Zeldovich-100 Meeting

Subatomic particles, Nucleons, Atoms, Universe: Processes and Structure

*International conference in honor of Ya. B. Zeldovich 100th Anniversary*

March 10–14, 2014
Minsk, Belarus
Yakov Borisovich Zeldovich
Short biography of Ya.B. Zeldovich

Born on March 8, 1914 in Minsk. Died on December 2, 1987 in Moscow.

Father — Zeldovich Boris Naumovich, lawyer, member of Soviet Advocate Collegia; Mother — Zeldovich (Kivelovich) Anna Petrovna, translator, member of Soviet Writers Union.

Since middle of 1914 to August 1941 lived in Petrograd (later Leningrad), up to summer of 1943 — in Kazan, since 1943 — in Moscow.

In 1924 entered secondary school right away to the 3rd form, finished the school in 1930. From autumn 1930 till May 1931 he studied at the courses and worked as a laboratory assistant at the Institute of Mechanical processing of minerals. In May 1931 became a laboratory assistant at the Institute of Chemical Physics of the Academy of Science of the USSR (ICP). He was connected with this Institute till his very last days.

As he began to work in the ICF without higher education, he spend much time to self-education. From 1932 till 1934 studied as a extra-mural student at the Phys-Math department of the Leningrad State University, but didn’t recieved any degree there. Later listened lectures at the Phys-Mech department of the Polytechnical Institute.

In 1934 joined ICF as a post-graduate student, in 1936 received PhD degree, in 1939 received degree of doctor of science (phys-math science).

From 1938 he was a head of a laboratory at the ICF. In the end of August 1941 was evacuated with the Institute to Kazan. In 1943 together with the laboratory came back to Moscow. From 1946 till 1948 was a head of theoretical department of the ICF. At the same time till 1948 worked as a professor in the Moscow
Institute of Physics and Engineering.

From February 1948 till October 1965 worked on military problems (the Nuclear Project). For great results in that field he was awarded with Lenin’s award and thrice — with the Gold Star of the Hero of Labour (the greatest award in peace time). During that period he was a head of division and co-head of the enterprise.

From 1965 till January 1983 was a head of division at the Institute of the Applied Mathematics of the Academy of Science of the USSR. From 1965 he is a professor at the Department of Physics of the Moscow State University, and a head of division of the Relativistic Astrophysics at the Sternberg Astronomical Institute.

From 1983 — a head of division at the Institute of Physical Problems of the Academy of Science of the USSR, and at the same time as a consultant of the direction of the Space Research Institute. From 1977 — a head of the Scientific Council on Fusion at the Academy of Science of the USSR.

In 1946 was elected as a corresponding member of the Academy of Science of the USSR, and in 1958 — as a full member.

*From the web site of Division of the Relativistic Astrophysics, Sternberg Astronomical Institute*

Conference information

Location National Academy of Sciences of Belarus, Minsk
Web page http://www.icranet.org/zeldovich2014
Organized by ICRANet
National Academy of Sciences of Belarus
International secretariat zeldovich2014@icranet.org
Local secretariat yukuroch@dragon.bas-net.by
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Aleksander Zhuk  
*Ministry of Education*
Preliminary Program
Monday, March 10th

08:00–09:00 Registration (in front of the conference hall)

Morning session

Cosmology

Chairman: Sergei Kilin

09:00–09:40 Zhores Alferov TBD
09:40–10:20 Rashid Sunyaev TBD
10:20–10:40 Coffee break
10:40–11:20 Vladimir Belinski "Generic solution with Friedman-like Big Bang"
11:20–12:00 Alexei Starobinsky "Quantum-gravitational particle creation and generation of metric fluctuations in cosmology"
12:00–12:40 Gennady Bisnovatyi-Kogan "Outer parts of large galactic clusters in presence of a dark energy"

12:40–15:00 Lunch

Afternoon sessions

1: Astrophysics and cosmology

Chairman: Lev Titarchuk

15:00–15:30 Narek Sahakyan "Galactic sources of high-energy neutrino"
15:30–16:00 Milos Kovacevic "High energy emission from GRBs within the golden sample of IGC (Induced Gravitational Collapse) paradigm"
16:00–16:30 Coffee break
16:30–17:00 Bruno Svertut Arsioli "Studying an IR-based sample of VHE ?-ray blazars candidates"
17:00–17:30 Elena Ovsiyuk "Dirac particle in presence of a magnetic charge in de Sitter Universe: exact solutions and transparency of the cosmological horizon"
17:30–18:00 Albert Minkevich "Gravitational interaction and gauge
approach to gravitation"

2: High energy physics

Chairman: Valery Shaparau

15:00–15:30 Mikhail Galynskii "On the Physical Meaning of the Sachs
Form Factors of the Proton and on the Violation of the Dipole Dependence
of GE and GM on Q^2"

15:30–16:00 George Krylov "Pair production and magneto-electric effects
in graphene monolayer quantum transport: quasi-relativistic approach"

16:00–16:30 Coffee break

16:30–17:00 Alexey Sery "To the Problem of Compton Rotation of
Photons in Strong Magnetic Field. Limit of total spin polarization of
electrons"

17:00–17:30 Ilya Bobovnikov "Constraints on Extra Neutral Gauge
Bosons from W^+W^- Production at the ILC"

3: Field theory

Chairman: Herman Mosquera Cuesta

15:00–15:30 Hendrik Ludwig "Collective Electronic Pulsation of
Compressed Atoms"

15:30–16:00 Halina Grushevskaya "Effects of resonant spin states in
strongly correlated many-electron systems"

16:00–16:30 Coffee break

16:30–17:00 Vladimir Pletyukhov "Massless and Massive
Gauge-Invariant Fields in the Theory of Relativistic Wave Equations"

17:00–17:30 Mikhail Sergeenko "Complex masses of resonances in the
potential approach"

17:30–18:00 Valery Sobol "Waves of helicon type in conductors and
semimetals"
Tuesday, March 11th

Morning session

Gamma-ray bursts and explosions

Chairman: Vyacheslav Kuvshinov

09:00–09:40 Remo Ruffini "Supernovae, Neutron Stars and Black Holes in the GRBs Era"

09:40–10:20 Marco Muccino "On the Binary Driven Hypernovae and the nested properties of their X-ray afterglows"

10:20–10:40 Coffee break

10:40–11:20 Yu Wang "GRB 130427A and SN 2013cq: Multi-wavelength Analysis of An Induced Gravitational Collapse Event"

11:20–12:00 Sergei Frolov "Controlled Detonation Combustion: Modeling and Experimentation"

12:00–12:40 Oleg Penyazkov "Cellular structure of detonation waves"

12:40–15:00 Lunch

Afternoon sessions

1: Chemical physics

Chairman: Oleg Penyazkov

15:00–15:30 Aleksandr Voitovich "The Kinetics of Diffusion Components Reactions and the Distribution of Components over Distances between Them"

15:30–16:00 Andrei Smetannikov "High temperature hydrodynamics of explosions and shock wave phenomena"

16:00–16:30 Coffee break

16:30–17:00 Sergey Fisenko "The Renaissance of the Becker-Doring-Zeldovich Theory of Nucleation Kinetics"

17:00–17:30 Pavel Grinchuk "Statistical description of the influence of random spatial distribution of solid particles in a gas suspension on the propagation of combustion front"
17:30–18:00 Oscar Rabinovich "Filtration Combustion of Solid Fuels: Models and Stability Problem"

2: Gravitation

Chairman: Vladimir Belinski

15:00–15:30 Fernanda Gomes de Oliveira "Gravitational waves vs. X and Gamma rays emission in a short gamma-ray burst"
15:30–16:00 George Pogosyan "The Kepler-Coulomb Problem on SO(2,2) Hyperboloid"
16:00–16:30 Coffee break
16:30–17:00 Pavel Efremov "Innermost stable circular orbits of spinning particles in Schwarzschild and Kerr metric"
17:00–17:30 Anton Ryabushko "New in the relativistic theory of the motion of bodies in space"
17:30–18:00 Viktor Red’kov "On geometry influence on the behavior of a quantum mechanical scalar particle with intrinsic structure in external magnetic and electric fields"

3: High energy physics

Chairman: Kanstantsin Babich

15:00–15:30 Andrei Tsytrinov "Spin determination of the 125 GeV diphoton resonance with centre-edge asymmetry at LHC"
15:30–16:00 Oleg Boyarkin "Heavy neutrinos in the left-right model"
16:00–16:30 Coffee break
16:30–17:00 Vasilij Lashkevich "Target mass corrections and beyond"
17:00–17:30 Yuriy Chernichenko "On relativization of physical features of strong interactions within the framework of the relativistic quasipotential approach"
17:30–18:00 Yakov Shnir "Broken baby Skyrmions"

19:00 Conference dinner
Wednesday, March 12th

Morning session

Astrophysics and cosmology

*Chairman: Yurii Kurochkin*

09:00–09:40 Valery Chechetkin "History of modeling of supernovae explosion"

09:40–10:20 Vladimir Kurt "Spectral deformation of CMB"

10:20–10:40 Coffee break

10:40–11:20 Mikhail Sazhin "Search for cosmic strings"

