculty of Physics, University of Belgrade and SASA
Title of the talk: ***Electron-phonon coupling anomalies in layers***

16:45–17:15 Bosiljka Tadić
Department of Theoretical Physics, Jozef Stefan Institute, Ljubljana
Title of the talk: ***Hyperbolic Geometry of Networks Emerging from Online Social Endeavors***

18:00–21:00 SYMPOSIUM DINNER
Konoba AKUSTIK
kafana sa dušom
Cara Dušana 13, Dorćol, Beograd

Saturday, 24 March 2018.

Faculty of Physics of University of Belgrade
Studentski trg 12 – 16, Block C, III floor
Physics amphitheatre – Hall 661

Chairman: Горан Попарић

10:00–10:30 Zoran Radović
Faculty of Physics, University of Belgrade and SASA
Title of the talk: ***Interplay of superconductivity and magnetism***

10:35–11:05 Vlatko Vedral
University of Oxford
Title of the talk: ***Which roads to quantum gravity can explain spatial entanglement of massive particle*****?**

11:10–11:40 Vladan Vuletić
Lester Wolfe, Massachusetts Institute of Technology
Title of the talk: ***Atomic clock below the standard quantum limit***

11:45–12:15 Časlav Brukner
Institute for Quantum Optics and Quantum Information, Vienna & Faculty of Physics, University of Vienna
Title of the talk: ***Quantum superpositions of causal orders***

12:20–12:50 Coffee break

Chairman: Duško Borka

12:55–13:25 Jelena Vučković
Stanford University, Stanford, CA, USA
Title of the talk: ***Quantum nanophotonics: from inverse design to implementations***

13:30–14:00 Čedomir Petrović
Brookhaven National Laboratory
Title of the talk: ***Thermoelectric Power Factor and Electronic Correlations in FeSb2***

14:05–14:35 Dejan Stojković
State University of New York at Buffalo
Title of the talk: ***Quantum aspects of gravitational collapse: non-locality and non-singularity***

14:40–15:10 Leonardo Golubović
Department of Physics and Astronomy, West Virginia University
Title of the talk: ***Physics of Rotating Space Elevators***

15:15 Closing

Abstracts of the lectures of the "Marko Jaric" award winners

CONTENTS

High Temperature Superconductors – The Current State

Miodrag Kulić
Institute for Theoretical Physics, Goethe University,
60 438 Frankfurt am Main, Germany

Abstract:

In this memorial article, devoted to the great Serbian physicist Marko Jarić, we give a short overview of the present situation in the field of high temperature superconductivity. It comprises cuprates (*HTSC*), Fe-based superconductors and interface *SC* in *FeSe/SrTiO3*, hydrogen-based SC – we call it *Alasca-RTSC*, such as H_3S with $T_c \approx 203$ *K*. Since the mechanism of pairing in *HTSC* and *Fe*-based SC are still not resolved – it is unclear is it due to spin fluctuations or phonon mediating glue, or both, we discuss the role of the electron-phonon interaction (*EPI*) in these materials. Special attention is devoted to the anisotropic *EPI* in *HTSC* cuprates and to A_{1g} modes in the *Fe*-based *SC* – due to *As* ions. In the, recently discovered, *Alaska-RTSC* the situation is simpler due to the absence of strong correlations, and the superconductivity is caused by the *EPI* interaction. It is well described by the strong-coupling Eliashberg equations. We discuss the possibility of high T_c in the metallic hydrogen under high pressure, where *SC* is dominated by the high-frequency hydrogen phonons. Some perspective in this field is discussed.

