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ABSTRACTS

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Coordinators: Vasily Beskin, Vladimir Dogiel

Superstrings and Higher-Spin Gauge Theory
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Quantum Field Theory
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High Energy Physics
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Condensed Matter Physics
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Nonlinear Dynamics
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Contents

Plenary Session

L. Faddeev

The New Life of the of Integrability (Solitons, Spin Chains and Some Aspects of High Energy Physics)

The classical notion of complete integrability of the hamiltonian system got new life during last forty years. It reappeared in the theory of solitons and after quantisation got several applications in condenced matter theory, led to new mathematical structure (quantum groups) and more recently entered the modern quantum field theory. I shall give a short survey of this development.

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V. Frolov

Black Hole Concept

Black holes are one of the most amusing predictions of the General Relativity. The first solution describing a black hole was found by Schwarzschild in 1916 soon after Einstein formulated his theory. Now, 95 years later, black holes play an important

role in the modern science. Stellar mass black holes, the final state of the evolution of massive stars, have been discovered. It is now believed that much more massive black holes are in the centers of many, even maybe most, galaxies, including our one. Black holes are the most powerful sources of the electromagnetic and gravitational radiation in the Universe. It is also possible that supermassive black holes have played an important role in the structure formation in the Early Universe. A black hole is now an important concept of the modern theoretical physics. Black holes are often used as probes of new ideas of quantum gravity, string theory, and models with large extra dimensions. The theory of black holes is also a source of interesting mathematical problems. In this talk I would like to discuss briefly the development of the black hole concept, their modern status, and unsolved problems.

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D. Kazakov
Constraints on Supersymmetry using 5/fb LHC data

There are many arguments in favour of Supersymmetry (SUSY) as the leading candidate for physics beyond the SM, like the unification of the coupling constants at the GUT (Grand Unified Theory) scale with SUSY masses in the TeV range, solving the hierarchy problem and electroweak symmetry breaking (EWSB) by radiative corrections . In addition the Lightest Supersymmetric Particle (LSP) has all the properties expected for the Weakly Interacting Massive Particles (WIMPS) of the dark matter, which is known to make up more than 80% of the matter in the Universe. Unfortunately, the ATLAS and CMS experiments did not find evidence for Supersymmetry using close to 5/fb of LHC data at a centre-of-mass energy of 7 TeV. We combine these LHC data with data on $\mathrm{B_s^0} \to \mu^+\mu^-$ (LHCb experiment), the relic density (WMAP and other cosmological data) and upper limits on the dark matter scattering cross sections on nuclei (XENON100 data). All together this leads to modern window for SUSY to be explored at the LHC in the nearest future.

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V. Klyatskin

On the Criterion of Stochastic Structure Formation in Random Media

It is shown that, in parametrically excited stochastic dynamic systems described by partial differential equations, spatial structures (clusters) can appear with probability one, i.e., almost in every system realization, due to rare events happened with probability approaching to zero. The problems of such type arise in hydrodynamics, magnetohydrodynamics, physics of plasma, astrophysics, and radiophysics. The general theory is illustrated by the examples of specific physical problems.

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M. Scully

QUANTUM PHOTOCELL: Increasing Efficiency via Quantum Coherence

Laser and photocell quantum heat engines (QHEs) are powered by thermal light and governed by the laws of quantum thermodynamics. To appreciate the deep connection between quantum mechanics and thermodynamics we need only recall that in 1901 Planck introduced the quantum of action to calculate the entropy of thermal light, and in 1905 Einsteins studies of the entropy of thermal light led himto introduce the photon. We here show how to use quantum coherence induced by external coherent fields [1] or by quantum noise [2] to improve the efficiency of a laser or photocell QHE. Surprisingly, this coherence can be induced by the same noisy (thermal) emission and absorption processes that drive the QHE. Furthermore, this noise-induced coherence can be robust against environmental decoherence. Application of these ideas to photosynthesis [3] will also be discussed.

[1] M.O. Scully, "Quantum Photocell: Using Quantum Coherence to Reduce Radiative Recombination and Increase Efficiency", Physical Review Letters, 104, 207701 (2010).
[2] M.O. Scully, K. R. Chapin, K, E. Dorfman, M. B. Kim, and A. Svidzinsky, "Quantum heat engine power can be increased by noise-induced coherence", PNAS, 108, 15097 (2011).
[3] G.S. Engel et al., "Evidence for wavelike energy transfer through quantum coherence in photosynthetic systems", Nature, 446, 782-786 (2007).

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A. Starobinsky
Dark Energy: Observational Properties and Theoretical Modelling

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K. Thorne
Black Holes: A New Golden Age

We are entering a new "golden age" of research on black holes. This golden age has been triggered by numerical simulations, aided by a new way to visualize the vacuum Riemann curvature tensor. This new visualization uses "tidal tendex lines" and "rame-drag vortex lines" that embody tidal gravity and differential frame dragging, in the same way as electric and magnetic field lines embody electromagnetism's electric and magnetic fields. These tools have revealednonlinear, dynamical, curved-spacetime structures around collidingblack holes, for example six vortexes of twisting space attached to generic, merging black-hole horizons. The golden agewill culminate with gravitational-wave observatories probing these nonlinear structures and probing other aspects of the nonlinear dynamics of curved spacetime.

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G. Tonelli

LHC Results on the Search for the SM Higgs Boson

The talk will describe the current status of the searches for the Standard Model Higgs Boson at LHC. Results coming from the two general purpose experiments, ATLAS and CMS will be presented in detail. In particular there will be a complete review of the studies done with the analysis of the full 2011 LHC data set. The talk will illustrate the search strategy in the full mass region so far explored by the LHC experiments (115-600 GeV). A special attention will be devoted to the study of the low mass region where both experiments are not able to provide exclusion limits below 127.5-129GeV due to a mild excess of events that seems to be accumulating around 125-126GeV. Although the excess seems to be compatible with the hypothesis of being the first hint of the presence of the SM Higgs boson in LHC data, its statistical significance is not strong enough to claim a discovery. The new data that are actually being collected within the 2012 LHC run will hopefully give a conclusive answer on the origin of the excess.

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H. Verlinde

Gravity: How can it Arise from Gauge Theory?

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A. Wolfendale
Cosmic Rays: an Overview

After a brief summary of the discovery of cosmic rays, and Vitaly Ginzburg's contributions to the early developments, the lecture will describe the present situation in a number of areas. The main content will be devoted to the way ahead in the many exciting fields where 'Cosmic Rays' have a big part to play; these fields will include: high energy interactions, cosmology, climatic effects, acceleration processes and the origin of life.

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X. Yin
Dissecting Holography with Higher Spins

I give an overview of some recent progress in understanding the duality between higher spin gauge theories in Anti-de Sitter space and conformal vector models.

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Astrophysics

M. Barkov

Rapid TeV and GeV Variability in AGNs as Result of Jet-Star Interaction

We propose a new model for the description of ultra-short and short flares from TeV and GeV AGNs by compact magnetized condensations (blobs), produced when red giant stars or gas clouds cross the jet close to the central black hole. Our study includes as a simple dynamical model as 2D relativistic HD for the evolution of the envelope lost by the star in the jet, and its high energy nonthermal emission through different leptonic and hadronic radiation mechanisms. We show that the fragmented envelope of the star can be accelerated to Lorentz factors up to 100 and radiate effectively the available energy in gamma-rays predominantly through proton synchrotron radiation or external inverse Compton scattering of electrons or proton-proton collisions. The model can readily explain the minute-scale TeV flares on top of longer (typical time-scales of days) gamma-ray variability as observed from the blazar PKS2155-304 and day-scale TeV flares from M87.

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V. Berezinsky
UHE Neutrino Astronomy: the View from 2012

Production and observation of cosmic UHE neutrinos with energies E $>10^{15}$ eV are reviewed. The 'reliably' predicted fluxes can be obtained for cosmogenic neutrinos produced in collisions of UHE extragalactic protons with CMB photons. The lower and upper limits on cosmogenic-neutrino fluxes are obtained using recent Fermi-satellite observations. Some attention is given to 'hidden' sources, considered in the past by V.L.Ginzburg. UHE neutrinos from the first stars in the universe ('bright phase') and cosmological topological defects are discussed.

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D. Bisikalo
Accretion Disks and Envelopes in Close Binary Stars

A review of physical processes occurring due the mass transfer between the components of close binary stars (CBS) is presented. Three dimensional gas dynamic simulations are used to determine the main properties of accretion disks and envelopes in different types of CBS. Special attention is paid to description of shock waves and density waves in the disks. It is shown that a new type <precession> density wave formed in the disks is a reason for the super-outbursts. Besides, its existence allows us to explain the mechanism of the formation of the common envelope in CBS.

In the frame of the self-consistent description of the MHD flows in CBS we have derived the conditions of the disk formation and found a criterion that splits two types of the flow corresponding to intermediate polars and polars. We have also investigated variations of the main characteristics of the disks depending on the value of the magnetic induction and analyzed the process of the magnetic field generations in the disks. In particular, it has been found that the quasi-periodic generation of the toroidal magnetic field in the disks leads to the alternation of the accretion and decretion regimes in the inner regions of the disk.

The main observational manifestations of the numerically found flow structure elements are also presented.

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R. Blandford

Holes, Jets and Cosmic Rays

Massive black holes in active galactic nuclei are able to create high speed jets that radiate synchrotron and inverse Compton radiation and might accelerate ultra high energy cosmic rays. New 3D simulations of hydromagnetic flow around black holes and outflowing jets will be presented and the manner in which the resulting jets can create a spectrum from radio to gamma ray frequencies will be discussed. The conditions that would have to be satisfied if they are to be the source of the highest energy cosmic rays will also be outlined.

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Generation of VHE Pulsed Radiation by the Pulsar Wind from Crab

We argue that recent reports of the surprise detection of pulsed, very-high-energy gamma radiation from Crab by the VERITAS and MAGIC atmospheric Cherenkov telescopes are best explained by inverse Compton scattering. Pulsed X-ray photons of the pulsar interact with ultrafast electrons of the wind predominantly in their acceleration zone. The wind, therefore, is the source of the pulsed gamma radiation and explains the observations with only three parameters: site of the acceleration of the wind, its final velocity, and the level of anisotropy. If this interpretation is correct, then detection of the pulsed very-high-energy gamma-ray emission implies the first observational evidence of the formation of a cold ultrafast electron-positron wind from the Crab pulsar.The results show that the acceleration of the wind to ultrarelativistic velocities should take place abruptly in a narrow cylindrical zone of radius between 20 and 50 thousand kilometers centered on the rotation axis of the pulsar.

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G. Brunetti

Turbulence, Cosmic Rays and Non-Thermal Emission in Galaxy Clusters

Clusters of galaxies and filaments are the largest structures in the present universe. Baryonic matter in clusters is typically heated to $10^7 - 10^8$ Kelvin, but there is room to accommodate a non negligible amount of non-thermal energy in the form of accelerated particles. Indeed evidence for non-thermal components comes from the discovery of diffuse (Mpc-scale) radio synchrotron emission in a fraction of galaxy clusters. The properties of the diffuse radio emission in galaxy clusters, including its connection with cluster mergers, suggest that turbulence and shocks generated during cluster mergers have a important role in the acceleration of relativistic particles in these systems. After giving a overview of the most important observational aspects from radio to gamma-rays, I will discuss the physics of turbulence and cosmic rays in galaxy clusters and the expected broad-band (radio to gamma rays) emission from these systems. Finally I will stress the importance of future observations with new generation radiotelescopes (LOFAR, ASKAP, SKA) to address the origin of non-thermal particles and magnetic fields in galaxy clusters.

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S. Bulanov

Extreme Field limits in the Interaction of Electromagnetic Waves with Matter

The progress in the development of extreme light sources will open new horizons for studying a wide range of fundamental science and astrophysics problems. The regimes of dominant radiation reaction, which completely change the electromagnetic wavematter interaction, will be revealed, resulting in a new extremely powerful source of ultrashort high-brightness gamma-ray pulses, and will shed light on the structure of the quantum vacuum and on the creation of matter by electromagnetic field.

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A. Bykov
Nonthermal Emission of Supernova Remnants

Supernova remnants are bright sources of the non-thermal radiation. Some of them (SN 1006, Crab Nebula, Tycho, RX J1713 and others) have nonthermal X-ray emission features that are well interpreted as synchrotron emission of ultra-relativistic electrons accelerated at shock waves. Particle acceleration process to be fast should be accompanied by effective amplification of fluctuating magnetic field. Amplitudes of these magnetic field fluctuations could be much higher than the mean magnetic field. The amplified magnetic field will affect the formation of SNR X-ray emission especially at the synchrotron spectral cut off regime. We review results of nonlinear modeling of X-ray images and spectra for SNRs and pulsar wind nebulae with efficient particle acceleration and strong magnetic field fluctuations. The X-ray images of synchrotron radiation are shown to be intermittent but may contain regular structures like synchrotron stripes in Tycho SNR discovered with Chandra observatory. The model predict the appearance of structures of different scales with highly polarized X-ray emission with high (up to 50%) degree of polarization. These structures can be used to study the spectral properties of turbulent magnetic field and their connections to the highest energy particles accelerated at SNR shocks. We discuss the perspective of X-ray observations in SNRs with X-ray and gamma-ray observatories.

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K.-S. Cheng
High Energy Emission from Pulsars

In this talk I will use outer magnetospheric gap model to explain the properties of gamma-ray pulsars observed by Fermi satellite, e.g. energy flux, cut-off energy, photon index, emission morphology, ratio between radio-quiet and radio-loud gamma-pulsar etc. We use a Monte Carlo simulation method to compare the model distributions with the observed distributions. Currently no radio-quiet gamma-ray millisecond pulsars are found, however in our model the radio-quiet gamma-ray millisecond pulsars are more than radio-loud gamma-ray millisecond pulsars. We will discuss some possible ways to identify the radio-quiet gamma-ray millisecond pulsars.

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A. Cherepashchuk
Black Holes in Binary Systems and Galactic Nuclei

A big progress in the observational investigations of the stellar mass and supermassive black holes has been achieved during last 40 years. Up to now 26 stellar mass black holes (MBH = $4-25$ MSun) in X-ray binary systems, as well as about several hundred of supermassive black holes in the galactic nuclei (MBH = $10^6 - 10^{10}$ MSun) have been discovered. New branch of astrophysics is developed now: black hole demography, in which the birth and growth of black holes and their relationship to other objects (stars, galaxies, etc.) in the Universe are investigated. Total number of stellar mass black holes in our Galaxy is $\sim$0.1% of the mass of its baryonic matter. Mass distribution for stellar mass black holes appears to be peculiar.

The number of discovered black holes in binary systems does not increase with decreasing of their masses. Some gap in the mass distribution for relativistic objects in the range M = 24 MSun may be suggested. A good correlation between masses of supermassive black holes in galactic nuclei and masses of their bulges as well as bulge stellar velocity dispersion is observed. Weak correlation between the mass of supermassive black hole and asymptotic rotational velocity of the galaxy may be suspected too. Recently a special observational program of spectroscopic observations of rotational velocities for galaxies with known masses of central supermassive black holes has been realized at Russian 6-meter telescope. Weak correlation between the masses of supermassive black holes and their asymptotic rotational velocities was confirmed. Correlation between masses of supermassive black holes and their rotational velocities at r = 1 kpc from the center is discovered. Masses of supermassive black holes are in good correlation with total indicative masses of galaxies consisting of baryonic and dark matter, which is better than correlation with asymptotic velocity. Using these observational data some constrains on the models of birth and growth for stellar and supermassive black holes may be imposed.

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A. Chernin

Global Dark Energy and Local Gravity-Antigravity Interplay

The global expansion of the observed Universe is controlled by antigravity, as it has been found in observations at horizon-scale distances 1000 Mpc. High accuracy observations with the Hubble Space Telescope enable us to identify strong antigravity effects on spatial scales 1-10 Mpc as well and measure the local dark energy density in expansion outflows around four groups and two clusters of galaxies. The result is independent of and consistent with the large-distance observations. It gives new empirical evidence for Einstein's universal antigravity described by the cosmological constant.

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D. Chernyshov, Dogiel V., Ko C.-M.

Stochastic Acceleration of Particles and Problem of Plasma Overheating

Stochastic acceleration is one of the processes responsible for formation of non-thermal spectra of particles in astrophysical plasma. It may be responsible for formation of hard X-ray emission from galaxy clusters, radio and gamma-ray emission from Fermi bubbles etc. However analytical and numerical estimations showed that due to interaction between particles from thermal and non-thermal parts of the spectrum the temperature of plasma increases significantly on timescales of acceleration. It means that plasma becomes overheated before the non-thermal tail is formed and therefore stochastic acceleration is ineffective.

We show that under some conditions the stocastic acceleration may effectivly generate non-thermal tails without overheating of plasma. Moreover, if the particle outflow towards non-thermal tail is high, stocastic acceleration may even cool the plasma. This process of cooling is somewhat similar to evaporation.

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B. Coppi

Shining Black Holes: Associated Classes of Plasma and Field Configurations and Magneto Gravitational Modes Characteristics

Conventional currentless disks that are commonly assumed to surround black holes are shown to be subject to the excitation of magneto gravitational modes [1] associated with the gradients of the rotation frequency, of the plasma density and temperature combined with the effects of gravity. Thus stationary current carrying plasma configurations that can be found by a fully non-linear analysis have been looked for and their features connected to those of the magneto-gravitational modes found by a linearized analysis.

In particular, two classes of plasma and field axisymmetric configurations are found all of them involving periodic sequences of plasma rings or solitary rings. These are:
i) Localized Differential Rotator configurations [2] that are connected mainly to the radial gradient of the rotation frequency;
ii) Localized Rigid Rotor configurations that are connected to the product of the vertical component of the gravitational force and the radial density gradient. The latter class of configurations does not require, unlike the former [2], the presence of a seed magnetic field.

Analytical representations of both classes of configurations are derived and the compatibility of these configurations with the presence of accretion processes is pointed out.
*Sponsored in part by the US Department of Energy.
[1] B. Coppi, A&A 504, 321 (2009)
[2] B. Coppi, Phys. Plasmas 18, 032901 (2011)

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L. Dorman
100-th Anniversary of CR Discovery, Development of Different CR Aspects and Contribution of V.L.Ginzburg in CR Astrophysics, Applications to the Problem on Space Weather Effects on Satellites, People Health, and the Earth's Environment

We shortly describe the history of cosmic ray (CR) discovery from the end of 19th century, and why this phenomenon obtained wrong name, discovery of positron, mesons and hyperons in CR, development of different aspects of CR research and contribution of V.L. Ginzburg in CR astrophysics. We give short information on the new book of I.V. Dorman and L.I. Dorman "Cosmic Ray Histor" (Springer, 2012) which dedicated to the 100-th anniversary of CR discovery (the presentation of signal exemplar planned at COSPAR Conference in India in July 2012). We consider also very important applications of CR to the problem of space weather effects on satellite operation (satellite anomalies), aircrafts, electronics, people health, agriculture production, and climate change.

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R. Ekers
Radio Wavelength Evidence for High Energy Particles in the Nearby Universe

In 1977 we detected a halo of synchrotron radio emission around the edge-on galaxy NGC4261. This provided direct evidence for Ginzburg's galactic halo cosmic ray containment model. Radio observations are excellent tracers of high energy particles and I will review some of the implications which have been drawn

from these observations. More recently we have been looking closely at our nearest AGN neighbour Centaurus A - Ginzburg's best case for any direct detection of high energy particles. We have extended our radio observations to include a search for lunar Askaryan emission from UHE neutrinos in the direction of Centaurus A.

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S. Fabrika

Supercritical Accretion Disks with Black Holes

We discuss objects where supercritical disk accretion onto black holes is realized. This is a supercritical accretor SS433 in our Galaxy, ultraluminous X-ray sources (ULXs, and probably, hyperluminous - HLXs) in local universe and supermassive black holes in early and obscured stages of quasar growth. We discuss observational appearances of the supercritical accretion in these objects. There are many convincing evidences that SS433 and ULXs are homogeneous type of objects and they are black holes of 'stellar masses'. There is no need in 'intermediate mass black holes'.

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K. Ferriere

Interstellar Magnetic Fields

I will review the observational properties of interstellar magnetic fields in the disk and halo of our Galaxy. These properties are inferred from a variety of observational methods, primarily based on polarization of starlight and of dust thermal emission, Zeeman splitting, Faraday rotation, and synchrotron emission. I will discuss each of these methods in some detail and explain what it tells us about the strength, direction, and spatial distribution of interstellar magnetic fields in our Galaxy. I will then compare the observational properties to theoretical predictions from dynamo theory.

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Cosmic Magnetobremsstrahlung: Fast Computing Codes and 3D Modeling Tools

Vitaly Ginzburg was among the very first scientists who recognized a fundamentally important role of the synchrotron radiation in astrophysics; moreover, he was the most enthusiastic promoter of this emission mechanism during 50ies, which ensured that the synchrotron theory became commonly accepted in the radio astronomy and then well beyond that. His fundamental pioneering review paper Cosmic Magnetobremsstrahlung (synchrotron Radiation) published along with Sergei Syrovatskii in ARR&A in 1965 remains an up-to-date and actively used (and cited) paper on the topic.

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A. Galper

Progress in Gamma-Ray Astronomy in Russia

Cosmic rays were discovered one hundred years ago. 60 years later galactic or extragalactic origin of cosmic rays is still not known. Vitaly Ginsburg proposed solution to this problem: the study of the gamma-ray emission from the Large and Small Magellanic Clouds. The intensity of the gamma-ray emission from these small galaxies, whose mass are known, will depend on the flux of extragalactic cosmic rays. Today this problem has been solved. This year marks 80 years since the discovery of dark matter in the universe. Today its nature is still not known. About 20 years ago, Vitaly Ginsburg proposed the way to solve this problem: the search for traces of self-annihilation of hypothetical dark matter particles in the diffuse flux of high-energy gamma-ray Galactic emission. Today we are moving in this direction.

