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ABSTRACTS

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List of Sections

Astrophysics
Coordinator: Vasily Beskin

Superstrings and Higher-Spin Gauge Theory
Coordinator: Mikhail Vasiliev

Quantum Field Theory
Coordinator: Igor Tyutin, Boris Voronov

High Energy Physics
Coordinator: Igor Dremin

Quantum Gravity and Cosmology
Coordinator: Andrei Barvinsky

Condensed Matter Physics
Coordinator: Petr Arseev, Evgeny Maksimov

Quantum Field Theory with External Conditions
Coordinator: Vladimir Ritus

Compilation: E. Skvortsov – program, D. Sobyanin – abstracts

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Contents

Plenary Session

G. Arutyunov

Gauge Theories from Quantum Strings

I review some of the recent progress towards understanding the relationship between the spectra of certain gauge and string theories based on the AdS/CFT correspondence and the idea of exact integrability.

Inst. for Theoretical Physics, Utrecht Univ.

R. Combescot

Superfluidity in Ultracold Fermi Gases

We present an overview of the field of ultracold Fermi gases and in particular of superfluidity in these systems, stressing the features which makes them of very high interest. We will consider the aspects of this field related to other known manifestation of superfluidity, as well as others which are unique and open to new physics. We will describe some prominent and striking experimental results and provide some theoretical analysis.

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S. Giddings

Black Holes, High-Energy Scattering, and Locality

Various considerations suggest that, despite its role as a cornerstone in quantum field theory, our current idea of locality may need modification. These include the black hole information paradox and properties of high-energy gravitational scattering, together with the apparent fact that local observables are only approximate constructs in a theory of gravity. However, naive modifications of locality produce paradoxes. Deduction of the principles of a theory of "locality without locality," whether string theory or not, poses a challenge perhaps comparable to the development of quantum mechanics, with implications reaching into cosmology.

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I. Klebanov

Strings, Branes and Gauge Theories

String theory was originally invented to describe strongly interacting particles, but soon after Quantum Chromodynamics emerged as the precise theory of strong interactions. A quarter century later it was understood that string theory and certain gauge theories akin to QCD are in fact different descriptions of the same physics. I will review some of the basic concepts in relating gauge theories to strings, and motivate the AdS/CFT duality by studying coincident D-branes. The talk will end with a discussion of the recent progress in understanding the supersymmetric Chern-Simons theories that arise on coincident supermembranes of M-theory, and of their dual AdS descriptions.

Princeton Univ.

P. Littlewood

A New Condensate of Matter and Light

Macroscopic phase coherence is one of the most remarkable manifestations of quantum mechanics, yet it seems to be the inevitable ground state of interacting many-body systems. In the last two decades, the familiar examples of superfluid He and conventional superconductors have been joined by exotic and high temperature superconductors, ultra-cold atomic gases, both bosonic and fermionic, and recently systems of excitons, magnons, and exciton-photon superpositions called polaritons, the subject of this talk. An exciton is the solid-state analogue of positronium, made up of an electron and a hole in a semiconductor, bound together by the Coulomb interaction. The idea that a dense system of electrons and holes would be unstable toward an excitonic (electrical) insulator is one of the key ideas underlying metal-insulator transition physics. The further possibility that an exciton fluid would be a Bose-Einstein condensate was raised over 40 years ago, and has been the subject of an extensive experimental search in a variety of condensed matter systems. Such a condensate would naturally exhibit phase coherence. Lately, some novel experiments with planar optical microcavities make use of the mixing of excitons with photons to create a composite boson called a polaritons that has a very light mass, and is thus a good candidate for a high-temperature Bose condensate. Good evidence for spontaneous coherence has now been obtained [1], though there are special issues to resolve [2] considering the effects of low dimensionality, disorder, strong interactions, and especially strong decoherence associated with decay of the condensate into environmental photons [3] — since the condensate is a special kind of laser.

1. J. Kasprzak, et al.Nature, 443, 409-415 (2006).
2. J. Keeling, F. M. Marchetti, M. H. Szymanska, P. B. Littlewood, Semiconductor Science and Technology, 22, R1-26 (2007).
3. M. H. Szymanska, J. Keeling, P. B. Littlewood, Physical Review B 75, 195331 (2007).

Cavendish Laboratory, University of Cambridge

B. Ovrut

The Heterotic String: From Super-Geometry to the LHC

Compactifications of the heterotic string and M-theory can admit a class of Standard Models whose four-dimensional spectrum is exactly that of the MSSM with one right-handed neutrino chiral multiplet per family. The super-geometry of these vacuum states will be discussed. The gauge group of this Standard Model is enhanced by an additional gauged U(1) B-L symmetry which contains R-parity and prevents rapid nucleon decay. However, B-L symmetry must be spontaeously broken at a scale not too far above the electroweak scale. We show, using a renormlization group analysis, that this is indeed the case. Interesting relationships between this B-L/Electroweak hierarchy, $tan\beta$ and the superpartner spectrum will be discussed.

Univ. of Pennsylvania

M. Shaposhnikov

Standard Model Higgs Boson and Cosmological Inflation

I will discuss cosmological inflation driven by the Higgs boson of the Standard Model. It will be argued that inflation is possible in a certain interval of Higgs masses. This range exceeds somewhat the interval of Higgs masses in which the Standard Model is a viable field theory all the way up to the Planck scale.

Ecole Polytechnique Federale de Lausanne

D. Shirkov

On Symmetry Breaking under Phase Transition

Discussion of symmetry in physical systems and in theoretical models. In particular, the spontaneous symmetry breaking (SSB) in quantum theory accompanying the phase transition. The issue that is related to Higgs mechanism and to quark-gluon plasma.
The main items are

- Symmetries and groups: discrete and continuous
- Symmetry of equation and of a solution
- Symmetries: classical and quantum
- What is the Symmetry of quantum system?
- SSB in Superfluidity and Superconductivity
- Broken and restored symmetry in QCD

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R. Sunyaev

The Richness and Beauty of the Physics of Cosmological Recombination

In our Universe the initial temperature of radiation was very high and hydrogen and helium were completely ionized. At redshifts $z \sim 1400$ the temperature dropped to 3800 K and, according to the Saha equation, the recombination of hydrogen should occur. In reality this process is strongly delayed and some frozen amount of electrons should be present till the reionization of the Universe at $z \sim 10$.

Process of recombination defines the position and the width of the last scattering surface which is crucial for the formation of the observed angular fluctuations of cosmic microwave background radiation (CMB), acoustic peaks and barionic oscillations in the distribution of galaxies and clusters of galaxies in space.

The recombination of hydrogen occurs under conditions of very low density and in the presence of black body radiation. As a result, usually insignificant atomic processes begin to play a role. They influence the shape of CMB acoustic peaks at a level which will be detectable by the Planck Surveyor spacecraft and we should take them into account when estimating the key parameters of the Universe from CMB data.

The recombination of hydrogen and helium leads to the appearance of recombinational lines in centimeter and decimeter spectral bands. Observations of these lines will make it possible to check the predictions of the big bang recombination theory and will open a possibility to measure directly the density of barions, the CMB monopole temperature and specific entropy of the Universe. Observations of helium recombination lines originated at redshifts 6000 and 2500 will open a way to measure the prestellar abundance of helium in the Universe.

Space Research Inst., Moscow

R. Venugopalan

Gluonic Matter in Collision at RHIC and the LHC

We discuss the partonic wavefunctions of nuclei at high energies (”the Color Glass Condensate”) and describe a scenario for how gluonic matter (”the Glasma”) is formed in bulk in heavy ion collisions at ultrarelativistic energies. This matter evolves to form a nearly perfect fluid–the Quark-Gluon Plasma. We outline how the experiments at RHIC and lattice studies have help develop our understanding of hot and dense QCD and how these ideas can be tested in future experiments at the LHC.

Brookhaven National Lab.

A. Artemiev, H. Malova, A. Petrukovich, and L. Zelenyi

Spontaneous Reconnection in Collisionless Plasma. Long Lasting Drama of Ideas

Complicated magnetic configurations containing numerous magnetic field reversals are widespread in nature. Each of such reversals is supported by corresponding current sheet (CS) which could often have very small thickness comparable to ion skin depth. Particle motion in such sheets has many specific features, because standard guiding center description completely fails especially for ions. Existence of such very thin (singular in terms of MHD) current sheets was predicted in a series of

papers by S.I. Syrovatsky and his colleagues published in late 60-ies and early 70-ies. Dramatic arguments between steady MHD reconnection models (by H. Petschek) and dynamic CS models by Syrovatsky school have been resolved only recently after measurements by closely spaced spacecraft systems made in the Earths magnetosphere. One of the most intriguing features of current sheets in collisionless plasma is their ability to accumulate tremendous amounts of magnetic energy (10^{15} J for magnetospheric substorms, 10^{24} J for solar flare associated sheets) and then suddenly sometimes almost explosively release them. We will demonstrate in this talk that such METASTABILITY is a principal intrinsic feature of current sheets in a hot plasma. Analysis of INTERBALL and especially 4-point CLUSTER data have shown that real current sheets observed in the Earths magnetotail very rarely resemble simplistic HARRIS current sheets which have been used for an early stability calculations.

Space Research Inst., Moscow

Sakharov Memorial Session

B. Altshuler

Andrei Sakharov as a Physicist in All Facets of His Life

The main stages of life and activities of Andrei Sakharov will be covered with an emphasize on his method of achieving the desirable non-trivial results. The analysis of Sakharov's plural works and deeds shows that his method in science, in designing nuclear weapons, in defending human rights, in manufacturing world security was one and the same: he always remained a man of exact sciences, a physicist, a construction engineer, an implementor. The visible result may be the figures in the end of a formula-saturated paper or release of a victim of political repressions no matter: in any case it was a sort of scientific research, and special holism of Sakharov's mentality proposed the essentially unexpected steps to the solution which were at first often misunderstood or sometimes even shocking for his contemporaries. For an epigraph of this Talk is taken Sakharov's motto: "Non-realized idea is not an idea yet". Demonstration of photos and fragments from films is included.

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Fradkin Memorial Session

L. Brink

Exceptional Symmetries in the Light-Cone Gauge and Possible Counter Terms

The exceptional symmetries E_7 and E_8 have been formulated in the light-cone gauge formulation of maximal supergravity in $d = 4$ and $d = 3$. They act very differently in this formulation in that all fields transform under the symmetries. The E_7 symmetry can be used to constrain possible counter terms.

Chalmers Univ. of Tech., Goteborg

A. Shabad

Early Fradkin

Memories about Professor Fradkin's personality and a review of his most important achievements in the early period will be given by his then student.

Lebedev Inst., Moscow

A. Tseytlin

Quantum Strings in $AdS_5 \times S^5$

I will review the Pohlmeyer reduction approach towards string theory in $AdS_5 \times S^5$. It is based on solving Virasoro constraints in terms of new set of fields algebraically related to supercoset currents. The resulting reduced theory is ultra-violet finite massive $2d$ Lorentz-invariant model of a generalized sine-Gordon type containing physical number of bosonic and fermionic degrees of freedom. It may serve as a basis for an alternative approach to solving string theory in $AdS_5 \times S^5$.

Imperial College London

M. Vasiliev

Conformal Higher-Spin Gauge Theories

Unfolded formulation of conformal higher-spin gauge theories will be presented.

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Astrophysics

A. Andrianov and V. Beskin

Limiting Polarization — Missing Link in the Theory of the Pulsar Radio Emission

In spite of forty years of extensive exploration there is no common point of view on the nature of the coherent radio emission of pulsars. Moreover, propagation effects in the pulsar magnetosphere were not analyzed carefully enough as well. We used the method of the wave propagation in the inhomogeneous media describing by Yu.A. Kravtsov and Yu.I. Orlov. This approach allows us to include into consideration not only the transition from geometrical optics to vacuum propagation but the shear of the magnetic field in the picture plane as well. It is demonstrated that for ordinary pulsars the polarization is formed inside the light cylinder at the distance $1000R$ from the neutron star, the circular polarization being $5-20\%$ which is just observed. Numerical simulation allows us to determine the polarization characteristics for arbitrary parameters of radio pulsars.

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D. Bisikalo

3D Modeling of Accretion Disks in Close Binaries: Shocks and Density Waves

In this report the main attention is paid at physics of accretion discs in binary systems and particularly at formation of waves in discs. The characteristic features and possible observational manifestations of the bow shock caused by the motion of the accretor and the disc in the gas of the circumbinary envelope; the "hot line" shock formed due to interaction between the circumdisc halo and the stream from inner Lagrange point, two arms of the tidal shock, and precessional spiral density wave are discussed. The analysis of the numerical model and comparison of computational results with observational data allow us to define more exactly the physical processes resulting in formation of structures in accretion discs in binary stars.

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G. Bisnovatyi-Kogan

Gamma Ray Bursts, Soft Gamma Repeaters, and Magnetars

Soft gamma repeaters (SGRs) had been collected in a separate group of objects from gamma ray bursts, being very close to them observationally. Only 6 SGRs had been discovered since 1979. They are considered as galactic objects, and 2 extragalactic giant SGR bursts were recently discovered. GRBs are identified as cosmological sources with red shifts sometimes exceeding 6. The most intriguing discovery of this year was observation of the prompt optical light curve of GRB 080318B, what should give an additional light to the nature of GRBs. SGRs are interpreted as highly magnetized neutron stars — magnetars. Due to slow rotation, magnetic field is considered as a main source of energy in magnetars, especially for their giant bursts. Observational data on SGR giant bursts are analyzed, and magnetar conception is criticized. Alternative model based on nuclear processes in neutron stars is discussed.

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S. Bogovalov and S. Kelner

Plasma Outflow from Dissipationless Accretion Discs

We consider a disk accretion under the condition when the angular momentum loss due to disk wind dominates the conventional viscous stress losses. In this case the dissipative processes can be fully neglected. The angular momentum and the energy of the accreted matter is carried out by a magnetized wind outflowing from the disc. The infalling matter advects the frozen magnetic field to the centre. The problem of the magnetic flux and energy accumulation at the gravitation centre is resolved due to variable polarity of the magnetic field in the disc. Accretion and outflow are connected by the conservation of the energy, mass and the angular momentum. The basic properties of the outflow, angular momentum and energy flux per particle in the wind, do not depend on the details of the structure of the accretion disc. We demonstrate that such solutions exist on the example of selfsimilar flows. In this case, the dependence of the accretion rate $\dot{M}$ depends on the disc radius r on the law $\dot{M} \sim r^{\frac{1}{2(\Lambda^2-1)}}$, where Λ is a dimensionless Alfvenic radius. The outflow predominantly occurs from the very central part of the disc provided that $\Lambda \gg 1$. The accretion/outflow mechanism provides transformation of the gravitational energy of the accreted matter into the energy of the outflowing wind with efficiency close to 100%. The final velocity can essentially exceed Kepler velocity at the site of the wind launch.

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D. Breitschwerdt

Modelling the Interstellar Medium in Star Forming Galaxies

The evolution of galaxies is driven by the continuous formation of stars out of interstellar matter (ISM). The ISM is a highly compressible and magnetized medium, characterized by Reynolds numbers, exceeding those in terrestrial laboratories by orders of magnitude. Supernova (SN) explosions of massive stars are the major energy source in the ISM, generating turbulence, heating the gas and also accelerating cosmic rays. Theinherent complexity and nonlinearity of the system require a careful approach, especially for advanced numerical 3D parallel computer simulations. We have built a bottom-up model of a turbulent SN driven ISM over the last years, emphasizing the necessity of critical numerical resolution appropriate for the physical processes included, and for sufficiently long evolution times for a dynamical equilibrium to be established. We have shown that both for hydro- and magnetohydrodynamical simulations, the distribution of the plasma into distinct "stable" phases does not occur in contrast to the standard 3-phase model, and that instead a considerable fraction of the gas mass resides in classically thermally unstable phases. We will show that turbulence has a significant influence on the structure and the evolution of the ISM, and compare our results to current observations. Finally, it will be emphasized that these results imply a change in paradigm, i.e. from a stable 3-phase to a highly turbulent ISM.

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G. Brunetti

Mergers between Clusters of Galaxies and Acceleration of High Energy Particles

Clusters of galaxies are ideal astrophysical environments to study particle acceleration in large scale structures. Radio observations unveil the presence of Mpc-scale synchrotron radiation due to relativistic particles and magnetic fields mixed with the thermal hot Inter-Galactic-Medium (IGM). Cluster mergers are probably the most important sources of non-thermal components: a fraction of the energy dissipated during these mergers should be channelled into shocks and turbulence that accelerate particles. After a review of the most relevant observations that constrain the properties of cluster non-thermal components, I will focus on theoretical aspects. First I will give a brief overview of particle acceleration mechanisms in clusters, then I will focus on the non-linear interaction between relativistic particles and MHD turbulence generated during cluster-cluster mergers. Diffuse cluster-scale radio and hard X-ray emissions are expected to be generated in massive clusters during mergers, while gamma ray emission is expected to be long-living and common in clusters. In next years LOFAR, FERMI and Cerenkov Arrays will provide crucial observations and I will discuss model expectations.

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S. Bulanov

Relativistic Laboratory Astrophysics with Relativistic Laser Plasmas

The prospects of using the laser radiation interaction with plasmas in the laboratory relativistic astrophysics context are discussed. The development of superintense lasers will provide the necessary conditions for experimental physics where it will become possible to study ultrarelativistic energy of accelerated charged particles, super high intensity electromagnetic radiation and the relativistic plasma dynamics [G. Mourou, T. Tajima, and S. V. Bulanov, Optics in the Relativistic Regime, Rev. Mod. Phys. 78, 309 (2006)]. A fundamental property of the plasma to create nonlinear coherent structures, such as relativistic solitons and vortices, collisionless shock waves and high energy particle beams, and to provide the conditions for relativistic regimes of the magnetic field line reconnection, makes the area of relativistic laser plasmas attractive for modeling of processes of key importance for relativistic astrophysics [S. V. Bulanov, T. Zh. Esirkepov,D. Habs, F. Pegoraro, T. Tajima, Relativistic Laser-Matter Interaction and Relativistic Laboratory Astrophysics, Eur. Phys. J. D (2009)]. We discuss the dimensionless parameters characterizing the processes in the laser and astrophysical plasmas. The collisionless shock wave, magnetic reconnection, vortex dynamics properties and extremely high power electromagnetic pulse generation in laser-matter interaction relevant to the problem of ultrarelativistic astrophysical plasmas are addressed.

Kansai Photon Science Inst., Kyoto & General Physics Inst., Moscow

A. Cherepashchuk

SS 433 — a Supercritically Accreting Microquasar with Black Hole

SS 433 is a massive X-ray binary system at advanced evolutionary stage with precessing relativistic jets ($v \approx 0.26c$) and supercritical, optically bright accretion disk. This unique microquasar exhibit several variabilities: precessional one ($P_{prec} \approx 162^d$), nutational ($P_{nut} \approx 6^d.28$) and orbital one ($P_{orb} \approx 13^d.08$). The analysis of new INTEGRAL hard X-ray observations of SS 433 revealed the value of mass ratio of the components $q = m_x/m_v \approx 0.3$ (m_x — the mass of relativistic object, m_v — the mass of optical A7I star). Using new spectroscopic data obtained by Hillwig and Gies (2008) the masses of the components were calculated as $m_x \approx 5.3 M_\odot$, $m_v \approx 17.7 M_\odot$, which implies the presence of black hole in the SS 433 binary system.