11:20–12:00 Alexei Pozanenko "Gamma-ray Burst GRB 130427A as a classical GRB registered from radio to GeV"

12:00–12:40 Alexey Aksenov "Radiative transfer in relativistic plasma outflows and comptonization of photons near the photosphere"

12:40–14:00 *Lunch*

14:00 Trip to Belarusian State Museum of Folk Architecture and Rural Lifestyle

19:00 "Nutcracker" ballet, the National Academic Bolshoi Opera and Ballet Theatre
Thursday, March 13th

Morning session

Relativistic astrophysics

*Chairman: George Krylov*

09:00–09:40 Nikolai Shakura "Wind Accretion: Theory and Observations"

09:40–10:20 Sandip Chakrabarti "Black Hole Astrophysics and the contribution of Zeldovich"

10:20–10:40 Coffee break

10:40–11:20 Lev Titarchuk "X-ray spectral index correlations vs mass accretion rate in neutron star and black hole X-ray binaries in their different spectral states. Theory vs observations"

11:20–12:00 Sergei Moiseenko "Development of the magneto-differential-rotational instability"

12:00–12:40 Kuantay Boshkaev "Defining multipole moments of neutron stars from QPOs"

**12:40–15:00 Lunch**

Afternoon sessions

1: Dark matter

*Chairman: Sergei Moiseenko*

15:00–15:30 Carlos Arguelles "Dark matter halos and super massive dark objects at sub-parsec scales: the nature of the dark matter particle"

15:30–16:00 Igor Satsunkevich "The role of Zeldovich anapole interactions and Majorana dark matter particles"

16:00–16:30 Coffee break

16:30–17:00 Valentin Gilewsky "Three ways to search for dark matter particles"

17:00–17:30 Oleg Tsupko "Influence of plasma on effects of gravitational lensing"
2: Alternative gravity

Chairman: Marek Demianski

15:00–15:30 Eduardo Bittencourt "Geometric Scalar Theory of Gravity"
15:30–16:00 Alexander Gorbatsievich "Exact spherically symmetric static solution for a charged central body within the framework of the 5-dimensional projective unified field theory"
16:00–16:30 Coffee break
16:30–17:00 Lev Tomilchik "Space-time scale noninvariance of the conformal geometry and its observable manifestations"
17:00–17:30 Yuri Vyblyi "Scalar-tensor theory of gravitation in Minkowski space-time"

3: High energy physics

Chairman: Yakov Shnir

15:00–15:30 Elena Kokouлина "The title Studies of pp interactions at high multiplicity at U-70"
15:30–16:00 Vasili Andreev "Constraints on Z – Z' mixing from W pair production at the LHC"
16:00–16:30 Coffee break
16:30–17:00 Inna Serenкова "Identifying large extra dimensions in dilepton and diphoton production at the Large Hadron Collider"
17:00–17:30 Olga Solovtsova "Manifestation of quark-hadron duality in e+e- annihilation into hadrons"
17:30–18:00 Kanstantsin Babich "Behavior and collapse of wave function of two-particles bound system with the Cornell potential"
Friday, March 14th

Morning session

Cosmology

Chairman: Alexander Gorbatsievich

09:00–09:40 Andrey Doroshkevich "Beyond the Lambda-CDM cosmology: complex composition of dark matter"

09:40–10:20 Marek Demianski "Cosmological constant—a brief history and recent results"

10:20–10:40 Coffee break

10:40–11:20 Arthur Chernin "Dark energy in systems of galaxies"

11:20–12:00 Maxim Khlopov "Zeldovich’s legacy in Cosmoparticle physics"

12:00–12:40 Ivan Siutsou "Dark Matter Massive Fermions and Einasto Profiles in Galactic Haloes"

12:40–15:00 Lunch

Afternoon sessions

1: Gravitation

Chairman: Sandip Chakrabarti

15:00–15:30 Grasiele Batista dos Santos "Perturbation theory of a cosmological model with non-null Weyl tensor"

15:30–16:00 Alexander Silenko "General description of Dirac particle in Riemannian spacetimes"

16:00–16:30 Coffee break

16:30–17:00 Igor Kanatchikov "Precanonical quantization approach to quantum gravity"

17:00–17:30 Sergei Cherkas "Solution of the discrete Wheeler-deWitt equation in the vicinity of small scale factors and quantum mechanics in spaces of the negative constant curvature"
2: Alternative gravity

Chairman: Ivan Siutsou

15:00–15:30 Jonas Pereira "Black hole mass decomposition in nonlinear electrodynamics and some of its consequences"

15:30–16:00 Herman Mosquera Cuesta "Nonlinear electrodynamics mechanism for formation of astrophysical charged black holes during gravitational collapse of massive stars"

16:00–16:30 Coffee break

16:30–17:00 Yury Tsalkou "Primordial Black Holes as a unique tool for early Universe exploration"

17:00–17:30 Voldemar Kudin "Limiting energy density and a regular gravitating spherically symmetric objects in Riemann-Cartan spacetime"

3: Field theory

Chairman: Yuri Vybuli

15:00–15:30 Eckhard Strobel "Fractional Effective Action at strong electromagnetic fields"

15:30–16:00 Viacheslav Kuvshinov "Colour Particles Propagation Through QCD Vacuum Media"

16:00–16:30 Coffee break

16:30–17:00 Valery Shaparau "Occurrence of squeezed and entangled gluon states in QCD and their influence on intermittency of hadrons"

17:00–17:30 Yurii Kurochkin "The Coulomb Green’s function in curved space."

17:30–18:00 Nikolai Rogovtsov "Aplication of General Invariance Relations Reduction Method to Solution of Mathematical Physics Problems"
Social program

Tuesday, March 12, 19:00 Conference dinner

Wednesday, March 13, 14:00 Trip to Belarusian State Museum of Folk Architecture and Rural Lifestyle

Wednesday, March 13, 19:00 "Nutcracker" ballet, the National Academic Bolshoi Opera and Ballet Theatre
Abstracts
Radiative transfer in relativistic plasma outflows and comptonization of photons near the photosphere

A.G. Aksenov
Institute for Computer-Aided Design, Russian Academy of Sciences, Russia

Coauthors: R. Ruffini, G.V. Veresnshagin

We study radiative transfer in plasma by kinetic Boltzmann equations for all particles. In the case of ultrarelativistically expanding outflow from the surface of the compact object the Fokker–Planck approximation to the Boltzmann equation gives the generalized Kompaneets equation which takes into account anisotropic distribution of photons developed near the photosphere. For the electron temperature dependence from radius $T \propto r^{-2}$ we found the low-energy photon index can be $\sim -1$ as typically observed in GRB.

Constraints on $Z - Z'$ mixing from $W$ pair production at the LHC

V.V. Andreev
The F. Skoryna Gomel State University, Belarus

Coauthors: A.A. Pankov

We discuss the expected sensitivity to $Z'$ boson effects of the $W$ boson production process at the Large Hadron Collider (LHC). The results of model dependent analysis of $Z'$ boson effects are presented in terms of $Z - Z'$ mixing angle and $Z'$ boson mass. We find that the process $pp \rightarrow W^+W^- + X$ allows to place stringent constraints on the $Z - Z'$ mixing angle which is of order $10^{-4} - 10^{-3}$ for $M_{Z'} = 3$ TeV at the nominal LHC energy and luminosity.

Dark matter halos and super massive dark objects at sub-parsec scales: The nature of the dark matter particle

Carlos Argüelles
ICRANet, Italy

We investigate the distribution of dark matter in galaxies by solving the equations of equilibrium of a self-gravitating system of massive fermions (inos) at selected temperatures and degeneracy parameters within general relativity. The most general solutions presents, as a function of the radius, a segregation of three physical regimes: 1) an inner core of almost constant density governed by degenerate quantum statistics; 2) an intermediate region with a sharply decreasing density distribution followed by an extended plateau, implying quantum corrections; 3) a decreasing density distribution $\rho \propto r^{-2}$ leading to flat rotation curves fulfilling the classical Boltzmann statistics. We apply this model for different dark matter galaxy halos, ranging from typical dwarf to big spirals. The mass of the inos are determined as an eigenfunction of the mass of the inner quantum cores. The lower limit on the particle mass found by Gunn and Tremaine (1979) on the grounds of an hybrid treatment based on iso-thermal spheres and quantum constraints is not confirmed here.
Studying an IR-based sample of VHE $\gamma$-ray blazars candidates (1WHSP_J)

Bruno S. Arsioli
Sapienza Universita di Roma, Italy

Blazars are the dominant type of extragalactic sources at microwave, hard X-ray, and $\gamma$-ray energies. In the most energetic part of the electromagnetic spectrum ($E > 100$ GeV) a large fraction of high Galactic latitude sources are blazars of the High Synchrotron peaked (HSP) type, that is BL Lac objects with synchrotron emission peaking in the UV or in the X-ray band. Building new large samples of HSP blazars is key to understand the properties of jets under extreme conditions, and to study the demographics and the peculiar cosmological evolution of these sources.

HSP blazars are remarkably rare, with only a few hundreds of them expected to be above the sensitivity limits of currently available surveys. To find these very uncommon sources, we have devised a method that combines WISE all sky survey data with multi-frequency selection criteria.