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Yu. Gnedin

Polarimetric Method of Determining Magnetic Fields in Accretion Disks around Black Holes

We present the method that allows to estimate the magnetic field strength in the accretion disks surrounding accreting black holes.The polarization is originated in the result of scattering of emission light in the magnetized accretion disk. The main feature of being produced polarization is the wavelength dependence of polarization degree and positional angle. It means that the polarization spectrum of scattered radiation depends strongly on the accretion disk models. This phenemenon allows testing the various models of accretion disk around black holes. We obtain the values of polarization parameters of various models of optically thick magnetized accretion disks.

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A. Goldwurm

High Energy Activity of the Massive Black Hole at the Center of our Galaxy

The Massive Black Hole (MBH) at the Galactic Center, associated to the compact radio, IR and X-ray source Sgr A*, is extremely quite nowadays since its average bolometric luminosity is estimated at less than 10^{-8} of its Eddington luminosity. However a random and weak flaring activity from Sgr A* is observed in the X-ray and infrared bands. Using X-ray and correlated multi-wavelenght observations of these hour-long Sgr A* flares, we have studied this type of activity and we have set new important constraints on the emission mechanism and on the physical conditions of the emitting region close to the black hole horizon. With the INTEGRAL and XMM long-term high-energy surveys of the Galactic Center region we have also discovered the decrease over the years of the hard X-ray emission from the Sgr B2 giant molecular cloud and the superluminal propagation of the neutral iron K emission at 6.4 keV line through the molecular clouds located close, in projection, to Sgr A*. These measurements trace the recent history of Sgr A*, since the variable high-energy molecular cloud emission is likely due to reflection and fluorescence excitation of cold molecular material, illuminated by high-energy radiation emitted by a powerful outburst of the central MBH occurred in the recent past, about few hundred years back. I will review these results and discuss present and future programs of observations of the Galactic Center massive Black Hole.

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V. Gurzadyan
Tracing the Galactic Halos

The cosmic microwave background data are used to trace the galactic halos. The analysis of the temperature excess in the Wilkinson Microwave Anisotropy Probes 3 band data in the direction of the nearby giant spiral galaxy M31 and indicates temperature asymmetry in the M31 disk and halo with a contrast up to about 130 microK/pixel, up to radius about 120 kpc. The geometrical structure of the temperature asymmetry points towards the effect modulated by the rotation of the M31 halo. This result may open a new way to probe the galactic halos, as relatively less studied entities.

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P. Haensel, Zdunik J.
Maximum Measured Mass of Neutron Stars and Equation of State of neutron Star Core

Maximum precisely measured pulsar mass puts constraints on the poorly know equation of state (EOS) of dense matter at supra-nuclear densities. Implications of the measurement of 2.0 Msun mass of a binary millisecond pulsar PSR J1614-2230

(October 2010) will be discussed. The problem of too soft "realistic" EOSs of dense baryonic matter with hyperons will be described. Two solution of "hyperon puzzle" will be discussed.

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H. Inoue

Two Topics on Temporal and Spectral Variations of X-Ray Sources

Two topics on temporal and spectral variations of X-ray sources are presented. Firstly, tidal-force-induced precessions of accretion disks are discussed. By considering energetics of a preccessing ring which is circularly rotating around a compact star under an influence of the tidal force from the companion star, it is strongly suggested that preccessions of accretion disks are often realized in close binaries. This preccession scheme can explain several observational facts from binary X-ray sources. Secondly, a new spectral model, "a variable partial covering model", for X-ray emissions from the Seyfert galaxies is proposed. This model is found to be able to describe most of the 1-40 keV spectral variations. In particular, an ionized iron K-edge of a heavily absorbed power-law component can explain most of the seemingly broad, so called "disk line", spectral feature, so that our model does not require an additional broad iron emission line.

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C.-M. Ko

Modified Newtonian Dynamics and its Application to Gravitational Lensing and Galactic Dynamics

MOdified Newtonian Dynamics (MOND) is a proposed alternative to the Dark Matter (DM) paradigm in interpreting the excess acceleration observed in many astrophysical objects. Simply stated, in small acceleration regime MOND generates a larger acceleration when compare to Newtonian dynamics. It has the same effect as putting more mass in Newtonian dynamics. The advantage of MOND is the source of gravity is provided solely by the observed luminous matter. To be fair, MOND has its own free parameter(s) in modelling. For instance, the acceleration scale under which the dynamics deviates from Newtonian. As gravitational lensing can probe the mass of the lens directly, we apply this equation to strong lensing systems in which the lens is an elliptical galaxy with available velocity dispersion measurement. Adopting the Hernquist model for the elliptical galaxy, we can calculate the mass of the lens and the acceleration scale of MOND.

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Spectral Redistribution of Gyroresonant Photons and Cyclotron Line Formation in Magnetized Atmospheres of Compact Stars

We consider the spectral redistribution of gyroresonant photons in the course of radiation transfer through magnetized plasma atmospheres of isolated compact stars.We point out the importance of the frequency redistribution of the gyroresonant photons to the process of radiation transfer and analyze its main effects in atmospheres of isolated compact stars with strong magnetic fields, where multiple scattering dominates over the absorption of photons. We estimate analytically and numerically the rate of this redistribution and show that photons escape from the line center, which in this case is one-dimensional (1D) in origin, is a very pronounced effect despite being strongly inhibited with respect to three-dimensional (3D) photon redistribution, which takes place in the case of atomic or ion spectral lines. The escape of photons from the cyclotron line greatly affects both the lines profile and the characteristic optical depth, from where the outgoing radiation originates. Through this, the spectral redistribution of gyroresonant photons changes the radiation pressure on the atmospheric plasma, what makes it one of the key phenomena need to be included in studies of cyclotron-driven winds.

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I. Kovalenko

Recent Progress in Understanding of Astrophysical Turbulence

I present a short review of recent achievements in physics of compressible turbulence in the astrophysical context. The subjects under discussion include: (i) manifestation of turbulence from small to large scales: accretion flows, contracting and collapsing clouds and violent interstellar medium; (ii) observational characteristics of astrophysical turbulence; (iii) computer modeling of astrophysical turbulence and up-to-date supercomputers' performance capabilities; (iv) structure and "geometry" of turbulence and its spectral characteristics; (v) transport and force properties of turbulence: beyond the Shakura-Sunyaev alpha-model; (vi) coherent structures in the turbulent astrophysical flows and their recognition via multiscale geometric decomposition and coherent vortices extraction by using curvelets and contourlets.

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A. Lagutin

Anomalous Diffusion of Cosmic Rays in the Galaxy

A key to understanding the mechanism of cosmic-ray origin and acceleration is the determination of how cosmic-ray particles propagate through the interstellar medium (ISM). If the medium is a quasi-homogeneous the propagation process can be described by a normal diffusion model.

However, during a last few decades many evidences, both from theory and observations, of the existence of multiscale structures in the Galaxy have been found. Filaments, shells, clouds are entities widely spread in the ISM. In such a highly non-homogeneous (fractal-like) ISM the normal diffusion certainly is not kept valid.

The main goal of the report is to discuss two models leading to what is known as "anomalous diffusion". In the first model, characterized by normal diffusion at the particle level, the anomalous pattern from cosmic rays source is due to variation of the diffusivity. The anomaly in the second model results from large free paths ("Levy flights") of particles between galactic inhomogeneities.

It is shown that in the framework of proposed anomalous scenarios it is possible to explain the locally observed basic features of the cosmic rays: difference between spectral exponents of proton, He and other nuclei, mass composition variation, "knee" problem.

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V. LUKASH

Early Universe, Black Holes and Cosmogenesis

A review talk considering:
- State of art of Cosmological Standard Model,
- Extrapolation of CSM in the past and initial conditions,
- Models of cosmogenesis based on integrable singularities.

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V. CHECHETKIN, M. GALANIN, **V. LUKIN**

Jets in Nature

Mechanisms of jets are disscussed. Several models will suggested.

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L. MAROCHNIK

Birth of Dark Energy by Quantum Metric Fluctuations

We show that in imaginary time quantum metric fluctuations of empty space form a self-consistent De Sitter gravitational instanton that can be thought of as describing the tunneling from "nothing" into De Sitter space of real time (no cosmological constant or scalar fields are needed). The first time, this mechanism is activated to give birth to a flat inflationary Universe. The second time, it is turned on to complete cosmological evolution of the Universe after energy density of matter drops below the threshold (energy density of instantons). An accelerated expansion takes over after the scale factor exceeds this threshold, which marks the birth of dark energy at the redshift ~ 1.44 and provides a possible solution to the "coincidence problem". The number of gravitons which tunneled into the Universe must be of the order of 10^{122} to create the observational value of the Hubble constant. This number has nothing to do with vacuum energy, which is a possible solution to the "old cosmological constant problem". The emptying Universe should possibly complete its evolution by tunneling back to "nothing". After that, the entire scenario is repeated, and it can happen endlessly.

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M. Medvedev

Cosmological Simulations Evidence in Favor of Multi-Component Flavor-Mixed Cold Dark Matter

Many cold dark matter (CDM) candidates are flavor-mixed particles, e.g., a neutralino, an axion, a sterile neutrino and some others. An unusual and rather counter-intuitive property of non-relativistic flavor-mixed particles has recently been discovered: in the process of mass-eigenstate conversions, they can escape (or "evaporate") from a gravitational potential even if they are initially trapped in it. Modern CDM cosmology has never accounted for the quantum-flavor-mixed nature of the particles. Here we present the results of the state-of-the-art LCDM cosmological simulations, which incorporate flavor-mixing. They demonstrate that a model of two-component flavor-mixed dark matter (2cDM) with small mass-degeneracy provides an excellent fit to astronomical data at both large and small scales. It shows substantial reduction of substructure and softening of central cusps in dark halos whereas the large-scale structure remains intact. This simultaneously resolves two outstanding problems of CDM cosmology known as the "substructure problem" and "core/cusp problem", yet it does not contradict apparent counter-examples and observational constraints. The 2cDM model makes a number of predictions for astronomical observations and direct detection experiments. Our findings evidence in favor of the multi-component CDM and greatly advance us toward unraveling the nature dark matter.

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A. Melatos
Nonequilibrium Avalanche Processes in Quantum Fluids in Neutron Stars

The first quantum mechanical (Gross-Pitaevskii) simulations are presented of large-scale vortex avalanches in the superfluid interiors of neutron stars, which are believed to cause the rotational glitches observed in radio telescope timing data. Several knock-on processes are identified which catalyse the avalanches, e.g. via proximity and acoustic processes. The simulation results are synthesized with cellular automaton models to try and explain the observed statistics of neutron star glitches. Agreement is achieved on several fronts, including with the classic Tsakadze laboratory experiments, but there are some fine-tuning issues, and fundamental questions about the collective behaviour of ultra-dense neutron superfluids (e.g. the role of turbulence) remain. It is shown that future gravitational-wave observations offer a realistic prospect of answering these questions.

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F. Melia

The $\mathbf{R_h} = \mathbf{ct}$ Universe

The growing tension between the predictions of LCDM and the actual observations is motivating a growing interest in re-visiting the foundational elements of the Friedmann-Robertson-Walker metric and its application to cosmology. In recent work, we have demonstrated that a strict adherence to the Cosmological principle and Wey's postulate compels the Universe's gravitational radius (coincident with the better known Hubble radius) to always equal ct, where ct is the distance light could have traveled in time t. Yet LCDM is only marginally consistent with this constraint. Tellingly, whereas LCDM fails to explain the angular correlation function of the CMB and the scale-invariant matter distribution over large distances, the so-called $R_h = ct$ Universe fares considerably better. In this talk, we will summarize the current status of this precision cosmology and the 6 or 7 direct comparisons between it and LCDM, demonstrating that the $R_h = ct$ Universe is a significantly better description of nature than the current standard model of cosmology.

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S. Nagataki

Numerical Simulations of Central Engine of Long Gamma-Ray Bursts

I would like to give a talk on the central engine of Long Gamma-Ray Bursts (LGRBs). I would like to show the current status of 3D-General Relativistic MHD (GRMHD) code that I have developped and is coupled with Adaptive Mesh Refinement (AMR) code 'Paramesh'. I would like to show 2D/3D simulations of collapsar (Black Hole and Accretion Disk at the center of a massive star) using my GRMHD code, and show how Blandford-Znajek process is working there. I would like to present briefly our numerical simulations of magnetars that is also a good candidate for the central engine of LGRBs.

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I. Novikov, A. Shatskiy

Stability Analysis of Wormhole

Wormholes can exist only in case of their stable. The model of a spherical wormhole is analyzed for stability. The matter of this wormhole is composed of a radial monopole magnetic field and a quasi-perfect phantom fluid. In the stationary case, the energy density of this fluid is negative and equal in magnitude to twice the energy density of the magnetic field. There is no pressure of this fluid in the stationary case (phantom dust), while in the case where the fluid energy density deviates from its stationary value the pressure is proportional to the deviation of the energy density from its stationary value. An example of a wormhole stable against radial perturbations has been obtained.

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I. Okamoto

How does Unipolar Induction Work in a Kerr Black Hole?

Landau et al.* described how unipolar induction works as an electromotive force (EMF) for a rotating magnetized conductor. The concept is easy to apply for "classical" objects, such as neutron stars (pulsars), etc. These objects may be regarded as possessing a material surface, which magnetic field lines are anchored at, thereby rotating with the same angular frequency as that of stars. A rotating black hole has, on the other hand, no material surface to pin down magnetic fluxes, nor freeze with, with no dynamo or unipolar induction at work on the horizon. It is nevertheless argued that the angular frequency of dragging of inertial frames ω couples with the field line angular frequency Ω_{F} in the steady em eigen-state, to create the inner general-relativistic domain, separated by the null surface $\mathrm{S_N}$ from the outer semi-classical domain, and the source for pair-plasma between the two domains will be expected to pin down magnetic field lines, thereby fixing $\Omega_{\mathrm{F}} = \omega(\ell_{\mathrm{N}})$ and to work as the EMF to drive electric currents maintaining the active magnetosphere through which the hole's rotational energy will be extracted outwardly for astrophysical loads. The problem reduces to the eigenvalue problem for Ω_{F} due to the criticality-boundary conditions.

* Landau et al., 1984, "Electrodynamics of Continuous Media", Elsevier, p 221, Tokyo.

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N. Prantzos
The Composition of Cosmic Rays and the Origin of Light Nuclides

I will discuss a new paradigm, in which cosmic rays are accelerated by the forward shocks of supernovae exploding in the winds of massive stars and in the interstellar medium; its main advantage is to explain quantitatively the observed high isotopic ratio of Ne22/Ne20 in cosmic rays. I will also present the implications of that idea for the evolution of the light nuclides Li, Be and B, which are produced by spallation of C, N and O nuclei during the propagation of cosmic rays in the Galaxy.

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V. Ptuskin V. Zirakashvili
Galactic Cosmic Rays: Acceleration in Supernova Remnants and Transport in Interstellar Magnetic Fields

We briefly discuss cosmic-ray acceleration and propagation in the Galaxy. Discussion includes the acceleration in supernova shocks, the possible explanation of energy dependent helium-to-proton ratio in cosmic rays, the nature of knee in cosmic ray spectrum and the transition to extragalactic component, the collective effects of cosmic rays in the Galaxy.

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N. Ikhsanov, **L. Pustil'nik**

Magnetic Accretion in Long-Period X-Ray Pulsars

Several long-period accretion-powered pulsars are observed to experience rapid spin-down trends. We show that all of the conventional accretion scenarios encounter major difficulties explaining this rapid spin-down. The difficulties can be, however, avoided within the magnetic accretion scenario in which the neutron star is assumed to accrete from a magnetized wind. The magnetic pressure in the accretion flow increases more rapidly than its ram pressure and, under certain conditions, significantly affects the accretion picture. The accretion flow in this case switches into a slab confined by the magnetic field of the accretion flow itself. We show that the spin-down torque applied to the neutron star accreting material from the slab is larger than that evaluated within a non-magnetic accretion scenario and is comparable with the spin-down torque inferred from observations.

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R. Rafikov, Metzger B., Bochkarev K.

Signposts of Planetary Systems around Metal-Rich White Dwarfs

Recent Spitzer observations have revealed presence of near-IR excesses in spectra of more than a dozen of metal-rich white dwarfs. These excesses are naturally interpreted as resulting from reprocessing stellar emission by compact, optically thick disks of dusty debris. The prevalent idea for their origin is the tidal disruption of asteroids scattered by massive unseen planets providing evidence for existence of the latter around white

dwarfs. This circumstellar material has also been proposed as the cause of high-Z element pollution of host white dwarf atmospheres. I will provide an overview of observations in this rapidly developing area, and will describe recent progress in understanding the transfer of high-Z material from the compact circumstellar debris disk onto the white dwarf surface.

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I. Royzen
Non-Trivial QCD Vacuum against Black Holes of a Stellar Mass

In course of the consolidation of nucleon (neutron) spacing inside a compact star, two key factors are expected to come into play side by side: the lack of self-stabilization against shutting into black hole (BH) and forthcoming phase transition - color deconfinement and QCD-vacuum reconstruction - within the nuclear matter the star is composed of. These phenomena bring the star to evolve in the quite different (opposite) ways and should be taken into account at once, as the gravitational compression is considered. Under the above transition, which is expected to occur within any supermassive neutron star (NS), the hadronic-phase (HPh) vacuum - a coherent state of gluon- and chiral $q\bar{q}$-condensates - turns, first near the star center, into the “empty”(perturbation) subhadronic-phase (SHPh) one and, thus, pre-existing (very high) vacuum pressure falls there down rather abruptly; as a result, the “cold” star starts collapsing almost freely into the new vacuum. If the stellar mass is sufficiently large, then this implosion is shown to result in an enormous heating within the star central domain (up to a temperature about 100-200 MeV or, maybe, even higher), what makes the pressure from within to grow up, predominantly due to degeneracy breaking and multiple $q\bar{q}$-pair production. Thus, a “flaming wall” could arise, which withstands the further collapsing and brings the star off the irrevocable shutting into BH. Instead, the star either may form a transient quasi-steady state (just the case of not too large star masses) and then, losing its mass, evolve gradually into the “normal” steady NS, or is doomed for self-liquidation in full (at higher masses).

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B. Rudak, E. de Ona-Wilhelmi, R. de los Reyes

Prospects for Studies of the local Universe with CTA

The Cherenkov Telescope Array (CTA) project is a unique worldwide project in the field of very high energy astronomy. By the end of this decade it will be the most sensitive open gamma-ray observatory at very high energies between a few tens of GeV and 100 TeV, with improved energy and angular resolution. The CTA project will be presented in this talk and an overview of its current preparatory phase will be given. The topics in astronomy and physics where CTA is expected to be attractive and to contribute significantly to in the near future will be presented and discussed.

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E. Elizalde, **V. Skalozub**

Spontaneous Vacuum Magnetization as the Source of Long Range Magnetic Fields in the Hot Universe

We propose that intergalactic magnetic fields have been spontaneously created at the reheating stage due to vacuum polarization of non-Abelian gauge fields. The zero magnetic mass for the fields of the such type was discovered recently. In the frameworks of the standard model, we relate the intergalactic magnetic field strength of the order $B \sim 10^{-15}$ G having the coherence scale ~ 1 Mpc with the field strenghts generated at temperature, T, higher than the electroweak phase transition temperature $T_{ew} \sim 100$ GeV. Some applications of the results obtained are discussed.

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D. Sob'yanin

Generalized Superstatistics, Branching Processes, and Pair Production in a Neutron Star Magnetosphere

Generalized superstatistics, or "statistics of superstatistics," is a new approach to the study of complex nonequilibrium systems with spatiotemporally inhomogeneous dynamics. Such systems are often characterized by hierarchical structures of dynamics formed as a result of the sufficient time-scale separation between different dynamical levels. Significantly, generalized superstatistics can be applied to nonstationary nonequilibrium systems. I first review the concept of generalized superstatistics. As an illustration, I then consider the system in which the supercritical

Sevast'yanov branching process takes place. In this system, the transformation of particles of several types occurs, and the number of particles increases exponentially. Finally, I present some new results of applying this approach to pair production in a neutron star magnetosphere.

D. N. Sob'yanin, Phys. Rev. E **84**, 051128 (2011).

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D. Sokoloff, D. Moss

Stellar Activity Waves: New Ideas

Well-known solar activity cycle is far to be just a cyclic behaviour of sunspot numbers. An activity wave propagates in earch solar hemisphere from middle latitudes to the solar equator. A more or less standard explanation of the phenomenon is given in terms of so-called dynamo based on joint action of differential rotation and mirror-asymmetric convection (or turbulence). From the formal viewpoint the proplem can be presented as a system of coupled parabolic equation rather to a wave equation. This formal distinction with conventional theory of wave propagation results in various peculiar feature of solar (and stellar) activity waves. For a long time activity waves was known for the Sun only while resently stellar activity observations become sufficient to isolate this phenomenon in stellar activity data. We discuss general properties of stellar activity waves in context of recent observational data.