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A. Chernin

Dark Energy in the Local Universe

The local Hubble cell is studied which is the Local group of galaxies together with the expansion outflow around it in the volume of 6 Mpc across. With the use of recent high precision HST data, it is demonstrated than the observed structure and kinematics of the cell provide clear evidence for the existence of dark energy and its strong dynamical effects on the spatial scale of several Mpc. The motions of the galaxies in the cell are affected by the interplay between the gravity of the galaxies and the antigravity of the dark energy background in which the cell is embedded. Gravity dominates the group while antigrav-

ity dominates the expansion outflow. The cell may serve as a natural setup for quantitative measurements of dark energy. It enables us to find that the local density of dark energy is close (if not exactly equal) to the global value known from the observations on the distances of ~ 1000 Mpc. The fact that antigravity is strong in the local universe makes the nearfield cosmology a new independent arena of dark energy studies.

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E. Churazov

AGN Feedback in Elliptical Galaxies and Clusters

The comparison of gravitational potential profiles of elliptical galaxies derived from X-ray and optical data suggests that the combined contribution of cosmic rays, magnetic fields and micro-turbulence makes ~10-20% of the gas thermal pressure. This in turn suggests that the dissipation time scale of energy supplied by an AGN is ~10% of the gas cooling time scale. Implications for the current paradigm of AGN feedback are discussed.

Max Planck Inst. for Astrophysics, Garching & Space Research Inst., Moscow

B. Coppi

High Energy Plasmas, General Relativity and Collective Modes in the Vicinity of Black Holes

Plasmas surrounding black holes can take different equilibrium configurations (such as sequences of density rings [1]) from to those (simple disks) derived by standard fluid theories. Starting from an axisymmetric disk with a "seed" magnetic field, axisymmetric modes as well as tri-dimensional spirals can be excited under the combined effects of the radial gradient of the plasma rotation frequency and of the plasma pressure gradient [2]. Unlike the case of the well known galactic spirals, the properties of the considered plasma spirals are strongly dependent on their vertical structure [3]. Axisymmetric modes are shown to produce vertical flows of thermal energy and particles in opposing directions and be candidates for the origin of the winds to emanating from disks in Active Galactic Nuclei (AGN's) [2]. The excitation of radially localized density spirals co-rotating with the plasma at a distance R_0 related to that of the radius R_ms of the marginally stable orbit around a black hole (which depends on $R_M \equiv GM_*/c^2$ and $a_* = J/(M_*c)$ where M_* is the black hole mass and J its angular momentum) can provide the explanation [4] for the observed Quasi Periodic Oscillations (QPO's) of the relevant X-ray emission. At the mode localization distance, $R = R_0$, the height of the disk is considered to be about the radius of the magnetically stable orbit and the conditions for the onset of coherent modes to exist while the electrons acquire a thermal energy $\simeq$ 0.5 MeV. Then the frequencies of the resulting QPO's are given by $f \simeq [2\pi c/(\alpha_{Ms}R_M)]/(2\alpha_T m_e/m_i)^{1/2} m_\phi$ where m_e and m_i are the electron and the ion mass, and $m_\phi = 3, 2$ is the spiral toroidal mode number of the prevailing lowest harmonics of spiral modes, α_{Ms} is the ration of the last stable orbit to $2R_M$, and α_T is the ratio of the plasma temperature to $m_e c^2$. These frequencies have the scaling $f \propto 1/M_*$ which is consistent with that derived from experiments, have numerical values relatively close to those observed and justify the 3:2 ratio of twin peak QPO's. Spiral modes [3] that are oscillatory in time, and are not localized can acquire their amplitudes from coupling to unstable modes, and produce transport [3] of angular momentum toward the outer region of the disk structure as necessary for a plasma accretion process to occur. *Sponsored in part by the U.S. Department of Energy.

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4. B. Coppi and P. Rebusco, Paper P5.154, E.P.S. Int. Conf. Pl. Phys. (Crete, Greece, 2008).

Massachusetts Inst. of Technology, Cambridge

A. Bamba, K.-S. Cheng, D. Chernyshov, V. Dogiel, A. Ichimura, H. Inoue, C.-M. Ko, M. Kokubun, Y. Maeda, K. Mitsuda, K. Nakazawa, D. Prokhorov, V. Tatischeff, N. Yamasaki, and T. Yuasa

Hard X-rays from the Galactic Center: Theory and Interpretation

We analyse new results of Chandra and Suzaku, which found a flux of hard X-ray emission from the compact region around Sgr A. We suppose that this emission is generated by accretion processes onto the central supermassive black hole when an unbounded part of captured stars obtains an additional momentum. As a result a flux of subrelativistic protons is generated near the Galactic center which heats the background plasma up to temperatures about 6-10 keV and produces by inverse bremsstrahlung a flux of non-thermal X-ray emission in the energy range above 10 keV. We present also arguments that protons from Sgr A may also produce a flux 6.4 keV line and bremsstrahlung continuum emission from molecular clouds.

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V. Dokuchaev

Small Scale Dark Matter Clumps in the Galaxy

The small-scale clumps of dark matter particles are efficiently disrupted by tidal forces during cosmological formation and evolution of the Galaxy. Surviving the remnants of small scale dark matter clumps is considered by modelling the tidal destruction of clumps in the early hierarchical structures formation and by stars in the Galaxy. It is shown that a substantial fraction of clump remnants may survive through the tidal destruction during the lifetime of the Galaxy if a radius of clump core is rather small. The resulting mass function of survived clumps is extended down to the mass of the core of the cosmologically produced clumps with a minimal mass. The dense remnants of clumps provide a suitable contribution to the amplification (boosting) of the dark matter annihilation signal in the Galaxy.

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E. Dudas

(In)vizible Z' and Dark Matter

We study the consequences of an extension of the standard model containing an invisible extra gauge group under which the SM particles are neutral. We show that effective operators, generated by loops of heavy chiral fermions charged under both gauge groups and connecting the new gauge sector to the Standard Model, can give rise to a viable dark matter candidate. Its annihilations produce clean visible signals through a gamma-ray line. This would be a smoking gun signature of such models observable by actual experiments.

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A. Fridman

Prediction and Discovery of Extremely Strong Hydrodynamic Instabilities due to a Velocity Jump: Theory and Experiments

The theory and experimental discovery of extremely strong hydrodynamic instabilities are described, viz. the Kelvin-Helmholtz, centrifugal, and superreflection instabilities. The discovery of the last two instabilities was predicted and the Kelvin-Helmholtz instability in real systems was revised by us.

Inst. of Astronomy, Moscow

C. Fronsdal

Heat and Gravitation

This is about problems in which General Relativity joins up with hydro and thermodynamics. A study of stellar structures, benefits from a formulation in terms of an action principle that involves the metric, radiation and any number of densities. The existence of a suitable, generally relativistic action is not in doubt, the problem has been to incorporate classical hydro and thermodynamics. Benefits include: The usual procedure of taking the radiation pressure to be in a fixed relation to the gas pressure is not needed. The theory incorporates a relativistic version of the classical equation of continuity, which has a profound impact on the choice of boundary conditions, and an exact, dynamical virial theorem that can be used to investigate the stability of atmospheres and stellar structures. Mixtures and chemical reactions have been treated, as well as molecular disasociation. Changes of phase are under investigation. It is well known that an action principle becomes really useful only when formulated without constraints, for only in that case is it possible to include additional degrees of freedom, by adding terms to the lagrangian.

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Yu. Gnedin

Axion Astronomy: The Basic Stages of Axion Searches by Astronomical Methods

I discuss the basic methods of searches for axions by astronomical methods. The history of the search for axions is presented. The main topics of my talk are: (a) ground-based cavity experiments with searching for galactic axions; (b) searching for hadronic axion decay line into galactic and extragalactic light, including the results of observations by Russian BTA-6m telescope; (c) experimental searches for solar (CAST experiment) and stellar axions; (d) the conversion of photons into axions in cosmic magnetic fields; (e) the novels of searcing for axions.

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E. Grigorenko and L. Zelenyi

Non-Adiabatic Ion Acceleration in the Current Sheet of the Earth Magnetotail

Ion non-adiabatic dynamics in the distant Current Sheet (CS) was considered in the frame of large-scale kinetic model. It was demonstrated that ion non-adiabatic interaction with the CS has resonant character and occurs at spatially localized sites of the CS called resonances. In course of such interaction, ions move along unperturbed Speiser orbits and are injected into the Plasma Sheet Boundary Layer (PSBL)almost without scattering, where they form field-aligned ion beams called beamlets. Each CS resonance accelerates ions in finite energy range which is defined by the value of local normal component of the magnetic field and by the value of quasi-steady dawn-dusk electric field. As a result, ion beamlets observed in PSBL should be localized in physical and velocity space. The important features of ion resonant acceleration are that it occurs in the region of CS with finite positive component of the normal magnetic field, i.e. in the region of closed magnetic field lines and that several spatially separated resonant sources may simultaneously operate in the CS. Recent observations in the distant and in the near-Earth magnetotail by Geotail and Cluster spacecraft confirmed these theoratical predictions.

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V. Gurzadyan

CMB, Structure, Backreaction

The properties of the maps of Cosmic Microwave Background (CMB) radiation will be discussed in relation to the inhomogeneities in the matter distribution. Kolmogorovs stochasticity parameter appears a convenient descriptor to trace the underdense regions in the large scale matter distributions, i.e. the voids, due to their hyperbolic and, hence, randomizing properties. Kolmogorov CMB map technique will be discussed which can reveal such non-Gaussianities as the Cold Spot, the plane-mirroring.

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Ya. Istomin

Synchrotron Radiation of a Pulsar Wind

At the moment of a switch off pulsar radio emission the magneto-dipole wave overtakes the wind, and their interaction takes place. The energy density in the wind is of the order of the energy density of the electromagnetic field in the magneto-dipole wave. Their ratio does not depend on the distance from the star. The powerful electromagnetic wave interacts with the pulsar wind, i.e. with the flux of relativistic electrons and positrons, and produces the synchrotron emission. Observation of this radiation give chance to measure a pulsar magnetic field and pulsar wind characteristics.

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I. Khriplovich

Capture of Galactic Dark Matter by the Solar System

We have calculated the amount of galactic dark matter captured by the Solar System as a result of its gravitational scattering by the planets. Thus obtained local density of dark matter near the planets is compared with the observational upper limits.

Budker Inst. of Nuclear Phys., Novosibirsk

C.-M. Ko

Cosmic Ray Acceleration and Its Evidences in Heliospherical Shocks

The existence of high energy particles from outer space was first demonstrated almost a century ago. After decades of investigations, we believe the origin of many (if not most) of them ought to be astrophysical shocks. Plenty observational evidences support shock acceleration of cosmic rays. In this presentation, I shall discuss shocks in the heliosphere where in situ measurements can be made. I shall give a short overview on various observed properties related to energetic particles near shocks, including temporal variation, energy spectrum, isotopic composition, self-excited waves, seed population, etc.

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V. Kocharovsky, Vl. Kocharovsky, and V. Martyanov

Self-Consistent Current Structures in Relativistic Collisionless Plasmas: Exact Solutions for Broad Classes of Particle Distributions

Recent progress in analytic understanding of origin and various properties of self-consistent quasi-static configurations of magnetic field and current structures emerging in anisotropic collisionless plasma is reviewed and applied to the problem of relativistic shocks in astrophysical plasmas.

In typical planar and cylindrical geometries, we find analytically a wide class of nonlinear stationary current structures which can be equally easy realized in relativistic and non-relativistic collisionless plasma. These solutions are based on the method of integrals of motion, and extend far beyond the known generalizations of non-relativistic Harris model. The obtained Grad-Shafranov type equations allow to analytically investigate and compare general properties and possible evolution of these structures. Among the properties of newly found stationary solutions we discuss the ratio of magnetic field energy to that of particles, the anisotropy of particle momentum distribution, the spatial scales and profiles of particle density, current and magnetic field, etc.

We carry out also the short wavelength instability analysis of these current sheets and filaments in the regions with small enough magnetic fields where this instability is expected to be the most pronounced. We point to peculiarities of the synchrotron radiation spectra of relativistic particles in self-consistent current sheets, which make it possible to study the structure and evolution of their currents and magnetic fields based on the observed radiation.

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V. Lukash

Rise and Fall of Structure Formation in the Universe

Formation of the large scale structure in the Universe, its decay due to DE gravitational action and possibilities to measure DE properties is reviewed.

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A. Melatos

Gravitational Waves from Neutron Stars: Probing Quantum Fluids at Nuclear Densities

Gravitational wave (GW) interferometers like Advanced LIGO will revolutionize our understanding of neutron star interiors and the physics of bulk nuclear matter. Recent observational and theoretical progress is reviewed, emphasizing how GWs will probe the collective processes in quantum fluids that cause pulsar glitches. Calculations are presented of the stochastic GW signal emitted by superfluid turbulence in a glitching pulsar, the burst signal emitted by superfluid vortex motion during the glitch itself, and the long-lived (weeks) periodic signal during the exponential relaxation phase after a glitch. It is shown how a GW detection can be inverted to measure the viscosity and compressibility of bulk nuclear matter and its state of superfluidity. The results are linked to radio pulsar timing data from the Parkes Multibeam Survey. It is shown that a new picture of glitch physics emerges when size and waiting-time statistics are disaggregated, partially resolving the long-standing homogeneity and scale-invariance paradoxes. Three new, complementary theoretical paradigms are discussed: (1) nearest-neighbour avalanches in a self-organized critical system, (2) coherent noise bursts in a noncritical system, and (3) global hydrodynamic instabilities (described at the multi-fluid and Gross-Pitaevskii levels).

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D. Melrose

Quantum Plasmadynamics and Quantum Fluid Models

Quantum plasmadynamics [1] (QPD) is a synthesis of the kinetic theory of plasmas and quantum electrodynamics, so that it includes all relativistic quantum effects: recoil, degeneracy, spin, pair creation and the critical magnetic field. There is an extensive recent literature on quantum fluid models, in which the fluid equations are written down with the quantum effects included through the Bohm potential. In this paper, the relation between quantum fluid theory and QPD is discussed. It is shown that the Bohm potential corresponds to the quantum recoil in a nonrelativistic model for the longitudinal response. The validity of generalizing the quantum fluid models to include electromagnetic effects, a background magnetic field and nonlinear effects is discussed critically. In particular the inclusion of nonlinear effects in the quantum fluid theory leads to a quantum generalization of the Zakharov equations; a derivation of Zakharov-like equations from QPD is discussed.

[1] D.B. Melrose, Quantum Plasmadynamics, Springer (2008)

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S. Nagataki

Toward Understanding GRB-Supernova Connection and Central Engine of Long GRB

The central engine of Long Gamma-Ray Bursts (GRB) is not known well although about 10 years have passed since the first discovery of SN-GRB connection. I would like to discuss the central engine of Long GRB and resulting explosive nucleosynthesis that determines the luminosity of the accompanying supernova. Especially, I would like to present my recent study on the collapsar scenario using a General Relativistic MHD (GRMHD) code that I have developed. Further, I have done numerical simulations on the collapsar scenario using ZEUS code by adding some microphysics such as a realistic equation of state and neutrino cooling/heating. Finally, I would like to show you our study on the explosive nucleosynthesis in jet-induced supernova explosions.

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V. Neznamov

The Isotopic Foldy-Wouthuysen Representation as a Possible Key to Understanding the Dark Matter

The paper considers, within the Standard Model, physical pictures of combinations and interactions of elementary particles, which are allowed within the isotopic Foldy-Wouthuysen representation. A hypothesis is suggested and proved that the properties of the world of dark matter do not contradict the two physical pictures considered in the paper.

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I. Novikov

Wormholes and Multiverse

We consider the hypothesis that some active galactic nuclei and other compact astrophysical objects may be current or former entrances to wormholes (WHs). A broad mass spectrum for astrophysical WHs is possible. We consider various new models of the static WHs including WHs maintained mainly by an electromagnetic field. We also discuss observational effects of a single entrance to WH and a model for a binary astrophysical system formed by the entrances of WHs with magnetic fields and consider its possible manifestation.

There is a hypothesis that the primordial WHs probably exists in the initial state of the expanding universe and can connect different regions in our universe and other universes in the model of Multiverse. It is possible that primordial WHs are preserved after inflation. In this case, the search for astrophysical WHs is a unique possibility to study the Multiverse.

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S. Odintsov

The Introduction to Modified Gravity as Dark Energy and Inflation

We review different models of modified gravity: F(R) theory, F(G) theory, scalar-Gauss-Bonnet gravity, non-local gravity, etc. Various formulations and the origin of some of these theories from strings are discussed. We suggest the class of viable models which pass the Solar System tests and cosmological bounds and may lead to the unification of early time-inflation with late-time acceleration complying with observational data.

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R. Rafikov

Gravitationally Unstable Accretion Disks

Outer parts of extended accretion disks should be cold enough to promote the operation of gravitational instability. This instability may trigger giant planet formation in protoplanetary disks and star formation in quasar disks. In this talk I will describe the main properties of gravitationally unstable disks, specifically concentrating on the phenomena of gravitoturbulence and fragmentation. A very important role of the gas thermal physics in the disk dynamics and the nonlinear outcome of the gravitational instability will also be described.

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M. Rengel

Tracing High Energy Radiation with Molecular Lines Emitted by the Deeply Embedded Protostar L1634

The ionization fraction (i.e., the electron abundance) is a fundamental parameter, is a crucial aspect for determining the chemical and physical evolution of star forming regions. In deeply embedded protostars, the ionization rate is dominated by cosmic rays. In spite that the cosmic-ray ionization rate is difficult to constrain, its estimated values present narrow discrepancies, tentatively attributed to X-rays from a central source (Doty et al. A&A, 418, 1021, 2004).

L1634 is a small, isolated dark cloud in Orion A. The cloud has been proposed to be either a remnant of the molecular material from which the nearby Orion OB1 association formed or a cloud pushed to its present location by the pressure associated with energetic events accompanying the evolution of the OB association (Maddalena et al. ApJ, 303, 375, 1986), then it is a suitable target for a study of high energy radiation. On the other hand, submillimetre observations of star forming regions can detect dust (thermal emission) and emission lines of embedded sources (e.g., Rengel et al. 2005)

We report a study of the physical and chemical properties of the core (two embedded protostars) L1634 by submillimetre observations (dust continuum, and line emission) and modeling. This allows us to place constraints on the cosmic ionization rate, among other parameters like the bolometric temperature and luminosity, age and mass. We find a high enhanced cosmic ray ionization rate of the gas around L1634, in the order of 10^{-17} s^{-1}.

This kind of evidences provides a more thorough understanding of the star forming processes and environments in dense regions.

