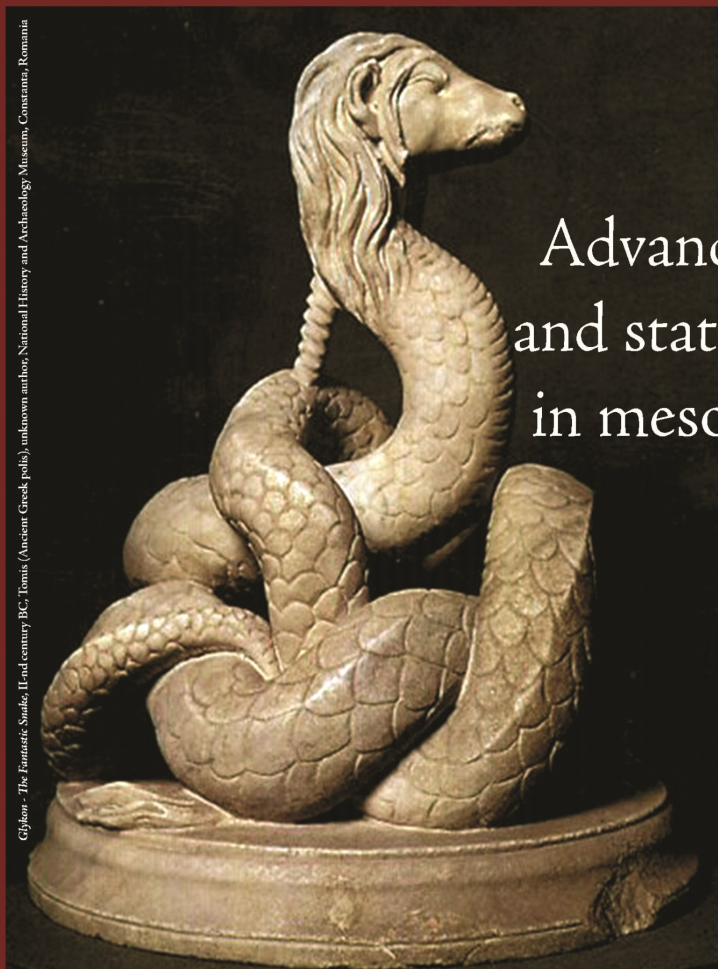
*Glykon - The Fantastic Snake*, II-nd century BC, Tomis (Ancient Greek polis), unknown author, National History and Archaeology Museum, Constanta, Romania

# Advanced many-body and statistical methods in mesoscopic systems

June 27–July 2, 2011
**Constanta, Romania**

*Organized by:*
**Horia Hulubei National Institute of Physics and Nuclear Engineering**
**Academy of Romanian Scientists ✦ Ovidius University**

**Topics**

✦ Foundations of quantum physics ✦ Equilibrium and non-equilibrium quantum statistics, including fractional statistics ✦ Quantum transport ✦ Phases and phase-transitions in mesoscopic systems, including superfluidity and superconductivity ✦ Quantum electromechanical systems ✦ Nanotubes and quantum dots ✦ Quantum dissipation, dephasing, noise and decoherence ✦ Quantum information - theory and applications ✦ Spin systems and their dynamics ✦ Fundamental symmetries in mesoscopic systems ✦ Phase transitions ✦ Exactly solvable models ✦ Various extensions of the Random Phase Approximation ✦ Open quantum systems ✦ Clustering, decay and fission modes ✦ Systematic versus random behavior of nuclear spectra

**Invited Speakers**

Yoram Alhassid, *Yale University, USA*
Boris Altshuler, *Columbia University, USA*
Virgil Baran, *University of Bucharest, Romania*
Miles Blencowe, *Dartmouth College, USA*
Victor Ciupina, *Ovidius University, Romania*
Jorge Dukelsky, *Instituto de Estructura de la Materia, CSIC, Spain*
Till von Egidy, *Technische Universität München, Germany*
Yuri Galperin, *University of Oslo, Norway.*
Steven M. Girvin, *Yale University, USA*
Pertti Hakonen, *Aalto University, Finland*
Mihai Horoi, *Central Michigan University, USA*
Francesco Iachello, *Yale University, USA*
M. Howard Lee, *University of Georgia, USA*
Roberto Liotta, *KTH Stockholm, Sweden*
Matti Manninen, *University of Jyväskylä, Finland*
Mihai Mirea, *IFIN-HH, Romania*
Jukka Pekola, *Aalto University, Finland*
Roman Schrittwieser, *Leopold-Franzens University, Austria*
Peter Schuck, *IPN Orsay & Laboratoire de Physique et Modélisation des Milieux Condensés, Grenoble, France*
Mika Sillanpää, *Aalto University, Finland*
Tudor Stanescu, *West Virginia University, USA*
Jouni Suhonen, *University of Jyväskylä, Finland*
Andrei Zaikin, *Forschungszentrum Karlsruhe Institut für Nanotechnologie, Germany*
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# Book of abstracts