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R. Sunyaev

The Black Body Photosphere of our Universe; Bose-Einstein and Y-type CMB Spectrum Distortions due to Energy Release in the Early Universe; Experimental Prospects

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G. Fleishman, **I. Toptygin**

Pecularities of Rare Ions Acceleration by Helical Turbulence in Solar Flares

We study the role of the turbulence helicity on the particle acceleration and find that a nonzero turbulence helicity has a remarkably strong effect on the particle acceleration. The main reason for this strong helicity effect is that the helical component of the turbulence induces, through a well-known alpha-effect, a regular large-scale electric field capable of directly accelerating charged particles (like in the models with DC field acceleration). We estimate the turbulence kinetic helicity based on measured photospheric and extrapolated values of the current helicity and take into consideration the helical turbulence effect on stochastic particle acceleration. We find that this induced large-scale electric field can be comparable with the electron and estimated effective ion Dreiser fields, which has an immediate effect on charged particle extraction from the thermal pool and their injection into stochastic acceleration process.We have discovered that this, so far missing but highly important, ingredient of the particle stochastic acceleration by turbulence at the flare site is naturally consistent with such puzzling flare manifestations as (a) enrichment of the accelerated particle population by 3He and other rare ions with Z> 1; (b) formation of electron beam by large-scale electric field; (c) spatial separation of sources of electron emission (X-rays) and proton emission (gamma-quanta).

This work was supported in part by NSF grant AGS-0961867, NASA grant NNX10AF27G to New Jersey Institute of Technology and grant 11.G34.31.0001 of Russian Ministry of Education and Science.

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G. Bisnovatyi-Kogan, **O. Tsupko**

Gravitational Lensing in Presence of Plasma

When a gravitating body is surrounded by a plasma, the lensing angle depends on a frequency of the electromagnetic wave due to refraction properties, and the dispersion properties of the light propagation in plasma. The last effect leads to dependence, even in the uniform plasma, of the lensing angle on the frequency, what resembles the properties of the refractive prism spectrometer. The strongest action of this spectrometer is for the frequencies slightly exceeding the plasma frequency, what corresponds to very long radiowaves. We discuss the observational appearances of this effect for the gravitational lens with a Schwarzschild metrics, surrounded by a uniform plasma.

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On the Generation and Disruption of a Picosecond Runaway Electron Beam in Air at Strong Overvoltage

The generation and disruption of the picosecond runaway electron beam in atmospheric pressure strongly overvolted gas gap is considered with emphasis on the runaway kinetics, the increase in emission current and plasma density, and beam-plasma instabilities [1]. It has been shown that a few-nanosecond low-voltage (10 kV) prepulse gives rise to a streamer. Application of the main high-voltage fast pulse (∼2 MV/ns) results in the runaway electron beam generation with the streamer electrons involved in the acceleration, and in increase of the electron emission from the cathode and the plasma density. At the high enough plasma density, fast beam instability disrupts the runaway electron beam.

References

1. S. A. Barengolts, G. A. Mesyats, M. M. Tsventoukh, and I. V. Uimanov, Appl. Phys. Lett. 100, 134102 (2012)

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V. Tsytovich

Physics of Transition Scattering and Some Recent Observations

Transition scattering as transition radiation of particles interacting with waves of dielectric permittivity (Ginzburg, Tsytovich, 1973) is discussed for applications. Impressive consequence of theoretical predictions is that, since any wave in a media (including high frequency electromagnetic waves), are followed by a wave of medium polarization, a heavy particle can in certain cases scatter waves with cross-sections close or larger than the Thompson cross-section for isolated electrons in vacuum. Five new developments are discussed: 1)so called Thompson scattering on plasma fluctuations, used for diagnostic in numerous experiments, is shown to be simply a sum of scattering on electrons and ions with interference of amplitudes of usual and transition scattering for electrons and with only transition scattering for ions (conservations of total energy and momentum of waves, electrons and ions is proved), 2) the theory of weakly turbulent, highly non equilibrium plasmas can be formulated only if the transition scattering is included, 3)the parametric instabilities in plasmas are shown to take into account the amplitudes of transition scattering, 4)the Raman and Mandelstam-Brillouin scattering in plasmas are resonance transition scattering, 5) the transition scattering by heavy self-organized dust structures is determined by coherently moving electrons in the structures if the wavelength of scattered wave is larger than the structure size. This can be used for interpretation of highly enhanced back scattering of radar radiation by dust clouds in upper mesosphere since no other effects can predict the observed very narrow Doppler shift of scattered radiation (of relative order less than 10^{-9}).

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D. Uzdensky

Magnetic Reconnection and Radiation in Astrophysics

Magnetic reconnection is a fundamental plasma process of rapid rearrangement of the magnetic field topology, often accompanied by a violent release of magnetic energy. This important and ubiquitous process powers many spectacular explosive phenomena in laboratory, space, and astrophysical plasmas, such as solar flares and magnetospheric substorms. Traditional reconnection research has focused on relatively tenuous solar-system environments, where radiation can be ignored. In contrast, in many astrophysical situations the energy density in reconnection regions is so high that radiation becomes important. In this talk I will give an overview of recent progress on radiative astrophysical magnetic reconnection — a new frontier in plasma astrophysics. I will outline the most important radiative effects that may influence reconnection dynamics and reconnection-powered particle acceleration: radiative cooling, radiation pressure, and Compton drag resistivity. I will illustrate these radiative aspects of reconnection with specific astrophysical examples, including magnetar flares; reconnection powering high-energy emission in pulsar magnetospheres; and recently discovered gamma-ray flares in the Crab Nebula.

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N. Vlahakis

Magnetized Astrophysical Jets

The characteristics of magnetized, relativistic, astrophysical jets will be discussed, focusing on two particular questions: their stability, and the role of the pressure of their environments. For the former, results of linear stability analysis of the relativistic magnetohydrodynamic (MHD) equations will be presented. For the latter, solutions of the steady-state MHD equations using the method of characteristics will be discussed, focusing on cases where rarefaction waves cause a bulk acceleration of the flow.

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D. KUSHNIR, **E. WAXMAN**

A New Mechanism for Deflagration to Detonation Transitions

The nature of the physical mechanisms driving a deflagration to detonation transition (DDT) is a basic open question in combustion theory. DDT is observed in laboratory experiments and inferred to play a key role in supernova explosions of type Ia. A new physical mechanism, that may be responsible for driving DDTs in these systems, is presented. Our proposed ignition mechanism differs from that proposed by Zel'dovich et al. (1970). Its relevance for DDT in laboratory experiments and SN Ia may be tested by both experiments and numerical simulations.

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A. ERLYKIN, **A. WOLFENDALE**

Fine Structure in Cosmic Ray Spectra Clues as to the Origin of the "Radiation"

The spectra of cosmic rays show not only the knee at about 3 PeV (discovered in Moscow) and the ankle at about 2 EeV but, in our view, other structure, too. Most noticeably there is a kink at about 200GV, suggesting the presence of a new component at lower energies and features in the knee region attributable

to different primary masses. The significance of the various structures will be assessed.

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D. Yakovlev, P. Shternin

Cooling Neutron Stars and Superfluidity of Superdense Matter

Neutron stars contain superdense nuclear matter which can be superfluid due to attractive component of nuclear interaction. The nature of superdense matter and the properties of superfluidity are still largely unknown. We outline current theories of superfluidity of neutrons and protons in neutron star cores and the effects of superfluidity on neutron star cooling. We use these results to interpret recent observations of a young (330 yr old) neutron star in the Cassiopeia A supernova remnant - the first observations of cooling of an isolated neutron star in real time. We show that these observations can be naturally explained by the onset of neutron superfluidity in the stellar core a few decades ago; it produces a splash of neutrino emission in the core and fast real-time cooling. We discuss the properties of superdense matter which can be constrained from observations of fast real-time cooling events. The work was supported by RFBR (grants 11-02-00253-a and 11-02-12082-ofi-m-2011), RF Presidential Program NSh-4035.2012.2, Ministry of Education and Science of Russian Federation (contract 11.G34.31.0001) and by the Dynasty Foundation.

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L. Zelenyi

“Dark” Electric Fields in the Earth Magnetotail and their Observable Manifestations

Structure of current sheet of Earth magnetotail is derermined by ion and electron contributions to the total cross-tail current. The overwhelming majority of current sheet models predict dominance of ion currents due to large ion temperature. In the magnetotail. In contrast to theory “in situ” spacecraft measurements usually demonstrate current sheets with strong electron currents. Amplitude of this current is substantially larger than estimates of diamagnetic current and currents due to the curvature of magnetic field lines.

We provide detailed experimental evidence for the existence of the earthward electric field in a thin current sheet of the Earth’s magnetotail. This field plays an essential role in the redistribution between ion and electron components of the cross-tail current via the cross-field drift. The corresponding effect is also manifested in the structure of ion distributions owing to the negative shift of cold core of the ion distribution. This field is usually too weak to be directly unambiguously registered by modern spacecraft electric sensors. This is why we call it “DARK”.

We also present the theory of earthward electric field formation based on the difference of motion of magnetized electrons and unmagnetized ions in the model of thin 2D current sheet. Theoretical estimates conforms well with estimates of the “DARK” field magnitude derived from Cluster measurements.

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V. Zirakashvili, V. Ptuskin

Acceleration of Cosmic Rays on the Forward and Reverse Shocks in Supernova Remnants

We investigate the production of galactic cosmic rays in supernova remnants. Nonlinear model of the diffusive shock acceleration is used to determine the spectra of protons, nuclei, electrons and positrons accelerated on the forward and reverse shocks of the remnant. It is shown that the spectra of nuclei and positrons which are accelerated mainly on the reverse shock are harder in comparison with the spectra of protons and electrons which are mainly accelerated on the forward shock.

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Superstrings and Higher Spin Gauge Theory

K. Alkalaev

The Massless Hook Field and the AdS/CFT Correspondence

The AdS/CFT correspondence for a simplest AdS mixed-symmetry “hook” field is considered at the kinematical level.

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I. Aref’eva

Holograpic Description of Quark-Gluon Plasma in Heavy-Ion Collisions

We use a holographic dual model for the heavy-ion collision to obtain the phase diagram of the quark–gluon plasma formed at a very early stage just after the collision.

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G. Arutyunov

Towards q-deformations of the Mirror TBA

The mirror Thermodynamic Bethe Ansatz (TBA) is a tool to determine the spectrum of the AdS_5 x S^5 superstring. After an extensive introduction I will discuss work in progress towards constructing a q-deformed version of the mirror TBA.

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I. Bandos

BMN Matrix Model from Multiple M0-Brane Equations in Eleven Dimensional pp-Wave Superspace

We obtain the Matrix model equations in the background of the maximally supersymmetric pp-wave solution of the 11D supergravity and discuss its relation with the Berenstein-Maldacena-Nastase (BMN) model.

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E. Bergshoeff

A New Road to Massive Gravity?

We discuss a general procedure of how to construct unitary higher-derivative gravity theories. As an example we apply this procedure to construct the 3D New Massive Gravity theory. We show how the same procedure can be used to construct a similar massive higher-derivative theory, be it so far only at the linearized level, in four dimensions. The connection with other massive gravity theories in the literature is discussed.

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N. Boulanger, P. Cook, D. Ponomarev

Comments about Higher-Spin and Duality. Part I: Spin-2 and E11

We show that off-shell Hodge dualisations relate E11 generators with certain fields arising from various dual formulations of linearized gravity in Minkowski spacetime.

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J. Buchbinder

Cubic Interaction Vertex of Higher-Spin Fields with External Electromagnetic Field

We study an interaction of charged integer higher spin massive and massless fields with external costant electromagnetic field. Interaction vertex in linear approximation in external field is constructed and conditions of causal propagation are formulated.

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M. Cederwall
The Gauge Structure of Generalised Geometry

The generalised diffeomorphisms in M-theoretic generalised geometry are examined. We show how the infinite reducibility reproduces the correct number of physical degrees of freedom. We also give a linear description of the section condition using objects generalising the pure spinors appearing in the context of doubled geometry.

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H. Dorn
Wilson Loop Remainder Function for Null Polygons in the Limit of Self-Crossing

We consider Wilson loops in planar N=4 SYM for null polygons in the limit of self-crossing. The analysis is based on a renormalisation group technique. We show that the result for the leading and next-leading divergent term of the two loop hexagon remainder in the limit of two crossing edges is in full agreement with the appropriate continuation of the exact analytic formula for this quantity. Furthermore, we determine the coefficients of the leading and next-leading singularity for the three loop remainder function. In the case of a self-crossing due to two coinciding vertices we analyse the leading divergence at two loop level.

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P. Fre, A. Sorin, M. Trigiante
Extremal Black Holes, Nilpotent Orbits and the Tits Satake Projection

The classification and construction of extremal multicentre black hole solutions of supergravity will be presented and reduced to a finite list of universality classes generated by the Tits Satake projection of non compact symmetric spaces.

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M. Gaberdiel
Minimal Model Holography

The conjectured relation between higher spin theories on AdS spaces and weakly coupled conformal field theories is reviewed. I shall then explain the evidence in favour of a concrete duality of this kind, relating a specific higher spin theory on AdS3 to a family of 2d minimal model CFTs.

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S. Giombi

Chern-Simons Vector Models and Higher Spins

I will present some new results on the CFT obtained by coupling 3d vector models to a Chern-Simons gauge field. In particular, I will show that such theory has a higher spin symmetry in the infinite N limit, and propose that it should be holographically dual to a parity breaking higher spin gravity theory in AdS4.

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A. Gorsky

Surprises of ϵ Deformed SYM Theory

We shall discuss iseveral unexpected issues concerning the supersymmetric Yang-Mills theory in the graviphoton background.In particular we shall consider the cyclic RG flows and specific BPS string solutions.

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M. Grigoriev

Parent BRST Approach to Higher Spin Gauge Fields

The metric-like and the frame-like approaches to HS dynamics can be unified into a general framework based on the AKSZ version of the BV formalism. If the equations of motion or Lagrangian is known in e.g. metric-like form the respective unfolded equations or frame-like Lagrangian is obtained systematically using the so-called parent formulation. As an illustration I plan to consider derivation of the frame-like Lagrangian for totally symmetric HS fields starting from the Fronsdal one. In so doing one finds some intermediate formulations which turn out to be very useful for generalizations. In particular, this gives an elegant way to describe massive and (partially-)massless mixed-symmetry fields on constant curvature backgrounds. The essential ingredient of the construction on the AdS space is the so-called twisted realization of the AdS and its Howe dual symplectic algebra. By using this technique we also derive a concise form of the off-shell constraints and gauge symmetries for totally symmetric fields on AdS space at the nonlinear level, where both the local AdS and the familiar $sp(2)$-symmetry are manifestly realized.

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S. Gukov

Quantization in Modern Mathematics and Physics

We all know Quantum Mechanics works. Almost everything in our everyday life is based on principles of Quantum Mechanics one way or another: from cellular phones to stability of atoms and, therefore, to the very existence of our Universe. Yet, every time the word "Quantum" is mentioned, it brings mystery and uncertainty. Ever since the discovery of Quantum Mechanics 100 years ago, it baffled the greatest minds of the 20th century. In this talk, I will review our quest for elusive mathematical framework that is supposed to describe "quantization" which, at various stages of its development, influenced many areas of physics and pure mathematics, including geometry and representation theory. As a result, some of the most sophisticated and esoteric math problems, such as knot homology and Langlands duality, can be formulated in terms of ... Quantum Mechanics!

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T. Hartman

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C. Hull

Double Field Theory and Duality

String theory on a torus requires the introduction of dual coordinates conjugate to string winding number. This leads to physics and novel geometry in a doubled space. This will be compared to generalized geometry, which doubles the tangent space but not the manifold. For a d-torus, string theory can be formulated in terms of an infinite tower of fields depending on both the d torus coordinates and the d dual coordinates. This talk focuses on a finite subsector consisting of a metric and B-field (both d x d matrices) and a dilaton all depending on the 2d doubled torus coordinates. The double field theory is constructed and found to have a novel symmetry that reduces to diffeomorphisms and anti-symmetric tensor gauge transformations in certain circumstances. It also has manifest T-duality symmetry which provides a generalisation of the usual Buscher rules to backgrounds without isometries. The theory has a real dependence on the full doubled geometry: the dual dimensions are not auxiliary. It is concluded that the doubled geometry is physical and dynamical.

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C. Iazeolla

Families of Exact Solutions of 4D Higher-Spin Gravity with Spherical, Cylindrical and Biaxial Symmetry

I shall discuss the main aspects of certain families of exact solution of four-dimensional higher-spin gravity admitting at least two commuting Killing vectors. After reviewing some basics of Vasiliev's equations, I shall turn to describing how such solutions are constructed. In particular, focussing on the spherically-symmetric ones, I shall highlight the algebraic and spacetime properties they share with gravitational black holes, and explain how, despite such similarities, their apparent curvature singularities may be resolved in higher-spin gravity.

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E. Ivanov, S. Fedoruk, O. Lechtenfeld

Supersymmetric Mechanics with Spin Multiplets and Nahm Equations

We report on a new type of N=4 supersymmetric mechanics with "semi-dynamical" bosonic spin variables described by d=1

Wess-Zumino term. These variables are accommodated by off-shell N=4 supermultiplets (4,4,0) or (3,4,1). Adding them allows one to reveal a new mechanism of generating conformal potentials in superconformal N=4 mechanics and to set up couplings to external self-dual non-abelian gauge fields. In the models with the spin (3,4,1) multiplet, a sort of Nahm equations for the triplet of the spin variables arises as the necessary condition of validity of N=4, d=1 Poincaré superalgebra on both the classical and the quantum levels.

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A. Jevicki

A Constructive Approach to AdS/CFT and Higher Spin Gravity

We will review a constructive, Large N approach to Higher Spin Gravity and AdS/CFT. In this framework the issue of defining the S-matrix of the theory will be discussed. For Vasiliev's theory dual to free O(N) fields the manifestation of the Coleman-Mandula theorem is considered.

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R. Kallosh

On Absence of Ultraviolet Divergences in Supergravity

We review the recent progress in computations of the 3-and 4-loop in N=8 and 3-loop in N=4 supergravities, which during

the last 5 years, unexpectedly, were found to be UV finite. We discuss various available explanations of these computations, including the duality current conservation. We argue that the perturbative finiteness of N=8 supergravity is plausible and discuss the future computations which may help to clarify this important issue.

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D. Lüst
Strings and (Non)–Geometry

In this talk I discuss the relation between strings and geometry. Due to stringy symmetries, there is a subtle mixing between the UV and the IR in string theory. As a result, stringy geometry goes be beyond standard Riemannian geometry. We show that the corresponding non-geometric backgrounds can be described by non-commutative or even non-associative geometries.

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R. Manvelyan
Radial Reduction and Cubic Interaction for Higher Spins in (A)dS Space

We present a new version of the radial reduction procedure to obtain cubic interactions of higher spin gauge fields in AdS_{d+1} dimensional space, from the corresponding cubic interactions in flat $d+2$ background. We modify the radial reduction procedure proposed previously by T. Biswas and W. Siegel in 2002 for the free field case. Then we apply the modified radial reduction scheme to interacting massless higher spin fields in Fronsdal's formulation, and develop a method to express all results in a direct AdS_{d+1} invariant way with AdS covariant derivatives. We present a consistent algorithm and define recursion relations for obtaining all corrections proportional to powers of the cosmological constant, and apply these results to the main interaction term.

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T. McLoughlin

New Dualities for Three-Dimensional Supergravity

The duality between color and kinematics in gauge theory scattering amplitudes is one of the most interesting results in recent years and one that has proved a useful tool in performing explicit calculations. Moreover, due to the connection between onsheel gauge theory and gravity amplitudes, it has hinted at a hidden algebraic structure in perturbative gravity. In this talk we provide evidence for analogous relations in three-dimensional supersymmetric ChernSimons matter theories; specifically we show that the amplitudes can be written so that the kinematic factors satisfy the fundamental identity of three-algebras. We further show that the amplitudes can be "squared" into the amplitudes of three-dimensional supergravity, thus providing evidence for a hidden three-algebra structure in the dynamics of the supergravity.

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R. Metsaev
BRST-BV Approach to Cubic Vertices of Higher-Spin Fields

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N. Boulanger, D. Ponomarev
Comments about Higher-Spin and Duality. Part II: Mixed-Symmetry Fields and Unfolding

In this Part II, we put into the frame formulation the results presented in Part I. This reformulation enables going beyond the spin-2 case and investigating various off-shell Hodge dualisations for higher-spin mixed-symmetry fields in Minkowski spacetime. In order to count the physical degrees of freedom, we look at the generalized Weyl tensors, taking advantage of unfolding techniques.

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A. Reshetnyak, J. Buchbinder
General Unconstrained Gauge-Invariant Lagrangian Formulations for Arbitrary Mixed-Symmetry Higher Spin Fields

An unconstrained Lagrangian descriptions of irreducible integer and half-integer higher-spin representations of the Poincare group with an arbitrary Young tableaux having k rows [1] and of the anti-de-Sitter group with an arbitrary Young tableaux having 2 rows [2] are constructed on a basis of the universal BFV-BRST method in metric-like formalism. We start with a description of both bosonic and then fermionic mixed-symmetry higher-spin fields in a flat space of any dimension in terms of an auxiliary Fock space associated with special Poincare modules. Then for both cases we realize a conversion of the initial operator constraint system (constructed with respect to the relations extracting irreducible Poincare-group representations) into a first-class constraint system. To do this, we find by means of Verma and generalized Verma modules the auxiliary representations of the constraint subalgebra and subsuperalgebra, to be isomorphic due to Howe duality to $sp(2k)$ algebra and $osp(k|2k)$ superalgebra and containing the corresponding subsystems of second-class constraints in terms of new oscillator variables.