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I. Royzen

QCD Against Black Holes

Along with compacting the baryon (neutron) spacing, two very important factors come into play: the lack of self-stabilization in the compact neutron stars and the phase transition — color deconfinement and QCD-vacuum reconstruction — within the nuclear matter. This is suggestive for the reasonability of taking into account both phenomena at once, as the gravitational collapse is considered. Since, under the above transition, the hadronic-phase vacuum (filled up with gluon and quark-anti-quark condensates) turns into the "empty" perturbation one and, thus, the very high pressure falls down rather abruptly, the formerly "cold" nuclear medium starts to implode into the new vacuum. If the mass of a star is quite large, then this implosion produces an enormous heating, which stops only after QGP of a temperature about 100 MeV is formed. As a consequence, GRBs with the energy releases, 4 to 5 orders higher than those of the typical supernovae ones, are expected. That is why a "burning wall" could be, probably, erected on the way of further collapsing the matter towards a black hole formation. Some unexpectedly powerful GRB's observed recently, which are poorly understood within the conventional framework, seem to gain a support for this hypothesis.

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Ya. Istomin and D. Sobyanin

Formation of a Pulsar Magnetosphere from a Strongly Magnetized Vacuum

We consider the motion of charged particles in the vacuum magnetospheres of rotating neutron stars with strong surface magnetic fields $B \gtrsim 10^{12}$ Gauss. We show that electrons and positrons are captured on the force-free surface (FFS) $\mathbf{E}\cdot\mathbf{B} = 0$. Using the Dirac-Lorentz equation, we investigate the dynamics of capturing particles and their further motion near the FFS. Far from the FFS the energy of particles is determined by the condition of balance between the power of accelerating electric field forces and the curvature radiation intensity. When being captured, the particles oscillate adiabatically along the magnetic field and simultaneously move over the FFS. We find the oscillation parameters and trajectories of the captured particles. We calculate the characteristic capture time and energy losses of particles due to curvature radiation and bremsstrahlung. Capturing particles results in the monotonous increase in the thickness of the layer of charged plasma accumulated near the FFS. We speculate on estimating the time of filling a pulsar magnetosphere with plasma.

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M. Artyushkova, H. Popova, and D. Sokoloff

Solar Cycle: New Asymptotic Solutions for Dynamo Equations

Unusual properties of dynamo waves which are considered as physical origin for solar activity cycle are discussed. We develop a WKB-like approach to describe the dybamo waves. We

demonstrate that the impuls of dynamo waves is a essentially complex quantity (rather a purely real or imaginary one as in more conventional branches on WKB theories).

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H. Sol

Observing the Sky at Very High Energy Gamma-Rays: Current Results and Perspective with CTA, the Cherenkov Telescope Array

During the last few years, a new branch of astrophysics at very high energy has emerged with the success of the current ground-based Cherenkov telescopes. Our cosmos revealed its richness when seen in the TeV range. More than 70 sources have been definitely confirmed as TeV emitters. Atmospheric Cherenkov detectors proved their capability to analyze them in details, get reliable spectra, monitor variable sources and produce light curves down to the minute scale, map the extended sources and even obtain bi-dimensional spectroscopy. New light was shed on many different types of cosmic sources, from pulsars and supernova remnants to active galactic nuclei. The new generation of detectors as CTA, the Cherenkov Telescope Array, should widely contribute to advances in astroparticle physics, astrophysics and cosmology.

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V. Tatischeff

Cosmic-Ray Acceleration in Radio Supernovae

Galactic cosmic rays are widely believed to be accelerated in expanding shock waves initiated by supernova explosions. The theory of diffusive shock acceleration of cosmic rays is now well established, but two fundamental questions remain partly unanswered: what is the acceleration efficiency, i.e. the fraction of the total supernova energy converted to cosmic-ray energy, and what is the maximum kinetic energy achieved by particles accelerated in supernova explosions? Radio observations of recent extragalactic supernovae can provide important pieces of information concerning these two questions. I will present a model to explain the impressive set of radio data available fo the supernova SN 1993J, which for the first time includes nonlinear effects of the diffusive shock acceleration mechanism. The results obtained for this supernova provide support to the scenario that massive stars exploding into their former stellar wind are a major source of high-energy Galactic cosmic rays.

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I. Toptygin

Large Scale Magnetic Field Generation by Accelerated Particles in Galactic Medium

Some problems of quasistationary magnetic fields generation in locality of accelerated particles sources in Galaxy are considered. We calculate in linear approximation electric current, pressure and secondary magnetic field created by point source of accelerated particles in homogeneous, but anisotropic medium.

The estimations of magnetic field show, that secondary field may be of the order of mean galactic field (a few microgauss) and larger. Secondary magnetic fields created large-scale (several parsecs) magnetic inhomogeneities in Galaxy. Consideration of total power cosmic rays generation in Galaxy (10^{40} erg/s) lead to secondary field several microgauss in disc. Such a field is of order of observable magnetic field without accounting alpha-effect.

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D. Uzdensky

Magnetic Reconnection in Astrophysics

Magnetic reconnection is an important basic plasma-physics process associated with a rapid change of magnetic field topology. It often leads to a violent release of magnetically-stored energy and thus powers many of the most spectacular and energetic phenomena in laboratory, space, and astrophysical plasmas. In this talk, I will first summarize the present status of our knowledge of magnetic reconnection and will present a simple physical criterion for the transition from the slow collisional to the fast collisionless reconnection regime. I will then describe some of the important astrophysical applications of this criterion and will demonstrate how it can help us understand magnetically-active coronae of stars and black-hole accretion disks as self-regulating, marginally collisionless systems. I will conclude by discussing important open questions and outlining the key directions of future research in astrophysical magnetic reconnection.

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A. Zakharov

Gravitational Lensing: from Micro to Nano

Pixel-lensing technique is one of the most efficient methods to find extra solar planets with low masses. Based on results of Monte Carlo simulations we discuss possibility to find planets near microlenses in the Andromeda galaxy. Assuming an existence of one planet per each microlens we conclude that pixel-lensing could give an opportunity to discover planets for a few percent of pixel-lensing events.

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Condensed Matter Physics

A. Bednorz and W. Belzig

Time-Resolved Counting Statistics for a Quantum Point Contact

We show that the naive formulation of time-resolved full counting statistics fails for high frequencies and leads to results, which could be interpreted as negative probabilities. We propose to construct a properly time-ordered positive-operator-valued measure, that combines counting statistics with detector backaction parametrized by a characteristic time tau [1]. The standard counting statistics is recovered in long time limit. In high frequency limit, for a weak coupling between the system and detector, the generating functional of counting statistics gains an additional Gaussian white noise component, that saves the positivity of the probability. It agrees with experiments since otherwise at strong coupling the noise measurements would be considerably modified due to the detector backaction. Finally, we also show that with more than one detector these nonclassical correlations can be directly measured.

[1] A. Bednorz and W. Belzig, Phys. Rev. Lett. 101, 206803 (2008).

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B. Altshuler, K. Efetov, and S. Syzranov

Transport in a Network of Josephson Junctions in the Insulating State

We consider motion of Cooper pairs in a system of Josephson junctions in the limit of a small coupling between the superconducting grains. In this limit the macroscopic superconductivity is destroyed due to Coulomb blockade. We show that in a sufficiently clean system the temperature dependence of the conductivity is described by an activation law with the gap equal to the energy of adding one Cooper pair to the grain. At stronger disorder or lower temperature one comes to the Anderson localization of the Cooper pairs and to a faster decay of the conductivity with temperature.

Ruhr Univ., Bochum

P. Fulde

Fractional Charges on Frustrated Lattices

We consider strongly correlated electrons on frustrated lattices, in particular on pyrochlore, checkerboard and kagome lattices. At certain lattice fillings excitations with fractional charges may exist. On checkerboard and kagome lattices they are confined by a constant force, i.e., like quarks. But on a pyrochlore lattice there is a phase with deconfined quasiparticles of charge e/2. This proves that there is no general relationship between fractional charges and fractional statistics.

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M. Kagan and K. Kugel

Nanoscale Phase-Separation in Manganites

Mechanisms of electron nanoscale phase-separation in manganite-type oxide materials are analyzed using a simple Kondo-lattice model with intersite Coulomb repulsion between electrons. This model predicts the instability of magnetic (or charge) homogeneous ordering toward the formation of droplet structures (magnetic polarons) for a wide parameter range in the phase diagram. Various types of free and bound magnetic polarons are examined on regular, anisotropic and frustrated (triangular) AFM-lattices. The transport properties such as resistivity, magnetoresistance and noise spectrum of phase separated materials are also discussed. In conclusion the formation of various type of orbital polarons is predicted in the framework of orbital tJ-model.

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A. Kamenev

Dynamic Correlation Functions of 1D Quantum Liquids

I shall describe a recent progress in understanding of energy and momentum resolved dynamic correlation functions of 1D quantum liquids. In particularly, it was realized that there are specific lines (modes) on the energy-momentum plane, where the correlation functions exhibit power-law singularities. The exponents of these singularities depend on momentum and may be computed exactly for integrable models. I shall discuss the physical origin of the singularities and ways they may be observed.

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K. Kikoin

Keldysh Model in Time Domain

The exactly solvable Keldysh model of disordered electron system in a random scattering field with long correlation length is converted to the model with long relaxation times in time domain. The problem is solved for an ensemble of two-level systems (TLS) with fluctuating well depths having the discrete Z_2 symmetry. It is shown also that symmetric TLS with fluctuating barrier transparency may be described in terms of the vector Keldysh model with random planar rotations in (xy) plane having continuous SO(2) symmetry. Application of this model to description of time-dependent fluctuations in quantum dots and optical lattices is discussed.

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A. Gorbatsevich and Yu. Kopaev

Toroidal Ordered States in Solids

It is shown that a new type of ordered state — ferrotoroic state is realized in crystals and can be realized in heterostructures with the help of methods of band-structure engineering. This state corresponds to the ordering of toroidal moments. Compact description of toroidal moments which can be formed by orbital currents or by localized spins is presented. In equilibrium toroics spontaneous electric currents exist on a scale of elementary cell with no net macroscopic current. Such macroscopic current emerges under non-equilibrium conditions and manifests itself as anomalous photogalvanic effect. Analogously macroscopic transport spin-currents can exist in non-equilibrium systems with broken spin-orbit symmetry.

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M. Kulic and E. Maksimov

Bosonic Spectral Function and the Electron-Phonon Interaction in HTSC Cuprates

We discuss accumulating experimental evidence related to the structure and origin of the bosonic spectral function in high-temperature superconducting (HTSC) cuprates near optimal doping. Some global properties of the spectral function, such as the number and positions of peaks, are extracted by combining the tunneling, ARPES optics and neutron scattering measurements. These methods give convincing evidence for strong electron-phonon interaction (EPI), with the coupling constant between 1-3, in cuprates near optimal doping. We also discuss some theoretical ingredients which are necessary to explain

the experimental results related to pairing mechanism in optimally doped cuprates. These comprise the Migdal-Eliashberg theory for EPI in strongly correlated systems which give rise to the forward scattering peak. The latter is due to the combined effects of the weakly screened Madelung interaction in the ionic-metallic structure of layered cuprates and many body effects of strong correlations. The most plausible pairing scenario in cuprates, which is conform with the experimental results, is that EPI is responsible for the strength of pairing, while the residual Coulomb interaction (by including spin fluctuations) triggers d-wave pairing.

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Yu. Lozovik

Collective Properties and Coherent Phases of Graphene

We discuss peculiarities in coherent phases and collective phenomena in graphene connected with its interesting electronic properties similar to ultrarelativistic physics. The coherent phase of electrons(e) and holes(h) due to their Coulomb attraction in two parallel, independently gated graphene layers separated by a barrier is considered. The essential distinctions with coupled quantum wells and 3D excitonic dielectric problem are due to Berry phase of electronic wave functions and different screening properties connected with the fact that electrons and holes behave in graphene as massless Dirac fermions. The energy gap in one-particle excitation spectrum for different interlayer distances and carrier concentrations is calculated. Influence of disorder is discussed. At large dielectric susceptibility of surrounding medium, the weak coupling regime holds even at arbitrarily

small carrier concentrations contrary to the case of nonzero effective masses. Strong coupled regime is discussed. Localized electron-hole pairs are absent in graphene, thus the behavior of the system versus coupling strength is cardinally different from usual BCS-BEC crossover. The e-h condensation in coupled graphene sheets can be observed through essential rise of e-h drag, Josephson-like phenomena etc. and can be used as nondissipative nanolectronic element.

Single and coupled graphene layers in strong perpendicular magnetic field is discussed. Magnetoexciton spectra and their effective magnetic mass in one and coupled graphene layers are studied in detail. The energy spectrum of collective excitations and superfluid transition of dipolar magnetoexciton system in coupled graphene layers are analyzed.

Plasma oscillations and instabilities in graphene and graphene array are discussed. The suppression of superfluid density and Kosterlitz-Thouless transition temperature by impurities is considered. Possible superconductivity in graphene is analyzed.

Yu.E.Lozovik, A.A.Sokolik, JETP Lett., vol. 87, 55-59 (2008), Physics-Uspekhi, 51, No.7, pp. 727-748 (2008).
O.L.Berman, G.Gumbs, Yu.E.Lozovik, Phys. Rev. B 77, 155433, 085401 (2008).

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S. Lepeshkin, M. Magnitskaya, and E. Maksimov

Peculiarities of Lattice Dynamics and the Melting of Alkali Metals

Melting of sodium and lithium under high pressure is theoretically studied on the basis of ab initio calculations of lattice dynamics. The phonon spectra and thermal atomic vibrations are calculated to evaluate the melting curve Tm(p) using the Lindemann criterion. The results are in good qualitative agreement with available experimental data. The anomalous behavior of sodium's Tm(p) is shown to be due to a softening of transverse phonons at $p \geq 30$ GPa. Essential distinctions between the phonon spectra of Li and Na under pressure result in different behavior of Tm(p) in fcc phases of Li and Na. Another consequence of these distinctions is that lithium's melting curve near the bccfcc transition is impossible to describe within the Lindemann approach.

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A. Mel'nikov

Localized Superconductivity and Little-Parks Effect in Superconductor/Ferromagnet Hybrids

The recent advances in understanding of the localized superconductivity phenomenon in ferromagnetic superconductors and superconductor/ferromagnet (S/F) hybrids will be discussed with particular stress on the effect of the domain structure on the superconducting order parameter nucleation. The tuning of the inhomogeneous magnetic field distributions in these systems offers a possibility to study and directly manipulate the localized superconducting nuclei and transport characteristics. Such manipulation allows to control not only the position and shape of superconducting nuclei but also their vorticity. The switching between the states with different vorticities results in the oscillating dependence of the critical temperature $T_c(H)$ similar to the Little-Parks effect. We also study the effect of the exchange field on the Little-Parks oscillations of T_c considering superconductivity nucleation in multiply connected systems such as cylinders or rings placed in electrical contact with a ferromagnet. We suggest a mechanism of switching between the states with different vorticities caused by the exchange field and associated with the oscillatory behavior of the Cooper pair wave function in a ferromagnet.

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S. Ovchinnikov and E. Shneyder

Isotope Effect, Phonon and Magnetic Mechanism of Pairing in High-T_C Cuprates in Strong Electron Correlaten Limit

Strong electron correlations are responsible both for the insulator ground state of undoped La_2CuO_4 and strong antiferromagnetic coupling J between neighbouring spins. We consider magnetic mechanism of superconducting pairing in the effective low energy $t - t' - t'' - J^*$ model with all parameters calculated *ab initio*. Interaction of strongly correlated electrons with different phonon modes is also incorporated. In a BCS type theory the $d_{x^2-y^2}$ gap is given by a sum of magnetic and phonon contributions. The phonon coupling parameter $\lambda = f(x)G$, where G is a combination of bare electron-phonon couplings for all modes and the function f depends on the hole concentration x due to strong electron correlations. We obtain independence of T_C and isotope effect on the strong electron-phonon coupling to the apical oxygen phonon mode. The main contribution to the only fitting parameter G is determined by a competition of the breathing and buckling modes. Fitting the parameter G from the isotope effect we obtain that magnetic and phonon contributions to the critical temperature T_C work together and are of the same order of magnitude.

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Yu. Rostovtsev and M. Scully

Nonlinear Optics Controlled by Quantum Coherence

Using quantum coherent effects provides means to control nonlinear optical processes in various media. We predict several new effects: for example, forward Brillouin scattering and enhancement and control of coherent generation in the backward direction by applying only forward propagating fields. The applications range from development of hyper-dispersive materials, improvement of spatial resolution beyond diffraction limit to generation of squeezed and entangled light.

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A. Rubtsov

Dual-Fermion Approach to Spatial Nonlocality of Correlated Electrons

We present an efficient diagrammatic method to describe nonlocal correlation effects in lattice fermion Hubbard-like models, which is based on a change of variables in the Grassmann path integrals. The local part of correlations is taken into the account in the transform of variables, so that the method starts with dynamical mean-field theory as a zeroth-order approximation. It therefore becomes possible to treat vertices of an effective single-impurity problem as small parameters. The nonlocal effects are treated diagramatically, as the new dual ensemble correspond to weakly interacting quasiparticles in the case of strong local correlations in the Hubbard model. The method is illustrated on the two-dimensional Hubbard model. The antiferromagnetic pseudogap, Fermi-arc formations, and non-Fermi-liquid effects due to the van Hove singularity are correctly reproduced by the lowest-order diagrams.

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M. Sadovskii

Multiple Bands — a Key to High — Temperature Superconductivity in Iron Arsenides?

In the framework of four-band model of superconductivity of iron arsenides proposed by Barzykin and Gor'kov [1] we analyze the gap ratios on hole-like and electron-like Fermi-surface cylinders. It is shown that experimentally observed (ARPES) gap ratios can be obtained only within rather strict limits on the values of intraband and interband pairing couplings. The main conclusion is the simple fact that the value of Tc in multiple bands systems is determined by the relations between partial densities of states on different sheets of the Fermi surface, and not by the total density of states at the Fermi level as in the standard BCS model [2]. The multiple bands electronic structure of iron arsenides leads to a significant enhancement of effective pairing coupling constant determining Tc, so that high enough Tc values can be achieved even for the case of rather small intraband and interband pairing interactions [2]. Ginzburg-Landau

expansion for this model is also briefly discussed.

[1] V. Barzykin, L.P. Gorkov. JETP Letters 88, 131 (2008)
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I. Suslov

Is There 2D Anderson Transition?

Roughly half of numerical investigations of the Anderson transition are based on consideration of associated quasi-1D systems and postulation of one-parameter scaling for the minimal Lyapunov exponent. If this algorithm is taken seriously, it leads to unambiguous prediction of the 2D phase transition. The transition is of the Kosterlitz-Thouless type and occurs between exponential and power law localization (Pichard and Sarma, 1981). This conclusion does not contradict numerical results if the raw data are considered. As for interpretation of these data in terms of one-parameter scaling, such interpretation is inadmissible: the minimal Lyapunov exponent does not obey any scaling. A scaling relation is valid not for minimal, but for some effective Lyapunov exponent, whose dependence on parameters is determined by scaling itself. If finite-size scaling is based on the effective Lyapunov exponent, existence of the 2D transition becomes not definite, but still rather probable. Interpretation of the results in terms of the Gell-Mann - Low equation is also given.