The sample was defined starting from a primary list of infrared colour-colour selected sources from the WISE all sky survey database, and applying further restrictions on IR-radio and IR-X-ray flux ratios. Using a polynomial fit to the multi-frequency data we estimated synchrotron peak frequencies and fluxes.

We assembled the largest existing list of confirmed and candidates HSP blazars. All 711 objects in the sample are expected to radiate up to the highest $\gamma$-ray photon energies. In fact, 249 of these sources are confirmed emitters of GeV $\gamma$-ray photons (based on Fermi-LAT catalogues), and 32 have already been detected in the TeV band. Probably all sources in the sample are within reach of the upcoming Cherenkov Telescope Array (CTA), and many may already be detectable by the current generation of Cherenkov telescopes during flaring episodes.

The sample includes 364 previously known objects, 71 new identifications and 278 HSP candidates (for which no optical spectra is available yet).

The present work represents a significant improvement compared to the Sedentary survey, the previously largest homogeneous sample of extreme HSP blazars.

A significant fraction of the objects in our sample are well outside the so called WISE blazar strip, especially as originally defined, implying that infrared colour-colour selection leads to incomplete samples, especially at low fluxes where the optical/infrared part of the spectrum is often dominated by the host galaxy and where harder IR sources are not detected in all WISE bands. Therefore, we have redefined our search in the IR color-color domain, and also included a new release of the IR database, the so called AllWise catalog (in progress).
Behavior and collapse of wave function of two-particles bound system with the Cornell potential

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Coauthors: V.V. Andreev

The Schrödinger and Semi-relativistic equations with the Cornell potential in momentum space solved numerically with high level precision with the help of original quadrature formula. Some effects related with the relativisation of kinetic energy term of Schrödinger equation, critical values of interaction constant $\alpha$, behavior and collapse of wave function of two-particles bound system with the Cornell potential are demonstrated.

Generic solution with Friedman-like Big Bang

V. Belinski
ICRANet, Italy

It is shown that some kind of the viscoelastic material can stabilize the Friedmann Big Bang. That is for such matter the generic solution of the gravitational equations possessing the quasi-isotropic Friedmann-like cosmological singularity exists.

Outer parts of large galactic clusters in presence of a dark energy

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Space Research Institute, Rus. Acad. Sci., Russia

Dark energy limits a radius of big clusters of galaxies, and may accelerate hot gas outflowing from the cluster as a wind. Collision of accelerated winds, in presence of a magnetic field, produce a situation favorable for acceleration of EHECR.

Geometric Scalar Theory of Gravity

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Coauthors: M. Novello, U. Moschella, E. Goulart, J.M. Salim, and J.D. Toniato

I will present a geometric scalar theory of gravity, analyze previous criticisms against scalar gravity and show how the present proposal avoids these difficulties. This concerns not only the theoretical complaints but also those related to observations. In particular, we show that the widespread belief of the conjecture that the source of scalar gravity must be the trace of the energy-momentum tensor - which is one of the main difficulties to couple gravity with electromagnetic phenomenon in previous models - does not apply to this case. From the very beginning this is not a special relativistic scalar gravity. The adjective "geometric" pinpoints its
similarity with general relativity: this is a metric theory of gravity. Some consequences of this new scalar theory are explored.

**Constraints on Extra Neutral Gauge Bosons from $W^+W^-$ Production at the ILC**

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Coauthors: *A.A. Pankov*

We discuss the potential of the International Linear Collider (ILC) to probe $Z - Z'$ mixing and $Z'$ mass by the reaction $e^+e^- \rightarrow W^+W^-$ with longitudinally polarized $e^+e^-$ beams. We perform here a generic analysis of the deviations of the differential cross section from the Standard Model prediction, and apply it to a specific class of extended weak gauge models called as ‘minimal-Higgs’ models. Results indicate that the corresponding bounds expected from the ILC(0.5 TeV) complement the present ones obtained from low energy electroweak data, and rapidly become quite stringent at the higher energy of the ILC(1 TeV). Also, we emphasize the importance of initial beam polarization in improving the sensitivity to $Z - Z'$ mixing.

**Defining Multipole Moments of Neutron Stars from QPOs**

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Coauthors: *Marco Muccino, Jorge Rueda, Remo Ruffini, Ivan Siutsou*

In light of the relativistic precession model (RPM), we present detailed analyses, extending the ones performed in the Schwarzschild and Kerr spacetimes. We consider the kilohertz (kHz) quasi-periodic oscillations (QPOs) in the Hartle-Thorne (HT) spacetime, which describes a rotating and deformed object. We derive the analytic formulae for the epicyclic frequencies in the HT spacetime and by means of these frequencies we interpret the kHz QPOs of low-mass X-ray binaries (LMXBs) of the atoll and Z - sources. Particularly we perform analyzes for a Z -source: GX 5-1. We show that the QPO data can provide information on the parameters, namely, the mass, angular momentum and quadrupole moment of the compact objects in the LMXBs.

**Heavy neutrinos in the left-right model**

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Coauthors: *G.G. Boyarkina*

Within the left-right-symmetric model contributions to the neutrino dipole magnetic moments (DMMs) coming from the singly charged Higgs bosons $\tilde{\delta}^{(\pm)}$ are calculated. It was demonstrated that the Higgs sector contributions to the DMMs could exceed the contributions
caused by the charged gauge bosons. The resonance transitions in the light left-handed neutrino beam moving in a matter and a magnetic field are investigated. Analysis showed that the structure of the heavy neutrino sector admits only two possibilities: (i) the heavy neutrino masses \( m_{N_a} \) are arbitrary while the mixing angles between the light and heavy neutrinos \( \theta_{aa} \) are equal to zero (NMD scheme); (ii) the mixing angles \( \theta_{aa} \) are nonzero but equal to each other whereas the heavy neutrino masses are quasi-degenerated (QMD-scheme). The processes of the productions and decays of the heavy right-handed neutrinos due to nonzero value of the neutrino DMMs \( \mu^{\nu \bar{N}} \) are considered.

**Black Hole Astrophysics and contribution of Zeldovich**

*Sandip Kumar Chakrabarti*

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Almost fifty years ago Zeldovich first saw through the underlying physical process of Compton scattering which must be important in understanding spectra from black holes candidates. I discuss the importance of Comptonization and show that more or less all the observations, including the formation of jets and outflows, QPOs and spectral/class transitions are intimately related to the Compton process.

**History of modelling of supernovae explosion**

*Valery Chechetkin*

Keldysh Institute of Applied Mathematics, Russia

**Solution of the discrete Wheeler-DeWitt equation in the vicinity of the small scale factors and quantum mechanics in spaces of the negative constant curvature**

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V.L. Kalashnikov Institut fur Photonik, Technische Universitat Wien, Vienna, Austria

Asymptotic of the solution of the discrete Wheeler-DeWitt equation is found in a vicinity of small scale factors. It is shown that this problem is equivalent to the solution of the stationary Schrödinger equation of in a (super-) space of constant negative curvature. The minimum positive eigenvalue from which a continuous spectrum begins is found.

**Dark energy in systems of galaxies**

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The dynamical effects of dark energy are discovered in the Local Universe on the spatial scales of 1-10 Mpc. The local density of dark energy is first estimated with the use of the
Hubble Space Telescope data. Local areas of cosmic space are identified where the antigravity produced by dark energy is stronger than the gravity produced by dark matter and baryons. The nearest such area is at the distance of 1-3 Mpc from the Milky Way. Local outflows of galaxies accelerated by the antigravity are predicted theoretically and this new cosmic phenomenon is studied around the nearby groups and clusters of galaxies.

**Cosmological constant—a brief history and recent results**

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Coauthors: *Ester Piedipalumbo*

Yakov B. Zeldovich was interested in a very wide range of subjects. Since early 1960s his interest shifted toward relativistic astrophysics and cosmology. I will review his papers on the cosmological constant and more recent developments: discovery of the accelerated expansion phase of the Universe and attempts to uncover the nature of dark energy.

**On relativization of physical features of strong interactions within the framework of the relativistic quasipotential approach**

*Yuriy Chernichenko*

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The new methods of the finding of the physical features strong interaction elementary particles is developed. Consideration is carried out within the framework of relativistic quasipotential approach on the basis of covariant Hamiltonian formulation of quantum field theory by transition to the three-dimensional relativistic configurational representation in the case of two interacting relativistic particles with arbitrary masses.

**Beyond the LambdaCDM cosmology: complex composition of dark matter**

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Coauthors: *M. Demianski*

The mass and composition of dark matter (DM) and the shape and damping scales of the power spectrum can be estimated through recent observations of DM dominated relaxed objects—dwarf galaxies and clusters of galaxies. Here the well known semi analytical model of formation of DM halos is utilized in order to describe main properties of corresponding objects and to estimate their redshifts formation. As is well known these redshifts are correlated with the initial power spectrum of density perturbations what in turn allows to partly reconstruct one. We consider the available sample of suitable observed objects including ~ 40 DM dominated galaxies and ~ 40 clusters of galaxies and show that observed characteristics of these objects are inconsistent with expectations of the standard ΛCDM cosmological model but
coincide to more complex DM models with significant contribution of the HDM–like power spectrum with relatively large damping scale ($\sim 10^{-30}$ Mpc). Such damping decelerates the formation of low mass objects but not suppresses them entirely. We show also that the central pressure of DM dominated objects is surprisingly weakly dependent upon their virial mass but it is very sensitive to impact of baryonic component. These preliminary inferences must be confirmed by using more representative observational basis with including – if possible – DM dominated objects with intermediate masses $M \sim 10^{10} - 10^{12} M_\odot$. Comparison of observed properties of such objects with numerical simulations will allow to obtain the final solution of this complex problem.