We propose a universal procedure of constructing unconstrained (in particular, constrained) gauge-invariant Lagrangians with reducible gauge symmetries describing the dynamics of both massless and massive bosonic and fermionic fields of any spin.

For the case of mixed-symmetry HS fields on AdS spaces, we realize the above program with peculiarities due to quadratic higher spin symmetry algebra and superalgebra respectively for bosonic and fermionic fields. These points are related to non-polynomial structure of oscillator realizations of Verma (generalized for fermionic fields) modules and of BRST operator construction for the corresponding quadratic algebra and superalgebras of the converted constraints. It is shown that the space of BRST cohomologies with vanishing ghost number is determined only by the constraints corresponding to an respective irreducible Poincare (AdS)-group representation.

We derive, as an example, a new unconstrained Lagrangian for bosonic generalized spin (2,1,1) fourth rank tensor on d-dimensional Minkowski space [1].

1. Buchbinder I.L., Reshetnyak A.A. General Lagrangian formulation for higher spin fields with arbitrary index symmetry. I. Bosonic fields// Preprint [arXiv:1110.5044[hep-th]].

2. Č Burdik and A Reshetnyak On representations of Higher Spin symmetry algebras for mixed-symmetry HS fields on AdS-spaces. Lagrangian formulation, 2012 J. Phys.: Conf. Ser. 343 012102, Preprint [arXiv:1111.5516[hep-th]].

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A. Sagnotti

CMB Imprints of a Pre-Inflationary Climbing Phase

We discuss the implications for cosmic microwave background (CMB) observables, of a class of pre-inflationary dynamics suggested by string models where SUSY is broken due to the presence of Dbranes and orientifolds preserving incompatible portions of it. In these models the would-be inflaton is forced to emerge from the initial singularity climbing up a mild exponential potential, until it bounces against a steep exponential potential of “brane SUSY breaking” scenarios, and as a result the ensuing descent gives rise to an inflationary epoch that begins when the system is still well off its eventual attractor. If a pre-inflationary climbing phase of this type had occurred within 6-7 e-folds of the horizon exit for the largest observable wavelengths, displacement off the attractor and initial-state effects would conspire to suppress power in the primordial scalar spectrum, enhancing it in the tensor spectrum and typically superposing oscillations on both. We investigate these imprints on CMB observables over a range of parameters, examine their statistical significance, and provide a semianalytic rationale for our results. It is tempting to ascribe at least part of the large-angle anomalies in the CMB to preinflationary dynamics of this type.

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H. Samtleben

New Superconformal Models in Six Dimensions

I review recent progress in the construction and classification of six-dimensional superconformal models with non-abelian tensor fields. A crucial ingredient in the construction is the introduction of higher-rank tensor fields. I discuss various examples and the possible relation to the (2,0) theories underlying the dynamics of multiple M5 branes.

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M. Kudrna, C. Maccaferri, **M. Schnabl**

Boundary State from Ellwood Invariants

Boundary states are given by appropriate linear combinations of Ishibashi states. We show that, given any OSFT solution, every coefficient of such a linear combination is given by an Ellwood Invariant of a slightly modified theory where it doesnt trivially vanish by the on-shell condition. Unlike the previous construction by Kiermaier et al., ours is linear in the string field. It is also manifestly gauge invariant and is suitable for solutions known only numerically. As a test of our construction we compute the energy momentum tensor of an analytic rolling tachyon solution and find it to agree with known results. We also compute the energy density profile of the tachyon lump solutions known so far only numerically and show that, as the level increases, it correctly approaches a sum of delta functions, supported on the locations of the lower dimensional D-branes.

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D. Kaparulin, S. Lyakhovich, **A. Sharapov**
Lagrange Anchor, Symmetries and Conservation Laws of Free Massless Fields

A Poincare covariant Lagrange anchor will be presented for the non-Lagrangian relativistic wave equations of Bargmann and Wigner describing free massless fields of spin s ¿ 1/2 in four-dimensional Minkowski space. By making use of this Lagrange anchor, we assign a symmetry to each conservation law and perform the path-integral quantization of the theory.

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P. Pasti, **D. Sorokin**, M. Tonin
Covariant Actions for Models with Non-Linear Twisted Self-Duality

We describe a systematic way of the generalization, to models with non-linear duality, of the space-time covariant and duality-invariant formulation of duality-symmetric theories in which the covariance of the action is ensured by the presence of a single auxiliary scalar field. It is shown that the duality-symmetric action should be invariant under the two local symmetries characteristic of this approach, which impose constraints on the form of the action similar to those of Gaillard and Zumino or in the non-covariant formalism. We show that the (twisted) self-duality condition obtained from this action upon integrating its equations of motion can always be recast in a manifestly covariant form which is independent of the auxiliary scalar and thus corresponds to the conventional on-shell duality-symmetric covariant description of the same model. Supersymmetrization of this construction is briefly discussed.

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K. Stelle
Supergravity Divergences and Puzzles

The talk will review the changing situation with ultraviolet divergences in supergravity theories, with a focus on the question whether cancellations have now been found that are not explained by normal field-theoretic nonrenormalization theorems.

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Boulanger N., Colombo N., **Sundell P.**
BRST-BV Treatment of Vasiliev's Four-Dimensional Higher-Spin Gravity

We provide Vasiliev's four-dimensional higher-spin gravity with a classical Batalin–Vilkovisky master action following the Alexandrov–Kontsevich–Schwarz–Zaboronsky approach to off-shell formulations of differential algebras. In particular, we pay attention to the requirements for globally-defined formulations on manifolds with boundaries and non-trivial atlases. We also comment on deformations of the bulk action by various boundary terms and the prospects of solving the full quantum master equation.

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M. Taronna

Higher-Spin Interactions: Three-Point Functions and Beyond

Recasting the Noether procedure in terms of generating functions, I will present its solution at the cubic level for massless and massive fields in constant curvature backgrounds, with particular attention to the transverse and traceless part of the couplings. The solution can be expressed in terms of relatively simple building blocks that are naturally related to spin-1 interactions and whose form in the massless case was first recovered from the tensionless limit of String Theory. Finally, as a first step towards a complete analysis of higher order interactions in constant curvature backgrounds, I shall also describe a class of higher-spin four-point functions in flat space together with the corresponding Lagrangian couplings with emphasis on their non-local nature. The construction clarifies the origin of old problems for these systems and links String Theory to some aspects of Field Theory that go beyond its conventional low energy limit.

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A. Tseytlin
Short Strings and Structure of Quantum AdS5 x S5 Spectrum

Using information from the marginality conditions of vertex operators for the AdS5 x S5 superstring, we determine the structure of the dependence of the energy of quantum string states on their conserved charges and the string tension. We consider states on the leading Regge trajectory in the flat space limit which carry one or two spins in AdS5 or S5 and an orbital momentum in S5, with Konishi multiplet states being particular cases, and compute their energies using semiclassical method.

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M. Valenzuela
Fractional Statistics of the Prokushkin-Vasiliev Higher Spin Field Equations

We show that in the vacuum regime of the Prokushkin-Vasiliev theory of higher spin gauge fields coupled with matter, which is equivalent to a Chern-Simons theory for the higher spin algebra, there may appear fractional spin higher spin fields, i.e. fields which interpolate the boson and fermion statistics.

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P. Vanhove
The ultraviolet Behaviour of N=4 and N=8 Supergravity

We will describe how the non-renormalisation theorems in string theory allow to derive strong contraints on the ultraviolet behaviour of pure extended N=4 and N=8 supergravity. In particular we will explain that a non-renormalisation theorem for the R^4 term forbids a three-loop divergence in the four-graviton amplitude in pure N=4 supergravity in four dimensions, and the D^6R^4 non-renormalisation theorems forbids divergences ultaviolet divergences until seven-loop in the four-graviton amplitude in pure N=8 supergravity in four dimensions.

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M. Vasiliev
Holography, Unfolding and Higher-Spin Theory

Holographic duality is argued to relate classes of models that have equivalent unfolded formulation. This phenomenon is illustrated by the AdS_4 higher-spin gauge theory shown to be dual to the theory of 3d conformal currents of all spins interacting with 3d conformal higher-spin fields of Chern-Simons type. Except for two particular reductions, the resulting 3d boundary conformal theory is nonlinear, providing an interacting version of the 3d boundary sigma model conjectured by Klebanov and Polyakov to be dual to the AdS_4 HS theory in the large N limit.

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H. Verlinde
Gravity from Instantons

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X. Yin
Symmetry Breaking in Higher Spin Holography

I analyze the breaking of higher spin symmetry and various other symmetries of Vasiliev's higher spin gauge theory in AdS spacetime by boundary conditions. This leads to the precise identification of the holographic dual of a large class of supersymmetric and non-supersymmetric Chern-Simons vector models. I also discuss the large N factorization and new symmetries at infinite N in the two-dimensional W_N minimal models.

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K. Zarembo
Exact Results for Wilson Loops in Supersymmetric Theories

Wilson loops in theories with N=4 and N=2 supersymmetry can be computed exactly in some cases, at any value of the coupling constant. I will discuss implications of these results for the gauge/string duality.

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Yu. Zinoviev
On Massive Gravity and Bigravity in Three Dimensions

We investigate possible self-interaction as well as interaction with gravity for massive spin 2 particles using frame-like gauge invariant description of such massive partilces.

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B. Zupnik
Superfield Methods in Three-Dimensional Supergravity

We review the superfield methods in d=3, N=1, 2 and 3 supergravities.

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Quantum Field Theory

K. Bering

A Triplectic Bi-Darboux Theorem and Para-Hypercomplex Geometry

We provide necessary and sufficient conditions for a bi-Darboux Theorem on triplectic manifolds. Here triplectic manifolds are manifolds equipped with two compatible, jointly non-degenerate Poisson brackets with mutually involutive Casimirs, and with ranks equal to 2/3 of the manifold dimension. By definition bi-Darboux coordinates are common Darboux coordinates for two Poisson brackets. We discuss both the Grassmann-even and the Grassmann-odd Poisson bracket case. Odd triplectic manifolds are, e.g., relevant for Sp(2)-symmetric field-antifield formulation. We demonstrate a one-to-one correspondence between triplectic manifolds and para-hypercomplex manifolds. Existence of bi-Darboux coordinates on the triplectic side of the correspondence translates into a flat Obata connection on the para-hypercomplex side. For more information, see arXiv:1110.6165. This work was done in collaboration with Igor Batalin.

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L. Bork

Form Factors in N=4 Maximally Supersymmetric Yang-Mills Theory

The structure of form factors of N=4 SYM stress tensor supermultiplet operator is discussed in the on-shell momentum superspace for MHV and NMHV helicity configurations as well as the duality between form factors/Wilson loops and form factors/amplitudes.

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L. Chekhov, Eynard B., Ribault S.

Calculating Quantum Liouville Theory Using Quantum Riemann Surfaces

We consider the Liouville action in terms of the Dotsenko–Fateev N-fold integral representation and the AGT hypothesis. We calculate the correlation functions of the model using the technique of quantum Riemann surfaces related to solutions of the Shroedinger (Riccati) equation. We find analogues of all objects of algebraic topology, including the holomorphic differentials, period matrix and Bergmann kernels and construct the topological recursion procedure allowing calculating all orders of 1/N expansion.

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G. Efimov
Unstable Oscillator and the Tachyon Field

Canonical quantization of unstable oscillator with $\omega^2 < 0$ is suggested. This scheme is adapted to the canonical quantization of the tachyon field. It turned out that the tachyon field does not break causality.

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A. Galajinsky
Near Horizon Black Holes in Diverse Dimensions and Integrable Models

A large class of extremal black holes in diverse dimensions exhibits conformal symmetry in the near horizon limit. We construct a canonical transformation which relates a massive relativistic particle moving near the horizon of the extremal black hole to the conventional conformal mechanics and discuss a reduction mechanism which yields new integrable models.

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I. Ginzburg
Charged Oscillator and Antioscillator in Magnetic field. Variation of Hidden Symmetries with Magnetic Field

That is problem of quantum and classical mechanics. The anisotropic plane oscillator in magnetic field is reduced to two oscillators with frequences dependent on field B. During variation of magnetic field system moves through many degenerated states with possible observable effects. The solutions are also applicable for the case of "antioscillator" - with imaginary frequences at B=0. When field become large enough the eigen frequences become positive but system acquire many wonderful proprties which can be subject for discussion.

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V. Kazakov
Discrete Integrable Dynamics for Exact Spectrum of Planar N=4 SYM Theory

The planar spectrum of anomalous dimensions of local operators of N=4 super-Yang-Mills theory is given by an infinite set of functional equations called AdS/CFT Y-system. This conjecture was confirmed in the weak coupling limit, reproducing the results of direct summation of millions of SYM Feynman diagrams, up to 5 loops for the most notorious Konishi operator, as well as in the strong coupling limit, reproducing, at least numerically, up to 3 loops of the quasiclassical expansion for the corresponding state on the string side of the AdS/CFT duality. The numerical solution of the Y system for Konishi and similar operators confirms all the known approximate data and gives accurate predictions at any strength of the gauge coupling, from week to strong coupling region. We will explain how to reduce the infinite Y-system to a finite set of non-linear integral equations (FiNLIE), using its integrable discrete Hirota dynamics and the analyticity properties of Y-functions.

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P. LAVROV
Soft Breaking of BRST Symmetry in Field-Antifield Formalism

Gauge dependence of Green's functions for gauge theories with broken BRST symmetry in the field-antifield formalism is investigated. It is shown that the effective action for these theories depends on gauges even on-shell.

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S. LEBEDEV
Spin Dependent Addition to the Mass of Relativistic Electron in QED with External Electric Field

A new expression is found for the spin-dependent contribution Δm_s to the self-energy of electron moving with a transverse momentum $p_\perp$ in an electric field. The structure of the asymptotic expansion of $\Delta m_s(r, \chi)$ as a function of two dynamical invariants $r = \gamma_\perp^{-2}$ and $\chi = \gamma_\perp |\mathcal{E}|/\mathcal{E}_c$ ($\gamma_\perp^2 \equiv 1 + p_\perp^2/m^2c^2,\ \mathcal{E}_c \equiv m^2c^3/|e|\hbar$) is clarified with the aid of this expression. $\Delta m_s(r, \chi)$ can be represented as a Taylor series w.r.t. r,

$$\Delta m_s = -\frac{\alpha m \widetilde{\gamma}}{\pi}\mathcal{F}_0(\chi) + r\mathcal{F}_1(\chi) + r^2\mathcal{F}_2(\text{ḩ}i) + \cdots, \tag{1}$$

where coefficients $\mathcal{F}_0(\chi), \mathcal{F}_1(\chi)$, etc., come up as the Mellin–type integrals and the dynamical invariant $\widetilde{\gamma} = \bar{p}eF\bar{s}/2m^3$ is expressed

through conserved components of momentum and spin. The major coefficient $\mathcal{F}_0(\chi)$ is universal and, in the case of corresponding interpretation of χ, describes well–known spin-dependent additions to the mass in three different cases of a constant external field (the limit $r \to 0$ supposing). The asymptotic properties of $\mathcal{F}_1(\chi)$ are studied in detail. The orders of magnitude for $\mathcal{F}_2(\chi)$, $\mathcal{F}_3(\chi)$ are also obtained. The comparison between those contributions have shown that in the quasiclassical region $\chi \ll 1$ the parameter of the above mentioned expansion is really r, whereas at $\chi \gg 1$ the true parameter is $r\chi^2 \equiv \beta^2$. In particular, the anomalous magnetic moment acquires, thanks to $\mathcal{F}_1$, a contribution logarithmically growing at $\chi \gg 1$. This does not violate the hierarchy of the terms of Taylor series being considered, provided that β remains smaller than unity. *Surgut Univ.*
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S. Lyakhovich, A. Sharapov

Lagrange Anchor and BRST Complex for General Gauge Systems

General gauge systems, not necessarily admitting least action principle, are discussed. The concept of the Lagrange anchor is explained whose existence is less restrictive for the dynamics than the existence of Lagrangian for the field equations. Examples of the Lagrange anchor are provided for the non-Lagrangian field theories, including self-dual YM equations. A general procedure is explained for constructing quantum master equation for not necessarily Lagrangian field theory admitting Lagrange anchor. It is also explained how the Lagrange anchor allows to extend the Noether theorem connecting conserved currents with symmetries in not necessarily Lagrangian dynamics.

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Yu. Makeenko
Reparametrization Path Integral in AdS and the Schwinger Effect

Reparametrization path integral plays the crucial role for constructing stringy representations of the Wilson loop in QCD, describing the minimal surface at the saddle point and its quantum fluctuations in the semiclassical approximation. I consider the reparametrization path integral in anti-de Sitter space (AdS) by extending Douglas' algorithm for finding minimal surfaces to AdS. The case of a circular boundary contour is elaborated. I discuss applications to $\mathcal{N} = 4$ super Yang–Mills: a circular Wilson loop and the Schwinger process, where a semiclassical correction to the critical constant electric field is computed. The results are compared with the one-loop effective action of superstring in $AdS_5 \times S^5$.

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V. Manko
New Uncertainty Relations Found Due to Probability Representation of Quantum States and Recent Experiments Confirming These Relations

New formulation of quantum mechanics and classical mechanics where system states are described by probability distributions is suggested. Classical and quantum equations evolution are given for this probability distributions. Extension to classical field theory is suggested. New experiments to check foundations of quantum and classical theories are proposed. Recently found new uncertainty relations in frame of the suggested probability representation of QM are checked experimentally in collaboration with Florence quantum optics group.

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M. Mensky

Group-Theoretical Derivation of Path Integrals for Particles and "History-Strings"

Relativistic path integral is derived from the Galilei-type relativistic semigroup which is closely connected with Path Group, expressing fundamental features of gauge theory and gravity (classical and quantum equivalence principle, non-Abelian Stokes theorem etc.). The derivation is carried out by the universal procedure allowing, given a (semi-)group G with the Galilei-type structure, to restore dynamics of elementary quantum objects (particles or their non-local analogues). The usual theory of a free particle is restored if G is Agashi-Roman-Santilli (ARS) group, a relativistic analogue of Galilei group with the Lorentz-invariant "proper time" instead of Galilean absolute time. The path integral form for dynamics follows if G is taken to be a generalized ARS semigroup, with the semigroup of trajectories instead of the translation group. The resulting path-integral dynamics may be interpreted as describing non-local objects of the type of "history-strings" (space-time lines elongating with time) which may manifest themselves as point particles in some conditions. The model of quarks as gauge-charged history-strings was early shown to explain confinement. Comparing the weight functional of the obtained path integral with Feynmans assumption determines the classical action up to the terms describing interaction through gauge or/and gravitational fields. Thus, the very concept of classical action and the principle of least action as well as geometric character of interactions are predetermined by the generalized ARS semigroup.

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V. MUKHANOV

Classical Dimensional Transmutation and Confinement

We observe that probing certain classical field theories by external sources uncovers the underlying renormalization group structure, including the phenomenon of dimensional transmutation, at purely-classical level. We perform this study on an example of $\lambda\phi 4$ theory and unravel asymptotic freedom and triviality for negative and positives signs of λ respectively. We derive exact classical β function equation. Solving this equation we find that an isolated source has an infinite energy and therefore cannot exist as an asymptotic state. On the other hand a dipole, built out of two opposite charges, has finite positive energy. At large separation the interaction potential between these two charges grows indefinitely as a distance in power one third.

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M. Olshanetsky
New Families of the Knizhnik-Zamolodchikov-Bernard Equations Related to WZW Models

The KZB equations is a system of equations for conformal blocks in the WZW theory related to a simple complex Lie group G and defined on a Riemann surface. We prove that for non-simply connected groups there exists a finite family of the KZB equations and transformations (the Hecke transformations) intertwined the the equations. The transformations correspond to including the Dirac monopoles in the underlying 3d theory. We give explicit formulas in the elliptic case.

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B. Ovrut
Phenomenological Heterotic Theory: Standard Models, the Renormalization Group and All That

A class of hidden sector polystable vector bundles will be presented that, when used in combination with SU(4) heterotic standard model bundles, lead to completely stable string vacua with exactly the particle spectrum of the MSSM with three right-handed neutrino supermultiplets. Threshold corrections, the effective Lagrangian with soft supersymmetry breaking and its scaling under the renormalization group are discussed. It is shown that gauged B-L symmetry and electroweak symmetry are radiatively broken with a small hierarchy over a wide range of initial parameters. Implications of these SU(4) heterotic standard models for the LHC are explored.

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V. Makarov, **A. Rukhadze**

Minkowski's Tensor or Abraham's Tensor?

It is proved that the question in the articles title formulated by V.L. Ginsburg has an unambiguous answer, i.e. Abrahams tensor. The statement is based on the method developed by V.L. Ginsburg and V.A. Ugarov [1].

1. V.L. Ginsburg and V.A. Ugarov, UFN 118, 176 (1976)

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I. Samsonov

N=4 SYM Low-Energy Effective Action in N=3 and N=4 Harmonic Superspaces

We develop various harmonic superspace formulations for the low-energy effective action in the N=4 SYM theory. We show that the leading part in the derivative expansion of the effective action has very simple and elegant form within the N=3 and N=4 harmonic superspace approaches.

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A. Semikhatov

Braided Hopf Algebras as the Framework for Logarithmic Conformal Field Theories

Braided Hopf algebras—specifically, Nichols algebras—capture significant part of the structure of logarithmic conformal field theories in two dimensions. Nichols algebras with diagonal braiding have been classified recently, and this classification is likely to have deep implications for logarithmic conformal models.