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S. Tikhodeev

Plasmon-Polariton Metamaterials

Metamaterials are artificial composite media recently proposed for new electromagnetic applications such as Veselago lens, cloaking and, more generally, transformation optics. In my talk a short overview of plasmon-polariton metamaterails based on nanostructured metals will be given. The special attention will be paid to the formation of collective polaritonic states in such systems, the effects of near-field and far-field interactions, the ways to control the optical strength and width of the resonances, and the resulting effective electromagnetic response.

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A. Zaikin

Interplay between Crossed Andreev Reflection and Disorder: Zero-Bias Anomaly and Charge Imbalance Peak

We analyze non-local effects in electron transport across three-terminal normal-superconducting-normal (NSN) structures. Subgap electrons entering S-electrode from one N-metal may form Cooper pairs with their counterparts penetrating from another N-metal. This phenomenon of crossed Andreev reflection (CAR) enables direct experimental realization of entanglement between electrons from spatially separated N-terminals. Combined with normal scattering at SN interfaces and disorder, CAR yields non-trivial behavior of the non-local conductance which we evaluate non-perturbatively at arbitrary interface transmissions. In particular, at low energies we predict strong enhancement of non-local conductance due to disorder-induced quantum interference of electrons in both N-metals. We also find that at intermediate temperatures non-local resistance exhibits a well pronounced peak which originates from a trade-off between charge imbalance and Andreev reflection. Our predictions are in a good agreement with recent experimental observations.

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G. Zarand

Geometric Spin Decay in Confined Mesoscopic Systems

First we show that at finite temperatures, in small external magnetic fields the spin-orbit coupling induced relaxation of an electron confined to a quantum dot is dominated by a relaxation mechanism, which is of geometrical origin. This relaxation process is exponential at finite temperature, and is dominated by coupling to electron-hole excitations at low temperatures. Then we study a particle confined to a ring and coupled to Ohmic fluctuations and show that in this case there exists a special direction: The spin component in this direction does not decay, while perpendicular components seem to decay algebraically for small rings even at $T = 0$ temperature.

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G. Kotliar, S. Savrasov, and N. Zein

GW+DMFT Approach for Electronic Structure Calculations in Real Compounds

We combine GW and DMFT approaches to calculate electronic structure of some compounds, including transition metals, semiconductors and transition metal oxides. We discuss extraction of double counting terms, renormalization of one-particle spectrum and interaction, energy dependence of interaction. Results are compared with LDA+DMFT calculations and the importance of self-consistent approach is stressed.

Kurchatov Inst., Moscow

High-Energy Physics

I. Belotelov

Dimuon Physics with CMS

Tests of the Standard Model (SM) and search of the new physics are important topics to be studied at the LHC. Muonic final states will provide clean signatures for many physics processes. A number of processes with high mass dimuons in a final states had been studied: Drell-Yan process, extended calibration sector neutral boson Z' and various scenarios of TeV scale gravity. In order to test SM prediction with LHC data careful study of CMS capabilities of measuring high mass dimuons has been conducted. All studies are performed with detailed detector simulation. The description of the detector performance used in the analysis correspond to those expected at the early stages of the data taking, for an integrated luminosity of up to 100 pb. Various issues associated with the reconstruction of high-pT muons and the CMS discovery potential in the dimuon channel presented here.

JINR, Dubna

E. Boos

Top Quark Physics

Various aspects of top quark physics at hadron and lepton colliders are discussed.

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M. Danilov

Physics and Detectors at ILC

The highlights of the physics case for the futute e+e- International Linear Collider (ILC) are briefly reviewed. The recent development of detector technologies and detector concepts for ILC is discussed.

ITEP, Moscow

D. Diakonov and V. Petrov

Confinement from Dyons

We build a semiclassical approximation to the Yang–Mills partition function at nonzero temperatures, based on monopoles or dyons of N kinds (for the SU(N) gauge group). Remarkably, the statistical mechanics of the ensemble of dyons experiencing Coulomb interactions can be described by an exactly solvable quantum field theory in three dimensions. It has the following striking features:
1) The free energy has the minimum corresponding to the zero average Polyakov line, as expected in the confining phase;
2) The correlation function of two Polyakov lines exhibits a linear potential between static quarks in any N-ality non-zero representation, with a calculable string tension;

3) The average spatial Wilson loop falls off exponentially with its area and the same string tension;
4) Massless gluons dissapear from the spectrum;
5) At a critical temperature the ensemble of dyons rearranges and de-confines;
6) The estimated ratio of the critical temperature to the square root of the string tension is in good agreement with the lattice data.
7) The same confinement mechanism works, in agreement with lattice observations, for the exceptional gauge group G2 whose center, unlike SU(N), is trivial.

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I. Dremin

QCD in the Nuclear Matter and Cherenkov Gluons

QCD in the nuclear matter is proposed and applied to demonstrate the production of Cherenkov gluons. The properties of the medium (its chromoelectric permittivity)are found from comparison with experimental data of RHIC. Effects at SPS and predictions for LHC are also considered.

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I. Ginzburg

The Evolution of Vacuum States and Phase Transitions in 2HDM during Cooling of Universe

We consider the evolution of phase states for the Two Higgs Doublet Model during cooling down of Universe after Big Bang. Different regions of modern values of parameters of model correspond different sequences of phase transitions. We discuss evolution of physical properties of the system during various possible ways of evolution of vacuum states. The opportunity with formation of dark matter only at intermidiate stage of Universe expansion is also considered.

Sobolev Inst. of Mathematics, Novosibirsk

B. Ioffe

Chirality Violating Vacuum Condensates in QCD

It is demonstrated that chirality violating vacuum condensates in massless QCD arise from zero mode solutions of Dirac equations in arbitrary gluon field. Basing on this idea, the model is suggested, which allows one to calculate quark condensate magnetic susceptibilities in the external constant electromagnetic field.

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A. Kaidalov

Nuclear Shadowing and Heavy Ion Collisions

Nuclear shadowing effects for quarks and gluons are calculated in the Gribov approach. Role of these effects in the processes of interaction of hadrons and nuclei with nuclei at high energies is investigated. A decrease of particle densities for heavy ion collisions in comparison with the Glauber model is predicted. Distributions of gluons in nuclei are used to predict a suppression of heavy quarkona. Calculation of J/psi suppression in D-Au and Au-Au collisions at RHIC are in a good agreement with experimental data. Predictions for LHC are formulated.

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D. Kharzeev

Topologically Induced Local $\mathcal{P}$ and $\mathcal{CP}$ Violation in Hot QCD Matter

It has been established experimentally that there is no global violation of $\mathcal{P}$ and $\mathcal{CP}$ invariances in QCD. However, the issue of $\mathcal{P}$ and $\mathcal{CP}$ symmetries in QCD is highly nontrivial because of the existence of topological solutions and the presence of axial anomaly in this theory ("the strong $\mathcal{CP}$ problem"). Even in the absence of global $\mathcal{P}$ and $\mathcal{CP}$ violation, topological fluctuations in QCD vacuum are believed to play an important role in the chiral symmetry breaking, thus being responsible for many properties of hadrons. I will argue that in the presence of very intense magnetic fields, topological fluctuations in hot QCD matter can be observed directly through the spatial separation of positive and negative electric charge signaling a <u>local</u> violation of $\mathcal{P}$ and $\mathcal{CP}$ symmetries. Recent result from

RHIC [1] provides an evidence for this phenomenon in heavy ion collisions. The local violation of parity manifests itself in heavy ion collisions at RHIC through the separation of positive and negative hadrons with respect to the reaction plane [2]; this charge separation induces an electric dipole moment of the produced hot quark-gluon matter. The charge separation stems from the interplay of strong magnetic field (and/or the angular momentum) in the early stage of the heavy ion collision and the presence of topological configurations in hot matter ("the chiral magnetic effect") [2-5]. This effect is only possible in the deconfined quark-gluon plasma phase because it is requires the separation of quarks over a large ("macroscopic" on the scale of hot matter size) distance. The observed signal does not imply a global violation since the sign of the left–right asymmetry fluctuates from one event to another. Nevertheless, because the multiplicity of produced hadrons is very large (several thousand), the quasi-classical description should apply and so the study of this phenomenon on the event-by-event basis is meaningful. It is very important to verify the observed effect and to study all possible backgrounds. The magnitude and the qualitative features of the asymmetry had been predicted [2] prior to the observation, and more refined estimates were presented in [4], but more detailed theoretical work is needed to establish unambiguously the origin of the effect. New theoretical results and proposals for future measurements will be presented in this talk.

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A. Kotikov

Small-x Behavior of Parton Densities and the Structure Function F2 for "Frozen" and Analytic Strong-Coupling Constants

Using the leading-twist approximation of the Wilson operator product expansion with "frozen" and analytic strong-coupling constants, we show that the Bessel-inspired behavior of the structure function F_2 at small values of x, obtained for a flat initial condition in the DGLAP evolution equations, leads to very good agreement with experimental data of deep-inelastic scattering at DESY HERA.

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M. Kirakosyan and <u>A. Leonidov</u>

Stochastic Jet Quenching in Nuclear Collisions

Energy losses of fast particles in randomly inhomogeneous medium created in high energy nuclear collisions are estimated. Effects due to critical opalescence are discussed.

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C. Llewellyn Smith

The Role of Sum Rules in the Discovery of the Standard Model

Sum rules for deep inelastic data are today seen as constraints on parton distributions, or ways of measuring the strong coupling constant. I shall recall their key historical role in i) suggesting and interpreting scaling, and ii) showing that partons are quarks and that gluons are also required.

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V. Novikov

Radiative Corrections, New Physics and LHC

Precision measurements of Z-boson parameters and new data on W-boson and t-quark masses put a strong constraints on New Physics beyond the Standard Model. We demonstrate that one extra generation of quarks and leptons still passes through electroweak constraints even when the masses of new particles are well above the direct mass bounds.

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M. Polikarpov

Lattice Study of Chiral Symmetry Breaking in Gluodynamics with Background Magnetic Field

We investigate the effect of a uniform background magnetic field on the chiral symmetry breaking in quenched SU(2) gauge

theory on the lattice. In agreement with the predictions of the chiral perturbation theory, the chiral condensate grows linearly with the field strength. In the background magnetic field near-zero eigenmodes of the Dirac operator tend to have more regular structure with larger Hausdorf dimensionality.

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Yu. Simonov

Gluelumps and Confinement

Confinement is shown to be produced by field correlators (FC) of special kind, and in particular integral of these yields string tension. It is demonstrated that FC themselves are easily calulated via gluelump propagators.The latter and gluelump masses are expressed via string tension, thus defining a selfconsistent set of equations, similar to mean field approach. Check of consistency is made at small and large distances,which includes separation of perturbative and nonperturbative contributions.As an important outcome the problem of seemingly different QCD mass scales (string tension, gluon condensate and glueball mass) is solved and it is shown that all three scales are produced by the unique mass, e.g. string tension or rho mass.

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A. Sissakian and A. Sorin

The Nuclotron-Based Ion Collider Facility at the Joint Institute for Nuclear Research: New Prospects for Heavy Ion Collisions and Spin Physics

A status report on the current development of the Nuclotron-Based Ion Collider fAcility (NICA) at the Joint Institute for Nuclear Research (JINR), which gives new prospects for heavy ion collisions (searching for the new states of QCD matter) and spin physics (nucleon spin structure), will be presented.

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A. Gulov and V. Skalozub

Renormalization Group Relations and Model-Independent Searchs for Z' within the Data of LEP Experiments

Approach to the model-independent searching for the heavy Z' gauge boson as a virtual state is developed which accounts for as a basic requirement the renormalizability of underlying unspecified in other respects model. This results in a set of relations between low energy couplings of Z' to fermions that reduces in an essential way the number of parameters to be fitted in experiments. On this ground the observables which uniquely pick out Z' in leptonic processes are introduced and the data of LEP experiments analyzed. It is obtained at 95 % confidence level that the mass is $0.8 < m_{Z'} < 1.2$ TeV. The couplings to the standard model fermions are also estimated. These estimates may serve as a guide for experiments at the

Tevatron and/or LHC. A comparison with other approaches and results is given.

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A. Smilga

Energy Losses in Hot Plasma Revisited

We present a mini-review of the problem of evaluating the energy loss of a ultrarelativistic charged particle crossing a thermally equilibrated high temperature e^+e^- or quark–gluon plasma. The average energy loss ΔE depends on the particle energy E and mass M, the plasma temperature T, the QED (QCD) coupling constant, and the distance L the particle travels in the medium. Two main mechanisms contribute to the energy loss: elastic collisions and bremsstrahlung. For each contribution, we use simple physical arguments to evaluate ΔE in different regions of the parameters. We rederive the known results and make some new observations. We emphasize, in particular, that, for light particles, the difference in the behavior of ΔE in QED and QCD is mostly due to the different way the problem is usually posed in these two cases. In QED, it is natural to study the energy losses of an electron coming from infinity. In QCD, the quantity of physical interest is the medium-induced energy loss of a parton produced within the medium. The famous quadratic dependence $\Delta E_{\mathrm{rad}} \propto L^2$ for thin plasma layers is not specific for QCD (as was assumed before), but holds also in QED if the radiating particle is created within plasma.

Subatech, Univ. de Nantes

A. Studenikin

Overview on Electromagnetic Properties of Neutrinos

A review on neutrino electromagnetic properties is given. We start with a derivation of the neutrino electromagnetic vertex function in the most general form that follows from the requirement of Lorentz invariance, for both the Dirac and Majorana cases. The problem of the neutrino form factors definition and calculation within different gauge models is considered. In particular, the neutrino electric charge form factor and charge radius, dipole magnetic and electric and anapole form factors are discussed. A detailed analysis of the neutrino magnetic moment in the Standard Model and beyond is given. Available experimental constraints on neutrino electromagnetic properties are also reviewed, and the most important experimental limits on neutrino magnetic moments are considered. The important neutrino electromagnetic processes involving a direct neutrino coupling with photons (such as neutrino radiative decay, neutrino Cherenkov radiation, spin light of neutrino and plasmon decay into neutrino-antineutrino pair in media) and neutrino resonant spin-flavor precession in a magnetic field are discussed. It is shown that studies of the neutrino electromagnetic properties can open a window to New Physics.

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O. Teryaev

Sum Rules for Spin-Dependent Parton Distributions, Gravitational Formfactors and Equivalence Principle

The QCD factorization implies the sum rules for the parton distributions when the relevant matrix elements are fixed by conservation laws or known from the other sources. The Ji's sum rules for Generalized Parton Distributions related to the hadronic matrix elements of energy-momentum tensors also control the coupling of hadrons to gravity. In particular, the anomalous gravitomagnetic moment (AGM) is known to be identically zero due to manifestation of Equivalence Principle (EP) discovered by Kobzarev and Okun in 1962.Models and lattice simulations are compatible with my earlier conjecture (violated by perturbative corrections but possibly restored in the nonperturbative domain) of the extended version of EP (EEP) when AGM = 0 separately for quarks and gluons. EEP naturally explains the value of $g = 2$ for vector mesons holding approximately within QCD sum rules and exactly in AdS/QCD. It is claimed that EP for spin-1 hadrons restricts also the contributions to forward matrix elements proportional to tensor polarization and explains the zero sum rule for the second moments of inclusive tensor spin structure functions. The available HERMES data on deuteron tensor spin structure function are compatible with EEP.

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R. Venugopalan

High Energy Factorization, Long Range Rapidity Correlations and a Ridge in A+A collisions at RHIC & LHC

We outline a formalism to compute multi-gluon production with arbitrary rapidity separations in nucleus-nucleus collisions at high energies. We discuss how this provides a "chronometer" of the early time strong color field dynamics in heavy ion collisions as well as a probe of multi-gluon correlations in the nuclear wavefunction. We show how our formalism provides a simple geometrical interpretation of striking results from the RHIC experiments on near side "ridge-like" two particle correlations.

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M. Volkov

Superconducting Non-Abelian Strings in Weinberg-Salam theory — Electroweak Thunderbolts

Classical solutions describing vortices carrying a constant electric current are constructed in the bosonic sector of the electroweak theory. These vortices exist for any ratio of the Higgs boson mass to Z boson mass and for any weak mixing angle. Their current is produced by a W-boson condensate confined in their core, and typically it can attain billions of Amperes. In the zero current limit the vortices reduce to Z strings, which suggests that there can be finite vortex pieces transferring electric charge between different regions of space, similar to thunder-

bolts. Short enough vortex pieces seem to be perturbatively stable, which suggests that small vortex loops could be stable as well.

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Yu. Kamyshkov, J. Tithof, and M. Vysotsky

Bounds on New Light Particles from High Energy and Very Small Momentum Transfer Neutron-Proton Elastic Scattering Data

We found that vector and axial-vector light particle exchanges are strongly bounded by high energy data; analogous bound for scalar particle is considerably weaker, while for pseudo-scalar there are no bounds at all. Our bounds provide exclusion of new forces at the distances from 2 to 200 fermi which corresponds to exchanged particle masses from 1 MeV to 100 MeV. These bounds are extracted in covariant approach as alternative to the bounds on couplings at larger distances extracted as a deviation from classical Newton gravity law.

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A. Zaitsev

The ATLAS Detector: Status and Plans

The ATLAS detector at Large Hadron Collider offers unprecedented opportunities to study in detail interactions in the unexplored energy range around 1 TeV, where new physical phenomena undoubtedly exist. The luminosity expected in the first year of LHC operation will make it possible to thoroughly tune and calibrate all subdetectors, clear up characteristics of the most intense processes, and search for new objects, such as the Higgs boson, light supersymmetric particles, and new heavy gauge bosons, with a sensitivity high enough to allow their observation.

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B. Zakharov

Mass Dependence of Radiative Quark Energy Loss in QCD Matter

We discuss the radiative quark energy loss in a finite-size quark-gluon plasma. The analysis is based on the light-cone path integral approach to the induced gluon emission. We show that mass effects can lead to an enhancement of the induced gluon emission from heavy quarks.

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V. Zakharov

Deconfinement Phase Transition in Mirror of Symmetries

We summarize and extend the evidence that the deconfinement phase transition in Yang-Mills theories can be viewed as change of effective non-perturbative degrees of freedom. Instead of strings living in four dimensions at low temperatures one has three-dimensional field theories above the critical temperature. The evidence is provided by dual models, analytical models and by lattice data. We concentrate mostly on the lattice data.

The talk is based on an original paper written in collaboration with M.N. Chernodub and A. Nakamura.