**Innermost stable circular orbits of spinning particles in Schwarzschild and Kerr metric**

*Pavel Efremov*

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In the present work the influence of spin of a test body on the parameters of innermost stable circular orbits (ISCO) in the Kerr and Schwarzschild backgrounds is considered. For the investigation of the influence of body’s spin on the parameters of motion the Mathisson-Papapetrou-Dixon equations are used. For the case of extreme Kerr background exact expressions for the parameters of ISCO are found. For the case when spinning energy of the body is much less than energy associated with mass of the BH linear in spin corrections for the ISCO parameters are obtained. For the first time the analytical expressions for the ISCO parameters in cases of slowly-rotating Kerr BH and extreme Kerr BH are found.


*Sergey P. Fisenko*

A.V. Luikov Heat and Mass Transfer Institute of National Academy of Sciences, Belarus

The formation of new phase clusters in supersaturated vapor is considered by Becker, Döring, and Zeldovich [1] as the Brownian motion over a thermodynamic barrier. In spite of the beauty of this theory, the discrepancy between experimental results and theoretical calculations is astonishing. It can reach 12–20 orders of magnitude of nucleation rate. Experimental data are usually smaller than theoretical results. The classical theory has one obvious drawback. It considers the kinetics of phase transition as isothermal. The methods of nonequilibrium statistical thermodynamics permitted the development of mathematical model of nonisothermal nucleation kinetics [2]. The simulation based on this model has shown that nonisothermal effects are responsible only for 1-2 orders of the famous discrepancy between the theory and experiment. During several last decades, numerous attempts at the development of more sophisticated theories have not decreased this discrepancy. The breakthrough has been made owing to the idea of the microstructure of supersaturation field in experimental devices for nucleation studies [3]. Microstructure results due to the feedback between growing cluster and
vapor state near it. Details of this approach are discussed in the paper. Finally, we can state that provided of temperature and vapor supersaturation are calculated correctly classical nucleation kinetics will describe experimental results with an accuracy of about one order of magnitude.

References

Controlled Detonation Combustion: Modeling and Experimentation

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In 1940, Ya. B. Zel’dovich has published his famous article "To the Question of Energy Use of Detonation Combustion" (JETP, 1940, Vol. 10, No. 17, pp. 1453-1461) where he proved theoretically that the thermodynamic cycle with detonation combustion is the most efficient for chemical ramjet engines. Since then there were many attempts worldwide to implement this cycle in practical devices. Reported herein are the physical principles and problems of controlling deflagration-to-detonation transition and detonation propagation in gaseous and two-phase reactive systems, as well as the most recent accomplishments of the author’s group at Semenov Institute of Chemical Physics in relevant numerical and experimental studies. Several examples of numerically designed, fabricated and tested detonation devices are discussed, namely a 2-MW pulse detonation burner operating on natural gas-air mixture and a large-scale rotating-detonation combustor operating on hydrogen-air mixture.

On the Physical Meaning of the Sachs Form Factors of the Proton and on the Violation of the Dipole Dependence of $G_E$ and $G_M$ on $Q^2$

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In the one-photon exchange approximation we discuss questions related to the interpretation of unexpected results of the JLab polarization experiments to measure the Sachs form factors ratio $G_E/G_M$ in the region $1.0 < Q^2 < 8.5$ GeV$^2$. For this purpose, we developed an approach which essentially is a generalization of the constituent-counting rules of the perturbative QCD (pQCD) for the case of massive quarks. We assume that at the lower boundary of the considered region the hard-scattering mechanism (HSM) of pQCD is realized.
Within the framework of the developed approach we calculated the hard kernel of the proton current matrix elements $J_p^{\pm,\delta,\delta}$ for the full set of spin combinations corresponding to the number of the spin-flipped quarks, which contribute to the proton transition without spin-flip ($J_p^{\delta,\delta}$) and with the spin-flip ($J_p^{-\delta,\delta}$). This allows us to state that: 1) around the lower boundary of the considered region the leading scaling behavior of the Sachs form factors has the form $G_E, G_M \sim 1/Q^6$; 2) the dipole dependence ($G_E, G_M \sim 1/Q^4$) is realized in the asymptotic regime of pQCD when $\tau >> 1$ ($\tau = Q^2/4M^2$) in the case when the quark transitions with spin-flip dominate; 3) the asymptotic regime of pQCD in the JLab experiments has not yet been achieved; 4) the linear decrease of the ratio $G_E/G_M$ at $\tau < 1$ is due to additional contributions to $J_p^{\delta,\delta}$ by spin-flip transitions of two quarks and an additional contribution to $J_p^{-\delta,\delta}$ by spin-flip transitions of three quarks.

**Three ways to search for dark matter particles**

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We try to separate the possible ways to find the dark matter particles: new sterile particles (only gravitation interaction), new type of super-weak interaction, unusual electromagnetic properties of ordinary particles. We discuss the critical experiments to distinguish these possibilities.

**Exact spherically symmetric static solution for a charged central body within the framework of the 5-dimensional projective unified field theory**

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The present paper is devoted to the investigation of the spherically symmetric static electro-vacuum solution within the framework of the 5-dimensional Projective Unified Field Theory. It was shown that in the special case of neutral central body this solution could be obtained with the help of a special conformal transformation from the well-known Heckmann-Jordan-Fricke solution. We mention that this solution describes the exterior field of a spherically symmetric static cosmic body as well as a naked singularity without any horizons.
Statistical description of the influence of random spatial distribution of solid particles in a gas suspension on the propagation of combustion front

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In a number of experimental studies on combustion of gas-solid suspensions a shift of the maximum velocity of combustion front to the area of fuel-rich mixtures was observed. This effect cannot be explained in the framework of the classical theory of combustion which is based on the model of uniform distribution of solid particles over the space. In this paper the statistical model of the combustion of gas suspension of solid particles is proposed. This model takes into account the influence of random spatial distribution of particles on the velocity of the combustion front. The Bose-Einstein distribution in the occupation numbers representation is used as the basic mathematical apparatus. The model explains the observed shift of the maximum velocity of combustion front. The limits of the proposed statistical model applicability to real gas suspensions were estimated.

Effects of resonant spin states in strongly correlated many-electron systems

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A kinetic equation for the matrix Green’s function has been utilized and its renormalization has been performed to find the correlation function of a negatively charged exciton. It has been shown that the coherent transport of negatively charged excitons is a typical feature for strong correlated systems. When applied to the narrow-gap semiconductors IV-VI or III-V compounds, it has been established that current of negatively charged excitons stabilizes the dipole polarization vector of resonance between $d(f)$- and $s(p)$-electron states. Valence of the Anderson resonance and the binding energy have been estimated.

Precanonical quantization approach to quantum gravity

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I show how quantization of gravity without 3+1 decomposition and infinite dimensional spaces of geometries can be based on the covariant Hamiltonian formalism of De Donder-Weyl (DW) known in the calculus of variations. I review my earlier work on Poisson-Gerstenhaber brackets found in DW theory, their quantization, which leads to what I call precanonical quantization, and the relation of precanonical quantization to the standard quantum field
theory in functional Schroedinger representation. When applied to the vielbein general relativity, precanonical quantization approach naturally leads to the description of quantum gravity in terms of the transition amplitudes between different values of spin connections at different points of space-time. Using the formalism based on De Donder-Weyl theory and its quantization I derive the analogue of the Schroedinger equation for those amplitudes. I also discuss the definition of the Hilbert space. As a simple application, I derive the distribution function of the expansion rates of quantum FLRW universes.

References:

Zeldovich’s legacy in Cosmoparticle physics
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The development of Zeldovich’s legacy in the fundamental relationship of Cosmology and Particle physics is reviewed.

Studies of $pp$ interactions at high multiplicity at U-70
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Coauthors: On behalf of SVD Collaboration

Study of high multiplicity events is important for understanding of strong interaction nature, especially hadronization. The Thermalization project carried out on U-70 accelerator (IHEP, Protvino) is aimed at the search for collective phenomena both in quark-gluon plasma and hadron system of secondary hadrons. On the level of 7 standard deviations the evidence of Bose-Einstein condensation of pions in the high multiplicity region has been confirmed at twofold increasing sampling. The observable excess of soft photon (energy smaller than 50 MeV) yield by very precision electromagnetic calorimeter (low energy threshold) indicates on the number of charged and neutral particle dependence. Such behavior can be explained by an active role of soft gluons. In the framework of gluon dominance model the estimation for the contribution of the charged exchange ($p+p\rightarrow p+n+\pi^++N\pi$) has been obtained.