## *Invited talks*

**Yoram Alhassid**
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### *The coexistence of superconductivity and ferromagnetism in nano-scale metallic grains*

**Abstract**
A nano-scale metallic grain in which the single-particle dynamics are chaotic is a zero-dimensional system described by the so-called universal Hamiltonian in the limit of a large number of electrons [1]. This Hamiltonian includes a superconducting pairing term and a ferromagnetic exchange term that compete with each other: pairing correlations favor minimal ground-state spin while the exchange interaction favors maximal spin polarization. Of particular interest is the fluctuation-dominated regime where the bulk pairing gap is comparable to the single-particle mean level spacing and the BCS theory of superconductivity breaks down. We find that superconductivity and ferromagnetism can coexist in this regime.

Signatures of the competition between superconductivity and ferromagnetism are identified in a number of quantities:

*Ground-state spin* [2]. The coexistence regime is characterized by a ground state in which a number of electrons in the vicinity of the Fermi energy are polarized while all other electrons are paired. The coexistence region is characterized by jumps of more than one unit in the ground-state spin.

*Conductance fluctuations* [3]. The tunneling conductance through an almost-isolated grain exhibits Coulomb blockade peaks as a function of a gate voltage. Pairing correlations leads to bimodality in the peak spacing distribution while exchange correlations suppress the conductance peak height fluctuations.

*Thermodynamic properties and their mesoscopic fluctuations* [4,5]. Pairing correlations lead to number-parity effects in the thermodynamic properties of the grain such as the heat capacity and spin susceptibility. The effects of spin exchange correlations differ qualitatively between the BCS and fluctuation-dominated regimes. In the BCS regime, the reentrant behavior in the spin susceptibility for an odd number of electrons is enhanced by exchange correlations. In contrast, in the fluctuation-dominated regime, this reentrant effect is suppressed by exchange correlations.

We have used two methods to calculate thermodynamic properties: (i) a quantum Mont Carlo method [4] and (ii) an approach in which exchange correlations are treated exactly using spin projection methods, while pairing correlations are treated in the static path approximation plus small amplitude time-dependent (quantal) fluctuations around each static value of the pairing field [5]. Odd-even effects in the number of electrons are captured by a number-parity projection.

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[5] K. Nesterov and Y. Alhassid, in preparation (2011).

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***Many-Body Anderson Localization***

**Abstract**
Localization of the eigenfunctions of quantum particles in a random potential was discovered by P.W. Anderson more than 50 years ago. In spite of its respectable maturity and intensive theoretical and experimental studies this field is far from being exhausted. Anderson localization was originally discovered in connection with spin relaxation and charge transport in disordered conductors. Later this phenomenon was observed for light, microwaves, sound, and more recently for cold atoms. Moreover, it became clear that the domain of applicability of the concept of localization is much broader. For example, it provides an adequate framework for discussing the transition between integrable and chaotic behavior in quantum systems. We will discuss current understanding of the Anderson localization and its manifestation in different physical situations. In particular, we will see how physics of disordered many-body quantum systems can be described in the framework of the Anderson Localization.

**Virgil Baran**
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***Kinetic approaches to phase transitions in strongly interacting matter***

**Abstract**
Strongly interacting matter manifests a very rich dynamical behavior and the associated phase diagram was intensively explored through heavy ions collisions during the last years. Around Fermi energies the nuclear multifragmentation shows up analogies with the liquid-gas phase transition. Within a microscopic transport model based on Boltzmann-Vlasov equation we investigate the kinetics of this process as well as the features related to the two-component character of the nuclear matter. The evolution of the fragmentation mechanism with the centrality and the role of various instabilities are also discussed. At ultra-relativistic energies recent results from RHIC experiments evidenced the manifestation of quarks and gluons degrees of freedom during the evolution of the hot fireball created in these collisions. Based on a relativistic transport model we inquire upon the role of chiral symmetry breaking on the collective features of expanding quark-gluon plasma.

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***Carbon nanostructures and applications***