ITEP, Moscow

I. Golutvin and A. Zarubin

LHC, CMS, RDMS — Status and Plans

JINR, Dubna

Quantum Field Theory

G. Barnich

New Aspects of Duality for Electromagnetism, Gravitation and Higher Spin Gauge Fields

The reduced phase space of free electromagnetism and of linearized gravity is known to be invariant under duality rotations. In a first step, this invariance is extended to a new formulation with enhanced gauge symmetry. The formalism is applied for the derivation of the thermodynamics for black hole dyons and the discussion of the charges for the linearized Taub-NUT spacetime. In a second step, it is shown that the reduced phase space of electromagnetism and linearized gravity is a bi-Hamiltonian system, with the duality generator as second Hamiltonian in a new Poisson bracket. The result generalizes to massless gauge fields of higher spin and shows that, at least on the linearized level, these theories possess one of the defining properties of integrable systems.

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A. Belavin

2-Dimensional Minimal Gravity in Matrix Model and Liouville approaches

Since the middle of 80's there exist two independent approaches to 2D Quantum Gravity,the continuous approach called Liuoville Gravity and the discrete one usually refered to as the Matrix Models. We obtain the explicit expressions for multi-points correlators of the p-critical One Matrix Model in the so called CFT frame and argue that they coincide with the ones obtained in $(2, 2p + 1)$ Minimal Liouville Gravity (or Minimal String Theory).

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K. Bering

A Comparative Study of Laplacians in Riemannian and Antisymplectic Geometry

On one hand, antisymplectic geometry shares many characteristic features with symplectic geometry, such as, a Jacobi identity and a local existence of Darboux coordinates. On the other hand, Riemannian geometry behaves classically quite differently from both odd and even symplectic geometry. Nevertheless, there exists a deep relationship between odd Laplacians in antisymplectic geometry and even Laplacians in (even) Riemannian geometry. For instance, in both cases, it is possible to add an odd (resp. even) scalar curvature term to the odd (resp. even) Laplacian. This, in turns, is related, on one hand, to a recently discovered two-loop odd scalar curvature term in the quantum master equation, and, on the other hand, a well-known two-loop Levi-Civita scalar curvature term in the quantum Hamiltonian for a particle in a curved Riemannian space. See also arXiv:0809.4269.

Masaryk Univ., Brno

G. Efimov

On Bound States in QFT

The problem of bound states in QFT is not formulated correctly up to now. Now it is accepted that a bound state is identified with a simple pole of corresponding amplitude of elastic scattering in a kennel with appropriate quantum numbers. The Bethe-Salpeter equation is an effective methods to find this pole.

In the fermion theory with Yukawa interaction it is shown that the kernel $K = K_0 + K_I$ of the Bethe-Salpeter equation in ladder approximation contain the singular part K_0 which is of the "fall at the center" potential type, describes a continuous spectrum only and leads to a restriction on the value of the coupling constant. The kernel K_I is responsible for bound fermion-fermion states.

It is known that in the Bethe-Salpeter equation in the ladder approximation in quantum electrodynamics gauge invariance is violated so that the results of calculations depend on form of the photon propagator. Binding energy of the 1^- state (orthopositronium) in QED is calculated using the one-photon exchange Bethe-Salpeter equation in the Feynman and Coulomb gauges for different coupling constants α. Calculations show there is a remarkable difference in values of the binding energy for different coupling constants in these two gauges.

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M. Grigoriev

Local BRST Cohomology and the Inverse Problem of Variational Calculus for Sigma Models of AKSZ Type

For a sigma model of AKSZ type with target space a Q-manifold, we show that the cohomology in the space of local functionals of the BRST differential is locally isomorphic to the cohomology of Q in the target space. An analogous result is shown to hold for the cohomology in the space of functional multivectors. The later cohomology groups are shown to provide a natural framework for the inverse problem of the calculus of variations, which is also applicable in the context of general gauge theories. General features of the construction and possible applications to AKSZ type sigma models are discussed.

Lebedev Inst., Moscow

V. Kadyshevsky

On New Concept of Local Quantum Field

In the given talk some ideas of the approach developed in papers [1-5] are discussed. The key point is the assumption that the mass spectrum of elementary particles described by local quantum fields should be cut at some mass value M. The new universal parameter M called the "fundamental mass" is introduced in quantum field theory (QFT) in a pure geometric way, namely, in the framework of the Euclidean formulation of QFT we postulate that 4-momentum space is the de Sitter space with radius M:

$$p_5^2 - p_1^2 - p_2^2 - p_3^2 - p_4^2 = M^2. \tag{1}$$

Quantum fields (scalar, spinor, vector, etc.) defined on the surface (1) can undergo the 5-dimensional Fourier transform. It is evident that in the configurational 5-space each field satisfies the free 5-dimensional Klein-Gordon type equation where x_5 plays the role of "time" and M is the "mass parameter". The corresponding Cauchy initial data at $x_5 = 0$ can be used as dynamical field variables. They can be applied to construct unambiguously a local Lagrangian gauge field theory generalizing the "Standard Model" and predicting new physical phenomena in the superhigh energy region $E \gtrsim M$ (according to our estimation $M \gtrsim 1$ TeV). It should be emphasized that the description of fermion fields in this approach has interesting specific features:

1. The solutions of the free 5-dimensional Dirac type equations derived from the above-mentioned 5-dimensional Klein-Gordon type equation play the role of the chiral fermion fields Ψ_L and Ψ_R.

2. In the new approach, one more 4-dimensional Dirac equation arises which has no analog in the usual theory. In other words, a new kind of fermionic matter is predicted. May be it is "dark matter"?

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L. Bork, D. Kazakov, G. Vartanov, and A. Zhiboedov

Infrared-Finite Observables in $N = 4$ SYM Theory

We consider the infrared structure of gluon amplitudes in $N = 4$ super Yang-Mills theory and demonstrate explicitly how the infrared divergences calculated earlier in the field theory and AdS/CFT approaches cancel when calculating the proper cross-sections on mass shell. We calculate also the remaining finite part for the gluon scattering in the leading order and investigate its dependence on kinematical variables. The general meaning of the S-matrix in conformal theories is discussed.

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P. Lavrov

BRST Structure for Quadratically Nonlinear Superalgebras

The structure of the classical BRST charge of quadratically nonlinear superalgebras is studied. Quadratic nonlinear superalgebras where a commutator (in terms of Poisson brackets) of the generators is a quadratic polynomial of the generators are considered. The explicit form of the BRST charge up to cubic order in Faddeev - Popov ghost fields for arbitrary quadratic nonlinear

superalgebras is found. The existence of constraints on structure constants of the superalgebra when the nilpotent BRST charge is quadratic in Faddeev-Popov ghost fields is pointed out.

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L. Lipatov

Integrability of High Energy Scattering Amplitudes in QCD and in $N = 4$ SUSY

We review the BFKL approach for the description of the high energy scattering in QCD in the leading and next-to-leading approximations. The gluon reggeization allows us to formulate an effective reggeon field theory. In the leading logarithmic approximation the theory is reduced to an integrable Heisenberg spin model. In the large-N_c limit for QCD and $N = 4$ SUSY the gluon production amplitudes in the multi-Regge kinematics contain the contributions of the Mandelstam cuts. The Hamiltonian for the corresponding reggeon composite states coincides with the local Hamiltonian of integrable open spin chain. We find explicitly its eigenfunctions and eigenvalues.

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J. Lukierski

Galilean Conformal and Superconformal Symmetries

We shall describe firstly the Galilean conformal symmetries, with nonrelativistic conformal translations describing constant accelerations. Further by nonrelativistic contraction $c \to \infty$ of

$N = 2$ and $N = 4$ four-dimensional superconformal algebras SU(2,2/N) we shall obtain the $N = 2$ and $N = 4$ Galilean superconformal algebras. We shall discuss as well the appearence of central charges. The "super" case has been investigated with J.A. de Azcarraga.

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S. Lyakhovich

Gauge Symmetry of Local Non-Lagrangian Dynamics

A systematic procedure is proposed for deriving all the gauge symmetries of the general, not necessarily variational, equations of motion. For the variational equations, this procedure reduces to the Dirac-Bergmann algorithm for the constrained Hamiltonian systems. Even though no pairing exists between the constraints and the gauge symmetry generators in general non-variational dynamics, certain counterparts still can be identified of the first- and second-class constraints without appealing to any Poisson structure. It is shown that the general local gauge dynamics can be equivalently reformulated in the involutive normal form. The last form of dynamics always admits the BRST embedding, which does not require the classical equations to follow from any variational principle.

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Yu. Makeenko

Duality between Wilson Loops and Scattering Amplitudes in QCD

Modern ideas about the duality between Wilson loops and scattering amplitudes in maximally supersymmetric Yang-Mills theory are extended to large-N (or quenched) QCD by using a representation of QCD meson scattering amplitudes through the Wilson loops. This duality is elaborated for string theory in flat space, identifying the asymptotes of the open-string disk amplitude, integrated over reparametrizations, and the Wilson loop in large-N QCD. Large loops, where the area law sets in, dominate in the kinematical regime of large momenta and the QCD scattering amplitude turns out to be a convolution of the usual Koba-Nielsen integrand and a certain kernel, reproducing the Regge-Veneziano spectrum. The kernel becomes momentum independent when the number of external particles is large and/or the quark mass is small, so the Veneziano-type dual amplitude then emerges.

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V. Manko

Probability instead of Wave Function — a Review of New Theoretical and Experimental Results

The probability representation of quantum mechanics, quantum optics and quantum gravity where, by means of generalyzed integral Radon transform, wave functions are mapped (invertably) onto standard probability distributions of measurable random variables both for continuous positions and discrete spin

projections is reviewed. The connection of the approach with Moyal star-product quantization is presented. New uncertainty relations where, with taking into account the purity parameter of quantum states, the new bound for product of dispersions of conjugate variables is considered. The experiment based on routin method to measure optical tomographic probability describing quantum state of photon, with proposal to check the uncertainty relation, is discussed. New tomographic entropy of quantum states and its relation to von Neumann entropy is considered and new experiments to check the known and new entropic uncertainty relations are proposed. Bell inequalities and their probabilistic generalizations are studied in framework of probability representation of quantum mechanics. Perspectives to extend the probability representation of quantum mechanics to quantum field theory are mentioned.

Lebedev Inst., Moscow

A. Mironov

Matrix Models Inspired Constructions for Topological Theories

Recent M-theory constructions in matrix models assume that there is a similar construction in topological theories. In particular, there should exist a global topological theory that unifies various topological theories in a kind of unique topological M-theory. Another example of this kind is provided by Kontsevich-Hurwitz theory, which can be studied by both matrix model and topological theory tools.

Lebedev Inst., Moscow & ITEP, Moscow

M. Olshanetsky

Monopoles and Integrable Systems

Established before correspondence between different integrable systems and r-matrices we explain following Kapustin and Witten in terms of singular solutions of the Bogomolny equation. This approach leads to classification of integrable systems of particles and integrable tops and corresponding r-matrices related to simple Lie groups. The systems have an additional topological characteristic related to the monopole charge.

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V. Rychkov

The Miracle of Conformal Boostrap in 4-Dimensions

In Conformal Field Theory, the first dynamical constraint appears at the 4-point function level. It follows from OPE and crossing symmetry, and is known as Conformal Bootstrap. Until recently, Conformal Bootstrap Equations were considered generally intractable. Last year, a practical method for systematic study of Conformal Bootstrap in *unitary* theories was proposed in arXiv:0807.0004. I will describe the method and some of its most striking applications. For example, I will present a bound on structure constants of 3 scalar fields as a function of their dimensions, and a bound on the dimension of the first scalar operator appearing in the OPE of two scalars. These bounds are universal, i.e. valid in any unitary 4-D CFT. I will also discuss possible relevance of the method in 2-Dimensions.

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A. Semikhatov

Quantum Groups and Logarithmic Conformal Theories: a Remarkable Duality

I discuss recent advances in the duality between quantum groups and vertex-operator algebras occurring in logarithmic conformal field theory models.

Lebedev Inst., Moscow

A. Slavnov

A Lorentz Invariant Gauge for the Yang-Mills Theory Free of Gribov Ambiguity

A new formulation of the Yang-Mills theory which avoids the problem of Lorentz invariant gauge fixing without Gribov ambiguity is proposed.

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A. Smilga

Comments on Thermodynamics of Supersymmetric Matrix Models

We present arguments that the structure of the spectrum of the supersymmetric matrix model with 16 real supercharges in the large N limit is rather nontrivial, involving besides the natural energy scale $\sim \lambda^{1/3} = (g^2 N)^{1/3}$ also a lower scale $\sim \lambda^{1/3} N^{-5/9}$. This allows one to understand a nontrivial behaviour of the mean internal energyof the system $E \propto T^{14/5}$ predicted by AdS duality arguments.

Subatech, Univ. de Nantes

V. Spiridonov and G. Vartanov

Superconformal Indices for $N = 1$ Theories with Multiple Duals

Recently some of elliptic hypergeometric integrals were interpreted as topological indices in $N = 1$ supersymmetric field theories. Coincidence of superconformal indices in Seiberg dual theories corresponds to nontrivial identities for these integrals. Analysing such relations, from known dual field theories we conjecture many new relations for integrals, and from a number of known integral identities, we come to many new Seiberg dualities.

The talk is based on the joint work with G.S. Vartanov hep-th/0811.1909.

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A. Tureanu

Symmetries of Noncommutative Quantum Field and Gauge Theories

The construction of noncommutative quantum field and gauge theories together with their underlying symmetries are discussed and a realization of the Cohen-Glashow VSR (Very Special Relativity) is presented. Some problems with noncommutative time are analyzed.

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A. Zamolodchikov

Confining Interactions in 1+1, and 't Hooft's Model of Mesons

Landau Inst., Chernogolovka & Rudgers Univ.

B. Zupnik

$N = 6$ Chern-Simons Theory in Harmonic Superspace

We consider the $N = 6$ Chern-Simons models in three-dimensional harmonic superspaces. The consistent $N = 6$ Chern-Simons-matter superconformal models can be formulated in the $N = 3$ harmonic superspace.

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Quantum Field Theory with External Conditions

M. Bordag

Vacuum Energy in Quantum Field Theory – Status, Problems and Recent Advances

Vacuum energy is a generic property of all quantum systems, from simple harmonic oscillator up to quantum field theoretic models. Its most famous manifestation is the Casimir effect. During the past decade it received significant attention due to its relation to the van der Waals forces and their applications in nano-technology. I will review some known fundamental results in the theory of vacuum energy together with opened problems. One of these is the reality of vacuum energy which has been questioned repeatedly.

Further I'll report on recent significant advances in the calculation of Casimir forces acting between bodies of nontrivial shape. For instance, these advances allowed, for the first time, calculating corrections to the proximity force approximation. Finally I'll discuss some problems which appear on the renormalization under the transition from smooth background fields to sharp boundary conditions.

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E. Elizalde

Vacuum Fluctuations and Cosmology

A new generation of precision data has brought up evidence which does not fit within the previously accepted model of the Cosmos evolution. In particular, its expansion rate seems to have been accelerating since many years ago. This evidence has led to the concept of dark energy whose nature could conceptually be understood as a cosmological constant, in its modern version (Zel'dovich) as a contribution of quantum vacuum fluctuations. But fitting the precise value of the cosmic acceleration has severe difficulties (e.g. the new cosmological constant problem, Weinberg). Regularization of vacuum contributions was never easy, as we will review. On the other hand, it is certainly possible to obtain, from quite natural arguments, some vacuum contributions that have the appropriate order of magnitud corresponding to the observed acceleration. Moreover, in braneworld models Casimir energy contributions may lead to the stabilization of interesting configurations, what also proves the relevance of vacuum fluctuations at a cosmological scale.

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G. Esposito

Casimir Apparatuses in a Weak Gravitational Field

We review and assess recent work on Casimir apparatuses in the weak gravitational field of the Earth. For a free, real massless scalar field subject to Dirichlet or Neumann boundary conditions on the parallel plates, the resulting regularized and renormalized energy-momentum tensor is covariantly conserved, while the trace anomaly vanishes if the massless field is conformally coupled to gravity. Conformal coupling also ensures a finite Casimir energy and finite values of the pressure upon parallel plates. These results have been extended to an electromagnetic field subject to perfect conductor (hence idealized) boundary conditions on parallel plates, by various authors. The regularized and renormalized energy-momentum tensor has been evaluated up to second order in the gravity acceleration. In both the scalar and the electromagnetic case, when studied to first order in the gravity acceleration, the theory provides a tiny force in the upwards direction acting on the apparatus. This effect is conceptually very interesting, since it means that Casimir energy is indeed expected to gravitate, although the magnitude of the expected force makes it necessary to overcome very severe signal-modulation problems.

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S. Fulling and K. Kirsten

Cosmological Pistons

The net force between parallel plates in a tube of finite cross section includes a contribution from the exterior region of the tube; the net force between like plates is attractive precisely because of this "piston" effect. The same argument applies to the compact extra dimensions of a Kaluza–Klein cosmology. Naive calculations that neglect the piston effect can predict a spurious repulsive Casimir force even between infinite parallel plates, as discovered by H. Cheng. We have analyzed the force for pistons of arbitrary cross section and arbitrary Kaluza–Klein geometry and verified that the piston is always attracted to the nearest wall. When the plate separation is small compared to the Kaluza–Klein dimensions, the force approaches the Casimir force in a space-time of the full dimension; when it is large, one gets the result expected for the dimension of the macroscopic space-time.

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S. Gavrilov and D. Gitman

Generalized Heisenberg-Euler Energy and Time Scales for Strong Electric Field Depletion

Quantum field theory with an external background can be considered as a consistent model only if back reaction is relatively small with respect to the background. To find the corresponding consistency restrictions on an external electric field and its duration in QED and QCD, we analyze the mean-energy density of quantized fields for an arbitrary constant electric field E, acting during a large but a finite time T. Using the corresponding asymptotic with respect to the dimensionless parameter eET^2, one can see that the leading contributions to the energy are due to the particle creation by the electric field. Assuming that these contributions are small in comparison with the energy density of the electric background, we establish the above-mentioned restrictions, which determine, in fact, the time scales from above of depletion of an electric field due to the back reaction.

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B. Kosyakov

The Self-Interaction Problem in Classical Electrodynamics of Even-Dimensional Spacetimes

The basic concepts of the Maxwell-Lorentz electrodynamics in flat spacetime of an arbitrary even dimension $d = 2n$ are briefly reviewed. The discussion relies heavily on three key notions: the *rearrangement* of the initial degrees of freedom resulting in the occurrence of *dressed* particles and *radiation*. We show that the retarded field strength $F^{(2n)}_{\mu\nu}$ due to a point charge in a $2n$-dimensional world can be algebraically expressed in terms of the retarded vector potentials $A^{(2m)}_{\mu}$ generated by this charge as if it were accommodated in $2m$-dimensional worlds nearby, $2 \le m \le n+1$. With this finding, the rate of radiated energy-momentum of the electromagnetic field takes a compact form. We compare the properties of the equation of motion for a dressed particle in $d = 4$ and $d = 6$ spacetimes. We show that the $d = 4$ Maxwell-Lorentz theory of massless charged particles does not experience rearranging its initial degrees of freedom. Massless charged particles do not radiate.