High energy emission from GRBs within the golden sample of IGC (Induced Gravitational Collapse) paradigm
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Discussion on Fermi-LAT instrument ability to detect the prompt and afterglow emission from GRBs in high energy range. Brief discussion on golden sample selection criteria of IGCs. Analyzing each GRBs within the golden sample in high energy range.
Pair production and magneto-electric effects in graphene monolayer quantum transport: quasi-relativistic approach

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We develop a quasi-relativistic theory for quantum transport in monolayer graphene. It is based on the Dirac – Hartry – Fock self-consistent field approximation and an assumption of anti-ferromagnetic ordering of sublattices. Within this approach a known and yet unsolved problem on minimal conductivity of graphene turns out to be satisfactory solved with value 4.83 (in units of $e^2/h$) when accounting for non-relativistic current only. Accounting for quasi-relativistic corrections to current due to the process of pairs production and magneto-electric effects we obtain the results for the minimal conductivity which are in a very good agreement with experimental data for monolayer graphene on different supports.

Limiting energy density and a regular gravitating spherically symmetric objects in Riemann-Cartan spacetime

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The conclusion about possible existence of the limiting energy density obtained in the framework of Poincare gauge theory of gravity (PGTG) is of principal meaning for massive superdense stars preventing its collapse [1]. The evolution of massive gravitating homogeneous dust sphere is studied in the frame of PGTG based on general expression of gravitational Lagrangian including both a scalar curvature and terms quadratic in the gravitational field strengths – the curvature and torsion tensors. Internal solution for metric and torsion functions is obtained by using co-moving coordinate system and integrating gravitational equations for homogeneous closed system [2] (similar to [3]). Obtained internal solution corresponds to dynamics of dust sphere in the form of oscillations between maximum and minimum values of energy density. External vacuum solution is obtained by numerical integration of system of gravitational equations of PGTG in spherically symmetric case, which contains 6+8 differential equations for two metric and 8 torsion functions. Matching of external and internal solutions is carried out. Gravitational equations for massive dust sphere were obtained by using restrictions on indefinite parameters of gravitational Lagrangian compatible with observational cosmological data.

Spectral deformation of CMB

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The physical processes during the cosmological recombination epoch (900 < z < 7000) are well known now. The most important effect to be observed in future is unique deviations of the CMB spectrum from a blackbody caused by the photon release during the recombination. These photons are added to the thermal CMB spectrum forming the hydrogen and helium recombination spectrum.

The dynamics of the hydrogen recombination process is controlled by two-photon transitions $2s \rightarrow 1s$ and Lyα photon escape during the multiple scattering in expanding medium. The contribution of two-photon transitions is about 57%, and this process is principal for the whole dynamics. The fraction of recombination photons is about $10^{-8} - 10^{-9}$ of the total energy density of the CMB spectrum, so the spectral distortion is expected to be very small. This contribution can increase to about $10^{-7} - 10^{-6}$ at 300 MHz, and it is the most convenient range to detect it.

Since the CMB spectrum does not depend on the direction, we can choose any sky point with less contribution of different background component (near the Galactic pole, for example). We can also use the non-polarization properties of the recombination spectrum for the detection.

Colour Particles Propagation Through QCD Vacuum Media

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Matrix density, entropy and other characteristics of colour particles in the stochastic QCD Vacuum are calculated and discussed.

Target mass corrections and beyond

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We consider target mass corrections to the structure functions of the deep-inelastic scattering by using the traditional Georgi-Politzer method, and also modern approaches. The methods solving the ‘threshold’ problem arising in the limit as the Bjorken variable x tends to unity are analyzed. This problem has been widely discussed in the literature ever since its appearance. We represent results of a new approach. We demonstrate, that in the large-x region, target mass corrections to structure functions calculated by using the new method noticeably differ that the commonly-used Georgi-Politzer method gives, as well as from other
approaches.

**Collective Electronic Pulsation of Compressed Atoms**

**Hendrik Ludwig**
ICRANet, Italy

I will discuss the equations that govern the monopole vibration modes of compressed atoms in the framework of the Thomas-Fermi model and present numerical solutions. Furthermore I will present an analytical solution for the case of very high compression and discuss its implications for high energy phenomena in the dynamical neutron star.

**Gravitational interaction and gauge approach to gravitation**

**A.V. Minkevich**
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1. Gravitation theory in Riemann-Cartan spacetime (Poincare gauge theory of gravity – PGTG) as a necessary generalization of metric theory of gravity in the framework of gauge approach by including of the Lorentz group to the gauge group corresponding to gravitational interaction. 2. PGTG based on general expression of gravitational Lagrangian including both a scalar curvature and quadratic in the curvature and torsion invariants and fulfilment of correspondence principle with general relativity theory (GR) in linear approximation in the metric and torsion tensors. 3. Gravitational interaction at cosmological scale and regular isotropic cosmology of accelerating Universe in Riemann-Cartan spacetime. Gravitational repulsion effect at extreme conditions and vacuum repulsion effect. 4. Regular massive objects in galaxies as alternative to singular black holes of GR. 5. Gravitational interaction at astrophysical scale and dark matter problem of GR. 6. Some unsolved problems of PGTG. 

*Literature:*

**Development of the magneto-differential-rotational instability**

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We present results of simulation of the magnetorotational supernova explosion. Differential rotation in the presence of the magnetic filed in core-collpase presupernova lead to the growth of the magnetic field. at the initial stage of the toroidal magnetic field amplification it grows linearly with time. At the developed stage al components of the magnetic field start to grow exponentially due to the development of the magneto-differential-rotational instability. The magnetorotational mechanism of the core-collapse supernova explosion gives explosion energy what corresponds to the theoretical predictions and observations.
Nonlinear electrodynamics mechanism for formation of astrophysical charged black holes during gravitational collapse of massive stars

Herman J. Mosquera Cuesta
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In an earlier paper (PRD 2003; Ruffini Festschrift Meeting 2002) I presented a mechanism inspired in brane-world physics which allows for mass disappearance (electrons, rather than protons, leaking) from the brane producing an asymmetry in an otherwise neutral (+, -) charge distribution lying on the brane (e.g. a star). As a result, an astrophysical charged black hole may form by end of a supernova gravitational collapse. Rather than such scenario, a new mechanism is introduced here by using foundational arguments stemming from nonlinear electrodynamics (NLED) which lead also to produce an astrophysical charged black hole upon the gravitational collapse of a massive star. The key point, in this case, is that NLED allows, as compared to the gravitational timescale, to make it longer the timescale for Coulombian (electrostatic) neutralization, which would otherwise take place at the inner crust-upper mantle charge separation interface inside a proto-neutron star much earlier than the gravitational collapse would take over. In such "stalled" charge separation state the aftermath of gravitational collapse of the inner core can be an astrophysical charged black hole. This picture may find proper realization in models of gamma-ray bursts (GRBs) in which the very central engine has to be (at least) a Reissner-Nordstrom black hole, which then drives vacuum polarization, "alla Schwinger" pair creation, and the full relativistic hydrodynamics and light curve evolution characterizing GRBs.

On the Binary Driven Hypernovae and the nested properties of their X-ray afterglows

Marco Muccino
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The induced gravitational collapse (IGC) paradigm addresses energetic (10^{52}–10^{54} erg), long gamma-ray bursts (GRBs) associated to supernovae (SNe). Their progenitors are tight binary systems composed of an evolved FeCO core and a companion neutron star (NS). Their emission is characterized by four specific episodes: Episode 1, corresponding to the on-set of the FeCO SN explosion and the accretion of the ejecta onto the companion NS; Episode 2, related the collapse of the companion NS to a black hole (BH) and to the emission of a long GRB; Episode 3, observed in X-rays and characterized by a steep decay, a plateau phase and a late power-law decay; Episode 4, corresponding to the optical SN emission due to the ^{56}Ni decay. We focus on Episode 3 and we show that, from the thermal component observed during the steep decay, its emission region has a typical dimension of \sim 10^{13} cm. We propose, therefore,
that the X-ray afterglow emission originates from a spherically symmetric SN ejecta expanding at $\Gamma \approx 2$ or, possibly, from the accretion onto the newly formed black hole, and we name these systems "binary driven hypernovae" (BdHNe). This interpretation is alternative to the traditional afterglow model based on the GRB synchrotron emission from a collimated jet outflow, expanding at ultra-relativistic Lorentz factor of $\Gamma \sim 10^2$–$10^3$ and originating from the collapse of a single object. We show then that the X-ray luminosities, in the rest-frame energy band $0.3$–$10$ keV, evidence a precisely constrained "nested" structure and satisfy precise scaling laws between the average prompt luminosity, $\langle L_{\text{iso}} \rangle$, and the luminosity at the end of the plateau, $L_a$, as functions of the time at the end of the plateau. All these features extend the applicability of the “cosmic candle” nature of Episode 3. The relevance of r-process in fulfilling the demanding scaling laws and the nested structure are indicated.