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A. Slavnov

Massless Limit of Nonabelian Higgs Model

It is shown that contrary to the statements present in the literature, in the massless limit the three dimensionally longitudinal coponent of the Yang-Mills field decouples, and the physical spectrum of the model consists of two transversal excitations corresponding to two polarizations of the massless Yang-Mills field and one massless scalar excitation.

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A. Smilga

Witten Index in Supersymmetric 3d Chern-Simons-Yang-Mills Theory

We calculate Witten index in N=1 supersymmetric CS-YM theory by analyzing its effective Hamiltonian in a small spatial

volume. This Hamiltonian involves a nontrivial Berry phase associated with the singularity in the slow variable space at the origin. The accurate treatment of this singularity and its contribution to the effective Hamiltonian gives the same result for the index as the result obtained earlier by Witten by analyzing the dynamics in the opposite limit of large volume. For certain values of parameters, the index is zero and supersymmetry is broken.

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M. Soloviev

Reconstruction in Quantum Field Theory with a Fundamental Length

An analog of Wightman's reconstruction theorem is established for nonlocal quantum field theory with a fundamental length. As an instructive example, we consider the normal ordered function :exp(ϕ^2): of a free field ϕ. We describe precisely the domain of analyticity of its n-point vacuum expectation values and show how the Wightman approach should be extended to include this model. In our setting, the Wightman generalized functions are defined on test functions analytic in a complex l-neighborhood of the real space and are localizable at scales large compared to l. The causality condition is formulated as continuity of the field (anti)commutators in an appropriate topology associated with the light cone. We prove that the relevant function spaces are nuclear and derive the corresponding kernel theorem, which provides the basis for the reconstruction procedure. Special attention is given to the accurate determination of the domain of the reconstructed quantum fields in the Hilbert space of states. We show that the primitive common invariant domain must

be suitably extended to implement the quasi-localizability and causality conditions.

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I. VOLOVICH

Time Irreversibility Problem and Functional Formulation of Classical and Quantum Theory

The time irreversibility problem is the dichotomy of the reversible microscopic dynamics and the irreversible macroscopic physics. This problem was considered by Boltzmann, Poincare, Bogoliubov, Landau and many other authors. V.L.Ginzburg called it the great open problem.

In this talk the following solution of the irreversibility problem is suggested: a formulation of microscopic dynamics is proposed which is irreversible in time. In this way the contradiction between the reversibility of microscopic dynamics and irreversibility of macroscopic dynamics is avoided since both dynamics in the proposed approach are irreversible.

A widely used notion of microscopic state of the system at a given moment of time as a point in the phase space and also a notion of trajectory and microscopic equation of motion do not have an immediate physical meaning since arbitrary real numbers are unobservable. We suggest that the physical meaning is attributed not to an individual trajectory but only to the probability distribution function on the phase space. The fundamental equation of the microscopic dynamics in the proposed "functional" approach is not the Newton equation but the Liouville equation or the Fokker-Planck equation for the distribution function of the single particle.

It is shown that the Newton equation in this approach appears as an approximate equation describing the dynamics of the expected value of the position and momenta for not too large time intervals. Corrections to the Newton equation are computed. This approach requires also reconsideration of the usual Kopenhagen interpretation of quantum mechanics.
Ref: I. V. Volovich, “Randomness in classical mechanics and quantum mechanics”, Found. Phys., 41:3 (2011), 516528; http://arxiv.org/pdf/0907.2445.pdf

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High-Energy Physics

M. Alfimov, Leonidov A.

Quantum Cherenkov Glue

Full quantum calculation of Cherenkov gluon radiation by quark and gluon currents and a Cherenkov decay of a gluon into a pair of Cherenkov gluons in transparent media is performed. Energy losses due to Cherenkov gluon radiation in high energy nuclear collisions are calculated. The angular distribution of the energy flow due to the radiation of Cherenkov gluons is analyzed.

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O. Andreev

Heavy Quark Potentials via Gauge/String Duality

We give some examples of calculations of the heavy quark potentials by string theory in 5D (10D). We also present a comparison of the results with those from different approaches: effective string theories in 4D, phenomenology, and the lattice.

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A. Andrianov, S. Kolevatov, R. Soldati

Flying of Vector Particles from a Parity Breaking (Chern-Simons) Medium to Vacuum and Back

The problem of propagation of photons and massive vector mesons in the presence of Lorenz and CPT invariance violating medium (Chern-Simons action) will be dicussed when the parity-odd medium is separated from the vacuum along a hyperplane. The solutions in different half-spaces will be matched in the cases of space-like,light-like and time-like Chern-Simons action by means of the Bogolubov transformations . Accordingly the two different Fock vacua happen to be mutually coherent states. The boundary mirror/transparency properties will be illustrated. They can help to register local parity violation in a finite volume of heavy ion fireball with axial charge and/or of a star with cold axion condensate degrading to its boundary.

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N. Brook

Particle Production and Minimum Bias Distributions at the Large Hadron Collider

The latest results on Particle Production and Minimum Bias event at Large Hadron Collider (LHC) are discussed. The results are compared to various QCD models incorporated in Monte

Carlo event generators and with other phenomenological models.

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D. Diakonov, A. Vladimirov

Fundamental Spinor Quantum Gravity Regularized on a Lattice

General covariance for fermions requires that the field variables to be used for gravitation theory are the tetrad and the Lorentz spin connection. This leads to Cartan's formulation of General Relativity, however nonperturbative field fluctuations are not restricted there because none of the possible general covariant action terms is sign-definite. A way out is to present the tetrad as a bilinear "current" of more fundamental fermion (spinor) fields. Path integrals over Grassmann variables are well defined for whatever sign of the fermion action. We suggest that in the ultraviolet limit quantum gravity possesses only spinor and gauge field degrees of freedom, like in the Standard Model. The theory can be easily regularized by putting it on a space lattice. It is explicitly invariant under local Lorentz transformations and, in the continuum limit, under diffeomorphisms. It is a theory that is well-behaved at small distances, and quantum fluctuations are well defined. All coupling constants are by construction dimensionless. The continuum limit is achieved at the phase transition line in the space of the coupling constants. Using lattice mean-field methods we show that the 2nd order phase transition indeed occurs as due to the spontaneous breaking of chiral symmetry, and that the emergent Goldstone field has a diffeomorphism-invariant action in the continuum limit. Our formulation of quantum gravity allows its unification with the Standard Model, and that will be also briefly discussed.

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I. Dremin

Elastic Scattering of Hadrons and the LHC Data

Elastic scattering of hadrons is reviewed. The latest LHC data of the TOTEM collaboration at 7 TeV and their fits are discussed. Phenomenological models are critically reviewed. Special attention is devoted to the Orear region beyond the diffraction peak where most models fail and to the ratio of the real and imaginary parts of the amplitude at nonzero transferred momenta. The black disk limit is discussed.

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V. Filinov, Yu. Ivanov, M. Bonitz, V. Fortov, P. Levashov

Quantum Simulation of Thermodynamic and Transport Properties of QuarkGluon Plasma

For quantum simulation of thermodynamic and transport properties of quark gluon plasma (QGP) within unified approach we combine path integral and Wigner (in phase space) formulations of quantum mechanics. Thermodynamic properties of a strongly coupled quark-gluon plasma (QGP) of constituent quasi-particles is studied by a color path-integral Monte-Carlo simulations (CPIMC). For simulations we have presented QGP partition function in the form of color path integral with new relativistic measure instead of Gaussian one used in Feynman and

Wiener path integrals. For integration over color variable we have also developed procedure of sampling color variables according to the group SU(3) Haar measure. It is shown that this method is able to reproduce the available quantum lattice chromodynamics (QCD) data.

The canonically averaged quantum operator time correlation functions and related kinetic coefficients are calculated according to the Kubo formulas. In this approach CPIMC is used not only for calculation thermodynamic functions but also to generate initial conditions (equilibrium spatial, momentum, spin, flavor and color quasiparticle configurations) for generation the color phase space trajectories being the solutions of related differential dynamic equations. Correlation functions and kinetic coefficients are calculated as averages of Weyl's symbols of dynamic operators along these trajectories. Using this approach we have calculated the diffusion coefficient and shear viscosity, which not bad agree with experimental data obtained at RIHC.

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K. Fukushima

Quest for the QCD Phase Diagram in Extreme Environments

A new state of matter out of quarks and gluons has been established in the relativistic heavy-ion collision experiment and the phase diagram of such QCD matter in extreme environments such as the high temperature, the high baryon density, and the intense magnetic field is of paramount importance among QCD theorists and experimentalists. I will review recent theoretical developments especially with emphasis on an interplay between the finite-density effect and the external magnetic field.

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V. Gavrilov

Recent results from CMS Experiment at LHC

Recent results from the CMS experiment are outlined. The results of the search for Higgs boson, SUSY partners, additional gauge bosons and large extra dimentions in proton-proton colleions as 7 TeV center-of-mass energy are presented. The selected results of the measuremets of the Standard Model processes are also reported.

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S. Godunov

Critical Nucleus Charge in a Superstrong Magnetic Field: Effect of Screening

A superstrong magnetic field stimulates the spontaneous production of positrons by naked nuclei by diminishing the value of the critical charge Z_{cr}. The phenomenon of screening of the Coulomb potential by a superstrong magnetic field which has been discovered recently acts in the opposite direction and prevents the nuclei with $Z < 52$ from becoming critical. For $Z > 52$ for a nucleus to become critical stronger B are needed than without taking screening into account.

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V. Grichine

Integral Hadron-Nucleus and Nucleus-Nucleus Cross Sections in the Glauber-Sitenko-Gribov Framework

Simple relations for the integral hadron-nucleus and nucleus-nucleus cross sections in the Glauber-Sitenko approach with the Gribov correction for inelastic screening were derived. The model provides fast and robust calculations of the total, inelastic, production, elastic, quasi-elastic and single diffraction cross sections. Comparisons with experimental data in a wide energy range of projectiles are presented. The model was developed for the simulation of high energy physics (in particular LHC) experiments and has broad applications in nuclear medicine, cosmic rays and astrophysics.

Comments: For the details see references: V.M. Grichine, A simple model for integral hadron-nucleus and nucleus-nucleus cross-sections, Nucl. Instr. and Meth., B267 (2009) 2460.
V.M. Grichine, A simplified Glauber model for hadron-nucleus cross-sections, EPJ, C62 (2009) 399.
More comparisons with experiment in a wider energy range will be presented.

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E.-M. Ilgenfritz

Influence of Magnetic Field on the Chiral/Deconfining Phase Transition

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A. LEONIDOV, KIRAKOSYAN M., MULLER B.

Turbulent Instabilities in Quark-Gluon Plasma

New instabilities of turbulent ultrarelativistic abelian and non-abelian plasma are described. Correponding properties of plasmons are discussed.

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A. MINAENKO

Search for Standard Model Higgs Boson in the ATLAS Experiment

The recent results for searches for the Standard Model Higgs boson at a center of mass energy of 7 TeV using 4.9 fb1 of data collectd with the ATLAS detector at CERN Large Hadron Collider are presented. The data were taken during 2011 year.

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I. DREMIN, **V. NECHITAILO**

Independent Pair Parton Interactions Model and Multiplicity Distributions at LHC

Multiplicity distributions of charged particles are analysed at LHC energies in the framework of the independent pair parton interactions (IPPI) model. It is shown that the number of soft pair parton interactions (and therefore the density of the partonic medium) is large and increases with energy. The mean multiplicity at each parton interaction grows also with energy. This growth depends on the width of the rapidity window. Similar conclusions are obtained in the multiladder exchange model (QGSM).

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G. Sharov

String Models, Stability and Width of Hadron States

Rotational motions of string configurations with massive points (string models of hadrons) are widely applied for describing excited states of mesons and baryons. For some string baryon models (linear and Y configurations) classical rotations appeared to be unstable with respect to small disturbances. This instability and its manifestations are investigated in detail. It is shown that the effect for the Y model is connected with multiple real frequencies in the spectrum of disturbances, but for the linear model its spectrum has exponentially growing modes, resulting in additional contribution to width of baryon states.

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V. Shevchenko

Towards Quantum Theory of Chiral Magnetic Effect

The phenomenon of chiral magnetic effect is addressed from quantum theory of measurements point of view. It is argued that measurement of total chiral charge of the fixed (fireball) volume inevitably leads to electric current – magnetic field correlation (inside this volume), which can be the reason for final particles charge asymmetries in heavy ions scattering.

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B. Sinha

The Enigma of the Perfect Fluid, Quark Gluon Plasma, AdS/CFT Limit of Viscosity per Entropy

With collision of two nuclei at ultrarelivistic energies such as at RHIC at USA and CERN at Geneva, hadrons, constituting the nucleus are expected to make a transition to its fundamental constituents, quarks and gluons, commonly referred to as Quark Gluon Plasma (QGP).

Recent experiments carried out at RHIC and more recently at LHC at Geneva, clearly indicate that QGP, rather than behaving as non interacting gas, tend to exhibit the properties of a perfect fluid, characterised by viscosity per entropy η/s, value close to zero; the AdS/CFT limit being $1/4\pi = 0.06$.

This scenario is also applicable to the microsecond old universe as well as to the neutron stars. A wide range of phenomena, including dipole resonance in the nuclei also exhibit this property.

A review will be presented.

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A. Snigirev

Hard Double Parton Scattering in Hadronic Collisions

The hard double parton scattering is reviewed in the framework of perturbative QCD. The related phenomenological effects are discussed.

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V. Kekelidze, A. Kovalenko, R. Lednicky, V. Matveev, I. Meshkov, **A. Sorin**, Trubnikov G.

Status of the NICA Project at JINR

The NICA (Nuclotron-based Ion Collider fAcility) project is now under realization phase at JINR (Dubna). The main goal of the project is an experimental study of hot and dense strongly interacting matter in heavy ion collisions at centre-of-mass energies $\sqrt{s_{NN}} = 4 - 11$ GeV (NN-equivalent) and average luminosity of 10^{27} cm^{-2} s^{-1} for Au(79+) in the collider mode (NICA collider). In parallel, fixed target experiments at the upgraded JINR superconducting synchrotron Nuclotron are carried out with extracted beams of various nuclei species up to Au(79+) with maximum momenta 13 GeV/c (for protons). The project also foresees a study of spin physics with extracted and colliding beams of polarized deuterons and protons at the energies up to $\sqrt{s} = 26$ GeV (for protons). The proposed program allows to search for possible signs of the mixed phase and critical endpoint as well as to shed light on the problem of nucleon spin structure. General design and construction status of the complex is presented.

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O. Teryaev
Axial Anomaly and Hadron Structure

The dispersive approach to Axial Anomaly and t'Hooft consistency principle lead to exact sum rules putting the stringent constraints for hadronic transition formfactors. In the presence of dimensionful parameters like the photon virtuality (and, possibly, temperature or chemical potential) the anomaly reveals itself as a collective effect of hadron spectrum. Combining non-Abelian anomaly with relocalization (Belinfante) invariance and Equivalence Principle results in the vanishing gluon spin contribution to nucleon spin structure.

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A. Rozanov, **M. Vysotsky**
CP Violation in D-Meson Decays and the Fourth Generation

LHCb collaboration measured CPV at the level of one percent in the difference of assymetries in $D^0(\bar{D}^0) \to \pi^+\pi^-, K^+K^-$ decays. If confirmed on a larger statistics and final systematics this would mean New Physics manifestation. The fourth quark-lepton generation can be responsible for the observed effect.

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P. Aurenche, **B. Zakharov**

Can the Glasma Affect Jet Quenching in AA-collisions at RHIC and LHC?

We study the synchrotron-like gluon emission in AA-collisions from fast partons due to interaction with the coherent glasma color fields. Our results show that for RHIC and LHC conditions the contribution of this mechanism to parton energy loss is much smaller than the radiative energy loss in the plasma phase.

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Quantum Gravity and Cosmology

B. Altshuler

New Glance at the Special Role of (3+1)-Dimensional De Sitter Space-Time

It is shown that gravity differential operator (generalized Lichnerowicz operator), defined conventionally as a second variation of Einstein's gravitational Action over contravariant components of metric tensor, is not plagued by tensor ghosts only in case of the 4-dimensional De Sitter background. Similar demand of absence of tensor ghosts of this operator singles out 4-dimensional Einstein Universe as a background and gives an interesting selection rule for dimensionalities of AdS_m and S^n subspaces of the Freund-Rubin background. Historically this research goes back to the study of the integral form of Einstein equations proposed earlier as realization of Mach principle in its formulation given by Einstein. However special role of 4 dimensions revealed here may be of essentially more general interest.

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E. Babichev

Some Solutions in Galileon Theory

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A. Barvinsky

Nonlocal Ghost-free Gravity Theory and Dark Energy

We suggest a class of generally covariant ghost-free nonlocal gravity models generating de Sitter or Anti-de Sitter background with an arbitrary value of the effective cosmological constant. These models interpolate between the general relativistic phase on a flat spacetime background and their strongly coupled infrared (Anti)-de Sitter phase with two propagating massless graviton modes and have nontrivial properties of their black hole thermodynamics.

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V. Berezin

On Classical Analogs of Quantum Black Holes

The model is built in which the main global properties of classical and quasi-classical black holes become local. These are the event horizon, “no-hair”, temperature and entropy. Our construction is based on the features of a quantum collapse, discovered when studying some quantum black hole models. But our model is purely classical, and this allows to use selfconsistently the

Einstein equations and classical (local) thermodynamics and explain in this way the "log 3"-puzzle.

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F. Bezrukov
Consistency and Predictions from the Higgs Inflation

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P. Binetruy
About Dark Energy

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C. Deffayet
Some Recent Results about Massive Gravity

Models of "massive gravity" are in part motivated by the wish to provide alternative explanations to the observed acceleration of the Universe by considering "Infra-Red" modifications to General Relativity (GR). The (unique) theory of a free massive graviton on flat space is known for a long time as the Pauli-Fierz theory. It is in particular plagued by the van Dam-Veltman-Zakharov discontinuity, which states that the Pauli-Fierz theory does not converge to linearized GR when one lets the mass of the graviton go to zero. A way out, relying on non linear completions of Pauli-Fierz theory, was however proposed by Vainshtein in the 70's. Such non linear completions introduce however generically new pathologies in the construction. I will introduce and discuss some recent efforts to better understand and cure the various problems encountered.

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V. Dokuchaev
Voyage Inside Black Hole

The planet and photon orbits of the third kind inside black holes are described. These orbits are stable, periodic and neither come out the inner Cauchy horizon nor terminate at the central singularity. Interiors of supermassive lack holes in the galactic centers may be inhabited by the advanced civilizations living on planets with the third-kind orbits. In principle, one can get information from the interiors of black holes by observing their white hole counterparts. Black hole is a unique object, permitting the verification of quantum gravity models at the Plank scales trough experimental exploration the central singularity. However, the one way voyage inside black hole is requested for this exploration.

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A. Filippov, E. Davydov

Cosmological and Static States in Generalized Affine Theories of Gravity: Analytic and Asymptotic Solutions, Ideas on Global Properties

We briefly describe the simplest class of affine theories of gravity in multidimensional space-times with symmetric connections and their reductions to two-dimensional dilaton-vecton gravity field theories (DVG). The distinctive feature of these theories is the presence of an absolutely neutral massive (or tachyonic) vector field (vecton) with essentially nonlinear coupling to the dilaton gravity. We emphasize that the vecton field can be consistently replaced by a new effectively massive scalar field (scalaron) with an unusual coupling to dilaton gravity. Thus for treating this vecton - scalaron duality, one can use methods and results of dilaton gravity coupled to scalars (DSG) in more complex DVG theories.

Then we present the DVG models derived by reductions of $D = 3$ and $D = 4$ affine theories and write a one-dimensional dynamical system simultaneously describing cosmological and static states with different parameters: including singularities, horizons, tachyonic masses, and wrong-sign (phantom) kinetic terms. Some exact and approximate analytic or asymptotic solutions are derived and a Master Integral Equation is proposed, which presumably may provide us a tool for uncovering global properties of the dynamical system. The most complete results were obtained for the 3-dimensional affine theory but our approach is fully applicable to studying static - cosmological solutions in multidimensional theories (esp., by using the scalaron - vecton duality) as well as to general one-dimensional DSG models (DSG-1).

The global structure of the solutions of integrable DSG-1 models can be usefully visualized by drawing their 'topological portraits' resembling the phase portraits of dynamical systems. We draw some examples of such portraits to better demonstrate a deep relation between cosmological and static states. We hope

that this tool may be of use in more complex theories.

More details on earlier results mentioned here can be found in arXiv data base (e.g., 0812.2616, 1003.0782, 1008.2333, 1011.2445, 1112.3023).

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V. Frolov
Spinoptics in a Curved Spacetime

In this talk we discuss how polarization of photons affects their motion in a gravitational field created by a rotating massive compact object. We briefly discuss gravito-electromagnetism analogy and demonstrate that spinoptical effects in many aspects are similar to the Strern-Gerlach effect. We use (3+1)-form of the Maxwell equations to derive a master equation for the propagation of monochromatic electromagnetic waves with a given helicity. We first analise its solutions in the high frequency approximation using the 'standard' geometrical optics approach. After that we demonstrate how this 'standard' approach can be modified in order to include the effect of the helicity of photons on their motion. Such an improved approach reproduces the standard results of the geometrical optics at short distances. However, it modifies the asymptotic behavior of the circularly polarized beams in the late-time regime. We demonstrate that the corresponding equations for the circularly polarized beam can be effectively obtained by modification of the background geometry by including a small frequency dependent factor. We discuss motion of circularly polarized rays the Kerr geometry.