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S. Lebedev

Spin-Dependent Part of the Mass Shift in Quantum and Classical Electrodynamics

Interaction between spin and orbit degrees of freedom of classical spinning charge determines, up to the factor of 3/2, the dominant term in the expansion of QED mass shift w.r.t.

characteristic parameter

$$\chi = \frac{e\hbar}{m^3c^4}\sqrt{(F_{\mu\nu}p_\nu)^2} \equiv \gamma\frac{F}{F_0}$$

($\chi \ll 1$; Lorenz factor $\gamma \gg 1$, $F_0 = m^2c^3/e\hbar$). Coefficient 3/2 is universal in the sense that it appears connecting classical and quantum expressions of $\Im\Delta m(S)$ (S being spin 4-vector) for three not reducible each other instances of external field configurations. We show that for the class of isometric world lines $x(\tau)$ ($u = \dot{x}$) this $\Im\Delta m(S)$ is asymptotically determined by the invariant $u \wedge \dot{u} \wedge \ddot{u} \wedge S/\sqrt{\dot{u}^2}$. The dependence of the total radiation probability $\lambda = -2\Im\Delta mc^2/\hbar$ on the spin direction helps understanding the building up of preferable polarization of relativistic particles scattered by external field. Consideration is also given to the boundary effects on spin radiation. In the presence of an ideal 'mirror' the imaginary part of the mass shift gets modified and non-zero real part $\Re\Delta m(S)$ appears. The dependence of λ on the distance from the mirror could be of some interest considering the problem of observation of the spin light.

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A. Lobanov

Pure Quantum States of Particles with Rotating Spin

The problem of rotation of spin is solved in full agreement with the basic principles of quantum mechanics. In particular, complete system of wave functions for a massive Dirac neutrino possessing anomalous magnetic moment in dense matter and in strong electromagnetic field is obtained. These functions describe neutrino with rotating spin and are eigenfunctions of

kinetic momentum operator. Using these wave functions it is possible to calculate probabilities of various processes with neutrino in the framework of the Furry picture. The dispersion law for the neutrino in dense magnetized matter is found. It is shown that group velocity of neutrino is independent of spin orientation.

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V. Nesterenko

Vacuum Energy of Electromagnetic Field in the Background of Cosmic String of a Finite Thickness

The cosmic strings are, as before, interesting for working out in detail cosmological scenario. Here the task arises of calculating the energy of physical fields in the background of a cosmic string. The vacuum energy density for infinitely thin cosmic string turns out to be nonitegrable at the origin. As a result, the total vacuum energy per a unit length along the string cannot be found. In order to avoid this drawback one can consider the cosmic string of a finite thickness. Such a string model may be introduced in different ways and a few papers were devoted to this subject. Here we propose to model the cosmic string of a finite thickness in the following way. Let us surround a straight infinitely thin cosmic string by a coaxial perfectly conducting cylindrical shell of a finite radius. In our previous paper [V.V. Nesterenko *et al*, Class. Quantum Grav. **20**, 431 (2003)] it was shown that the heat kernel coefficient a_2 vanishes for such a configuration. Hence the zeta-function technique enables one to calculate a finite value of the vacuum electromagnetic energy in the problem at hand without using explicit renormalization procedure.

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A. Bubnov, O. Kharlanov, and V. Zhukovsky

Vacuum Polarization and Casimir Effect within (3+1)D Maxwell-Chern-Simons Electrodynamics with Lorentz Violation

Within the framework of the Lorentz-violating (3+1)-dimensional extended electrodynamics including the CPT-odd Chern-Simons term and a phenomenological constant vector parameter b in the Dirac Lagrangian, we calculate the effective action with exact account for the constant electromagnetic field and consider the electromagnetic field between two parallel perfectly conducting plates. We calculate the nonvanishing term in the effective action, quadratic in b exactly, and also the correction to the Casimir force, which is attractive and quadratic in the Chern-Simons term. This result disagrees with the one calculated by M.Frank and I.Turan in 2006 and based on wrong equations of motion. Compared to the experimental data, our results place constraints on the absolute values of b and the Chern-Simons term.

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Quantum Gravity and Cosmology

B. Allen

Gravitational Wave Astronomy

The efforts to detect gravitational waves are surveyed. Current first-generation ground-based detectors have already made observations of astrophysical relevance. Upcoming second- and third-generation ground-based detectors, as well as space-based detectors and pulsar timing array detectors should enable direct observations of gravitational waves, and provide new astronomical insights.

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B. Altshuler

Unexpected Physical Contents of the Fluxbrane Throat-Like Solutions in Type IIA and Type IIB Supergravities

Radion effective potential which meets the demands of early inflation is unambiguously received with use of background so-

lutions of equations of the Type IIA or Type IIB supegravities. Reissner-Nordstrom deformation of the background results in the tiny positive deviation from zero of the value of radion potential in its extremal point fixed by Israel jump conditions at the UV top of the throat; this deviation coincides with the observed value of the Dark Energy density. Spectra of Kaluza-Klein gauge fields and of Fermions are calculated at the fluxbrane throat-like backgrounds. Flux plays the role of Higgs scalar generating the electroweak-scale mass of non-Abelian KK gauge field. Also Pauli-type flux term permits to receive the value of electron neutrino mass in the "twisted" spectrum of Dirac equation thus giving the "seesaw" scale without seesaw mechanism. The drastic difference of profiles in extra space of the right and left neutrinos wavefunctions explains the unobservability of the right neutrino thus joining it to plethora of candidates for Dark Matter.

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A. Andrianov

Stable Phantom Cosmology Based on (C)PT Symmetry

The PT symmetric flat Friedmann model of two scalar fields is considered with positive kinetic terms. While the potential of one ("normal") field is taken real, that of the other field is complex. A complex classical solution of the system of the two Klein-Gordon equations is described in compatibility with the Friedmann equation. The solution for the normal field is real while the solution for the second one is purely imaginary, realizing classically the "phantom" behavior. Such an approach is inspired by the quantum theory of PT symmetric non-Hermitian

Hamiltonians, whose spectrum is real and bounded from below. The energy density and pressure are real and the corresponding geometry is well-defined. The Lagrangian for the linear perturbations has the correct potential signs for both the fields, so that the problem of instability does not arise. The background dynamics is determined by a classical action of two real fields: one normal and one "phantom". Remarkably, the phantom phase in the cosmological evolution is transient and the Big Rip never occurs. Our model is confronted with well-known quintom models, which include manifestly a phantom field and suffers from instabilities and the Big Rip.

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I. Arefeva

Catalysis of Black Holes Production at the LHC

Recently, black hole and brane production at the LHC has been widely discussed and the conclusion is that if the scale of quantum gravity is of the order of few TeVs, the mini-black hole production in proton-proton collisions at the LHC is near of a threshold. We discuss several possibilities to catalyze this process as well as catalysis of production of the mini-wormholes/time machines (spacetime regions with closed timelike curves which violet causality) at the LHC and future colliders.

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E. Babichev

Spherically Symmetric Solutions in Massive Gravity and the Vainshtein Mechanism

I will discuss spherically symmetric solutions of massive gravity. In particular, I will concentrate on the decoupling limit, for which the Goldstone picture is especially useful. I will consider the Vainshtein mechanism and will show that the system of equations left over in the decoupling limit has regular solutions featuring a Vainshtein-like recovery of solutions of General Relativity. I will also discuss the issues of spherically symmetric solutions for the full system.

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A. Barvinsky

CFT Driven Cosmology and the DGP/CFT Correspondence

We discuss a recently suggested new model of quantum initial conditions for the Universe in the form of the microcanonical state in spatially closed cosmology driven by large N conformal field theory. This model suggests a possible solution to various aspects of the cosmological constant problem by restricting the landscape of cosmological solutions and features a new mechanism for a cosmological acceleration stage. This stage is followed by Big Boost singularity — a rapid growth up to infinity of the scale factor acceleration parameter. We also present a dual 5D braneworld description of this model. The 5D side of the duality relation is represented by the generalized model of brane induced gravity in the Schwarzschild-de Sitter bulk. The bulk and the induced 4D cosmological constants are constrained by the requirement of regularity at the de Sitter horizon of the Euclidean Schwarzschild-de Sitter bulk. They belong to the vicinity of the upper bound of the cosmological constant range which is enforced by the 4D CFT and coincides with the natural gravitational cutoff in the theory with many quantum species N.

Lebedev Inst., Moscow

V. Berezin

Classical Analogs of Quantum Schwarzschild and Reissner-Nordstrom Black Holes

The models of classical matter distribution are constructed that: 1)obey classical Einstein equations; 2)have an Unruh's temperature equal to the corresponding Hawking's temperature for Schwarzschild and Reissner-Nordstrom black holes; 3)their parameters subject to the relations obtained from the quantum models for spherically symmetric thin shells.

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C.-M. Chen

Dilatonic Black Holes in Gauss-Bonnet Gravity

We show that four-dimensional Einstein-Maxwell-Dilaton-Gauss-Bonnet gravity admits asymptotically flat extremal black hole solutions with a degenerate event horizon of AdS type. Black holes must be endowed with an electric charge and with magnetic charge (dyons).

Purely electric solutions exist for the dilaton coupling con-

stant less than the critical value 0.488219703. Relation between the mass, the electric charge and the dilaton charge at both ends of the allowed interval of dilaton coupling is reminiscent of the BPS condition for dilaton black holes in the Einstein-Maxwell-Dilaton theory.

The extremal dyonic black holes in the same theory without the Gauss-Bonnet term exist only for discrete values of the dilaton coupling constant. The Gauss-Bonnet term acts as a dyon hair tonic enlarging the allowed values of dilaton coupling to continuous domains in the plane with the magnetic charge. The entropy of new dyonic black holes interpolates between the Bekenstein-Hawking value in the limit of the large magnetic charge (equivalent to the vanishing Gauss-Bonnet coupling) and twice this value for the vanishing magnetic charge.

C.-M. Chen, D. V. Gal'tsov and D. G. Orlov, "Extremal black holes in D = 4 Gauss-Bonnet gravity," Phys. Rev. D **75**, 084030 (2007) [arXiv:hep-th/0701004].
C.-M. Chen, D. V. Gal'tsov and D. G. Orlov, "Extremal dyonic black holes in D = 4 Gauss-Bonnet gravity," Phys. Rev. D **78**, 104013 (2008) [arXiv:0809.1720 [hep-th]].

Nation Central Univ., Taiwan

A. Filippov

On Einstein-Weyl Unified Model of Gravity, Dark Energy and Dark Matter: a Brief History and the New Interpretation, Simplest Dimensional Reductions, Static and Cosmological Solutions

I give a summary of my recent work on reinterpreting Einstein's 'unified models of gravity and electromagnetism' (1923) as a naturally unified theory of dark energy (cosmological constant) and dark matter (neutral massive vector particle having only gravitational interactions). After a brief account of Einstein's work and related earlier work of Weyl and Eddington, I present an approach to finding basic solutions of the simplest variant of the Einstein models. The spherically symmetric static solutions and homogeneous cosmological models are considered in some detail. In the static case, we show that there exist solutions with two horizons and derive their expansions near the horizons. In cosmology, we show how to find the expansions of possible solutions near the origin and derive nonlinear equations for the scale factor. It is important that the homogeneous isotropic cosmology is only possible for the flat space (this remark is also relevant to some reductions in string theory). The structure of the solutions seems to hint at a possibility of a realistic inflation mechanism that does not require adding scalar fields. Further extensions and simple models including matter are briefly discussed.

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A. Frolov

Primordial Non-Gaussianity from Preheating

The idea of inflation (a period of rapid quasi-exponential expansion of the Universe) neatly solves several issues in cosmology. While the Universe is inflating, its contents is cold. Eventually, inflation ends and the field driving the inflation must decay, depositing energy into high-energy particles. This process, known as reheating, starts the hot big bang history as we know it. I will discuss a few scalar field models of reheating, which for all their simplicity have rich physics involving parametric resonance, non-linear evolution, and turbulence, and illustrate their dynamical behavior with simulations using a new numerical solver I developed. Most interestingly, preheating can create primordial non-Gaussian fluctuations at potentially observable levels, which could give a glimpse of physics at energies we know very little about.

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V. Frolov

Black Holes and Hidden Symmetries

The talk contains a brief review of recent results on hidden symmetries in higher dimensional black hole spacetimes. We show how the existence of a principal CKY tensor (that is a closed conformal Killing-Yano 2-form) allows one to generate a 'tower' of Killing-Yano and Killing tensors responsible for hidden symmetries. Any solution of the Einstein equations with a non-degenerate principal CKY tensor is described by the Kerr-NUT-(A)dS metric. The hidden symmetries generated by the principal CKY tensor imply complete integrability of geodesic equations and the complete separation of variables in the Hamilton-Jacobi, Klein-Gordon, Dirac and gravitational perturbation equations in the general Kerr-NUT-(A)dS metrics. Equations of the parallel transport of frames along geodesics in these spacetimes are also integrable.

Univ. of Alberta

D. Fursaev

Quantum Entanglement, Topology, and Entropy of a Wormhole

A role of non-trivial topology in the definition of entanglement entropy in a quantum gravity theory is discussed. The arguments are presented that a traversable wormhole is characterized by an intrinsic entropy, S, which measures an entanglement of quantum states in two universes connected by the wormhole. The entropy is given by the Bekenstein-Hawking formula in terms of the area of a least area minimal hypersurface embedded in the wormhole throat. It is shown that properties of the wormhole entropy are in agreement with basic properties of the von Neumann entropy. An intriguing property of S is that it allows variational formulae (like in case of the first law of black hole mechanics) with an analog of the energy and the surface gravity.

Dubna International Univ. & JINR, Dubna

S. Giddings

Think Globally – Observe Locally

Gravity apparently does not permit precise local observables, yet in the cosmological context we are constrained to observe locally. This talk will describe aspects of the problem of formulating gauge invariant observables that are approximately local, using relational ideas. Their relevance in quantum de Sitter space will be briefly discussed, together with what appear to be intrinsic limitations on such locality.

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A. Grib

On the Hypothesis of Superheavy Particles as Particles of Dark Matter

The hypothesis that the main part of dark matter is constituted by superheavy neutral particles with the mass of the order of the Grand Unification scale $M_X = 10^{14}$ GeV is investigated. The arguments for the hypothesis are the following. Calculations show that creation of these particles by the gravitation of the early Friedmann Universe with subsequent decays of some of them called short living X_s on quarks could lead to the observable baryon charge of the Universe. The other part of these particles called long living X_l could disappear due to weak interaction with the baryon charge but some number of them survived as modern dark matter. In active galactic nuclei (AGN) considered as rotating black holes due to Penrose process dark matter particles can be converted into X_s and the decays of them identical to processes in the early Universe lead to observable UHECR in the Auger experiment. Possible verification of the hypothesis by observations of UHECR neutrinos from AGN and interior of planets are discussed.

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A. Barvinsky, A. Kamenshchik, C. Kiefer, A. Starobinsky, and C. Steinwachs

Asymptotic Freedom in Inflationary Cosmology with a Non-Minimally Coupled Higgs Field

We consider the renormalization group improvement in the theory of the Standard Model Higgs boson playing the role of

an inflaton with a strong non-minimal coupling to gravity. It suggests the range of the Higgs mass between 124 GeV and 180 GeV compatible with the current CMB data, which is very close to a widely accepted range dictated by the known electroweak vacuum stability and perturbation theory bounds. We find the phenomenon of asymptotic freedom induced by this non-minimal curvature coupling, which brings the theory to the weak coupling domain everywhere except the lower boundary of this range, adjacent to the instability threshold of the theory. The renormalization group running of a basic quantity A – the anomalous scaling in the non-minimally coupled Standard Model, which analytically determines all characteristics of the CMB spectrum – brings A to small positive values at the inflation scale. This property is crucial for the above results and also might underlie the formation of initial conditions for the inflationary dynamics in quantum cosmology.

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M. Katanaev

Inside the BTZ Black Hole

We consider static circularly symmetric solution of three-dimensional Einstein's equations with negative cosmological constant (the BTZ black hole). The case of zero cosmological constant corresponding to the interior region of a black hole is analyzed in detail. We prove that the maximally extended BTZ solution with zero cosmological constant coincides with flat three-dimensional Minkowskian space-time without any singularities and horizons. The Euclidean version of this solution is shown to have physical interpretation in the geometric theory of defects in solids describing combined wedge and screw dislocations.

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A. Koshelev

String Field Theory Rolling Tachyon, Non-Locality and Dark Energy

We consider the dynamics of the open string tachyon condensation in a framework of the cubic fermionic String Field Theory including a non-minimal coupling with closed string massless modes, the graviton and the dilaton. We note that the dilatonic gravity provides several restrictions on the tachyon condensation and show explicitly that the influence of the dilaton on the tachyon condensation is essential and provides a significant effect: oscillations of the Hubble parameter and the state parameter become of a cosmological scale. We give an estimation for the period of these oscillations (0.1-1.0) Gyr and note a good agreement of this period with the observed oscillations with a period (0.15-0.65) Gyr in a distribution of quasar spectra. Cosmological perturbations are analyzed and evolution of perturbations is studied. Several novel effects compared to canonical local scalar field cosmologies are stressed.

The talk is mainly based on:

1. I.Ya. Aref'eva, A.S. Koshelev, “Cosmological Signature of Tachyon Condensation”, JHEP 0809:068,2008, arXiv:0804.3570.
2. Alexey S. Koshelev, “Non-local SFT Tachyon and Cosmology”, JHEP 0704:029,2007, hep-th/0701103.
3. A.S.Koshelev and S.Yu.Vernov, ”Scalar perturbations in non-

local theories", work in progress.
4. A.S.Koshelev, "Non-local cosmological models for Dark Energy", work in progress.

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A. Linde

Inflationary Multiverse and String Theory Landscape

I will briefly review the present status of inflationary cosmology (theory and observations). Then I will describe recent progress in implementing inflation in string theory. Finally, I will discuss the problem of probability measure in the theory of inflationary multiverse.

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A. Matveev

Unfolded Description of AdS_4 Black Hole

We present unfolded description of AdS_4 black hole with generic parameters of mass, NUT, magnetic and electric charges as well as two kinematical parameters one of which is angular momentum. A flow with respect to black hole parameters, that relates the obtained black hole unfolded system to the covariant constancy condition for an AdS_4 global symmetry parameter, is found. The proposed formulation gives rise to a coordinate-independent description of the black hole metric in AdS_4. The black hole charges are identified with flow evolution parameters while its kinematical constants are the first integrals of the black

hole unfolded system expressed via invariants of the AdS_4 global symmetry parameter. It is shown how the proposed method reproduces various known forms of black hole metrics including the Carter and Kerr-Newman solutions. Free flow gauge parameters allow us to choose different metric representations such as Kerr-Schild, double Kerr-Schild or generalized Carter-Plebanski in the coordinate-independent way.

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B. Meierovich

Spontaneous Symmetry Breaking in Multidimensional Gravity. Vector Order Parameter

The theories of brane world and multidimensional gravity are widely discussed in the literature. A natural physical concept is that a distinguished surface in the space-time manifold is a topological defect appeared as a result of a phase transition with spontaneous symmetry breaking. The macroscopic theory of phase transitions allows considering the brane world concept self-consistently, even without the knowledge of the nature of physical vacuum.