**Gravitational waves vs. X and Gamma rays emission in a short gamma-ray burst**

*F.G. Oliveira*

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Coauthors: *Jorge A. Rueda, R. Ruffini*

The recent progress in the understanding the physical nature of neutron stars (NSs) and the first observational evidence of a genuinely short gamma-ray burst (GRB), GRB 090227B, allow to give an estimate of the gravitational waves versus the X and gamma-rays emission in a short GRB. NS binaries represent good candidates for the detection of gravitational waves emitted during the spiraling-in and final merging phase of the system that leads to the short GRB emission. The data analysis of the GRB 090227B by Muccino et al. (2013) have been shown to be consistent with a NS binary progenitor with masses $M_1 = M_2 = 1.34 \, M_\odot$, radii $R_1 = R_2 = 12.2$ km, and a crust thickness $\Delta r \approx 0.47$ km, obtained from the new mass-radius relation by Belvedere et al. (2012) of NSs fulfilling global charge neutrality. Muccino et al. (2013) estimated that GRB 090227B is located at redshift $z \approx 1.6$, corresponding to a luminosity distance $d_L \approx 12.2$ Gpc. We assess the detectability of this source by the Advanced LIGO interferometer computing the signal-to-noise ratio (SNR) averaged over all polarizations and possible positions of the source with respect to the interferometer. We simulate the dynamics of the binary up to the contact point using the effective one-body formalism (EOB) in the fourth post-Newtonian approximation. We find that the gravitational waves signal would have been produced an SNR=0.32 for a redshift $z = 1.61$. We find that, instead, this GRB would have been detected with an SNR = 5 if it would have been located at a redshift $z \approx 0.09$, or $d_L \approx 0.38$ Gpc. We compute the total energy emitted in gravitational waves during the complete spiraling-in phase up to merger, $\Delta_{\text{GW}}^{\text{max}}$, and compare it with the emission observed in X and gamma rays, $E_{\text{GRB}}^{\text{tot}} = 2.83 \times 10^{53}$ erg. We obtain that the emission of X and gamma rays in a short GRB by a binary NS merger is one order of magnitude larger than the gravitational wave emission. We show also that $\Delta_{\text{GW}}^{\text{max}}$ is overestimated when computed from the classic non-relativistic two-point masses approximation.
The Coulomb Green’s function in curved space

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The Green’s function of the Schroedinger equation in the three-dimensional space of constant negative curvature is constructed in the form of an eigenfunction expansion. The cases of the free motion and of the motion in the Coulomb field are considered. The possibility of explicit summation over eigenstates is discussed and closed form expressions for certain cases are presented.

Dirac particle in presence of a magnetic charge in de Sitter Universe: exact solutions and transparency of the cosmological horizon

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The Dirac equation for particle with spin 1/2 in presence of the Abelian monopole is solved exactly on the background of cosmological de Sitter model in static coordinates. Variables are separated with the use of technique of Wigner D-functions. The system of radial equations is solved in hypergeometric functions. The complete set of spinor wave solutions is constructed. For all values of quantum numbers, energy $E$ and conserved extended angular momentum $j$, two pairs of linearly independent solutions are specified: running waves (to and from de Sitter horizon) and standing waves (regular and singular at $r=0$. It is shown that the known algorithm for calculation of the reflection coefficient $\Gamma_{Ej}$ on the background of de Sitter space-time presumes an additional constrain on quantum numbers of solutions $ER/hc \gg j$, where $R$ stands for the curvature radius; beyond these solutions any constructive recipe to get expression for $\Gamma_{Ej}$ does not exist. Taking into account this constrain, one straightforwardly gets $\Gamma_{Ej} = 1$. So, the monopole background does not affect the transparency properties of de Sitter cosmological horizon.

Cellular structure of detonation waves

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The cell size plays a role of the basic length scale indicating characteristic distances at which the detonation wave can recover peak flow parameters, i.e., pressure, temperature, and energy release, and in this way it self-sustains the non-decaying propagation. For this reason, the cell size is an important scale factor responsible for the wave stability at diffraction and transient detonation phenomena. The formation of cells is the result of the strong coupling and
interaction between chemical and gasdynamic processes that proceed in a post-shock flow of the propagating detonation. This interaction occasionally generates necessary conditions across the flow field for the next cell re-initiations in time and in space. When these conditions are not reached the decoupling results in both the disintegration of a detonation structure and the subsequent transition into the low-velocity propagation mode. The knowledge of critical gas parameters released along the cells required for the decoupling is important for both practice and theory, because they determine a stability of the detonation. This work addresses to systematic measurements of shock wave and reactive flow parameters released along the marginal and normal detonation structures of different regularity with objectives to establish critical flow conditions required for completion and reinitiation of the cell cycle.

Black hole mass decomposition in nonlinear electrodynamics and some of its consequences

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We generalize the Christodoulou-Ruffini mass formula (mass decomposition expression for Einstein-Maxwell black holes) for any spherically symmetric and nonlinear charged black hole in the context of reversible transformations. To obtain such a mass-energy decomposition, we use an alternative and consistent way that circumvents the difficulties to get it analytically in the traditional approach of black hole thermodynamics. By extrapolating this mass-energy decomposition as also being valid for the most general transformation undergone by a black hole, we also show that the known first law of black hole thermodynamics is its direct consequence. Such a mass decomposition naturally takes into account thermodynamic aspects of the problem, mandatory for its proper description. It may address controversial issues in black hole astrophysics, such as naked singularities, once their associated masses and charges are not independent variables anymore. This will be shown to be the case in Einstein-Born-Infeld black holes, where the effective Lagrangian to the electromagnetism is taken to be the analogous to the one derived by Born and Infeld in the 30s, and known to be the one arising in String Theory in the limit of low energies.

Massless and Massive Gauge-Invariant Fields in the Theory of Relativistic Wave Equations

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Consideration is given to massless and massive gauge-invariant spin 0 and spin 1 fields (particles) within the scope of a theory of the generalized relativistic wave equations with an extended set of the Lorentz group representations. The results obtained may be useful as regards the application of a relativistic wave-equation theory in modern field models.
The Kepler–Coulomb Problem on $SO(2,2)$ Hyperboloid

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In this note the Kepler–Coulomb problem in hyperbolic space: $z_0^2 + z_1^2 - z_2^2 - z_3^2 = R^2$ is discussed.

Gamma-ray Burst GRB 130427A as a classical GRB registered from radio to GeV

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One of the brightest Gamma-ray Burst (GRB) in gamma-ray and in optic ever observed the GRB 130427A is an excellent example of nearby (redshift = 0.34) classical long duration GRB. We present observational properties of the GRB 130427A, and based on observational data we discuss common features of gamma-ray bursts, models of bursts and still unresolved problem of theory and observations of GRBs.

Filtration Combustion of Solid Fuels: Models and Stability Problem

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Specialists in biomass thermal treatment and combustion, waste incineration, and combustion synthesis are well aware of problem concerning planar front stability for solid-fuel filtration combustion. There are a few major factors responsible for instability of this kind of combustion, and the challenge to find ways to depress the development of inclined fronts, hot spots, and incomplete combustion of gaseous and solid reactants is tough but is of great practical importance. The inevitable inhomogeneity of filtration combustion bed and the growth of its permeability due to burning-out are often considered as the main causes for the instability. But the most universal reason for destruction of planar combustion front is the fact that filtration permeability strongly depends on the temperature. This phenomenon, referred to as thermo-hydrodynamic or thermo-filtration instability, is imminent for all systems with gas filtration and should be considered in the first place because all other factors of instability play their parts against this background. The presented results of numerical simulation show that in the case of solid-fuel filtration combustion the thermal-filtration instability causes such specific and undesirable phenomena as incomplete combustion of solid reactant and a breakthrough of
the gas out of reactor bed. The dimensionless criteria determining the boundaries of instability region were found, which allows to avoid the unstable cases in practice. This communication is an example of how Zeldovich’s ideas on flame instability are utilized within the modern framework in a new, more complex situation.

On geometry influence on the behavior of a quantum mechanical scalar particle with intrinsic structure in external magnetic and electric fields

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Relativistic theory of the Cox’s scalar not point-like particle is developed in presence of electromagnetic and gravitational fields. This theory is specified in simple geometrical backgrounds: Euclid’s, Lobachevsky’s, and Riemann’s. Wave equations for the Cox’s particle, relativistic and non-relativistic, are solved exactly in presence of external uniform magnetic and electric fields in the case of Minkowski space. Non-trivial additional structure of the particle modifies the frequency of a quantum oscillator arising effectively in presence if external magnetic field. Extension of these problems to the case of the hyperbolic Lobachevsky space is examined. In presence of the magnetic field, the quantum problem in radial variable has been solved exactly; the quantum motion in z-direction is described by 1-dimensional Schrödinger-like equation in an effective potential which turns out to be too difficult for analytical treatment. In the presence of electric field, the situation is similar: radial equation is solved exactly in hypergeometric functions, an equation in z-variable can be treated only qualitatively because of its complexity. Similar analysis has been performed for spherical Riemann space model. General conclusion can be done: the role of large scale structure of the Universe depends greatly on the form of basic equations for elementary particle, any modification of them lead to new physical phenomena due to non-Euclidean geometry background.