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D. FURSAEV
Renyi Entropy in CFT

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D. GALTSOV, P. SPIRIN
Bremsstrahlung in Transplanckian Collisions

We discuss various approaches to calculate bremsstrahlung in transplanckian collisions in the framework of the models with large extra dimensions with an emphasis on the problem of creation of black holes at colliders.

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D. GORBUNOV
Minimal Extensions of the Standard Model and Tests of the Great Desert at LHC

Let me take a phenomenological approach to extend the Standard Model of particle physics (SM). We have to explain neutrino oscillations, dark matter phenomena, baryon asymmetry of the Universe, flatness, homogeneity and isotropy of our World on cosmological scales. There are minimal extensions of the SM capable of explaining all problems above, which do not involve new physics at 1 TeV scale at all. Moreover, with very little new physics (new particles and interactions) one does the job. How can LHC (dis)prove this picture? I shall argue that then the major tasks are study of the Higgs potential and measurement

of top-quark mass and Yukawa coupling.

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B.-L. Hu, Cho H.T.

Stochastic Gravity: Stress Tensor Fluctuations in (anti) de Sitter Spacetimes

Semiclassical gravity (SCG) theory provides a self-consistent description of spacetime dynamics and quantum matter fields through the expectation values of their quantum stress energy tensors [1]. When their fluctuations become large, as could happen in the early universe or late stages of black hole collapse, SCG may fail to provide an accurate description. The proper framework to address issues involving the dynamics of fluctuations in the matter field and in the metric tensor consistently is stochastic gravity [2]. The fluctuations in the matter field is contained in the noise kernel which is the expectation value of the stress energy bi-tensor acting as a source for the Einstein-Langevin equation, from which one can obtain the induced metric fluctuations in the background spacetime. Stochastic gravity is currently investigated for metric fluctuations in evaporating black holes [3] and cosmological structure formation [4]. We present recent results [5] in the calculation of the noise kernels of quantum fields in anti-de Sitter spacetimes via the zeta function method and describe briefly the cosmological and black hole backreaction programs.

[1] E. Calzetta and B. L. Hu, “Closed time-path functional formalism in curved spacetime: Application to Cosmological Backreaction Problems” Phys. Rev. D35, 495 (1987)
[2] B. L. Hu and Enric Verdaguer, “Stochastic gravity: Theory and Applications”, in Living Reviews in Relativity 11 (2008) 3

[arXiv:0802.0658]
[3] B. L. Hu and Albert Roura, "Metric fluctuations of an evaporating black hole from back-reaction of stress tensor fluctuations", Phys. Rev. D 76, 124018 (2007)
[4] Albert Roura and Enric Verdaguer, "Cosmological perturbations from stochastic gravity", Phys. Rev. D 78, 064010 (2008)
[5] H. T. Cho and B. L. Hu, "Stress-energy Tensor Correlators of a Quantum Field in Euclidean R^N and AdS^N spaces via the generalized zeta-function method" Phys. Rev. D84, 044032 (2011)

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M. Iofa
Graviton Emission and Nucleosynthesis in Warped Cosmological Models

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A. Kamenshchik
Soft and "Hard" Singularities in Classical and Quantum Cosmology

Some cosmological models, based on perfect fluids, scalar fields and tachyon fields, possessing soft (or sudden) singularities are studied in the framework of classical and quantum cosmology. It appears that the effect of quantum avoidance of singularities is present when these singularities are traversable at the classical level. The paradox arising in the model based on the mixture of the anti-Chaplygin gas and dust is analyzed and an approach to its solution is suggested.

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M. Katanaev, I. Mannanov
Three-Dimensional Gravity, Dislocations, and the Riemann-Hilbert Problem

The expression for the free energy of arbitrary static distribution of wedge dislocations is proposed. In the framework of geometric theory of defects, the free energy is given by the Euclidean action for (1+2)-dimensional gravity interacting with point particles. Relative movement of particles in gravity corresponds to bending of dislocations. The equations of equilibrium are analyzed and reduced to the Riemann-Hilbert problem. For two dislocations, the solution is found explicitly through hypergeometric functions.

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C. Kiefer, M. Krämer
Can Effects of Quantum Gravity be Observed in the Cosmic Microwave Background?

In any approach to quantum gravity, it is crucial to look for observational effects. In my talk, I discuss how quantum gravitational contributions to the anisotropy spectrum of the cosmic microwave background arise in the framework of quantum geometrodynamics (Wheeler-DeWitt equation). From the present non-observation of these contributions, we find a constraint on the Hubble parameter of inflation. I also compare these results with the predictions from loop quantum cosmology.

Ref.: C. Kiefer and M. Krämer, Phys. Rev. Lett. 108, 021301 (2012).

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F. Bezrukov, **D. Levkov**, S. Sibiryakov

Semiclassical Transitions with Black Hole in the Intermediate State

We suggest a new semiclassical method for calculating the elements of the gravitational S-matrix. The method allows us to describe transitions between asymptotically flat spacetimes, e.g., collapse of matter into black hole followed by complete evaporation of the black hole. We illustrate the method in the simplest model with spherically symmetric dust shell

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M. Libanov

Conformal Mechanisms for Generation of Cosmological Density Perturbations

We consider theories which explain the flatness of the power spectrum of scalar perturbations in the Universe by conformal invariance, such as conformal rolling model and Galilean Genesis. We argue that intrinsic potentially observable effects, which include statistical anisotropy and non-Gaussianity of a peculiar form, are characteristic of the entire class of conformal models.

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K. Maeda

Accelerating Universe in Effective String Theory

We study cosmological solutions in the effective heterotic string theory with a'-correction terms in string frame. It is pointed out that the effective theory has an ambiguity via field redefinition and we analyze generalized effective theories due to this ambiguity. We restrict our analysis to the effective theories which give equations of motion of second order in the derivatives, just as "Galileon" field theory. This class of effective actions contains two free coupling constants. We find de Sitter solutions as well as the power-law expanding universes in our four-dimensional Einstein frame. The accelerated expanding universes are always the attractors in the present dynamical system.

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S.P. Miao, R. Woodard

Issues Concerning Loop Corrections to the Primordial Power Spectra

We expound some principles in an attempt to clarify the debate over infrared loop corrections to the primordial scalar and tensor power spectra from inflation. Among other things we note

that existing proposals for nonlinear extensions of the scalar fluctuation field ζ introduce new ultraviolet divergences which no one understands how to renormalize. Loop corrections and higher correlators of these putative observables would also be enhanced by inverse powers of the slow roll parameter ϵ. We propose an extension which should be better behaved.

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L. Modesto

Super-Renormalizable Multidimensional Quantum Gravity

I introduce a perturbatively super-renormalizable and unitary theory of quantum gravity in any dimension D starting from the four dimensional case. The theory presents two entire functions, a.k.a. “form factors”, and a finite number of local operators required by the quantum consistency as well as unitarity (absence of ghosts and any other state) of the theory itself. The theory is power-counting renormalizable at one loop and finite from two loops upward. I essentially present three classes of form factors, systematically showing the tree-level unitarity. It is right now under investigation a possible N=1 supersymmetric extension of the theory in four dimensions. Preliminary results indicate that the nonlocal supergravity theory is power-counting super-renormalizable and tree level unitary with the same particle content of the local N=1 supergravity. In contrast to the local (quadratic-)higher derivative supergravity in its nonlocal generalization all the states fill up in N=1 supergravity multiplet. We believe that the extended SO(N) supergravity, for N=4 and/or N=8, can be off-shell divergence-free also at one loop. At semiclassical level I prove that the gravitational potential is regular in r = 0 for all the choices of form factors compatible with renormalizability and unitarity. For two out of three form factors the black hole solutions are regular and the classical singularity is replaced by a "de Sitter-like core" in r=0. For one particular form factor, I prove that the D-dimensional "Newtonian cosmology" is singularity-free and the Universe spontaneously follows a de Sitter evolution at the "Planck scale" for any matter content. I conclude stating that, in the ultraviolet regime, the spectral dimension takes on different values for the three cases: less than or equal to "1" for the first case, "0" for the second one and "2" for the third one. Once the class of theories compatible with renormalizability and unitarity is defined, the spectral dimension has the same short-distance "critical value" or "accumulation point" for any value of the topological dimension D.

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D. Nesterov

Monodromies and Functional Determinants in the CFT Driven Quantum Cosmology

We apply the monodromy method for the calculation of the functional determinant of a special second order differential operator which arises in applications of the early Universe theory and, in particular, determines the one-loop statistical sum for the microcanonical ensemble in cosmology generated by a conformal field theory (CFT). This ensemble realizes the concept of cosmological initial conditions by generalizing the notion of the no-boundary wavefunction of the Universe to the level of a special quasi- thermal state which is dominated by instantons with an oscillating scale factor of their Euclidean

Friedmann-Robertson-Walker metric.

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A. Nikishov, Ritus V.
Gravitational Radiation from Masses in a Keplerian Orbit

We consider the polarizations of gravitational radiation from masses in a Keplerian orbit. The relativistic corrections are also evaluated.

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D. Polarski
Dark Energy

I will review some of the approaches adopted in order to obatin an accelerated expansion rate at the present time.

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E. Pozdeeva
Stability of de Sitter Solutions in Modified Gravity

A nonlocal gravity model, which does not assume the existence of a new dimensional parameter in the action and includes a function $f(\Box^{-1}R)$, with $\Box$ the d'Alembertian operator, is considered. The model is proven to have de Sitter solutions only if the function f satisfies a certain second-order linear differential equation. The de Sitter solutions corresponding to the simplest case, an exponential function f, are explored, without any restrictions on the parameters. If the value of the Hubble parameter is positive, the de Sitter solution is stable at late times, both for negative and for positive values of the cosmological constant. Also, the stability of the solutions with zero cosmological constant is discussed and sufficient conditions for it are established in this case. New de Sitter solutions are obtained, which correspond to the model with dark matter, and stability is proven in this situation for nonzero values of the cosmological constant.

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M. Sasaki

Conformal Frame independence in Cosmology

In cosmology, we encounter various conformal frames of the metric. They are mathematically equivalent, but it is often said that they are physically different, leading to different physical results. In this talk, I show that although physical interpretations may be very different from frames to frames, observationally they are equivalent to each other.

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D. Blas, M. Ivanov, **S. Sibiryakov**

Constraining Deviations from Lorentz Invariance on the Dark Sector

I will consider a class of cosmological models where dark energy and / or dark matter exhibit deviations from Lorentz invariance. The homogeneous expansion of the Universe in these models is practically indistinguishable from the standard LambdaCDM cosmology. On the other hand, the evolution of the cosmological perturbations differs markedly from the standard case. I will discuss, at which level this type of deviations from Lorentz invariance is constrained by the present-day and upcoming cosmological observations.

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

Non-Minimal Higgs Inflation and Frame Dependence in Cosmology

We present some results of the non-minimal Higgs inflation model and discuss the frame dependence of quantum corrections. Cosmological models with a scalar field non-minimally coupled to gravity are usually formulated in the so called Jordan frame parametrization. It is often useful to perform a field transformation to the so called Einstein frame which formally resembles the situation of Einstein Gravity with a minimally coupled scalar field. The tree-level action is invariant under field reparametrizations so that at this level both frames are mathematically equivalent. However, we explicitly show that already at the one-loop level this is no longer true since the

effective action is not invariant under field reparametrizations. This problem of frame dependence also manifests itself in the scenario of non-minimal Higgs inflation.

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T. Tanaka, Y. Urakawa

Infrared Divergence in Cosmological Perturbation Theory

It has been an issue of debate whether the inflationary infrared(IR) divergences are physical or not. Our claim is that, at least, in single-field models, the answer is “No”. We have explicitly shown that the IR divergence is absent in the genuine gauge-invariant quantity at the leading order in the slow-roll approximation. However, the initial quantum state is constrained by the condition of the absence of IR divergence.

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A. Toporensky, M. Ivanov

Stable Superinflating Solutions in f(R) Gravity

We consider super-inflating solutions in modified gravity for several popular families of f(R) functions. Using a scalar field reformulation of f(R)-gravity we describe how the form of effective scalar field potential can be used for explaining existence of stable super-inflation solutions in the theory under consideration. Several new solutions of this type have been found analytically and checked numerically.

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V. Vanyashin

Cold Dark Matter Cannot Comprise Relic Axions

A primordial axionic condensate undergoes a gigantic Bose-Einstein enhancement of electromagnetic decay. Coherence of emitters and quantum parametric resonance cooperate to produce an exponentially growing avalanche of superradiant photon pairs. As a result, the axionic condensate survival on cosmological timescales turns out to be improbable.

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S. Vernov

Analysis of Scalar Perturbations in Nonlocal Cosmological Models

We develop the cosmological perturbations formalism in models with a single minimally coupling non-local scalar field dynamics and nonlocal modified gravity models, which are equivalent to local gravity models with nonminimally coupling nonlocal scalar fields. The nonlocal scalar field originate from the string field theory description of the rolling tachyon. We construct the equation for the energy density perturbations of the nonlocal scalar field and analyze the perturbations in the neighborhood of the known exact solutions.

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A. Vikman
G-Bounce

I will discuss a wide class of models which realise a bounce in a spatially flat Friedmann universe in standard General Relativity. The key ingredient is a noncanonical, minimally coupled scalar field belonging to the class of theories with Kinetic Gravity Braiding / Galileon-like self-couplings. In these models, the universe smoothly evolves from contraction to expansion, suffering neither from ghosts nor gradient instabilities around the turning point. The end-point of the evolution can be a standard radiation-domination era or an inflationary phase. The talk is based on arXiv:1109.1047v2 [hep-th], JCAP11(2011)021

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A. Vilenkin
Did the Universe have a Beginning?

We discuss three candidate scenarios which seem to allow the possibility that the universe could have existed forever with no initial singularity: eternal inflation, cyclic evolution, and the emergent universe. The first two of these scenarios are geodesically incomplete to the past, and thus cannot describe a universe without a beginning. The third, although it is stable with respect to classical perturbations, can collapse quantum mechanically, and therefore cannot have an eternal past.

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M. Volkov
Hairy Black Holes and Cosmologies in the Ghost-Free Massive Gravity

We present cosmological and black hole solutions in the recently proposed ghost-free massive gravity with two dynamical metrics. Apart from the 'standard' cosmologies which are matter-dominated at early times but show the late time self-acceleration, there are also more exotic solutions without the initial singularity. The black holes comprise several classes, depending on their asymptotic behavior, all of them supporting a short-range massive graviton hair outside the regular event horizon. The horizon is common for both metrics, and its temperatures defined with respect to each metric coincide.

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B. Whiting
Stochastic Gravitational Wave Background Results from LIGOs Long-Baseline Interferometers

Theories which describe the physics of the early Universe frequently include scenarios for the production of gravitational waves. For cosmic superstring models, gravitational waves which survive to the current epoch would have resulted from the superposition of a large number of unresolved sources while, more generically, the gravitational wave production might be related to the equation of state characterizing matter and energy in the very early Universe. Whatever cosmic physics model is actually responsible for creating a stochastic background of gravitational waves, we can expect its unique imprint to be evident today, just as the thermal history of the early Universe has imposed a unique black body temperature, and a precise fluctuation spectrum, on the cosmic microwave background (CMB). Direct measurement of the amplitude of a stochastic GW background is therefore of fundamental importance for understanding the evolution of the Universe during its earliest moments, when it was undergoing processes which are inaccessible to more standard astrophysical observations. I report on recently published limits on the amplitude of the stochastic gravitational-wave background, using the data from a two-year science run of the Laser Interferometer Gravitational-wave Observatory (LIGO). The result constrains the energy density of the stochastic gravitational-wave background normalized by the critical energy density of the Universe, in the frequency band around 100Hz, to be less than 6.9×10^{-6} at 95% confidence. Impact on several models for the early Universe is discussed.

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K. Leonard, **R. Woodard**

Graviton Corrections to Maxwell's Equations

We use dimensional regularization to compute the one loop quantum gravitational contribution to the vacuum polarization on flat space background. Adding the appropriate BPHZ counterterm gives a fully renormalized result which we employ

to quantum correct Maxwell's equations. These equations are solved to show that dynamical photons are unchanged, provided the free state wave functional is appropriately corrected. The response to the instantaneous appearance of a point dipole reveals a perturbative version of the long-conjectured, "smearing of the light-cone". There is no change in the far radiation field produced by an alternating dipole. However, the correction to the static electric field of a point charge shows strengthening at short distances, in contrast to expectations based on the renormalization group. We check for gauge dependence by working out the vacuum polarization in a general 3-parameter family of covariant gauges.

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O. Zaslavskii
Acceleration of Particles by Black Holes

We suggest brief review of the effect of acceleration of particles by rotating and charged black holes to unbound energies in the centre of mass frame. Simple and general explanations of the effect are given: (i) the kinematic one based on the behaviour of relative velocity of colliding particles near the horizon, (ii) the geometric one, based on properties of particles' four-velocities with respect to a local light cone near the horizon. The similar effect near the inner black hole horizon is also discussed and the role of the bifurcation point is revealed.

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A. Zelnikov, V. Frolov

Classical Self-Energy of Charges near Higher-Dimensional Black Holes and Anomalies

We study the problem of self-energy of charges in higher dimensional static spacetimes. Application of regularization methods of quantum field theory to calculation of the classical self-energy of charges leads to model-independent results. The correction to the self-energy of scalar charges due to the gravitational field of black holes of the higher dimensional Majumdar-Papapetrou spacetime is calculated exactly. It vanishes in even dimensions, but acquires a non-zero value in odd dimensional spacetimes. The origin of the self-energy correction in odd dimensions is similar to that of the conformal anomaly in quantum field theory in even dimensional spacetimes.

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Condensed Matter Physics

V. Anisimov

Density Functional and Dynamical

DFT+DMFT method in Wannier functions realization is described and its application to a number of narrow-band systems reported. The studied material comprise SrVO3, V2O3, Li2VO4, NiO, MnO, FeSb2, LaOFeAs, KCuF3, Ce. The dynamical mean-field theory (DMFT) is a powerful tool to study Coulomb correlations. In order to use it for real materials it should be combined with the density functional theory (DFT) methods. Wannier functions are used as localized orbitals basis to define Hamiltonian parameters. Coulomb interaction parameters are obtained in "constrained DFT" calculations. DFT+DMFT method was applied to a number of narrow-band materials where correlation effects result in various anomalous physical properties: strongly correlated metals (SrVO3), metal-insulator transition (V2O3, MnO), heavy fermions in d-system (Li2VO4), charge transfer insulator (NiO), correlated covalent insulators (FeSi, FeSb2), novel superconductor (LaOFeAs), Jahn-Teller distortions (KCuF3) or f-electrons localization (Ce).

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I. Božović
Solving the High-Tc Superconductivity Puzzle – One Atomic Layer at a Time

We use atomic-layer-by-layer molecular beam epitaxy (ALL-MBE) to synthesize atomically smooth thin films, multilayers and superlattices of cuprates and other complex oxides. [1] In this talk, I will review our recent experiments on such films and superlattices that probe the basic physics of high-temperature superconductivity (HTS). Some key questions in HTS physics about the dimensionality, relevant interactions, the roles of (in)homogeneity and fluctuations are answered as follows.
(i) In an isolated single CuO2 plane without holes, quantum spin liquid forms.[1]
(ii) In an isolated CuO2 plane doped with holes, HTS can occur with Tc higher than in the bulk. [2]
(iii) HTS cuprate samples can be quite homogeneous (have a very uniform SC gap, etc.).[3] (iv) HTS and anti-ferromagnetism separate on the scale of 1 in space and 1 eV in energy. [4]
(v) Pseudo-gap and SC states mix on the 1,000 length scale (Giant Proximity Effect) .[5]
(vi) In-plane charge excitations are strongly coupled to out-of-plane lattice vibrations. [6]

(vii) Strong phase fluctuations drive the SC transition, but 10-15 K above Tc they fade out.[7]

[1] Suter et al., PRL 106, 237003 (2011).
[2] Bozovic et al., PRL 89, 107001 (2002); Gozar et al., Nature 455, 782 (2008); Smadici et al., PRL 102, 107004 (2009), Logvenov et al., Science 326, 699 (2009), Butko et al., Adv. Mater. 21, 1 (2009), Zhou et al., PNAS 107, 8103 (2010).
[3] Abbamonte et al., Science 297, 581 (2002); Shim et al., PRL 101, 247004 (2008).
[4] Bozovic et al., Nature 422, 873 (2003).
[5] Bozovic et al., PRL 93, 157002 (2004); Morenzoni et al., Nature Comm. 2, 272 (2011).
[6] Gedik et al., Science 316, 425 (2007); Radovic et al., PRB 77, 092508 (2008)
[7] Sochnikov et al., Nature Nanotech. 5, 516 (2010); Bilbro et al., Nature Physics 7, 298 (2011); Bollinger et al., Nature 472, 458 (2011).

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I. Burmistrov
Enhancement of the Critical Temperature of Superconductors by Anderson Localization

Influence of disorder on the temperature of superconducting transition is studied within the sigma-model renormalization group framework. Electron-electron interaction in particle-hole and Cooper channels is taken into account and assumed to be short-range. Two-dimensional systems in the weak localization and antilocalization regime, as well as systems near mobility edge are considered. It is shown that in all these regimes the Anderson localization leads to strong enhancement of the transition temperature related to the multifractal character of wave functions. The details can be found in I.S. Burmistrov, I.V. Gornyi, A.D. Mirlin, Phys. Rev. Lett. 108, 017002 (2012).

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A. Chaplik

Electrostatic Screening and Friedel Oscillations in Nanostructures

Screening of the Coulomb interaction accounting for the Friedel oscillations in the structures with multicomponent low-dimensional electron plasma is considered. Calculations are made for nanotubes, double quantum wells (DQW) and superlattices. Screening of an impurity potential by neutral particlesindirect dipolar excitons, as well as Friedel oscillations in a hybrid electronexciton system, are also investigated.