Gravitational properties of topological defects (cosmic strings) in two extra dimensions are considered in General Relativity employing a vector as the order parameter. All previous considerations were done using the order parameter in the form of a multiplet in a plane target space of scalar fields, see [1] and references there in. The difference of these two approaches is analyzed and demonstrated in detail.

Regular solutions of the Einstein equations are studied analytically and numerically. Regular configurations have a growing gravitational potential and are able to trap the matter on the brane. If the energy of spontaneous symmetry breaking is high, the potential can have several points of minimum. Identical in the uniform bulk spin-less particles, being trapped within the separate minima, acquire different masses and appear to an observer on brane as different particles with integer spins.

[1] K.A.Bronnikov, B.E.Meierovich. JETP, 2008, vol. 133, No. 2, pp. 293-312.

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M. Mensky

Path Group and Quantum Equivalence Principle

Path Group, generalizing the translation group, has been defined by the author as a set of (classes of) continuous curves in Minkowski space (in a more general case, in any group space). A quantum analogue of the equivalence principle is formulated in terms of Path Group. It leads to the definition (slightly different from the definition suggested by DeWitt) of a path integral for an arbitrary curved space-time. The motion of quantum particles in a curved space-time is determined by this principle even in case of nontrivial topology. This is applied for the analysis of gravitational thermal effects (of the type of the Unruh and Hawking effects). Path Group deals with space-time relations even if the manifold structure of the physical space-time is not fixed. This makes this formalism promising in quantum gravity.

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E. Mottola

Macroscopic Quantum Effects in Gravity: Dark Energy and Condensate Stars

The low energy effective action of gravity in any even dimension generally acquires non-local terms associated with the trace anomaly, generated by the quantum fluctuations of massless fields. The local auxiliary field description of this effective action in four dimensions requires two additional long range scalar fields, not contained in classical General Relativity, which remain relevant at macroscopic distance scales. The auxiliary scalar fields depend upon boundary conditions for their complete specification, and therefore carry global information about the geometry and macroscopic quantum state. Semi-classiclly the scalar potentials provide coordinate invariant order parameters describing divergences of the stress tensor on event horizons, and their fluctuations can induce a phase transition at a black hole event horizon, leading to an entirely different non-singular endpoint of gravitational collapse, a gravitational condensate star, with the dark energy equation of state p=-rho in its interior. Like a black hole, a fully collapsed object of this kind would be cold and dark, but unlike a classical black hole a gravastar has no singularity, no event horizon, and no information paradox.

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M. Sasaki

Non-Gaussian Curvature Perturbations from Multi-Brid Inflation

We propose a class of multi-field hybrid inflation models, dubbed *multi-brid inflation.* We show that multi-brid inflation

models can account for a large non-Gaussian parameter f_{NL}^{local} as well as for a detectable tensor-to-scalar ratio.

Kyoto Univ.

I. Sawicki

Dark Matter via Many Copies of the Standard Model

I will discuss a cosmological scenario based on the existence of many copies of the standard model. Baryons of the hidden copies can then naturally account for the dark matter. The appropriate density of perturbations and the correct dark-matter abundance are simultaneously generated during reheating. I will show that for the natural values of inflaton coupling constants, dictated by unitarity, the dark-matter abundance is predicted to be proportional to the ratio of observed cosmological parameters: the square of the amplitude of cosmological perturbations and the baryon-to-photon number ratio.

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S. Sibiryakov

Sigma Models for Lorentz Group and Superluminal Propagation in Two Dimensions

I consider a family of non-linear SO(1,1) sigma models in two space-time dimensions, where SO(1,1) is the Lorentz group. These theories are asymptotically free; I argue that they are well defined non-perturbatively, at least for some values of parameters. The peculiarity of these models is that, despite being Poincare invariant, they exhibit superluminal propagation of signals. This is possible due to existence in two dimensions of the "instantaneous" causal structure, with one of the light cone variables being a global time. This causal structure is invariant under the Poincare group if one gives up the spatial parity. Being coupled to gravity the "instantaneous" theories mix with the Liouville field. I speculate on the possibility of using the resulting models to construct (non-critical) string theories with unconventional properties by introducing the instantaneous causal structure on the world-sheet.

The talk is based on the work done in collaboration with S. Dubovsky

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P. Fre and A. Sorin

Supergravity Black Holes and Billiards and Liouville Integrable Structure of Dual Borel Algebras

We show that the supergravity equations describing both cosmic billiards and a large class of black-holes are, generically, both Liouville integrable as a consequence of the same universal mechanism. This latter is provided by the Liouville integrable Poissonian structure existing on the dual Borel algebra B_N of the simple Lie algebra A_{N-1}. As a by product we derive the explicit integration algorithm associated with all symmetric spaces U/H^* relevant to the description of time-like and space-like p-branes. The most important consequence of our approach is the explicit construction of a complete set of conserved involutive hamiltonians that are responsible for integrability and provide a

new tool to classify flows and orbits. We believe that these will prove a very important new tool in the analysis of supergravity black holes and billiards.

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A. Starobinsky

Present Status of $f(R)$ Models of Inflation and Dark Energy

Since 1980, a variant of the $f(R)$ fourth-order theory of gravity (with small one-loop corrections) was known to provide an internally self-consistent scenario of the early Universe with an initial quasi-de Sitter (inflationary) stage followed by the graceful exit to the radiation-dominated FRW stage via the period of reheating in which all matter in the Universe arises as a result of gravitational particle creation. Its predictions regarding spectra of primordial density perturbations and gravitational waves remain in agreement with the most recent observational data. A few years ago it was proposed to use $f(R)$ gravity for description of dark energy in the present Universe. However, this problem appeared to be more complicated, so many attempts in this direction failed. Still recently some $f(R)$ models of dark energy have been found which can satisfy laboratory, Solar system and cosmological tests. To avoid formation of additional singularities, viable $f(R)$ models of present dark energy should have the same asymptotic behaviour for large R as $f(R)$ models of inflation. Unified description of inflation and present dark energy in $f(R)$ gravity is possible, but leads to completely different reheating after inflation.

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A. Toporensky

Regular and Chaotic Dynamics in Scalar Field Cosmology

A transient chaos in a closed FRW cosmological model with a scalar field is studied. We describe different chaotic regimes and show that the type of chaos in this model depends on the scalar field potential. We have found that for sufficiently steep potentials or for potentials with large cosmological constant the chaotic behavior disappears. For shallow potentials stable periodic trajectories and surrounding islands of regular dynamics appear in a chaotic "sea".

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S. Vernov

The NEC Violation and Classical Stability

Field theories which violate the null energy condition (NEC) are of interest for the solution of the cosmological singularity problem and for models of dark energy with the equation of state parameter $w < -1$. Generally speaking models that violate the NEC have ghosts,therefore, are unstable and physically unacceptable. However, the possibility of existence of the dark energy with $w < -1$ encourage the investigation of such models. It is almost clear that such a possibility can be realized within an effective theory, while the fundamental theory should be stable.

The stability of isotropic cosmological solutions in the Friedmann-Robertson-Walker (FRW) and Bianchi I metric is considered. We prove that the stability of isotropic solutions in the Bianchi I metric for positive Hubble parameter follows from their stability in the FRW metric. This result is applied for models inspired by string field theory, which violate the NEC. Sufficient conditions for the Lyapunov stability of isotropic kink type solutions in the Bianchi I metric have been found. Examples of stable isotropic solutions are presented.

The talk is based on the paper arXiv:0903.5264 by I.Ya. Aref'eva, N.V. Bulatov, L.V. Joukovskaya, and S.Yu. Vernov.

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A. Vikman

Spontaneous Lorentz Symmetry Breaking and Horizons

General spacetime-dependent solutions spontaneously break Lorentz symmetry. Thus the dynamics of perturbations around these backgrounds should be described by an action which is not Lorentz invariant. In particular, this trivial phenomenon is interesting for the kinetically coupled theories where even the front velocity for the propagation of perturbations becomes different form the speed of light. Thus, for such theories, the causal relations between different events should be appropriately adjusted. This may in turn change the notion of horizons and correspondingly change the thermal properties of the system. In the talk I will discuss particular examples of such theories emphasizing the issues related to causality, stability and thermodynamics.

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M. Volkov

Stationary Ring Solitons in Field Theory — Knots and Vortons

We review the current status of the problem of constructing classical field theory solutions describing stationary vortex rings in Minkowski space. We describe the known up to date solutions of this type, such as the static knot solitons stabilized by the topological Hopf charge, the anomalous solitons stabilized by the Chern-Simons number, the non-Abelian monopole rings. Passing to the rotating solutions, we describe the spinning Q-balls, spinning skyrmions, and rotating monopole-antimonopole pairs. We then present the first explicit construction of vortons as solutions of the elliptic boundary value problem. We also describe the analogs of vortons in the Bose-Einstein condensates, analogs of spinning Q-balls in the non-linear optics, and also moving vortex rings in superfluid helium and in ferromagnetics.

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I. Volovich

Sakharov‘s Extra Timelike Dimensions and Hawking‘s Chronology Protection Conjecture

According to the Sakharov hypothesis the multiverse can contain spacetimes with different signatures of the metric including extra timelike dimensions. In such spacetimes there are closed timelike curves, i.e. time machines. Hawking conjectured that the laws of physics are such as to prevent time travel on all but sub-microscopic scales. However, as a general principle this conjecture is failed.

In this talk new results on the solutions of the Cauchy problem for the wave equation on the spacetime with CTC will be reported. We prove that there are some constraints to the initial data which are necessary and sufficient for the existence of global solution. Quantization of the fields with such constraints is considered and its relevance to the problem of tachyons which appear in theories with extra timelike dimensions are mentioned. Prediction of production of wormholes and CTC at the LHC will be discussed.

[1] I.Ya. Aref'eva, I.V. Volovich,Time Machine at the LHC, Int.J.Geom.Meth.Mod.Phys.5(2008)641-651.
[2] O.V. Groshev, N.A. Gusev, E.A. Kuryanovich, I.V. Volovich, arXiv:0903.0741.

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R. Woodard

A Phenomenological Model of Inflation from Quantum Gravity

I present a class of nonlocal, purely metric field equations which reproduce the time dependence of the quantum gravitational back-reaction on inflation at leading logarithm order. I show how these models generically end inflation in a novel way, during which the Hubble parameter oscillates. The instabilities resulting from brief violations of the weak energy condition should lead to rapid reheating. I also describe the generation of primordial perturbations.

This is work done in collaboration with Nikolaos Tsamis of the University of Crete.

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O. Zaslavskii

Quasi-Black Holes

Objects that are on the verge of being extremal black holes but actually are distinct in many ways are called quasi-black holes. Quasi-black holes are defined here and treated in a unified way through the displaying of their properties. The main ones are (i) their geometry remains perfectly regular everywhere, in spite of the existence of infinite redshifts, (ii) in the limit, outer and inner regions become mutually impenetrable and disjoint, although, in contrast to the usual black BHs, this separation is of a dynamical nature, rather than purely causal. It is also shown that QBHs have to be extremal, if we accept only finite surface stresses. If, however, such stresses are allowed, we derived mass formula for the quasi-black hole that coincides with that for black holes but is obtained from different physical assumptions.

Based on materials of recent papers:

Jose P. S. Lemos and Oleg B. Zaslavskii, Quasi black holes: definition and general properties. Phys. Rev. D Vol.76, No.8, 084030 (2007).

J. P. S. Lemos and O. B. Zaslavskii, Mass formula for quasi-black holes, Phys. Rev. D 78, 124013 (2008).

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Superstrings and Higher Spin Gauge Theory

O. Andreev

String Free Energy, Hagedorn and Gauge/String Duality

I give examples of modeling the string free energy whose behavior mimics that of QCD: a power-law at high temperature and an exponential decrease at low temperature. Although the effective description is in terms of strings, no limiting temperature exists, as expected for a crossover.

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I. Antoniadis

Aspects of String Phenomenology

CERN

G. Arutyunov

Towards the Exact Spectrum of the $AdS_5 \times S^5$ Superstring. I

We discuss an approach for finding the exact spectrum of the $AdS_5 \times S^5$ superstring based on the Thermodynamic Bethe Ansatz for the accompanying mirror model.

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I. Bandos

SDiff Invariant Bagger-Lambert-Gustavsson Model and Its $N = 8$ Superspace Formulation(s)

We review briefly the BLG (Bagger-Lambert-Gustavsson) model, which had been proposed to describe a low energy dynamics of multiple supermembrane system, with emphasis on its version with 3-algebra realized as the algebra of Nambu brackets (NB). This NB BLG model possesses the infinite dimensional volume preserving diffeomorphism symmetry (SDiff3) and gives an example of $N = 8$ supersymmetric SDiff3 gauge theory in $d = 3$.

We discuss the general properties of SDiff gauge theories and describe two superfield formulation of the NB BLG model. The on-shell description in standard $d = 3$ $N = 8$ superspace is based on an SDiff3 covariant superembedding-like equation imposed on octet of scalar superfield dependent, in addition, on coordinates of compact 3-dimensional manifold M3.

The off-shell $N = 8$ superfield formulation becomes possible in superspace completed by a set of constrained bosonic spinor coordinates, called the pure spinor superspace. We discuss the properties of this superspace, peculiar features of the pure spinor superspace action, and its specific in the case of infinite dimensional SDiff3 3-algebra.

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I. Bars

Super Yang-Mills Theory in 10+2 Dimensions as Another Step toward M-Theory

In this talk, first I will describe why the usual formulation of physics (1T-physics) is certainly incomplete, because it is unable to predict certain subtle phenomena, but is only able to verify their existence and their properties. For this reason the usual approach may be inadequate for the eventual construction of M-theory. Then I will give a brief summary of the principles of 2T-physics and how this has led successfully to the usual Standard Model and General Relativity in 3+1 dimensions as "shadows" of corresponding field theories in 4-space and 2-time dimensions, with additional new predictions in 3+1 dimensions that are consistent with all known phenomena so far. Then, the first extension of 2T-physics into higher dimensions in a supersymmetric setting will be given in 10+2 dimensions for the Super Yang Mills theory (SYM). It will be shown that this theory is the parent theory for the $SN = 1$ SYM in 9+1 dimensions and for the famous $N = 4$ SYM in 3+1 dimensions, thus providing a new higher dimensional perspective for this theory that continues to be intensely studied. The new 10+2 SYM is considered to be a first step toward supergravity in 10+2 dimensions and M-theory in 11+2 dimensions in the context of 2T-physics.

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L. Baulieu

Soft Breaking of BRST Invariance for Introducing Non-Perturbative Infrared Effects in a Local and Renormalizable Way

We explain non-perturbative infrared effects leading to a modification of the long distance behavior of gauge theories through a soft breaking of the BRST invariance is investigated. The method reproduces the Gribov-Zwanziger action describing the restriction of the domain of integration in the Feynman path integral to the Gribov region and a model for the dynamical quark mass generation is presented. The soft symmetry breaking relies on the introduction of BRST doublets and massive physical parameters, which allow one to distinguish the infrared region from the ultraviolet one, within the same theory.

LPTHE, Univ. Paris VI

N. Beisert

Dual Superconformal Symmetry and Integrability in AdS/CFT

In recent years two intriguing observations have been made for $N = 4$ super Yang-Mills theory and for superstrings on $AdS_5 \times S^5$: In the planar limit the computation of the spectrum is vastly simplified by the apparent integrability of the models. Furthermore, planar scattering amplitudes of the gauge theory display remarkable features which have been attributed to the appearance of a dual superconformal symmetry. This talk reviews the connection of these two developments.

Max Planck Inst. for Gravitational Phys., Golm

X. Bekaert

On Higher Spin Interactions with a Scalar Field

Cubic couplings between a complex scalar field and a tower of symmetric tensor gauge fields of each rank are considered. Following Noether's method, the tensor gauge fields interact with the scalar field via minimal coupling to an infinite set of conserved currents. The corresponding cubic vertex is written in a compact form by making use of Weyl's symbols. This enables the explicit computation of the non-Abelian gauge symmetry group and the four-scalar elastic scattering tree amplitude for an exchange of any symmetric tensor field. The summation of these amplitudes for an infinite tower of gauge fields is possible and several exact examples are provided where the total amplitude exhibits fast (e.g. exponential) fall-off in the high-energy limit.

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A. Bengtsson

Spacetime Pictures of Higher Spin Gauge Interactions

Returning to an old idea of a certain two-particle relativistic system as an underlying mechanical model for higher spin gauge fields, a space-time picture for the interactions is proposed. The resulting algorithm generates vertices to all orders.

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E. Bergshoeff

A New Massive Gravity Theory in Three Dimnesions

We introduce a new massive gravity theory in three dimensions and discuss some of its properties.

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N. Boulanger, C. Iazeolla, and P. Sundell

The Unfolding of General Tensor Fields in AdS

We review the recent results arXiv:0812.3615 and arXiv:0812.4438 where the unfolding of arbitrary-shaped Young-tableau tensor gauge fields in AdS spacetime was presented.

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I. Buchbinder

Gauge Invariant Approach to Lagrangian Constructions for Higher Spin Field Theories

We review the applications of BRST-BFV construction to higher spin field theories. The problem of finding the Lagrangians for higher spin fields on curved manifolds is reformulated as a problem of finding the BRST-BFV charge on the base of relations defying the fields with given spin. These relation are treated as the first class constraints of some gauge theory with initially unknown Lagrangian. We show that such a construction restricts the manifold to be a constant curvature space.

The Lagrangians for massless and massive higher spin fields are formulated in terms of BRST-BFV charge and automatically possess a gauge invariance. Explicit Lagrangian consructions are given for bosonic and fermionic higher spin fields in AdS space, for fields with mixed symmetry of indices and for totally symmetric and antisymmetric fields. A possibility to construct the higher spin field interactions on the base of such a formalism is also discussed.

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M. Cederwall

Operators on Pure Spinor Spaces

Pure spinors are relevant to the formulation of supersymmetric theories, and provide the only known way to maintain manifest maximal supersymmetry. The (non-linear) pure spinor constraint makes it nontrivial to find well defined operators on pure spinor wave functions. We discuss how such operators are defined. We also discuss some work in progress where the construction is used. One application concerns covariant gauge fixing in maximally supersymmetric Yang-Mills. Another issue is the construction of a manifestly supersymmetric action for 11-dimensional supergravity in terms of a scalar superfield.

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J. de Boer

Macroscopic Quantum Effects near Black Holes

Gravitational entropy arises in string theory via coarse graining over an underlying space of microstates. In this talk I will discuss the implementation of this idea in the context of supersymmetric black holes in four dimensions. In particular, I will show that this idea leads to the prediction that effective field theory breaks down in a new way near a black hole due to large macroscopic quantum effects. I will also try to argue that most of the microstates are inaccessible in supergravity, and that one would need massive closed string degrees of freedom to probe all of them.