Application of General Invariance Relations Reduction Method to Solution of Mathematical Physics Problems

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In this report the main stage of solving a number of mathematical physics (MF) problems in analytical, semi-analytical and numerical forms by the help of general ideas and constructions of the general invariance relations reduction method (GIRRM) will be presented [1,2]. This method uses the invariance of solutions of various problems of MF with respect to sets of operations that are partitions, decompositions, embedding, extension, factorization and so on. In general these sets are not groups (in particular symmetry groups). In GIRRM by general invariance relations (GIRs) are meant consequence of invariance of MF problem solutions with respect to such operations. GIRs in fact relate to each other solutions of the

**Supernovae, Neutron Stars, and Black Holes in the GRBs Era**

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The comprehension of GRBs is currently evolving on a daily basis thanks to one of the largest collaborations of detectors and instruments from space and the earth in the human history and a deep theoretical understanding. From the earlier understanding of the vacuum polarization process creating electron-positron plasma in a Kerr Newman Black Hole as the energy source, a model linking the observed structure of the GRB to the circumburst medium has been developed leading to a detailed understanding of short GRB’s. The coincidence of long GRBs with supernovae offers the greatest opportunity to introduce a “Cosmic Matrix” scenario in which four different astrophysical systems participate in less the 200 seconds in the laboratory frame. The "in" state is a Supernova interacting with a companion neutron star: it gives origin to an "out" state formed by a Black Hole and a newly born neutron star. Prediction and observational evidence are presented and perspectives for a unified scenario are given.

**New in the relativistic theory of the motion of bodies in space**

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Galactic sources of high-energy neutrino

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The recent results from ground based gamma-ray detectors (HESS, MAGIC, VERITAS) provides a population of TeV galactic gamma-ray sources which are potential sources of high energy neutrinos. Since the gamma-rays and neutrinos are produced from decays of neutral and charged pions, the flux of TeV gamma-rays can be used to estimate the upper limit of neutrino flux and vice versa; detectability of neutrino flux implies a minimum flux of the accompanying gamma-rays (assuming internal and external absorption of gamma-rays is negligible). Using this minimum flux it is possible to find the sources which can be detected with cubic-kilometer telescopes. I will discuss possibility to detect high energy neutrinos from powerful galactic accelerators, such as Supernova Remnants (SNRs) and Pulsar Wind Nebulae (PWNe) and show that likely only two sources (RX J1713.7-3946 and RX J0852.0-4622) will be detected by current generation of instruments (IceCube and Km3Net). It will be shown also that galactic binary systems could be promising sources of high energy neutrinos. In particular, neutrinos and gamma-rays from Cygnus X-3 during recent gamma-ray activity will be discussed, showing that in the future such kind of activities could produce detectable flux of neutrinos.

Perturbation theory of a cosmological model with non-null Weyl tensor

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We study scalar perturbations of a class of metrics with constant spatial curvature, where it was found a non vanishing Weyl tensor in the presence of an energy-momentum tensor with an anisotropic pressure component. The latter, in its turn, is due to the presence of a primordial stochastic magnetic field which breaks the homogeneity of the spacetime. We take the Quasi-Maxwellian formalism of General Relativity as our framework, which offers a naturally covariant and gauge-invariant approach to deal with perturbations that are directly linked to observational quantities. It is shown that this anisotropic pressure component helps to increase the growth rate of the perturbations, possibly playing the role of dark matter in structure formation.
The role of Zeldovich anapole interactions and Majorana dark matter particles

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We discuss the possibility and consequences of Majorana dark matter particles with anapole electromagnetic interaction. Majorana fermion may has only one electromagnetic characteristic - anapole moment. The anapole interaction was discovered in nucleus, but theoretical evaluation of anapole interaction is still uncertain.

Search for cosmic strings

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Cosmic strings were considered by Prof. T. Kibble and Prof. Ya.B. Zeldovich as very important ingredients of cosmic fabric. They are linear structures of cosmological scales whose search has been actively conducted in recent years. Progress in constructing theoretical models and investigating the properties of cosmic strings and a significant growth of observational resources provide extensive possibilities for the search of such objects by several independent observational methods. These methods include searching for the events of gravitational lensing of distant background sources by strings and searching for the distinctive cosmic microwave background anisotropy induced by strings. We discuss these techniques and propose the methods of searching for strings oriented toward the latest spacecraft, including the Planck project.

Identifying large extra dimensions in dilepton and diphoton production at the Large Hadron Collider

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Arkani-Hamed, Dimopoulos, and Dvali have proposed a model (ADD) of low-scale quantum gravity featuring large extra dimensions. In this model, the exchange of Kaluza-Klein towers of gravitons can enhance the production rate of lepton and photon pairs at high invariant mass in proton-proton collisions at the LHC. By considering the present and future LHC energy regimes, we reanalyze the potential of the LHC to discover the effects of large extra dimensions and to discriminate between various theoretical models.
Complex masses of resonances in the potential approach

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Complex masses of resonances in the potential quark model are obtained. Two exact asymptotic solutions for the QCD motivated potential are used to derive the resonance complex-mass formula. The centered masses and total widths of mesonic resonances are calculated.

To the Problem of Compton Rotation of Photons in Strong Magnetic Field. Limit of total spin polarization of electrons

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In present work the research is done according to the suggestion of V.G. Baryshevsky and V.V. Tikhomirov. The effect of Compton rotation of the plane of polarization of hard X-(soft gamma-) photons in the absence of magnetic field was theoretically predicted by V.G. Baryshevsky and V.L. Luboshitz in 1965 and was experimentally tested on iron at early 1970s. The formula for the angle of rotation must be revised at the presence of quantizing magnetic field (so far unachievable in terrestrial conditions) because of significant changes of electron wavefunctions and high degree of electron spin polarization. In relativistic approach in the framework of tree approximation the difference of Compton forward scattering amplitudes in quantizing magnetic field is calculated for an electron in the ground state and circularly polarized hard X-photons moving at arbitrary angle to magnetic field with opposite helicities. A formula is obtained for the calculation of Compton rotation angle of the plane of linear polarization of photons per unit path in electron gas in the limit of total spin polarization of electrons. The effect can influence the radiation spectra of superdense astrophysical objects with ultrastrong magnetic fields (as an alternative to photon splitting). Besides, one can estimate electron density in cosmic plasma and the degree of its ionization from the formula for the angle of rotation per unit path where other quantities can be measured or estimated.

Wind Accretion: Theory and Observations

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A review of wind accretion in high-mass X-ray binaries is presented. We focus attention to different regimes of quasi-spherical accretion onto the neutron star: the supersonic (Bondi) accretion, which takes place when the captured matter cools down rapidly and falls supersonically toward NS magnetosphere, and subsonic (settling) accretion which occurs when plasma remains hot until it meets the magnetospheric boundary. Two regimes of accretion are separated by an X-ray luminosity of about $4 \cdot 10^{36}$ erg/s. In the subsonic case, which sets in at
low luminosities, a hot quasi-spherical shell must be formed around the magnetosphere, and the actual accretion rate onto NS is determined by the ability of the plasma to enter the magnetosphere due to Rayleigh-Taylor instability. In turn, two regimes of subsonic accretion are possible, depending on plasma cooling mechanism (Compton or radiative) near the magnetosphere. The transition from the high-luminosity \((L > 3 \cdot 10^{35} \text{ erg/s})\) Compton cooling to the low-luminosity \((L < 3 \cdot 10^{35} \text{ erg/s})\) radiative cooling can be responsible for the onset of the ‘off’ states repeatedly observed in several low-luminosity slowly accreting pulsars, such as Vela X-1, GX 301-2 and 4U 1907+09. The triggering of the transition may be due to a switch in the X-ray beam pattern in response to a change in the optical depth in the accretion column with changing luminosity. The inverse transition from a steady low-luminosity state to an unstable Compton-dominated state accompanied by strong flaring activity is also possible and can underly the outbursts observed in some Supergiant Fast X-ray Transients.

**Occurrence of squeezed and entangled gluon states in QCD and their influence on intermittency of hadrons**

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Theoretical justification for the occurrence of squeezed and entangled color states in QCD is given. Nonperturbative contribution of the squeezed and entangled gluon states to the pion correlation functions is estimated. Antibunching and bunching of the pions is revealed. Reducing the value of the scaling exponent in the transition from a coherent to squeezed states is showed by investigation of the influence of entanglement and squeezing effects on intermittency and scaling of the final hadron states taking into account the phase transition from the color particles to hadrons.

**Broken baby Skyrmions**

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We present our recent results related with investigation of violation of rotational symmetry in the two-component planar Skyrme model with minimal coupling. Here we consider multisoliton configurations of degree one to six both in the "old" baby Skyrme model and in the "new" double vacuum model coupled via symmetry violating term. It is shown that the coupling parameter induces the isorotation of the configuration. Then the pattern of the symmetry breaking strongly depends on the coupling strenght, in the strong coupling limit the first component regains the rotational symmetry whereas the second component becomes symmetric w.r.t. the digedral group of symmetry.
General description of Dirac particle in Riemannian spacetimes

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We give a general description of a Dirac particle in Riemannian spacetimes. The metric of the spacetime is completely arbitrary, allowing for the discussion of all possible inertial and gravitational field configurations. In this framework, we find the Hermitian Dirac Hamiltonian for an arbitrary classical external field (including the gravitational and electromagnetic ones). In order to discuss the physical content of the quantum-mechanical model, we further apply the Foldy-Wouthuysen transformation, and derive the quantum equations of motion for the spin and position operators. We analyze the classical limit of these equations and compare the results with the dynamics of a classical particle with spin in the framework of the standard Mathisson-Papapetrou theory and in the classical canonical gravity. The comparison of the quantum mechanical and classical equations of motion of a spinning particle in an arbitrary gravitational field demonstrates their complete agreement.