**Abstract**
The nanostructured materials based on carbon nanotubes and related carbon structures are of current interest for much of the materials community. More broadly then, nanotechnology presents the vision of working at the molecular level, atom by atom, to create large structures with fundamentally new molecular organization. In this paper are reported some methods regarding the synthesis and characterization of carbon based nanostructures (carbon-metal nanocomposites thin films, iron carbon nanoparticles, carbon nanotubes, etc) related to application in industry, especially in fuel cells manufacture and also in coatings of the divertor's part of the fusion reactors. It is well known that the fuel cells could contribute to the reduction of the pollution emission and the fossil fuels due to the conversion efficiency which is higher than the other energy conversion systems. There are many possibilities to improve the efficiency and to reduce the weight of the fuel cells by the integration of new nanostructured materials. Free coating droplets and growth without defects is critically important to achieve high performance of tribological characteristics and wear resistive coatings. The main task is to develop a method which provides high deposition rates, adherence to the substrate, high purity of the film and low roughness, tailoring by the operation conditions the structure of the thin film. The following synthesis procedures are presented: Thermionic Vacuum Arc (TVA) method, laser pyrolysis, iron carbon nanoparticles catalyzed growth of nanotubes, sol-gel methods, etc. The characterization of nanostructures has been made by transmission electron microscopy procedures, electron diffraction procedures, X-ray analysis, Mossbauer spectroscopy, Auger spectroscopy and electron energy loss spectroscopy. The structure of the coating was defined by the metal clusters of several nanometer-sizes which are dispersed into the carbon host matrix. The inclusion of metal clusters into the carbon coating is expected and confirmed to reduce the residual stress of the coating, which may result in the successful deposition of metallic substrates without an intermediate layer. The result will be estimated in a innovative energy technology which will integrate fuel cells with batteries and supercapacitors thin films, playing such an important role in the development of next generation electric vehicles with potential applications in other areas.
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***Integrable Richardson-Gaudin models in mesoscopic physics***

**Abstract**
The exact solution of the SU(2) pairing Hamiltonian with non-degenerate single particle orbits was introduced by Richardson in the early sixties. Although it passed almost unnoticed, it was recovered in the last decade in an effort to describe the disappearance of superconductivity in ultra-small superconducting grains.

Since then it has been extended to several families integrable pairing models, the

Richardson-Gaudin models, and it has been widely applied to small grains, quantum dots and atomic nuclei where finite size effects play an important role. Moreover, the exact wave function provides useful insights on the structure and phases of superfluid systems in the BCS to BEC transition.

In this talk I will review some of the achievements in the application of the SU(2) Richardson-Gaudin models to mesoscopic systems as well as new results for the phase diagram of s-wave and p-wave cold atom superfluids.

**Till von Egidy**[1], D. Bucurescu[2]
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***Statistical nuclear properties***

**Abstract**
A general outlook of phenomenological methods used to describe the level densities in nuclei will be given. Two well-known two-parameter formulas of level densities have been used, namely those of the Back-Shifted Fermi Gas (BSFG) model and the Constant Temperature (CT) model. A common ingredient in both is the spin distribution function, which depends, in Ericsons's parametrization, on another parameter, the spin-cutoff parameter σ. A realistic phenomenological description of all these parameters has been obtained by considering the experimental data of 310 nuclei between $^{18}F$ and $^{251}Cf$, consisting of the complete level schemes at low excitation energies and the s-wave neutron resonance spacings at the neutron binding energy. For the spin distributions, we use a method which compares various experimental and calculated moments in the energy-spin plane, and determine a simple formula that describes the spin cutoff parameter as a function of mass number and excitation energy. Also, an even-odd spin staggering in the spin distribution of the even-even nuclei has been found, for which a simple formula was proposed. Using this newly defined spin distribution function, an empirical set of parameters of the BSFG and CT models was determined by fitting both the low-energy levels and the neutron resonance spacings. For these parameters, simple parametrizations were proposed that involve only quantities available from the mass tables. These formulas allow reasonable estimations of the level density parameters for nuclei far from stability. Both the BSFG and CT models describe equally well the level densities at energies up to at least the neutron binding energy. In the end, we discuss recent experimental evidences showing that at lower excitation energies the nuclei obey better the CT model, therefore suggesting that in this regime they are quantum mechanical systems with a constant temperature.

**Yuri Galperin**
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***Low-Frequency Noise as a Source of Non-Gaussian Decoherence in Qubits***

**Abstract**
I will review recent activities on theory of decoherence of a qubit in the environment consisting of two-state fluctuators, which experience transitions between their states induced by

interaction with a thermal bath. Due to interaction with the qubit the fluctuators produce 1/f-noise in the qubitâ€™s eigenfrequency leading to its decoherence. The main problem is that in many important cases the relevant random process is non-Gaussian. Consequently the results in general cannot be represented by pair correlation function of the qubit eigenfrequency fluctuations. A way to analyze the problem is introducing of a spin-fluctuator model where the qubit is treated as a Â½-spin interacting with a set of two-state fluctuators. This is modification of the famous spin-boson model where interaction of a Â½-spin with bosons is explicitly taken into account. I will outline the spin-boson model, present its main results, and discuss relevance of the model to present experimental situation.

**Steven M. Girvin**
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***Recent Progress in Strong-Coupling Circuit QED***

**Abstract**
A revolution is underway in the construction of "artificial atoms" out of superconducting electrical circuits. These macroscopic "atoms" have quantized energy levels and can emit and absorb quanta of light (in this case microwave photons), just like ordinary atoms. Unlike ordinary atoms, the properties of these artificial atoms can be engineered to suit various particular applications, and they can be connected together by wires to form quantum "computer chips". This so-called "circuit QED" architecture has given us the ability to do strong-coupling non-linear quantum optics in a new regime using electrical circuits and to perform rudimentary quantum algorithms on small quantum processors. It will also allow study of strongly interacting many-body polariton lattices.