Inst. Theoretical Phys., Amsterdam

S. Brodsky and G. de Teramond

Light-Front Holography and Gauge/Gravity Duality: Applications to Hadronic Physics

Starting from the bound state Hamiltonian equation of motion in QCD we derive relativistic light-front wave equations in terms of an invariant transverse variable which measures the separation of the quark and gluonic constituents within the hadron at equal light-front time. These equations of motion in physical space-time possesses remarkable algebraic structures and integrability properties dictated by the conformality properties of the theory and are shown to be equivalent to the equations of motion which describe the propagation of spin-J modes in anti-de Sitter (AdS) space. Its eigenvalues give the hadronic spectrum and its eigenmodes represent the probability distribution of the hadronic constituents at a given scale. We extend the AdS construction to include integrable confining structures and find their corresponding higher-dimensional geometrical interpretation. We also describe the correspondence of fermion string modes in AdS and baryonic states in light-front QCD. Applications to the meson and baryon spectrum are discussed.

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B. de Wit

Near-Horizon Analysis of $D = 5$ BPS Black Holes and Rings

Supersymmetry enhancement at the horizon of BPS black holes and rings in five space-time dimensions with eight supersymmetries, imposes stringent conditions on the fields and the geometry. For example, the BPS near-horizon geometry follows irrespective of the details of the Lagrangian. From the horizon behaviour alone the entropy and the attractor equations are derived. For spinning black holes, the results only partially agree with previous work, where additional input was used beyond the near-horizon data. In particular, the results fail to agree with four-dimensional results in the presence of higher-derivative interactions. Arguments are presented for this discrepancy. For the black rings, the horizon behavior leads to results which are consistent with the four-dimensional case, although subtle issues remain.

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V. Didenko

Towards Black Holes in Higher Spin Gauge Theory

The new exact solution of $4d$ bosonic higher spin gauge theory generalizing AdS_4 Schwarzschild black hole is proposed.

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H. Dorn

On Timelike and Spacelike Minimal Surfaces in AdS_n and the Alday-Maldacena Conjecture

We discuss timelike and spacelike minimal surfaces in AdS_n using a Pohlmeyer type reduction. The differential equations for the reduced system are derived in a parallel treatment of both type of surfaces, with emphasis on their characteristic differences. In the timelike case we find a formulation corresponding to a complete gauge fixing of the torsion. In the spacelike case we derive three sets of equations, related to different parameterizations enforced by the Lorentzian signature of the metric in normal space. On the basis of these equations, we prove that there are no flat spacelike minimal surfaces in AdS_n, $n \geq 4$ beyond the four cusp surfaces used in the Alday-Maldacena conjecture. Furthermore, we give a parameterization of flat timelike minimal surfaces in AdS_5 in terms of two chiral fields.

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V. Forini

Reciprocity in AdS/CFT

Evidence is given, both at weak and at strong coupling in perturbation theory, that a generalization of the Gribov-Lipatov reciprocity is an asymptotic property of anomalous dimensions for twist operators in $N = 4$ SYM as well as of the energies of their dual string configurations.

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D. Francia

On Unconstrained Higher Spins of Any Symmetry

Established results due to Fronsdal and Labastida describe free higher-spin gauge fields in terms of tensors subject to certain algebraic constraints. Such constraints, on the other hand, are not suggested by String Theory and conflict with the linear 'geometry' available for these fields. I will thus describe a proposal, among several available, allowing "minimal" Lagrangian formulations of the same systems devoid of constraints, and applicable to bosons and fermions of any symmetry type, with or without higher derivatives. I will finally comment on the geometrical meaning of the construction.

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S. Frolov

Towards the Exact Spectrum of the $AdS_5 \times S^5$ Superstring. II

The string hypotheses for the $AdS_5 \times S^5$ mirror model is formulated, and used to derive a set of Thermodynamic Bethe Ansatz equations which encodes the exact spectrum of the $dS_5 \times S^5$ superstring.

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A. Gorsky

Quantum Geometry of the Momentum Space and Amplitudes in $N = 4$ SYM Theory

We discuss loop MHV amplitudes in the $N = 4$ SYM theory in terms of the effective gravity in the momentum space with the IR regulator branes as degrees of freedom. Kinematical invariants of external particles yield the moduli spaces of complex or Kahler structures providing the playground for the Kodaira-Spencer(KS) or Kahler type gravity. We suggest fermionic representation of the loop MHV amplitudes in the $N = 4$ SYM theory assuming the identification of KS fermions with the IR regulator branes. The BDS-like anzatz has the interpretation of semiclassical limit of a fermionic correlator. It is argued that fermionic representation implies a kind of integrability on the moduli spaces relevant for the amplitudes. We conjecture the interpretation of the reggeon degrees of freedom in terms of the open strings stretched between the IR regulator branes.

ITEP, Moscow

C. Hull

Double Field Theory, String Theory and Duality

The zero modes of closed strings on a torus – the torus coordinates plus dual coordinates conjugate to winding number – parameterize a doubled torus. In closed string field theory, the string field depends on all zero-modes and so can be expanded to give an infinite set of fields on the doubled torus. String field theory is used to construct a theory of massless fields on the doubled torus. Key to the consistency is a constraint on fields and gauge parameters that arises from the level matching condition in closed string theory. The symmetry of this double field theory includes usual and dual diffeomorphisms, together with a T-duality acting on fields that have explicit dependence on the torus coordinates and the dual coordinates. Along with gravity, a Kalb-Ramond field and a dilaton must be added to support both usual and dual diffeomorphisms. A fully consistent and gauge invariant action on the doubled torus to cubic order in the fields is constructed. The doubled geometry is physical and the dual dimensions should not be viewed as an auxiliary structure or a gauge artifact.

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C. Iazeolla

A Fibre Approach to Harmonic Analysis of Unfolded Higher-Spin Field Equations

Vasiliev's unfolded formulation describes the dynamics of fields of all spins in AdS spacetime in terms of covariantly constant master-fields valued in Lorentz-covariant slices of the star-product algebra A of functions on the singleton phase space.

This provides a dual fibre description of the local degrees of freedom in terms of functions in the enveloping algebra of the underlying AdS isometry group, and associated finite and infinite-dimensional representations. We perform spectral decomposition and harmonic expansion directly in the enveloping algebra, respectively as direct and inverse mappings of the fibre basis elements of the free master-fields to maximally compact slices of A. We recover in this way the standard particle states as nonpolynomial functions in A. However, such a fibre approach does not refer a priori to lowest nor highest-weight states, and naturally incorporates the familiar composite massless modules together with linearized runaway solutions into a bigger, indecomposable module. The latter has no energy bound and is unitarizable in a rescaled trace-norm rather than in the standard Killing norm.

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H. Itoyama

Deviation of AdS Minimal Area from BDS Extrapolation at a Wavy Circle

We present work done in collaboration with D. Galakhov, A.Mironov and A. Morozov, (arxiv:0812.4702 and earlier papers of ours), where we introduced a method of waving the boundary of an AdS minimal surface by infinitely many parameters. In the case of a wavy circle, we are able to show explicitly that the value of the double loop integral (log of the abelian Wilson loop average), which represents the BDS extrapolation from weak to strong coupling region, deviates from the Ads minimal area unless they are protected by conformal invariance.

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V. Kazakov

TBA for AdS/CFT

I will review the recently developed thermodynamic Bethe ansatz approach (TBA) to the superstring sigma model on $AdS_5 \times S^5$ background. It is built to enable us to calculate, using the AdS/CFT correspondence, the full spectrum of anomalous dimensions of the local operators in the 4-dimensional supersymmetric Yang-Mills theory with $N = 4$ supersymmetries ($N = 4$ SYM) in the planar limit, at any YM coupling. In particular, the dimensions of the most interesting "short" operators, such as Konishi operator, should be available by that method which already correctly reproduces the known 4-loop Konishi dimension, as well as the full asymptotic Bethe ansatz equations of Beisert, Eden and Staudacher for the "long" operators at any YM coupling. A concise form of TBA equations, known as the Y-system, will be presented for the AdS/CFT system and its analytical properties will be discussed.

Ecole Normale Superieure & Univ. Paris VI

I. Klebanov

AdS_4/CFT_3 Correspondence and M2-Branes

We review the BLG and ABJM supersymmetric Chern-Simons gauge theories. We then discuss their relevant deformation that preserves SU(3) global symmetry and $N = 2$ supersymmetry. Its AdS dual is proposed to be a warped product of AdS_4 and a certain squashed and stretched 7-sphere. Tests of this correspondence are presented.

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V. Krykhtin

Lagrangian Formulation of Massive Fermionic Totally Antisymmetric Tensor Field Theory in AdS_d Space

We apply the BRST approach, developed for higher spin field theories, to Lagrangian construction for totally antisymmetric massive fermionic fields in AdS_d space. As well as generic higher spin massive theories, the obtained Lagrangian theory is a reducible gauge model containing, besides the basic field, a number of auxiliary (Stuckelberg) fields and the order of reducibility grows with the value of the rank of the antisymmetric field. However, unlike the generic higher spin theory, for the special case under consideration we show that one can get rid of all the auxiliary fields and the final Lagrangian for fermionic antisymmetric field is formulated only in terms of basic field.

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R. Manvelyan

Off-Shell Construction of Some Trilinear Higher Spin Gauge Field Interactions

Several trilinear interactions of higher spin fields involving two equal ($s = s_1 = s_2$) and one higher even ($s_3 > s$) spin are presented. Interactions are constructed on the Lagrangian level using Noether's procedure together with the corresponding next to free level fields of the gauge transformations. In certain cases when the number of derivatives in the transformation is $2s - 1$ the interactions lead to the currents constructed from the generalization of the gravitational Bell-Robinson tensors. In other cases when the number of derivatives in the transformation is more than $2s - 1$ we obtain the finite tower of interactions with

smaller even spins less than s_3 in full agreement with our previous results for the interaction of the higher even spins field with a conformal scalar.

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T. McLoughlin

Scattering Amplitudes in Supersymmetric Chern-Simons Matter Theories

We discuss the scattering matrix in supersymmetric Chern-Simons models with a particular focus on those theories relevant to recent developments in the AdS_4/CFT_3 correspondence. Curiously the structure of this scattering matrix in three spacetime dimensions is equivalent to (a) the two-dimensional worldsheet matrix found in the context of AdS/CFT integrability and (b) the R-matrix of the one-dimensional Hubbard model.

Max Planck Inst. for Gravitational Phys., Golm

G. Papadopoulos

Geometry Supersymmetric Backgrounds

I shall summarize the progress that has been made the last few years towards the classification of supersymmetric solutions of 10- and 11-dimensional supergravity theories. Then I shall describe the solution of the Killing spinor equations of the Heterotic supergravity in all cases. As an example I shall give all solutions of the Heterotic supergravity which preserve 1/2 of supersymmetry. In particular, I shall demonstrate that the geometric data, like the metric and 3-form field strength, can be determined by anti-self dual connections with Lorentzian gauge groups over hyper-Kaehler 4-manifolds.

King's College London

A. Reshetnyak

BFV-BRST Operators and Fock Space Realizations of Verma Modules for Non-Linear Superalgebras Underlying Lagrangian Formulations for Mixed-Symmetry HS Fields in AdS Spaces

The method of Verma modules construction for non-linear (super)algebras and their realizations as formal power series in elements of Heisenberg (super)algebras is developed for the case of non-linear both integer and half-integer HS symmetry superalgebras corresponding to mixed-symmetry HS fields in AdS_d spaces subject to Young tableaux with 2 rows. The above construction serves to additively convert the initial HS symmetry (super)algebra with a set of the first and second class constraints into converted non-linear (super)algebra with a set of only first-class constraints. Corresponding exact nilpotent BFV-BRST operators for converted non-linear (quadratic) algebra and superalgebra determined for corresponding integer and for half-integer HS fields are found. It is shown the BFV-BRST operators correspond to formal gauge theories of the second rank. Universal procedures for constructing the gauge-invariant Lagrangians with reducible gauge symmetries describing the dynamics of free bosonic and fermionic fields of any generalized spins are developed. The computer program on the language C# to verify within symbolic computations the correctness of given oscillator realization for the Verma module and nilpotency

of the BFV-BRST operators for nonlinear superalgebras is suggested.

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R. Roiban

Scattering Amplitudes in $N = 4$ Super-Yang-Mills and $N = 8$ Supergravity

We discuss recent calculations of higher-loop scattering amplitudes in $N = 4$ super-Yang-Mills and $N = 8$ supergravity, outlining their relations and their consequences.

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I. Samsonov

$N = 3$ Superfield Formulation of the ABJM and BLG Models

We construct the classical actions of the Aharony-Bergman-Jafferis-Maldacena (ABJM) and Bagger-Lambert-Gustavsson (BLG) models in the $N = 3$, $d = 3$ harmonic superspace. These are three-dimensional superconformal field models with $N = 6$ and $N = 8$ supersymmetry, respectively, which give the low-energy description of multiple M2-branes. In our formulation only minimal gauge interaction of matter superfields is admissible, without any explicit superfield potential, while the correct interaction potentials for scalar and spinor component fields emerge after the elimination of auxiliary fields. The possibilities of using various gauge groups are discussed.

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H. Samtleben

Tensor Hierarchies and the Trombone

I review the structure of non-abelian tensor fields that typically appear in gauged supergravities. In particular, I will discuss a new class of supersymmetric theories in which the global scale invariance is gauged. A particular feature of these theories is an additional positive contribution to the effective cosmological constant.

Univ. of Lyon

E. Skvortsov

Gauge fields in (anti)-de Sitter space and connections of its symmetry algebra

The generalized connections of the (anti)-de Sitter space symmetry algebra, which are differential forms of arbitrary degree with values in any irreducible (spin)-tensor representation of the (anti)-de Sitter algebra, are studied. It is shown that arbitrary-spin gauge field in (anti)-de Sitter space, massless or partially-massless, can be described by a single connection. A 'one-to-one' correspondence between the connections of the (anti)-de Sitter algebra and the gauge fields is established. The gauge symmetry is manifest and auxiliary fields are automatically included in the formalism.

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D. Sorokin

Type IIA String in $AdS_4 \times CP^3$ Superspace

Recent progress in understanding AdS_4/CFT_3 correspondence has requested the knowledge of an explicit form of the superstring action in type IIA superbackground whose bosonic subspace is $AdS_4 \times CP^3$. We show how the required $AdS_4 \times CP^3$ superspace with 32 fermionic directions can be obtained by the dimensional reduction of the $D = 11$ $AdS_4 \times S^7$ superspace. We also show that the previously constructed $OSp(6|4)/U(3) \times SO(1,3)$ supercoset string action with 24 fermions describes only a subsector of the complete Green-Schwarz superstring. It is still to be ascertained whether the type IIA superstring in the complete $AdS_4 \times CP^3$ superbackground is classically integrable.

INFN, Padova

G. Bossard, H. Nicolai, and K. Stelle

Universal BPS Structure of Stationary Supergravity Solutions

Stationary supergravity solutions studied from the point of view of timelike dimensional reduction have special duality group features related to the noncompact nature of the corresponding supersymmetry automorphism group/sigma model isotropy group. The BPS solutions lie on nilpotent duality orbits, whose structure is linked to a failure of the Iwasawa decomposition. This approach allows for a general classification of BPS and non-BPS stationary supergravity solutions.

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P. Sundell

Geometry, Invariants and Integrability in Higher-Spin Gauge Theory

An action principle for Vasiliev's (nonlinear) unfolded dynamics is provided by the Ikeda–Kazinski–Lyakhovich–Sharapov sigma model for the N-graded on-shell module, which is a Q-manifold that may be deformed by Poisson and higher polyvector field structures upon (on-shell) duality extensions. The full classical piece of the corresponding Batalin–Vilkovisky action is given explicitly using a "Russian formula", and is found to be annihilated by the (point-split) Laplacian in the leading order in curvatures of the auxiliary frame. The boundary geometry in the softly broken phase is captured globally by p-form observables constituting an on-shell equivariant Sullivan cohomology. The locally detectable boundary degrees of freedom are measured by on-shell de Rham closed zero-forms, which are unfolded analogs of "trivial" constants of motion, showing up already in the unbroken phase. The formalism is applied to Vasiliev's full "4D" higher-spin field equations which come from a five-dimensional Ikeda model with QP structure and homotopy extensions to arbitrary odd-dimensional base manifolds. de Rham closed boundary observables, generalizing the infinite set of zero-form observables proposed by the speaker and Sezgin a while ago, are computed explicitly in expansions in Weyl curvatures by using closed homotopy integrals to regularize star-products and localize supertraces. Finally, we speculate on whether this form of integrability can descend to (super)gravities with a cosmological constant.

This talk is based on soon-to-appear collaborations with N. Boulanger, C. Iazeolla and E. Sezgin.

Scuola Normale Superiore, Pisa

P. Vanhove

Simplicity in the Structure of $N = 8$ Supergravity Amplitudes

Recently, there have been remarkable progresses on the analysis of the multi-loop amplitudes in supergravity in various dimensions using string theory and in field theory methods. There are strong indications that four-dimensional maximal supergravity theories have a better ultraviolet behaviour than expected from a conservative implementation of on-shell superspace. The pure spinor formalism allowed us to make concrete predictions for the structure of higher-loop four-graviton amplitudes that have been confirmed so far by all explicit field theoretic amplitude computations. As well beside the constraints from supersymmetry, the amplitudes in colorless gauge theories have a much more simple structure than guessed from a traditional approach based on a Lagrangian and Feynman graphs formalism. We will explain how a string based approach makes obvious fundamental cancellations in colorless gauge amplitudes, leading to the no-triangle property of N=8 supergravity one-loop amplitude.

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A. Van Proeyen

The Embedding-Tensor Formalism with Fields and Antifields

The duality-symmetric formulation using embedding tensors with constraints has been developed in recent years especially in view of applications in supergravity. The formalism makes use of extra fields and gauge transformations with zero modes. This suggests that the Batalin-Vilkovisky or field-antifield method is appropriate to study such theories. We discuss aspects of the use of fields and antifields for the hierarchy of gauge transformations in the embedding-tensor formalism.

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K. Zarembo

Integrability in Superconformal Chern-Simons Theory and AdS_4/CFT_3

An exact equivalence of superconformal Chern-Simons-matter theory and string theory on $AdS_4 \times CP^3$ is a new example of the AdS/CFT duality. This AdS/CFT system turns out to be integrable, and eventually exactly solvable by Bethe ansatz.

Ecole Normale Superieure, Paris

Yu. Zinoviev

On Frame-Like Gauge Invariant Formulation for Massive Mixed Symmetry Fields

We consider frame-like gauge invariant formulation for massive mixed symmetry bosonic and fermionic fields. We use Skvortsov formalism for massless mixed symmetry bosonic fields in flat Minkowski space as well as its extension to the massless fermionic fields. Using these massless fields as our building blocks, we construct gauge invariant description for massive fields, which works equally well both in flat Minkowski space, as well as in (anti) de Sitter spaces with non-zero cosmological constant. This, in turn, allows us to investigate all possible massless and partially massless limits for such particles.

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