Dark Matter Massive Fermions and Einasto Profiles in Galactic Haloes

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On the basis of a fermionic dark matter model we fit rotation curves of The HI Nearby Galaxy Survey (THINGS) sample and compare our 3-parametric model to other models widely used in the literature: 2-parametric Navarro–Frenk–White, pseudoisothermal sphere, Burkhert models, and 3-parametric Einasto model, suggested as the new "standard dark matter profile" model by Chemin et. al., AJ 142 (2011) 109. The results from the fitting procedure provides evidence for an underlying fermionic nature of the dark matter candidate, and are as well in consistency with density profiles characterized by a novel central compact region at sub-parsec scales.

High temperature hydrodynamics of explosions and shock wave phenomena

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Manifestation of quark-hadron duality in $e^+e^-$ annihilation into hadrons

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To compare theoretical results and experimental data one often uses the concept of quark-hadron duality which establishes a bridge between quarks and gluons, a language of theoreticians, and real measurements with hadrons performed by experimentalists. The Adler $D$-function is of interest from the point of view of quark-hadron duality, as this function turned out to be a smooth function without traces of the resonance structure which is observed for the function $R(s)$, the normalized cross-section for the process $e^+e^-$ annihilation into hadrons. We consider various physical quantities and functions generated by $R(s)$ and a good agreement between our results and experimental data down to the lowest energy scale is achieved. We determine that the reason for this agreement associated with quark-hadron duality.

Waves of helicon type in conductors and semimetals

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In the region below the plasma range the conditions of existing the transverse electromagnetic waves in conducting medium are considered. In noncompensated metals with the open Fermi surface the helicon-like waves are possible in the region of the microwave band.

Quantum-gravitational particle creation and generation of metric fluctuations in cosmology

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The quantum-gravitational effect of particle creation and vacuum polarization of quantum fields, including the gravitational one, in cosmology which Ya. B. Zeldovich pioneered, among others, from 1970 had later become a foundation for the mechanism of generation of small inhomogeneous scalar and tensor metric fluctuations in the inflationary scenario of the early Universe which predictions are confirmed by recent observations. Moreover, in some of the inflationary models including the pioneer $R + R^2$ one (1980), this effect is also responsible for the production of all observed matter from vacuum. I review these most interesting applications of this effect in cosmology. Also discussed is the present observational status of the confirmation of a small deviation of the primordial spectrum of scalar metric fluctuations (adiabatic matter density perturbations) from the exactly flat one proposed by Zeldovich in 1972 (along with Harrison). Such a deviation is a generic property of inflationary models apart from a very special subclass of them.
Fractional Effective Action at strong electromagnetic fields

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In 1936, Weisskopf [K. Dan. Vidensk. Selsk. Mat. Fys. Medd. XIV (1936)] showed that for vanishing electric or magnetic fields the strong-field behavior of the one-loop Euler-Heisenberg effective Lagrangian of quantum electro dynamics (QED) is logarithmic. This result can be generalized for different limits of the Lorentz invariants. The logarithmic dependence can be interpreted as a lowest-order manifestation of an anomalous power behavior of the effective Lagrangian of QED.

X-ray spectral index correlations vs mass accretion rate in neutron star and black hole X-ray binaries in their different spectral states. Theory vs observations

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We present details of observations of neutron star (NS) and black hole (BH) binaries and the first principle theory of X-ray spectral formation in neutron star (NS) and black hole (BH) binaries. We show our model predicts the spectral index correlation vs mass accretion rate as in the case of NS as well in the BH case. In BHs the spectral index should increase and then saturate with mass accretion rate because the index as an inverse of Comptonization parameter Y and Y-parameter saturates with the high mass accretion in the converging flow onto BH. Comparison of this model prediction with X-ray observations shows that in BH case the index, indeed, correlates and then saturates with mass accretion rate. Moreover this index-mass accretion rate correlation allows us to estimate BH masses and distance to the source. While in NS sources the observations shows that the index stays the same independently of spectral state of the source which can be possible if the energy release in the disk is always much smaller of that at NS TL (boundary layer).

Space-time scale noninvariance of the conformal geometry and its possible observable manifestations

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It is supposed that the geometry of the General Relativity flat limit can be described by semi-direct product of the Special Conformal Transformations and Lorenz groups, locally isomorphic to Poincare group. The possible observable manifestations of such a supposition are
considered. It is show that the detected Universe accelerated expansion can be treated as a pure kinematical effect of the proposed space-time geometry. The radar procedure of the distance determination in conformal space-time is described. It is hown that the space intervals conformal contraction gave rise to anomalous violet frequency shift during the monochromatic signal propagation over the closed path. Its relative value equals the Hubble constant multiplied by duration of propagation. The predicted phenomenon is the local manifestation of the cosmologic expansion and, in principle, is accessible to experimental detection.

**Primordial Black Holes as a unique tool for early Universe exploration**

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Proposed first by Ya.B. Zeldovich and I.D. Novikov, Primordial Black Holes have become a very effective tool for the early Universe study. These fundamental objects appear as a consequence of basic cosmological principles and carry information about the cosmological stages inaccessible by other means. This talk describes the evolution of Primordial Black Holes in the modern cosmological models with additional spatial dimensions. It is shown that the rate of accretion onto Primordial Black Holes increases significantly in the five-dimensional Randall-Sundrum Type II braneworld cosmology due to the collisions of particles of cosmological background leading to a revision of the possible observational manifestations of the extra spatial dimension. Considering Randall-Sundrum II braneworld in the context of ADS/CFT-correspondence it is shown how mass spectrum of Primordial Black Holes modifies both in scale-invariant and blue limits if they are able to radiate conformal modes effectively. Another possibility of Primordial Black Hole detection, connected with the interaction of Primordial Black Holes with dense compact objects, is also considered and respective constraints on the Primordial Black Hole mass fraction in the six-dimensional Arkani-Hamed-Dimopoulos-Dvali braneworld are obtained. It is shown that the absorption of a neutron star by an extra dimensional Primordial Black Hole imposes an upper limit of the six-dimensional Planck mass.

**Influence of plasma on effects of gravitational lensing**

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We discuss an influence of plasma on gravitational lensing. In presence of plasma the photon deflection angle depends on the photon frequency, and gravitational lensing becomes chromatic. We have derived formulae for calculation of the deflection angle with account of gravitation and plasma presence. The positions and magnifications of images are different for different wavelengths in presence of plasma. These effects are significant for very long
Spin determination of the 125 GeV diphoton resonance at LHC by the centre-edge angular asymmetry

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We discuss the discrimination of a 125 GeV spin-parity $0^+$ Higgs-like boson decaying into two photons, against the hypothesis of a minimally coupled $JP = 2^+$ narrow diphoton resonance with same mass and giving the same total number of signal events under the peak observed at LHC. To that purpose we apply, as the basic observable of the analysis, the center-edge asymmetry ACE asymmetry of the cosine of the polar angle of the produced photons in the diphoton rest frame. This asymmetry can in principle be determined from the angular distributions recently measured by the ATLAS and CMS collaborations at ECM = 8 TeV and 20 fb$^{-1}$. We find that, considering the rather large uncertainty currently affecting the determination of ACE, this asymmetry allows to exclude the spin-2 hypothesis.

Scalar-tensor theory of gravitation in Minkowski space-time

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In Minkowski space-time we regard the scalar and tensor fields, which form together the effective Riemann metric for a matter Lagrangian. The demand of minimal interaction, including tensor selfinteraction, leads to Einstein equations for finding tensor field and the nonlinear equation for scalar one. The cosmological scenario in given theory leads to existence of slow-rool regime of cosmological expansion in agreement with modern observations.

GRB 130427A and SN 2013cq: Multi-wavelength Analysis of An Induced Gravitational Collapse Event

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Binary systems constituted by a neutron star and a massive star are not rare in the universe. The Induced Gravitational Collapse (IGC) paradigm interprets Gamma-ray bursts (GRB) as the outcome of a neutron star that collapses into a black hole due to the accretion of the ejecta coming from its companion massive star that underwent a supernova event. GRB
130427A, which has the largest fluence in γ-rays and the longest simultaneous observation in optical, X-ray and GeV bands. This GRB provides an unique opportunity so far to understand the multi-wavelength observation within the IGC paradigm, our data analysis found a low Lorentz factor blackbody radiator and common power-law behaviors with the same decaying index from optical, X-ray (0.3KeV - 10KeV) till very high energy (100MeV - 100GeV) in the spectrum and the light curve respectively of episode 3, which comply to the IGC mechanisms. We consider these findings as two of the clues that GRB 130427A belongs to the IGC GRBs. We predicted on GCN 14526 the emergence of a supernova on May 2, 2013, later the supernova 2013cq was successfully detected on May 13, 2013.