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**Pertti Hakonen**
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***Superconductivty in nanocarbons***

**Abstract**
Superconductivity in nanocarbons is an intriguing topic. It may involve many competing phenomena, like Luttinger liquid behavior owing to strong electron-electron interactions in 1D, Kondo physics due to odd, unpaired electronic spin, Coulomb phenomena due to charge quantization, and Cooper pair correlations induced by superconducting contacts. In this talk I will give a brief review of our work on proximity-induced superconductivity in carbon nanotubes and graphene. Applications of supercurrents to sensitive electrometry and determination of electron-electron interactions will also be discussed.

**Mihai Horoi**
Central Michigan University, USA

***The Emergence of Deformation in Nuclei and Atomic Cluster***

**Abstract**
It is well know that atomic nuclei and atomic clusters exhibit properties that can be related to intrinsic deformation. The physical signals of deformation are different, but one can show that for these two mesoscopic systems one can identify the sizes for which they undergo shape transitions using a simple criteria. In my talk I will give examples of shape transitions in these system and I would show how it can be identified experimentally looking to the binding energy per particle vs $n^{-1/3}$, where $n$ is the number of particles. It is also know that most mesoscopic systems exhibit prolate deformations. It is interesting to understand why the emergence of prolate deformation is dominant. In my talk I will present some quantum mechanisms that could explain the dominance of the prolate shapes in nuclei.

**Francesco Iachello**
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***Quantum phase transitions in algebraic models of many-body systems***

**Abstract**
The theory of quantum phase transitions (QPT) and excited state quantum phase transitions (ESQPT) in algebraic models of many-body systems will be reviewed. As a specific example, the phase structure and phase diagram of the interacting boson model of atomic nuclei, as obtained both from a semi-classical and a quantal analysis, will be discussed. Finite size scaling, particularly important for mesoscopic systems, will also be reviewed. Experimental evidence for QPT in nuclei will be presented. Finally, QPTs in mixed Bose-Fermi systems will be briefly discussed.

**M. Howard Lee**
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***Dynanics of a finite system and transition to the thermodynamic limit***

**Abstract**
Dynamical properties such as the autocorrelation function in many body systems whether at the ground state or in the classical domain may be calculated by the techniques of the recurrence relations method. For this talk we shall consider a system of a classical harmonic oscillator chain of finite length in 1d and calculate the velocity autocorrelation function analytically. In the Laplace transformed space, this function is expressed in a finite continued fraction in an explicit form, which translates into a periodic solution in time space. Such a form would represent a special example in dynamics of a mesoscopic system. But if one takes the thermodynamic limit, the continued fraction becomes an infinite one, but summable. As a result, one can obtain the dispersion relation and the density of frequencies or the spectrum. What is perhaps most remarkable is that the spectrum has an invariant measure isomorphic to what one finds in a standard 1d chaotic map. The chaotic behavior emerges only at the thermodynamic limit, thus absent at a mesoscopic scale.

**Roberto Liotta**

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***Many-body processes in the continuum***

**Abstract**
New experimental facilities make it possible to reach very unstable many-body systems with properties which cannot be analyzed without including the continuum part of the spectrum. In this talk a formalism suitable to treat such unstable systems is presented and applications to recent experimental data in nuclear physics are discussed.

**Matti Manninen**
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***Localization of particles and vortices in quantum dots and cold atom clouds***

**Abstract**
In a quasi-two-dimensional quantum dot in a semiconductor heterostructure the electrons are trapped in a nearly harmonic confinement. When the electron density is small enough the electrons will localize in a Wigner molecule, a finite size realization of the Wigner crystal. A perpendicular magnetic field reduces the density and puts the electron system in rotation. The rotational motion causes vortex formation. The vortices can be understood as holes in the electron see and, being quasiparticles, they will also localize in a Wigner molecule. Using exact many-body computations we have show that the localization of electrons and vortices is similar and that the excitations of the Wigner molecule are classical vibrational and rotational states.

In the case of cold atom clouds the atoms are trapped in a nearly harmonic trap. The atom cloud can be put in rotation with a rotating laser field. The rotational motion pushes the cloud to be quasi-two-dimensional, making the systems to be similar to that of electrons in a quantum dot. However, in the in the case of atoms the interaction has a short range and the atoms can be fermions or bosons. The rotation causes vortex formation or atom localization in a Wigner molecule. We have found that the vortex formation has ”universal” features: It is similar to bosons and fermions and quite independent of the interaction between the particles. The similarity between bosons and fermions can be understood with help of the composite fermion picture which suggests that the fermion wave function is the boson wave function multiplied by a simple Slater determinant. The vortices which are present in the boson system are then carried out in the fermion system. For a recent review see Rev. Mod. Phys. 82, 2785 (2010).