Key words: High and room temperature superconductivity

Describing the non-equilibrium processes, from plasma physics to fundamental principles and back to practical applications

Zoran Lj. Petrović
Institute of Physics, University of Belgrade,

Abstract:

Rather than being exception, often described by small perturbation to the thermal equilibrium, non-equilibrium processes are ubiquitous, omnipresent and are the most important to understand in order to grasp the progression from the initial creation to the emergence of intelligent life. A profound, transition from the thermal equilibrium plasma in the early stages of the universe to the formation of galaxies, stars and other astronomical objects is driven by the external gravitational force. A model of such a system is the emergence of non-equilibrium plasma when weakly ionized gas is subjected to the external electric field. Direct influence of the field on the formation of the energy distribution function of charged particles allows one to control very accurately all the relevant processes. Selecting conditions will lead to the predominant effect of different atomic and molecular collisions that may act selectively in tailoring the distribution function. Especially, some processes may play the role of Maxwell's demon, thus promoting kinetic effects such as negative mobility, negative differential conductivity, attachment and diffusion cooling (or heating) and many more. Being able to adjust the distribution in a complex manner opens the door to numerous applications of the non-equilibrium plasmas from plasma etching of integrated circuits to plasma triggering of specific signaling channels in live cells that may be the basis for plasma induced medical procedures and application of plasmas in agriculture.

Key words: non-equilibrium plasma, transport, Maxwell's demon, plasma applications

Electron-phonon coupling anomalies in layers

Milan Damnjanović
NanoLab, University of Belgrade

Abstract:

Due to (quasi)-two-dimensionality, layered structures exhibit quite a specific behaviour. Presented systematic symmetry based analysis of all such systems enlightens significant deficiencies of electron-phonon coupling (within first order theory) in particular oblique, rectangular, square and hexagonal diperiodic lattices, among which are superconducting CuO2 sheet, atomically thin hBN and graphene. Some of the manifestations are: absence of the totally symmetric phonons, inefficiency of the conditions providing Kohn singularity, nonlinear acoustic branches, electronic states decoupled from phonons, spontaneous symmetry breaking, exceptions from the Jahn-Teller theorem.

Hyperbolic Geometry of Networks Emerging from Online Social Endeavors

Bosiljka Tadić
Department of Theoretical Physics, Jožef Stefan Institute, Ljubljana

Abstract:

Spontaneous evolution of networks in physical world obeys certain optimization principles at different stages of the network growth. The developed complex architecture often exhibit hidden geometries with emergent hyperbolicity, the proximity of nodes in graph metric space, which facilitates flow between them. In social systems, on the other hand, the co-evolving networks embody human interactions, which are governed by different principles and depend on communicated cognitive or emotional contents. We investigate two types of social networks emerging from knowledge-sharing social endeavors: the graph that contains explicit knowledge derived from the empirical data of knowledge-creation processes by Questions and Answers [1,2] and a social graph built through IRC chats [3,4] devoted to Ubuntu problems solving. By testing Gromov 4-point criterion of hyperbolicity [5], we show that structure of these empirical networks is δ-hyperbolic. Furthermore, we demonstrate how algebraic topology methods can reveal the geometric descriptors from which the hyperbolicity of the structure originates. Moreover, their aggregates can be related to the appearance of logical connections among used knowledge contents and emotion flow along different layers induced by the presence of chat Bot in the emergent social graph.

References from abstract:

[1] M. Mitrović Dankulov, R. Melnik, and B. Tadić, "The dynamics of meaningful social interactions and the emergence of collective knowledge", Scientific Reports **5**, 12197 (2015).

[2] M. Andjelković, B. Tadić, M. Mitrović Dankulov, M. Rajković, and R. Melnik, and, "Topology of innovation spaces in the knowledge networks emerging through questions-and-answers", PLOS One **11**, e0154655 (2016).

[3] V. Gligorijević, M. Šuvakov, B. Tadić, "Building social networks of online chats with Users, Agents and Bots", Complex Networks and their Applications, Ed. Hochine Cherifi, Cambridge Scholar Pub. (2013).

[4] B. Tadić, M. Šuvakov, "Can human-like Bots control collective mood: Agent-based simulations of online chats", Journal of Statistical Mechanics Theory and Experiment, **10**, P10014 (2013).

[5] E. Jonckheere, P. Lohsoonthorn, F. Ariaei, "Scaled Gromov Four-Point Condition for Network Graph Curvature Computation", Internet Mathematics **7**, 137-177 (2011).