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O. Dolgov

Is there a Fundamental Limit on the Critical Temperature?

The restrictions due to requirements of stability for the possible mechanisms of high-temperature superconductivity are discussed. The condition for the static dielectric function to be positive is reexamined. It is argued that the static dielectric function not only can but indeed must be negative in many stable systems, including most of the conventional metals. In the literature up to now a number of incorrect and unfounded statements exist. One of these - that the static dielectric function cannot be negative - is discussed in detail, as well as its consequence, a strong coupling limit on the transition temperature T_c. Proofs are given that the static dielectric function not only can but indeed must be negative in many stable systems, including most of the conventional metals. Various types of electron - electron interaction in superconducting cuprates are discussed. An importance of the electron - phonon interaction in cuprates is highlighted. The role of spin-fluctuations effects in novel multiband superconductors is connsidered.

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M. Feigelman, L. Ioffe, E. Cuevas, M. Mezard

Superconductor-Insulator Transition, Energy Localization and Level Statistics

The origin of continuous energy spectrum in large disordered interacting quantum systems is one of the key unsolved problems in quantum physics. While small quantum systems with discrete energy levels are noiseless and stay coherent forever in the absense of any coupling to external world, most large-scale quantum systems are able to produce thermal bath, thermal transport and excitation decay. This intrinsic decoherence is manifested by a broadening of energy levels which acquire a finite width. The important question is what is the driving force and mechanism of transition(s) between two different types of many-body systems - with and without decoherence and thermal transport ? Here we address this question via two complementary approaches applied to the same model of quantum spin - 1/2 system with XY-type exchange interaction and random transverse field. Namely, we develop analytical theory for this spin model on a Bethe lattice [1] and implement numerical study of exact level statistics [2] for the same spin model on random graph. The relevance of this spin model to the study of pseudogaped superconductivity and S-I transition in some amorphous materials (InOx, TiN) was proposed theoretically in [3] and supported by scanning tunnelling spectroscopy and transport experiments [4]. Both theoretical and numerical studies [1,2] predict the presence of two quantum phase transitions which separate three different phases: A) ordered phase (superconductor with a pseudogap), B) disordered noisy phase (hopping insulator), and C) disordered coherent phase (absolute insulator without charge or energy transport). For the phase B a hard-gap activation behavior is predicted, with a gap value vanishing at the transition to the ordered phase A.

[1] M. V. Feigel'man, L. B. Ioffe, and M. Mezard, Phys. Rev. B 82, 184534 (2010).
[2] E. Cuevas, M.V. Feigel'man, L. B. Ioffe, and M. Mezard, submitted to Nature Comm.
[3] M.V. Feigel'man, L. B. Ioffe, V.E. Kravtsov and E. Cuevas, Ann. Phys., 325, 1390 (2010).
[4] B. Sacepe, T. Doubochet, C. Chapelier et al, Nature Phys. 7, 239 (2011).

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M. Kagan
Superconductivity in Repulsive Fermi-Systems at Low Density

In the large variety of models such as 3D and 2D Fermi-gas model with hard-core repulsion, 3D and 2D Hubbard model, and Shubin-Vonsovsky model we demonstrate the possibility of triplrt p-wave pairing at low electron density. We show that the critical temperature of the p-wave pairing can be strongly increased in a spin-polarized case or in a two-band situation already at low density and reach experimentally observable values of (1-5)K. We also discuss briefly d-wave pairing and high-Tc superconductivity with $T_c \sim 100$K which arises in the t-J model in the range of parameters realistic for cuprates.

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D. Khomskii
Coupled Electricity and Magnetism in Frustrated Mott insulators: Spontaneous Currents, Dipoles and Monopoles

The standard point of view is that at low energies Mott insulators exhibit only magnetic properties, while charge degrees of freedom are frozen out, because electrons are localized. I demonstrate that in general this is not true [1, 2]: for certain spin textures there exist quite nontrivial effects in the ground and lowest excited states, connected with charge degrees of freedom. In particular this may happen in frustrated systems, e.g. containing triangles or tetrahedra as building blocks. I will show that in some cases there may exist spontaneous circular currents in the ground state of insulators, proportional to the

scalar chirality; this clarifies the meaning of the latter and opens the ways to directly experimentally access it. For other spin structures there may exist spontaneous charge redistribution, so that average charge at a site may be different from 1. This can lead to the appearance of dipole moments and possibly of the net spontaneous polarization. This is a novel, purely electronic mechanism of multiferroic behaviour. In particular I show [3] that such electric dipoles should exist in spin ice materials at every tetrahedra with three-in/one-out or one-in /three-out spin configurations, which are equivalent to magnetic monopoles. Thus there should be an electric dipole attached to each magnetic monopole in spin ice. This leads to electric activity of magnetic monopoles, and opens the possibility to control magnetic monopoles by electric field. The possibility to use chirality as qubits will be also discussed.

[1] L.N.Bulaevskii, C.D.Batista, M.V.Mostovoy and D.I.Khomskii, Phys.Rev.B 78, 028402 (2008)
[2] D.I.Khomskii, JPCM 22, 164209 (2010)
[3] D.I.Khomskii, Nature Comm. in press

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Kondo Effect in Terms of Gell-Mann Matrices

It is shown that the generic local symmetry of the Anderson Hamiltonian used for descritipon of Kondo effect is the dynamical SU(4) symmetry of four-level systems. The Anderson Hamiltonian is rewritten in terms of Gell-Mann matrices of 4th rank, which serve as the generators of this symmetry. The effect of Kondo screening is interpreted in terms of the hierarchy of SU(n) symmetries with n changing from 4 to 2 in a process of renormalization group transformation. The similarity between the Kondo screening of spin 1/2 in presence of strong Coulomb repulsion $U > 0$ and the Kondo resonance for pair tunneling through molecules with $U < 0$ is a direct manifestation of implicit SU(4) symmetry of the Anderson/Kondo model.

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Symmetrization of Superconducting Coulomb Pairing Potential due to Electron-Phonon Interaction

We show that, due to mirror nesting of the Fermi contour of two-dimensional electron system, superconducting Coulomb pairing can be described by a quasi-one-dimensional potential that oscillates in the real space. Such a repulsive potential, completed with pairing attraction that corresponds to phonon mechanism of superconductivity and includes the effect of forward scattering in electron-phonon interaction, turns out to be "more symmetrical" in the real space. This symmetrization results in a non-trivial topology of the superconducting order parameter and in considerable increase of the transition temperature.

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A. Korotkov
Probing "Inside" Quantum Collapse with Solid-State Qubits

We discuss what is "inside" the quantum state collapse due to measurement, and what happens if the collapse is stopped half-way. For particular setups with solid-state qubits the answer is rather simple: the qubit state changes in accordance with gradually acquired information, without loss of its purity (no decoherence). The simple theory of such measurement leads to a number of experimentally testable predictions. So far five such experiments have been realized with superconducting qubits: partial collapse, uncollapse (measurement reversal), monitoring and quantum feedback of persistent Rabi oscillations, and partial measurement with continuous output. The dynamics "inside" quantum collapse can be potentially useful, for example for decoherence suppression and in quantum feedback.

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M. Kuliĉ
Pairing in Cuprates and Fe-Based Superconductors - is it so Simple as it is Claimed?

We argue that the superconducting pairing in HTSC cuprates and Fe-based pnictides can not be explained without including the electron-phonon interaction (EPI). The role of low- and high-energy spin fluctuations in cuprates and pnictides is discussed by analysing the recent magnetic neutron and inelastic x-ray scattering measurements. The effects of impurities in both systems are discussed. Theoretical models, which include EPI and the Coulomb interaction in both systems, are introduced. The talk

is devoted to our unforgetable friends, teachers and colleagues, Vitalii Lazarevich Ginzburg and Evgenii Grigorievich Maksimov.

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A. Lichtenstein, H. Hafermann, A. Rubtsov, M. Katsnelson

Electronic Structure, Non-Local Correlation Effects and Superconductivity in Cuprates

Dynamical mean field theory (DMFT) in combination with the first-principle LDA-scheme (LDA+DMFT) is an optimal starting point to go beyond static density functional approximation and include effects of spin and charge fluctuations in strongly correlated cuprates. In order to go beyond the local approximation we investigate a cluster generalization of the DMFT scheme as well as analytical dual-fermions scheme which include a full interaction vertex of impurity problem and spin fluctuations in the ladder approximation. We analyzed the stability of the d-wave superconductivity and effects of bi-layer and multilayer formation in cuprate.

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Yu. Lozovik

Collective Properties and Phases of Dirac Electrons in Topological Insulators

Topological insulators is the new state of matter that was recently became to sudy both theoretically and experimentally.

3D topological insulators have insulating bulk and topologically protected helical states on the surface that can be described by Dirac-like equation for massless particles analogously to electrons in graphene. Similarity and distinctions between chiral Dirac electrons in graphene and on the surface of topological insulator will be discussed. Collective excitations, spin-plasmons, and different phases of Dirac electrons in topological insulator and topological insulator based structures are considered. Properties of new quasiparticles, dyons - coupled electrons and magnetic monopoles (originated from magnetoelectric effect in topological insulators covered by magnetic will be discussed.

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I. Mazin
Where to Look for New Superconductors?

V.L. was a relentless proponent of the idea that there is no fundamental limit for the superconducting temperature, and if we had not found a high-Tc superconductor yet, it was only because we did not look at the right place. It turned out, he was right. The old set of rules, usually associated with the name of Berndt Matthias, appears to be very wrong. One, and then another system were found literally in the opposite corner of the room. In my talk, I will look at the story from the point of view of a popular, relatively traditional, and strongly favored by V.L. concept of a "pairing glue", and will argue for a new, "iron age" set of rules that hopefully could lead to further discoveries in the quest for new superconductors.

References: Vitaly Ginzburg and High Temperature Superconductivity: Personal Reminiscences. I.I. Mazin, Physica C468, 105 (2008); Superconductivity gets an iron boost. I. I. Mazin, Nature, 464, 183 (2010)

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A. Melnikov

Topological Transitions in Electronic Spectra of Vortex Clusters in Type-II Superconductors

We report on the results of theoretical study of the electronic structure of multivortex configurations in type-II superconductors taking account of both the effect of the quasiparticle tunneling between the vortex cores and elastic quasiparticle scattering at the sample boundaries and/or different types of defects. We investigate the field-dependent behavior of anomalous spectral branches crossing the Fermi level and the structure of resulting multisheeted Fermi surface. On the basis of the Bogoliubov-de Gennes theory we study the topological transitions in quasiparticle spectra of vortex systems, governed by an external magnetic field and trans-port current. We analyze two generic examples of such transitions: (i) opening of Fermi surface segments corresponding to the creation of a vortex-antivortex pairs; (ii) merging of different Fermi surface segments via the Landau-Zener tunneling. The basic properties of vortex matter such as pinning and transport characteristics, heat transport in the vortex state and peculiarities of the local density of states are shown to be strongly affected by these changes in the Fermi surface topology.

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S. Ovchinnikov, Yu. Orlov

Temperature Dependent Electronic Structure of Mott Insulators with Singlet Spin State

Unusual temperature dependence of the electronic structure and magnetic properties of Mott insulators with spin singlet ionic configuration is studied within the LDA+GTB approach. Examples of such systems are given by LaCoO3 at low temperatures and magnesiowustite Mg1-xFexO under high pressure above spin state crossover. Inside the large Mott-Hubbard gap the in-gap band appears with a number of states proprtional to the concentration of excited high spin states. With temperature increase the top of the in-gap band and bottom of the conductivity crosses resulting in the metal state and appearance the Pauli-type magnetic susceptibility. A metal region is predicted inside the Earth low mantle at the depth 1500-2000km where the pressure is 50-80GPa and magnesiowustite is the second abandoned mineral.

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L. Pitaevskii

Ultracold Atoms as a New Tool in Condensed Matter Physics

The lecture is devoted to a popular presentation of experiments with trapped ultra cold gases. These experiments open new possibilities for the condensed matter physics, permitting to create new substances, which cannot exist in usual conditions, demonstrate fundamental quantum phenomena in a visual way and to check sometimes exotic theoretical predictions. The possibility of tuning atom-atom interactions, using the Feshbach resonance, is particularly fruitful.

In some details experiments with Bose-Einstein condensates, strongly interacting Fermi gases and atoms in optical lattices are described.

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Spin-droplet State of Interacting Two-dimensional System

Spin arrangement of a strongly interacting low-dimensional system is a notoriously difficult long-standing problem. Besides being of fundamental interest, it recently regained attention due to dramatic effect of a magnetic field on the metal-insulator transition in a two-dimensional electron system (2DES), as well as attractive perspectives of exploiting electron spin for quantum computing. Electron transport measurements in the metallic phase, at relatively high densities, found a spectacular enhancement in electrons' effective mass and spin susceptibility due to strong Coulomb interaction. Whether or not interaction leads to ferromagnetic ordering as density is further reduced so far remains debatable.

Analytical treatment of strong interactions is uncontrollable. A minuscule number of electrons in a low density 2DES make most of direct experimental methods for spin magnetization measurements inapplicable. We present direct experimental evidence for spontaneous formation of "nanomagnets": large spin droplets in the strongly interacting dilute 2DES in the insulating phase, obtained by thermodynamic magnetization measurements performed on several high mobility (low disorder) 2DES samples. As density increases, these droplets persist across the metal-insulator transition (MIT), coexist with itinerant electrons, and gradually vanish in the metallic phase. In contrast, no indication of spin droplets was observed for low-mobility samples. We believe that the interplay between droplets and itinerant electrons in the vicinity of the MIT should be incorporated in its theory.

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A. Rosch

Emergent Electrodynamics of Skyrmionic Magnetic Whirls in Chiral Magnets

A lattice of magnetic whirls – so-called skyrmions – can be stabilized by the interplay of Dzyaloshinskii-Moriya interactions in chiral magnets and thermal fluctuations [1]. We discuss how electric and spin currents couple to these skyrmions. As the spin of the electrons locally adjusts to the magnetic texture, the electron picks up a Berry phase. The effects of these time-dependent Berry phases are best described by "artificial" electric and magnetic fields of an emergent electrodynamics which couple to the spin and the spin currents. The efficient Berry phase coupling together with a partial cancellation of pinning forces (collective pinning) due to the stiffness of the skyrmion lattice allows to explain theoretically experiments [2], which show that skyrmion lattices can be controlled by ultrasmall current densities. Using tiny gradients of temperature or magnetic field it is also possible to induce rotations of the skyrmion lattice. The topologically quantized winding number of the skyrmions induces exactly one quantum of emergent magnetic flux per skyrmion. Therefore one can also determine quantitatively the emergent electric field induced by a moving skyrmion following Faraday's law of induction as has been measured in recent experiments [3].

[1] S. Muehlbauer et al., Science 323, 915 (2009).
[2] F. Jonietz et al., Science 330, 1648 (2010).
[3] T. Schulz et al., Nature Physics, (2012).

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A. Rubtsov, M. Katsnelson, A. Lichtenstein

Dual Bosons: a Description of Collective Phenomena in Correlated Systems

The difficulty about the description of collective modes in correlated systems is that their physics is essentially nonlocal. In this situation, a serious revision of the effective-medium concept is needed. The simplest effective-medium approximation, called EDMFT, is purely local and consequently fails for a number of important cases, in particular for the description of plasmons. We construct an efficient perturbation theory around the effective-medium result for the fermionic and the bosonic degrees of freedom. This theory takes into account all local correlations of fermions and collective bosonic modes and interpolates between itinerant and localized regimes of electrons in solids. It is shown that dual ladder summation gives a conserving approximation beyond EDMFT. General expression for the plasmonic dispersion in correlated media is obtained. It is also shown that effective superexchange interactions in the half-filled Hubbard model can be derived within the dual-ladder approximation.

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M. Sadovskii, E. Kuchinskii, I. Nekrasov

Generalized Dynamical Mean-Field Theory for Strongly Correlated Systems

We review the recently proposed generalization of dynamical mean-field theory (DMFT) for strongly correlated electronic systems towards the account of different types of additional interactions, necessary for correct physical description of many experimentally observed phenomena. Among these we consider:
(1) interaction of electrons with antiferromagnetic (or charge density) fluctuations of order parameter in high-Tc superconductors leading to the formation of pseudogap state,
(2) scattering of electrons by static disorder and its role in general picture of Anderson - Hubbard metal-insulator transition,
(3) electron - phonon interaction and corresponding anomalies of electronic spectra in strongly correlated systems.
Our DMFT+Σ approach is based on taking into account these interactions by introducing additional self-energy Σ (in general momentum dependent) into conventional DMFT scheme and calculated in a self-consistent way within the standard set of DMFT equations. We formulate the general scheme of calculations for both one-particle (spectral functions and densities of states) and two-particle properties (e.g. optical conductivity). We examine the problem of pseudogap formation, including the Fermi arc formation and partial destruction of the Fermi surface, metal - insulator transition in disordered Anderson-Hubbard model, and general picture of kink formation within electronic spectra of strongly correlated systems. DMFT+Σ approach can be generalized to LDA+DMFT+Σ to describe realistic materials with strong electron correlations.

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S. Savrasov

Weyl Metal States and Surface Fermi Arcs in Iridates

We investigate novel phases that emerge from the interplay of electron correlations and strong spin-orbit interactions. We focus on describing the topological semimetal, a three-dimensional phase of a magnetic solid, and argue that it may be realized in a class of pyrochlore iridates (such as Y2Ir2O7) based on calculations using the LDA + U method. This state is a three-dimensional analog of graphene with linearly dispersing excitations and provides a condensed-matter realization of Weyl fermions that obeys a two-component Dirac equation.
It also exhibits remarkable topological properties manifested by surface states in the form of Fermi arcs, which are impossible to realize in purely two-dimensional band structures. For intermediate correlation strengths, we find this to be the ground state of the pyrochlore iridates, coexisting with noncollinear magnetic order. A narrow window of magnetic *axion* insulator may also be present. An applied magnetic field is found to induce a metallic ground state.

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A. Semenov, A. Zaikin

Dephasing of Cooper Pairs and Subgap Electron Transport in Superconducting Hybrids

We argue that electron-electron interactions fundamentally restrict the penetration length of Cooper pairs into a diffusive normal metal (N) from a superconductor (S). In the limit of low temperatures this Cooper pair dephasing length L_φ remains finite and does not diverge. We evaluate the subgap conductance of NS hybrids in the presence of electron-electron interactions and demonstrate that this new length L_φ can be directly extracted from conductance measurements in such structures.

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S. Sharapov, A. Varlamov

Strong Enhancement of the Peltier-Seebeck Effect in Gapped Graphene

There exist experiments indicating that at certain conditions like an appropriate substrate a gap of the order of 10 meV can be opened at Dirac points of a quasi-particle spectrum of graphene. We demonstrate that opening of such a gap can result in appearance of a fingerprint bump of the Seebeck signal when the chemical potential approaches the gap edge. A magnitude of the bump can be up to one order higher than already large value of the thermopower occurring in graphene. Such a giant effect accompanied by the non-monotonous dependence on the chemical potential is related to the emergence of a new channel of quasi-particle scattering from impurities with the relaxation time strongly dependent on the energy. Reproducing the existing results for the case of gapless graphene we demonstrate a failure of the simple Mott formula in the case under consideration.

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R. Suris

Nanostructures as the Instrument for the Materialization of the Problems from the Textbook on Quantum Mechanics

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Electronic Quasiparticle Spectrum in Semiconductor Nano-Objects

The features of an electronic quasiparticle spectrum in nano-objects (semiconductor nanoclusters and large organic molecules) are studied analytically and numerically using the GW approximation, hybrid functionals and density functional theory (DFT). We show that the self-energy operator of the GW method contains the contributions of two types: (i) compensating the self-interaction of electrons in the Hartree potential and (ii) describing the exchange interaction between electrons relating to different energy levels. The former contribution is much larger in value. It dominates, in particular, in correction to the gap width and the spin-splitting of a quasiparticle spectrum in magnetic nano-objects. Analytical expressions indicate that these quantities depend mainly on electron localization and electronic screening in nano-objects. To check these results, we calculated: (1) the $Si_{34}DH_{36}$ nanoclusters (D= P, As, Sb, S, Se, and Te), (2) the $Si_{35}H_{36}$ cluster charged by one or two electrons, (3) the metal phthalocyanine (MPc) molecules, where two central H atoms of Pc are replaced by one M-atom (M=Zn, Cu, Ni, Co, Fe, Mn, and Cr). The results of different methods are analyzed and compared with experimental photoemission spectra of several MPc. It is found that DFT provides quasiparticle spectra, which are qualitatively incorrect, while the method of hybrid functional reproduces them rather well. Our calculations show that single atom doping, and single electron charging as well, causes spin effects, which are observable even in nano-objects of 3-5 nm in diameter. This fact is of significant interest for spintronic applications.