The atom cloud can also be trapped in an optical lattice superimposed with the harmonic trap making the atoms to localize in the lattice sites of the optical lattice. Such system can be described well with the Hubbard model. We have studied an optical lattice with a flat band and shown that when the harmonic confinement is removed part of the atoms are mobile and fly out while part will remain localized in the states corresponding to the flat band (Phys. Rev. A 82, 041402 (2010)).

**Mihail Mirea**
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***Strong dissipation regime in nuclear disintegrations***

**Abstract**

The coupling of collective degrees of freedom with the microscopic ones causes dissipation and a modification of the adiabatic potential. The term dissipation usually refers to exchange of energy, linear momentum or angular momentum, by all kind of damping from collective motion to intrinsic heat.

A measure of the dissipated energy can be obtained solving the time dependent pairing equations (that are similar to the Hartree-Fock-Bogoliubov ones). A deep connection with the Landau-Zener transitions is included in the time dependent pairing equations: pairs undergo Landau-Zener transitions on virtual levels with coupling strengths given by the magnitude of the gap. A problem appears in solving these equations in the case of seniority one nuclear systems: the unpaired nucleon located on the blocked level will remain on the same level during the deformation of the system. Due to this phenomenon, the system cannot end in its ground state after a disintegration.

In this presentation, a generalization of the time dependent pairing equations is presented by including the Landau-Zener effect in the superfluid model. These new equations allows a mixing of seniority one configurations that allows us to obtain a ground state at the end of the process. An application concerning the C14 emission is offered and its fine structure is explained. These new equations are furthermore used to evidence a dynamical pair breaking effect that could explain the fine odd-even effect in cold fission. Finally, the time dependent pairing equations are used to deduce a model for non-adiabatic cranking inertia.

**Jukka Pekola**

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***Andreev current and photon-assisted tunneling as error processes in a hybrid single-electron turnstile***

**Abstract**

I describe the processes influencing the synchronous transfer of electrons though a SINIS single-electron turnstile. I present the potential of this method for quantum metrology, based on pumping and counting experiments, demonstrating controlled suppression of Andreev current and environment activated tunneling, and close to ideal properties of aluminium as a BCS superconductor [1-5].

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**Roman Schrittwieser**
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**Peter Schuck**
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***Superfluidity-kill at overlow of trapped fermions. Quantal and semiclassical studies.***

**Abstract**
We show in slab geometry with a finite transverse potential in solving BCS gap equation that gap goes to zero when the container gets full. This quantal result is reproduced with a novel Thomas-Fermi approach. It is a general feature that in abruptly widening containers, gap as a function of Fermi energy becomes strongly quenched at the transition point. First results seem to indicate that gap becomes enhanced when the container suddenly narrows from a certain energy on. Relevance to cold atom physics and superfluid neutrons in the crust of neutron stars will be pointed out.

**Mika Sillanpää**
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***Electromechanical microwave amplification, and micromechanical resonator cooled down close to the motional ground state***

**Abstract**
Micromechanical resonators affected by radiation pressure forces allow to address fundamental questions on quantum properties of mechanical objects, or, to explore quantum limits in measurement and amplification. A promising setup for the purpose is an on-chip microwave cavity coupled to a micromechanical resonator. A high electromechanical coupling energy, achieved in our setup by coupling from a flexural beam resonator via an ultranarrow 10 nm vacuum gap, facilitates operation near the quantum regime. We have prepared and observed such a a 30 MHz micromechanical resonator very close to the ground state of its motion. By applying microwave irradiation to the cavity at the red mechanical sideband, we cooled the fundamental flexural mode to thermal occupancy of only 1.5 quanta.

In the opposite regime, under blue sideband irradiation, pump photons will be down-converted, transferring energy into the mechanical resonator. We demonstrate, both theoretically and experimentally, the possibility of using this regime as a microwave amplifier, with noise properties approaching the quantum regime. The addition of a probe signal will induce coherent stimulated emission, leading to its amplification up to 30 dB. A full quantum theory is found to be in a good agreement with the experiment.

**Tudor Stanescu**
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**Majorana Fermions in Semiconductor Nanowires**

**Abstract**
We show that a semiconductor nanowire proximity-coupled to an s-wave superconductor can be, under appropriate circumstances, in a quantum topologically ordered state that supports exotic Majorana excitations. The key to realizing quantum topological order is the coexistence of spin-orbit coupling with proximity-induced superconductivity and an externally-induced Zeeman field. We present the central results of a detailed theoretical study of multichannel semiconductor nanowires, including the phase diagram as a function of chemical potential and Zeeman field, the effects of disorder on the stability of the Majorana modes localized at the ends of the wire, and experimentally-relevant quantities such as the local density of states and the tunneling conductance. These results represent critical steps toward understanding the key experimental conditions required for the realization and detection of Majorana fermions in solid state systems.