Which roads to quantum gravity can explain spatial entanglement of massive particle?

Vlatko Vedral
University of Oxford

Abstract:

In my talk I will present an argument for why we need to quantize gravity. This is based on a simple interference argument with two massive particles, each of which affects the other one gravitationally [1]. The claim is that if the field interacts locally with the masses and it manages to induce entanglement between theM, then the field itself must have at least two non-commuting observables [2]. This experiment can be realized with present technology. If successful, it would eliminate theories based on "gravitationally" induced collapse (e.g. Diosi, Penrose [3]) as well as those employing a semi-classical description of gravity (such as quantum field theory in curved space time [4]) [5].

Key words: quantum entanglement, quantum gravity

References:

[1] C. Marletto and V. Vedral, Witness gravity's quantum side in the lab, Nature 11th July 2017.
[2] C. Marletto and V. Vedral, arXiv:1707.06036 (2017).
[3] Diósi, L. Phys. Rev. Lett. A 40, 1165 (1989), R. Penrose, Gen. Relat. Gravit. 28, 581–600 (1996).
[4] N. D. Birrell and P. C. W. Davies, Quantum field theory in curved space (Cambridge Monographs on Mathematical Physics, 1982).
[5] C. Marletto and V. Vedral, forthcoming (2017).

Atomic clock below the standard quantum limit

Vladan Vuletic
Massachusetts Institute of Technology

Abstract:

Quantum-mechanically correlated (entangled) states of many particles are of interest in quantum information, quantum computing and quantum metrology. In particular, they have the potential to significantly improve atomic clocks to levels where they can be used to probe new physics. Metrologically useful entangled states of large atomic ensembles (spin squeezed states) have been experimentally realized in proof-of-principle experiments with very limited clock stability on a hyperfine transition. We report progress towards implementing spin squeezing and other many-body entangled states in a state-of-the-art optical-transition clock using a trapped ytterbium ensemble.

Quantum superpositions of causal orders

Časlav Brukner
Institute for Quantum Optics and Quantum Information, Vienna, Austria &
Faculty of Physics, University of Vienna, Austria

Abstract:

One of the most deeply rooted concepts in science is causality: the idea that events in the present are caused by events in the past and, in turn, act as causes for what happens in the future. If an event A is a cause of an effect B, then B cannot be a cause of A. The possible interplay between quantum mechanics and general relativity may, however, require superseding such a paradigm. I will introduce a framework of "process matrices", which allows describing "superpositions of causal order", where one cannot say that A is before or after B. The framework reduces to the standard quantum framework whenever the causal order is fixed. I will show that such indefinite causal structure offers advantage in communication and computation, and discuss their realization in the gravitational field of a massive object in a spatial superposition.

Key words: Quantum causality, quantum information, quantum superpostion, space-time

Quantum nanophotonics: from inverse design to implementations

Jelena Vučković
Stanford University, Stanford, CA, USA

Abstract:

Nanophotonic structures that localize photons in sub-wavelength volumes are possible today thanks to modern nanofabrication and optical design techniques. Such structures enable studies of new regimes of light-matter interaction, quantum and nonlinear optics, and new applications in computing, communications, and sensing. The traditional quantum nanophotonics platform is based on InAs quantum dots inside GaAs photonic crystal cavities. Recently, alternative material systems have emerged, such as color centers in diamond and silicon carbide, that could potentially bring the described experiments to room temperature and facilitate scaling to large networks of resonators and emitters. Finally, the use of inverse design nanophotonic methods that can efficiently perform physics-guided search through the full parameter space, leads optical devices with properties superior to state of the art, including smaller footprints, better field localization, and novel functionalities.