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D. van der Marel

Fermi-Liquid Behavior of Strongly Renormalized Electrons in Transition Metal Oxydes

Many of the interesting properties of electrically conducting materials arise from the electrons condensed into a liquid state. Quantum fluctuations, strength and nature of the interactions between electronic quasiparticles and effective dimensionality of the material control the state of matter, the outcome of which spans a huge range of different possibilites including superconductivity, Mott-insulating behaviour and the Fermi-liquid state. SrTiO3 is a semiconductor which, when doped with a low density of electrons, becomes a good conductor with relatively high mobility and strong temperature dependence of the electrical resistivity and the infrared optical conductivity. At low temperatures the material becomes superconducting with a maximum reported Tc below 1 K with a dome-shaped doping dependence of Tc, both in the 3D bulk material and at the 2D LaAlO3/SrTiO3 interface. The DC resistivity below 100 K has a T^2 temperature dependence. The quasiparticles are in the anti-adiabatic limit with respect to electron-phonon interaction, which renders the interaction mediated through phonons effectively non-retarded. According to Landau Fermi-liquid theory the quasi-particle relaxation-rate, $1/\tau(w,T)$, should be proportional to $w^2 + (pT)^2$. This temperature and frequency dependence of the quasi-particle relaxation-rate can be measured using optical spectroscopy. From the strength of the T^2 term and the value of Tc we estimate the Landau parameters of n-type SrTiO3. These parameters are comparable to those of liquid 3He, indicating interesting parallels between these Fermi-liquids despite the differences between the composite fermions from which they are formed. Differences and commonalities with the high Tc cuprates shed illuminating light on the physics of superconductivity observed in these materials.

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V. Volkov, Yu. Latyshev

Aharonov-Bohm Oscillations of Resistance of Perforated Graphene

We observed that resistance of graphene flakes perforated with nano-holes demonstrate periodic magneto-oscillations with the periodicity corresponding to the flux quantum hc/e per nano-hole area. The effect resembles the Aharonov-Bohm effect. The results are associated with the existence of the edge electron states of the Tamm-type around nano-hole. A theory of the edge states of the Dirac fermions in graphene is developed. The Weyl-Dirac equation with general boundary condition on nano-hole edge is solved. The existence of clockwise and counter-clockwise edge states running around antidot and corresponding to different valleys is predicted. The energies and contribution of these states in conductance undergo oscillations periodic on magnetic field. The results are consistent with experimental ones.

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A. Zaikin, D. Golubev

Coulomb Blockade and Antiblockade of Non-Local Electron Transport in Metallic Conductors

We argue that Coulomb interaction can strongly influence non-local electron transport in normal-superconducting-normal structures and emphasize direct relation between Coulomb effects and non-local shot noise. In the tunneling limit non-local differential conductance is found to have an S-like shape and can turn negative at non-zero bias. At high transmissions crossed Andreev reflection yields positive noise cross-correlations and Coulomb anti-blockade of non-local electron transport. Non-trivial Coulomb anomalies in non-local electron transport are also found provided the central electrode becomes normal. Experiments on non-local electron transport with Coulomb effects can be conveniently used to test inelastic electron relaxation in metallic conductors at low temperatures.

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Nonlinear Dynamics

I. Aronson

The Ginzburg-Landau Equation and Contemporary Non-Equilibrium Physics

The Ginzburg-Landau equation is one of the most-studied nonlinear equations in the physics community. It describes a vast variety of phenomena from nonlinear waves to second-order phase transitions, from superconductivity, superfluidity, and Bose-Einstein condensation to liquid crystals and strings in field theory. In my lecture I'll illustrate the impact of the Ginzburg-Landau theory on the field of contemporary non-equilibrium systems, from self-assembling active magnetic colloids to living biological systems, such as suspensions of swimming microorganisms.

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V. Bykov, Mass U.

Manifolds Based Model Reduction for Reacting Flow Systems

The role of numerical simulations in quantitative system analysis of most engineering and scientific problems was enhanced. The main reason for that is growing computational power and increasing efficiency of numerical algorithms. There is a tendency to develop more and more complex mathematical models describing the system at hand. This trend is very challenging with respect to modeling and numerical simulations since the developed detailed models become computationally prohibitive even for the most up-to-date soft- und hardware computational facilities. For instance, it is commonly recognized that high dimensionality, non-linearity and stiffness of typical chemical reaction mechanisms of combustion complicate enormously numerical treatment of the system describing chemically reacting flows. Thus, definition of key parameters controlling the system dynamics and finding critical regimes automatically has become a crucial issue. In the proposed presentation a manifolds based method of automatic model reduction will be introduced and discussed as a main tool to cope with the system complexity and its high dimensionality.

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A. Chechkin

First Passage Processes for the Two Paradigmatic Models of Anomalous Diffusions

The problems of the first passage across a boundary are the corner stones of the theories of random walks and consequently, of modern statistical physics; they also have a great variety of applications. Anomalous diffusion refers to processes where the mean square displacement does not grow linearly in time, but instead exhibits non-linear behavior with the exponent larger or smaller than unity, thus giving rise to super- or subdiffusion, respectively. Anomalous diffusion phenomena have recently been observed in a wide variety of complex systems. In the talk we dwell on the first passage processes for the two paradigmatic models of anomalous diffusion. The first model is the Levy flight process, that is the Markovian process with independent increments distributed with the heavy-tailed non-Gaussian Levy stable probability law. The second model is the fractional Brownian motion, that is non-Markovian Gaussian process whose increments are strongly correlated. We discuss the first passage processes for the semi-infinite domain and for the truncated harmonic potential well. The physical examples coming from stochastic climate dynamics and kinetics of proteins motivated our studies.

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W. Ebeling, A. Chetverikov, G. Roepke, M. Velarde

Coherent Electron Transport Mediated by Solitonic Excitations

First we recall several observations on how electrons can be trapped by nonlinear excitations e.g. in polydiacetylen crystals. Then we study models of soliton-like excitations in chains and layers of atoms interacting by Morse forces. Including the coupling to embedded electrons we investigate the bound states between charges and solitonic excitations thus leading to solectrons that generalize Davydovs supersonic electrosolitons and Zolotaryuk's lattice polarons. The atomic lattice dynamics is given by nonlinear classical Langevin equations including nonlinear couplings and sources of noise. It is shown that solitonic excitations are of high stability against perturbations. The dynamics of free embedded electrons is modelled in the framework of tight-binding approximations and stochastic master equations. Several effects as the formation of pairs and degeneracy are discussed and a Fokker-Planck transport theory following Gogolin's approach is given. Potential applications including novel forms of charge transfer in polymers and controlled electron transfer in layers at the nano-scale are discussed.

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S. Fedotov

Anomalous Transport and Nonlinear Fractional Subdiffusive Equations

I will talk about how to incorporate the nonlinear terms into subdiffusive fractional partial differential equations. I will discuss applications of these equations in physics and biology: chemotaxis, subdiffusion in dendrites and porous media, etc. It will be shown that the standard subdiffusive fractional equations with constant anomalous exponent are not structurally stable with respect to the non-homogeneous variations of exponent.

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V. Gubernov, A. Kolobov, A. Polezhaev

Investigation of Combustion Wave Stability in Chain-Branching Models

In this work we investigate the stability of the premixed combustion waves in the models with two-step chain-branching kinetics in the adiabatic limit in two spatial dimensions. It is shown that either wave or cellular instabilities emerge for the Lewis number for fuel greater or smaller than one respectively. On the Lewis number for fuel vs activation energy parameter plane, the critical parameter curve for wave (cellular) instability is a monotonically decaying (increasing) function, which tends to one for large values of activation energies and grows infinitely (vanishes) as the activation energy is decreased to some critical value (zero). Decreasing the recombination parameter, which corresponds to the relation between the characteristic times of the branching and recombination reactions, makes the combustion waves more stable by increasing the region of parameter values for stable traveling wave solutions. Increasing the ambient temperature is demonstrated to have similar stabilizing effect on combustion waves. The effect of the varying the Lewis number for radicals is shown to be more complex and depends on the regime of recombination. It is demonstrated that as the critical parameter values for the onset of instability are crossed, either pulsating or cellular two-dimensional solutions emerge. The properties of these solutions are studied. A comparison of the results of this paper with known data from the literature for deflagration of hydrogen-oxygen mixtures is made.

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V. Klyatskin

Stochastic Dynamo in Random Acoustic Fields

The problem on excitation of the magnetic field (stochastic dynamo) by random acoustic field of velocities is considered on the basis of the functional method of the method of successive approximations. Under conditions of absence of acoustic wave attenuation in the first (diffusion) approximation, the statistical Lyapunov characteristic parameter of magnetic field energy $\alpha = -\lim_{t\to\infty} \frac{\partial}{\partial t} \langle \ln E(\mathbf{r}, t) \rangle$ vanishes. This means that no structure formation (clustering) is present in the magnetic field realizations in the scope of this approximation. The possibility of clustering magnetic field energy is governed by the sign of the statistical Lyapunov characteristic parameter calculated in the second approximation of the method. It is shown that clustering driven by the acoustic field velocity is realized with probability one, i.e., almost in every individual realization. The characteristic setup time of clustering is evaluated.

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V. Kurdyumov

Rotating and Pulsating Premixed Flames in Narrow Channels with a Circular Cross-Section

The propagation of premixed flames in channels with a circular cross-section subject to a Poiseuille flow is considered accounting for heat-losses by conduction to the channel's wall. It was found that, depending on the Lewis number, the flow rate and the heat losses intensity, symmetric and non-symmetric together with steady and oscillatory propagation modes are possible. The question addressed was whether conductive heat-losses can trigger the oscillatory behavior for flames which are stable in the planar flame case.

Global linear stability analysis of two-dimensional steady-states was performed and the results of the stability analysis were successfully compared with the results of the direct 3D numerical simulations. The propagation regimes with rotating and pulsating flame dynamics were identified.

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E. Kuznetsov

Collapse in Hydrodynamics and the Kolmogorov Spectrum

Recent numerical experiments in the framework of the Euler equations for two colliding Lamb vortex dipoles (P. Orlandi, S. Pirozzoli and G. F. Carnevale, J. Fluid Mech. (2012), vol. 690, pp. 288-320) testify to favor of the collapse appearance when the vorticity becomes infinite in a finite time according to the law $(t_0 - t)^{-1}$, the collapse region vanishes like $(t_0 - t)^{1/2}$, and the velocity component parallel to the vorticity blows up proportionally to $(t_0 - t)^{-1/2}$. During the collapse the region of the maximal vorticity represents the pancake-like structure. In this paper it is shown that all these self-similarities can be obtained from the analysis of the singularity while breaking of vortex lines. In the collapse instant the vorticity Ω gets the singularity of the Kolmogorov type: $\Omega \sim x^{-2/3}$ where x coincides with the direction of the breaking.

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S. Panyukov, **A. Leonidov**

On Kinetic Theory of Energy Losses in Randomly Heterogeneous Medium

An equation describing distribution of energy losses of the particle propagating in fractal medium with quenched and dynamic heterogeneities is derived.

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M. Monastyrsky

Phase Transitions in Membranes of High Genus

We consider phase transitions in Membranes of high genus. Our construction is based on the relation between Membranes embedded in R^3 and associated minimal surfaces in S^3. Using this relation we suggest a unified approach to phase transition in different types of membranes. Some new results concerning stability of membranes, defects in membranes will be also presented.We discuss also the problem of fluctuation of membranes and the structure of extremal but not minimal surfaces.

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A. Panfilov

Anatomical Modeling of Electrical and Mechanical Function of the Heart

Cardiac arrhythmias and sudden cardiac death is the leading cause of death accounting for about 1 death in 10 in industrialized countries. Although cardiac arrhythmias has been studied

for well over a century, their underlying mechanisms remain largely unknown. One of the main problems in studies of cardiac arrhythmias is that they occur at the level of the whole organ only, while in most of the cases only single cell experiments can be performed. Due to these limitations alternative approaches such as mathematical modeling are of great interest. From mathematical point of view excitation of the heart is described by a system of non-linear parabolic PDEs of the reaction diffusion type with anisotropic diffusion operator. Cardiac arrhythmias correspond to the solutions of these equations in form of 2D or 3D vortices characterized by their filaments. In my talk I will present a basic introduction to cardiac modeling and mechanisms of cardiac arrhythmias and briefly report on main directions of our research, such as development of virtual human heart model, and study organization of ventricular fibrillation due to dynamical instabilities in cardiac tissue and due to tissue heterogeneity. I will also report on modeling mechano-electric feedback in the heart using reaction-diffusion mechanics systems and ventricular fibrillation mechanisms due to deformation of cardiac tissue.

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A. Pikovsky

Chaotic Destruction of Anderson Localization in Nonlinear Lattices

We discuss what happens to Anderson localization in a disordered lattice if a nonlinearity is present. The situation is relevant for lattices of coupled oscillators, for a Bose-Einsten condensate (described by a nonlinear Gross-Pitaevsly equation) in a disordered potential, and to light propagation in a disordered nonlinear medium. Our main model is a discrete Anderson chain with a nonlinear term (nonlinear Schroedinger lattice with disorder). We discuss three problems: (i) How an initially localized wave packet spreads; (ii) How a regular wave is transmitted through a nonlinear disordered layer; and (iii) How a thermalization in a finite disordered lattice occurs. In all cases nonlinearity leads to a weak chaos and delocalization.

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A. Polezhaev, M. Borina

Spatial-Temporal Patterns Arising in Active Media in the Vicinity of the Wave Bifurcation

Diffusion instability is a reason of different spatial-temporal patterns observed in physical, chemical and biological systems. Two types of diffusion instability are known: Turing and wave ones. While Turing instability is responsible for stationary nonuniform patterns, wave instability gives rise to a great variety of spatial-temporal regimes. First we give a short overview of patters observed experimentally in chemical systems. Then we discuss patterns which can arise in the vicinity of the wave bifurcation. Namely, we consider patterns which arise due to polymodal interaction right after the wave bifurcation and obtain the conditions for them to occur. Also we suggest the scenario of transition from standing waves to traveling waves with the half-wavelength observed in experiments.

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Yu. Romanovsky, Kargovsky A.

Mathematical Models of Molecular Motors

On the basis of concrete experimental data the mathematical models of F1ATPase and Kinesin are under construction. F1ATPase works as a mechano-chemical three-phase motor, which induces the rotation of a rotor with loading. Kinesin a two-stroke walking motor providing transport of various "cargos": mitochondria, lysosomes, etc. along the tubulin tubules in living cells. Models are reduced to systems of the generalized Van-der-Pol or Rayleigh equations. The force torques are described by high order polynomials, elasticity forces are nonlinear, and inertia is determined by the time of ATP hydrolysis. Results of modeling are compared with experimental recordings of F1ATPase rotor rotation and Kinesin steps.

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E. Rumanov

Critical Chaos

We consider a system placed into heat bath and undergoing at the same time external influence (supply, pumping). After times exceeding time of relaxation, established modes form. Between them dynamical chaos is possible with locally smooth phase trajectories. However near bifurcation another CRITICAL chaos is observed with Brownian trajectories. It's due to amplified weak noise inherent to any real system. The chaotic pulsating spectrum differs from that of initial one: soft modes prevail.

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V. Sirota, K. Zybin

Vortex Filaments and Velocity Statistics in Hydrodynamic Turbulence

We present a further development of a statistical theory of turbulence based on the inviscid Navier-Stokes equation (Zybin et al.,2007). The main idea is that many statistical properties of a turbulent flow, in particular velocity structure functions, are governed by rare occasions, which in turn are governed by a linear stochastic equation (Zybin et al. 2008; 2010). We believe vortex filaments to be these occasions. In this work, we suggest an explanation of the difference between transverse and longitudinal scaling exponents of velocity structure functions observed in experiments and simulations. Combining the Vortex filament model with Multifractal conjecture, we calculate both kinds of scaling exponents of different orders (inside the inertial range), without any fitting parameters. The results are in very good agreement with the data of simulations (Benzi et al. 2010, Gotoh et. al. 2002).

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Non-Linear Waves' Evolution in Meta-Stable Media

Self-sustaining waves can propagate in meta-stable media; energy needed to support such waves is released by the wave itself. The examples are waves of combustion, waves of boiling in overheated liquids, waves of thermonuclear fusion. As a rule, two regimes of propagation exist, subsonic and supersonic; the difference is based on the different mechanisms of medium activation.

Processes of transition between those regimes are less studied up to now, in comparison with pure subsonic or supersonic modes. Knowing mechanisms of controlling detonation initiation is important in order to work out effective preventive measures, such as suppressing deflagration to detonation transition (DDT) in case of combustible mixture ignition, and mitigation of a detonation wave in case it is already developed. On the other hand, the advantages of burning fuel in a detonation regime in comparison with slow burning at constant pressure attract increasing attention to pulse detonation burning chambers and to their possible application to new generation engines. In a broad sense, the regimes of deflagration and detonation indicate propagation of self-sustaining exothermal waves in meta-stable medium, and the difference of mechanisms induces essential differences in the wave structure and propagation velocity. In a narrow sense, those regimes are waves of combustion and detonation in combustible mixtures, while the exothermicity is a consequence of heat release in chemical reactions (burning), physical transformations (thermonuclear fusion) or phase transitions (waves of overheated liquid boiling wherein accumulated heat energy is transformed into the energy of compressed vapor). This lecture contains a review of the results obtained in theoretical and experimental investigations of DDT processes in gases. Influence of internal geometry and flow turbulization on the detonation onset is considered; the influence of temperature and fuel concentration in the unburned mixture is discussed. Different scenario of self-sustaining wave evolution upon ignition are analyzed.

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Nonergodicity and Inhomogeneity in Single Particle Tracking

Many experiments on the motion of particles in crowded environments (artificial or biological, e.g. in cell interior) hint towards anomalous diffusion, mostly subdiffusion. The nature of this subdiffusion can be quite diverse, and therefore needs for description within theoretical models based on different physical assumptions. Recent development in single particle tracking techniques urges for understanding what information about the physical (or biological) system can be extracted from particle trajectories, and how this information can be extracted, i.e. how different model assumptions about the nature of the subdiffusive process can be falsified within statistical tests. The difference between time-inhomogeneous, non-ergodic models (trap model, continuous-time random walks) and ergodic ones (fractional Brownian motion and motion under geometric restrictions, e.g. in percolation) is deeply rooted in the thermodynamics of the corresponding processes. The distinction of these classes is therefore relatively simple and can be done either by running a test for ergodicity (e.g. the test based on comparing the moving time average with the ensemble average) or a one for time homogeneity (e.g. the p-variance test). The distinction within the ergodic class is tricky. This one can be based on specific tests of homogeneity of filling of the space by the corresponding trajectory and will be discussed in some detail based on analytical and numerical examples.

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A. Starik, Bezgin L., Kopchenov V., Sharipov A., Titova N.

Chain Reactions with Excited Molecules: Application to Novel Combustion Concepts

The lecture addresses the comprehensive analysis of chain reactions with excited molecules, theoretical investigations of potential energy surfaces and rate constants of the reactions with electronically excited singlet oxygen molecules O2(a1), O2(b1) in H2-O2 and CH4-O2 systems. The special issue how to build the reaction mechanism with participation of excited molecules for modeling the chain-energy-branching reactions is considered in detailed manner. The results of the validation of such mechanism are also reported. The different aspects of the application of vibrationally and electronically excited molecules for combustion enhancement for various systems are extensively studied. The great attention is paid to modeling study of laser-induced and plasma-assisted combustion in supersonic premixed and non-premixed flows and comparative analysis of the advantages of different approaches to enhance the ignition and combustion by non-equilibrium plasma as well as to control the pollutant formation in combustible mixtures and practical devices.

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O. Bernus, H. Dierckx, **H. Verschelde**

Geometric Structures in Anisotropic Excitable Media

In anisotropic excitable media, the dependence of propagation velocity on direction and position can be geometrically encoded in a non Euclidean metric tensor equal to the inverse diffusion tensor. Scroll wave filaments and wave fronts can be viewed as strings and branes propagating in curved space.

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Nonlinear Physics in the Study of Synthetic Genetic Oscillators

We model the dynamics of the synthetic genetic oscillator Repressilator equipped with quorum sensing mechanism which provides the coupling between oscillators. In addition to a circuit of 3 genes repressing each other in a unidirectional manner, the model includes a phase-repulsive type of the coupling module implemented as the production of a small diffusive molecule — autoinducer (AI). We show that the autoinducer (which stimulates the transcription of a target gene) is responsible for the disappearance of the limit cycle through the infinite period bifurcation and the formation of a stable steady state for sufficiently large values of the transcription rate. We found conditions for hysteresis between the limit cycle and the stable steady state. The parameters' region of the hysteresis is determined by the mRNA to protein lifetime ratio and by the level of transcription-stimulating activity of the AI. In addition to hysteresis, increasing AI-dependent stimulation of transcription may lead to the complex dynamic behavior which is characterized by the appearance of several branches on the bifurcation continuation, containing different regular limit cycles, as well as a chaotic regime. The multistability which is manifested as the coexistence between the stable steady state, limit cycles and chaos seems to be a novel type of the dynamics

for the ring oscillator with the added quorum sensing positive feedback.

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V. Zykov, Bodenschatz E.
Wave Patterns Selection in Excitable Media

Spiral waves and wave segments in excitable media play an important role in spatio-temporal pattern formation in a variety of different physical, chemical and biological systems such as cardiac tissue, catalytic surface reactions, concentration waves in the Belousov-Zhabotinsky reaction or during cell aggregation of Dictyostelium discoideum. A free-boundary approach is elaborated to derive universal relationships between the medium excitability and the main parameters of a rigidly rotating spiral waves and stabilized wave segments. In addition to commonly considered TT waves (the wave front and the wave back are trigger waves) we have studied TP waves (the wave front is a trigger wave while the back is a phase wave). The results obtained in this study indicate an important role of a specific dimensionless parameter as a universal characteristic of the medium excitability. For TP waves as well as for TT waves this parameter appears quite naturally after a rescaling of the free-boundary equations that stress its generality. However, a strong quantitative difference between the properties of TT and TP waves is clearly demonstrated on the considered example of the stabilized wave segment and rigidly rotating spiral waves.

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