**Jouni Suhonen**
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***Many-body methods for nuclear processes triggered by the interplay of strong and weak interactions***

**Abstract**
The atomic nucleus consists of strongly interacting nucleons, protons and neutrons, and the description of its properties challenges many-body methods based on a fully quantum-mechanical treatment of the problem. The structure of the many-nucleon wave functions obtained by the many-body methods can be tested by transitions between these states. In the weak-interaction processes the initial and final nuclear wave functions belong to different nuclei and the overlap between the nuclear wave functions and the leptonic wave functions becomes an interesting issue. At the same time these weak processes can involve atomic many-electron states giving an intriguing new dimension to the decay problem. Examples of such decays are beta decays with exceptionally small decay energies and various channels of double beta decays, the slowest processes that have ever been measured in Nature.

**Andrei Zaikin**
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***Crossed Andreev Reflection***

**Abstract**
Low energy electron transport in hybrid structures composed of a normal metal (N) and a superconductor (S) is governed by Andreev reflection (AR) which causes non-zero subgap conductance of such structures. In NSN systems two additional *non-local* processes come into play. One such process corresponds to direct electron transfer between two N-metals through a superconductor. Another process is the so-called Crossed Andreev Reflection (CAR): An electron penetrating into the superconductor from the first N-terminal may form a Cooper pair together with another electron from the second N-terminal. In this case a hole will go into the second N-metal and AR becomes a non-local effect. Both these processes contribute to the non-local conductance of hybrid multi-terminal structures which has been directly measured in several recent experiments.

In this talk I will review recent progress in our theoretical understanding of various aspects of CAR which we describe non-perturbatively at arbitrary voltages, temperature, degree of disorder, spin-dependent interface transmissions and their polarizations. Special attention will be devoted to the effect of Coulomb interaction on CAR. I will demonstrate that interaction effects in non-local transport and non-local shot noise in three-terminal NSN systems are intimately related. This relation turns out to be much more complicated than in the local case because of (*a*) a variety of different processes contributing to non-local shot noise and (*b*) positive cross-correlations which may occur in normal-superconducting hybrids. In particular, in the case of fully open NS barriers only positive cross-correlations in shot noise due to CAR survive and yield *Coulomb anti-blockade* of non-local electron transport. I will also compare our theoretical predictions with recent experimental observations and demonstrate good agreement between theory and experiment.

## *Contributed talks*

**Ciprian Sorin Acatrinei**
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### *Quantum Physics with Generalized Commutation Relations*

**Abstract:**
Possible consequences of generalized commutation relations (including space noncommutativity) will be discussed in the context of condensed matter physics.

**Alexandru Aldea**
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### *Zero bias anomalies in the Kondo regime of single and double quantum dots*

**Abstract**
The zero bias anomaly (ZBA) of the differential conductance of mesoscopic systems (and not only) is a fingerprint of the electron-electron interaction. The common example is the enhancement of the conductance due to Kondo correlations in single dots. In complex meso-systems, in principle, the suppression of the conductance at zero bias might also be possible due to the simultaneous effects of interference and correlation.

We show that even in single dots, in a multiple lead configuration, the shift from enhancement to suppression is allowed if the voltage applied on the leads is not symmetric. The differential conductance exhibits a peak-dip crossover, the effect being controlled by the strength of the asymmetry and the ratio of the dot-lead couplings [1].

The double dot system we take into consideration consists in an interacting dot connected to external leads and a tunneling coupled side dot. A gate potential is applied on the side dot, so that the whole system mimics a meso-transistor. In what concerns the problem of the ZBA, we give plausibility arguments and show numerical results proving the peak-dip crossover of the nonlinear conductance when either the temperature or the gate potential on the side-dot is changed.

The results are obtained using an extended Anderson model, the Keldysh transport formalism and the equation of motion technique extended to the non-equilibrium case and complex mesoscopic structures [2].

References:
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**Alexander Andreev**

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**Effect of fragment deformations on mass asymmetry of fission**

**Abstract**
The mass distribution of fission fragments is described using the scission-point model. Fissioning nucleus at scission is described as the dinuclear system (two interacting nuclei in touch). The model allows us to calculate the equilibrium dinuclear system fragment deformations at scission. It is shown that the fragment deformations have a key influence on the shape of the mass distribution of fission fragments. In some cases the mass distribution calculated with equilibrium deformations is asymmetric while calculations with the ground-state deformations of fission fragments give symmetric mass distribution. According to our calculations for the fissioning nuclei 180-196Hg the shape of the mass distributions changes from the asymmetric to the symmetric with the increase of neutron number. The asymmetric mass distribution of fission fragments of 180Hg has been recently observed. The mean total kinetic energy of the fission fragments, which is also sensitive to the fragment deformations at scission, is well reproduced in our calculations.

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***Universal features in the thermodynamics and heat transport by particles of any statistics***

**Abstract**
In this talk I shall present the concept of thermodynamic equivalence in parallel with the property of statistics independence of the one-dimensional (1D) heat and entropy conductivities.