Key words: quantum optics, cavity QED, invderse design, quantum networks

Thermoelectric Power Factor and Electronic Correlations in FeSb2

Čedomir Petrović
Brookhaven National Laboratory

Abstract:

Recent interest in thermoelectric energy conversion induces a wide interest in the materials with high thermoelectric performance [1-2]. A narrow distribution or a large peak in the electronic density of states close to the Fermi level is considered favorable for a high thermopower [3-4]. Such peak could be induced by the resonant level dopants in semiconductors [5-6] or by the magnetic interaction between the local magnetic moment and itinerant electrons in correlated electron systems [7-8]. Some strongly correlated metals show enhanced thermopower and power factor [9-10]. In this talk I will discuss FeSb2 [11-13], a correlated electron semiconductor similar to FeSi [14] that was found to host a record-high thermoelectric power [15]. I will show even higher values of thermoelectric power factor – highest for any material in nature – can be obtained by subtle conducting states that emerge from synthesis-induced metal-insulator transition [16] and how high values of thermopower can be rationalized within the electronic model of multiband thermoelectricity [17]. This will be followed by some recent developments within Center for Computational Design of Functional Strongly Correlated Materials and Theoretical Spectroscopy.

References:

[1] Proc. Natl. Sci. U.S.A. 93, 7436 (1996) [2] Nat. Mater. 7, 105 (2008) [3] Nature 473, 66 (2011) [4] Science 321, 1457 (2008) [5] Science 321, 554 (2008) [6] Energy Environ. Sci. 5, 5510 (2012) [7] Solid State Phys. 51, 81 (1998) [8] Prog. Theor. Phys. 34, 372 (1965) [9] Proc. Natl. Acad. Sci. U.S.A. 109, 3243 (2012) [10] Phys. Rev. B 83, 125209 (2011) [11] Phys. Rev. B 72, 045103 (2005), [12] Phys. Rev. B 67, 155205 (2003), [13] Phys. Rev. Lett. 109, 256401 (2012) [14] Phys. Rev. Lett. 71, 1748 (1993) [15] Europhys. Lett. 80, 17008 (2007), [16] Phys. Rev. B 86, 115121 (2012), [17] Phys. Rev. B 82, 085104 (2010).

Quantum aspects in gravitational collapse: non-locality and non-singularity

Dejan Stojkovic
State University of New York at Buffalo

Abstract:

We study the end stages of gravitational collapse of the thin shell of matter in ingoing Eddington-Finkelstein coordinates. We use the functional Schrodinger formalism to capture quantum effects in the near singularity limit. We find that that the equations of motion which govern the behavior of the collapsing shell near the classical singularity become strongly non-local. This reinforces previous arguments that quantum gravity in the strong field regime might be non-local. We managed to solve the non-local equation of motion for the dust shell case, and found an explicit form of the wavefunction describing the collapsing shell. This wavefunction and the corresponding probability density are non-singular at the origin, thus indicating that quantization should be able to rid gravity of singularities, just as it was the case with the singular Coulomb potential.

Physics of Rotating Space Elevators

Leonardo Golubović and Steven Knudsen
Department of Physics and Astronomy
West Virginia University

Abstract:

The physics of Space Elevators connecting the Earth with outer space has recently attracted increased attention, in part due to the discovery of ultra-strong materials such as carbon nanotubes and diamond nano-thread structures. In this article we review a new venue in space elevator physics: Rotating Space Elevators (RSE) [L. Golubović and S. Knudsen: "Classical and statistical mechanics of celestial scale spinning strings: Rotating space elevators", Europhysics Letters 86(3), 34001 (2009)]. The RSE is a double rotating system of strings reaching outer space. Objects sliding along the RSE string (sliding climbers) do *not* require internal engines or propulsion to be transported far away from the Earth's surface. The RSE thus solves a major problem in the space elevator technology which is how to supply the energy to the climbers moving along the string. RSE strings exhibit interesting nonlinear dynamics and statistical physics phenomena. Satellites and spacecraft carried by sliding climbers can be released (launched) along RSEs. RSE strings can host space stations and research posts. Sliding climbers can be then used to transport useful loads and humans from the Earth to these outer space locations.

ОДРЖАВАЊЕ СИМПОЗИЈУМА МЈ 2018 ПОМОГЛИ СУ:

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