I shall give an unifying microscopic interpretation of these phenomena based on the similarity between the excitation spectra of systems of different exclusion statistics and I shall show that, like the thermodynamic equivalence, the 1D heat and entropy conductivities are independent of statistics at any temperature.

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***Phonon Influence on Emission Spectra of Biexciton and Exciton Complexes in Semiconductor Quantum Dots***

**Abstract**
The effect of longitudinal optical (LO) phonon on the emission spectra of biexciton and exciton complexes in semiconductor quantum dots (QDs) is theoretically investigated. The predicted resonantly excited photoluminescence of linearly polarized light in cylindrical InAs/AlAs QD nanostructure is compared with the experimental results. The exciton and biexciton binding energies are computed and appearance of LO phonon replicas in the photoluminescence spectra of the nanostructure is discussed.

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***Some aspects of superfluidity in the one-dimensional Bose gas***

**Abstract**
Different aspects of superfluidity in one dimension (1D) are discussed. It is shown that the Hess-Fairbank effect takes place in 1D at zero temperature. In particular, the rotational inertia of an interacting 1D Bose gas in a finite ring is zero. Nevertheless, our results indicate that the frictionless motion of impurities depends sensitively on the strength of interactions in the gas. In general, this is possible only in a limit of weak interactions. Recently, experimental test with ultra-cold atoms have begun and quantitative predictions for the drag force experienced by moving obstacles have become available. We obtain the phase diagram of frictionless motion for the gas immersed into a moving shallow optical lattice or a moving random potential. In this case the drag force, a quantitative measure of superfluidity, can be zero at specific values of velocity and the gas density even for strong interactions.

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***Deviation from the Bloch law in nanoscopic ferromagnets***

**Abstract**
It is known that saturation magnetization of ferromagnetic nanoparticles and nanoclusters deviates strongly from the Bloch $T^{-3/2}$ law. To describe the deviation one usually uses a modified power law T with a size dependent exponent, which is motivated simply by its flexibility in fitting the observed behavior. By considering the Heisenberg spin model we derive an explicit expression in terms of a magnon gas which generalizes the Bloch formula to a finite size system. Comparison to the experimental data shows a good agreement with the observed behavior and gives a better understanding of its physics.

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***Shell-model versus clustering: volume versus surface effects***

**Abstract**
Medium and heavy nuclei are typical mesoscopic objects. Their finite size leads to the shell structure, as a volume effect, and alpha-clustering as a surface phenomenon. It is shown that the standard shell-model, very successful in describing energy levels and electromagnetic transitions, is not able to describe the alpha-decay width and B(E2) values in alpha-like nuclei as 212-Po. We derive a linear relation between the logarithm of the reduced width and the fragmentation potential, by assuming a pocket-like interaction potential. It turns out that all experimental data concerning alpha, cluster and proton emission satisfy this rule. Based on this result, we show that a surface cluster component in single particle wave functions of the amplitude about 0.3 is able to simultaneously describe the alpha-decay width and intra-band

B(E2) values in 212-Po.

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***Account of d-electron magnetic orbital interactions at describing the transition-metal pair potentials***

**Abstract**
At last years, nanoparticles of pure transition metals immobilized on the dielectric matrixes are widely used in different fields of advanced technologies: as carriers and transmitters of information, as an effective catalytic materials, etc.

Description of the effective pair interaction in the transition metal is a hard task since the d-electron contribution to the potential energy in this case is non-pairwise in principle. There are a number of approximated forms for an effective pair potential in transition metals. We use the Wills-Harrison (WH) approach [1]. Here, the correction to WH model which accounts for the magnetic orbital interaction between d electrons of different atoms is suggested. The dependency of the WH effective pair interaction on the named above correction is studied for pure Fe, Co, and Ni. The Bretonnet-Silbert (BS) local model pseudopotential [2] is used to calculate the nearly-free-electron-theory contribution to the pair potential as it was proposed in [3].

It is found that the larger deviation from the diagonal d-state coupling with respect to the magnet quantum number is, the smaller the depth of the first minima of the pair potential and the softer its repulsive part for all metals under consideration. The effect under study sharply arises in Fe and in less degree in Ni.

This work is supported by the Ural Branch of the Russian Academy of Sciences (project 09-T-3-1012), Federal Agency on Science and Innovations (contract 02.740.11.0641), and RFBR (project 11-03-01029-a).

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***Cooperative nonlinear interaction of squeezed light with the system of two-level radiators***

**Abstract**
In this report it is describe the nonlinear excitation of two cavity modes by stream of inverted ensemble of radiators prepared in the coherent state relatively the dipole forbidden transition.

The coherent excitation of the atomic ensemble is transferred to bimodal cavity field so that the stet of this quantum field can be described in the framework of SU(1,1) algebra for bi-photonic operators. The master equation for such system was obtained in paper [1]. In this reports, taking into account the processes with excitation of four photons in the process of nonlinear interaction between quasi-spin atomic system and bi-boson cavity fields the new Fokker-Plank equation is proposed for the description of quantum processes in the system. The exact steady state solution of this equation is found in order to undusted the emission process which takes place in the cavity.
This description of nonlinear interaction between two subsystems can be regarded in the two limits: a) good cavity limit, which corresponds to the situation when the life time of the photons in the cavity is larger then flaying time of the radiators through the cavity; b) bad cavity limit in which the spontaneous emission tame is larger than lifetime of photons in the cavity. For both situation it is obtained the Fokker-Plank equations and was analyzed the behavior of quantum fluctuation and proprieties of atomic and field distribution. The new type of Fokker-Planck equations was obtained, and exactly solved for stationary case using the coherent states, defined on the Roman surfaces of SU(2) and SU(1,1) symmetry. This problem can be applied for small atomic system like quantum dotes, photonic crystal etc.

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***A new method of construction of mutually unbiased bases for two-qubit systems***

**Abstract**
One of the most important goal in a quantum information experiment is the ability to determine the final state, which was generated by a communication protocol. Suppose that we have an unknown quantum state and our task is to extract as much information as possible by performing any measurement on the state. When the dimension of the Hilbert space is finite, it was proved that the optimal tomography is obtained if a special class of states is used: mutually unbiased bases (MUBs) [1].

The MUBs constitute now a basic ingredient in many applications of quantum information processing: quantum tomography, quantum key distribution required in cryptography [2], discrete Wigner function [3], quantum teleportation [4], quantum error correction codes [5].

MUBs can be constructed using different methods, which depend on the dimension d. Klimov et all. used the finite Fourier transform to obtain muticomplementary operators and then MUBs [6]. This algorithm generates only a special class of MUBs, the one which contains the eigenvectors of tensor products of the Pauli operators X and the identity, or Z and the identity.

Wootters [7] and Gibbons et all. [8] proposed a method to associate the MUBs to the so-called discrete phase space. The phase space of a d-level system (qudit) is a d X d lattice, whose coordinates are elements of the finite Galois field GF(d). Further a state is associated to a line in the discrete phase space. The set of parallel lines is called a striation [7]. It turns

out that the MUBs are determined by the bases associated with each striation.

Here we present a new algorithm for finding MUBs for two-qubit systems. We derive a set of equations in the Galois field and show that the solutions of these equations are sufficient for obtaining any arbitrary table of striation-generating curves in the discrete phase space. Then, to each point of this table we associate an operator and then we build 5 classes of 3 commuting operators, whose eigenvectors represent MUBs.

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***Generalized Master equation approach to mesoscopic time-dependent transport***

**Abstract**
We use a generalized master equation (GME) formalism to describe the non-equilibrium time-dependent transport through a nanometric sample when connected to semi-infinite biased leads. The reduced density matrix of the sample is found by numerically solving the differential GME without resorting to the traditional Markov and rotating wave approximations. Our method captures the sequential tunneling processes, the contact regions between the leads and the sample being controlled by time-dependent switching functions of various shapes. The electron dynamics within the sample, i.e the time dependent population of the many-body states, is related to the currents established in the leads. These degrees of freedom of the sample are related to its size and geometry and to the effects of the Coulomb interaction between electrons. The latter is included in the many-body states of the sample via the so-called "exact diagonalization method". The implemented GME formalism can be used to describe both the initial transient regime immediately after the coupling of the leads to the sample and the evolution towards a steady state achieved in the long time limit.

In this presentation we describe the propagation of electric pulses through a quantum wire sample simulating a turnstile pumping experiment at small electric bias. One lead is fixed to one end of the quantum wire whereas the other lead is connected at various other sites along the wire. The currents in both leads depend on the placement of the second lead. The currents reflect the charge distribution in the sample and the local charge fluctuations at the contacts.

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***Effects of strong correlations on the transmission phase through quantum dots***

**Abstract**
We study the effect of electronic correlations on the zeros of transmission through quantum dots and the related phase lapses observed experimentally. We generalize the embedding model for the calculation of the conductance to be able to address the transmission phase. We combine the embedding method and DMRG calculations to extract the transmission modulus and phase for a simple model of quantum dot with discrete levels coupled to two leads as a function of the gate voltage. The shape of the Fano resonances and the number of phase lapses are both modified by the presence of correlations.

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***Facets of contextual realism in quantum mechanics"***

**Abstract:**
In recent times, there is an upsurge of interest in demonstrating the quantum contextuality. In this proceedings, we explore the two different forms of arguments that have been used for showing the contextual character of quantum mechanics. First line of study concerns the violation of the noncontextual realist models by quantum mechanics where second line of study that is qualitatively distinct from the earlier one, demonstrates the contextuality within the formalism of quantum mechanics. In the former case one requires a realist model that ï¬ˆxes the individual measured values and a noncontextuality condition needs to be imposed on that values. The notion of the property of the noncontextuality of the realist models can be characterized by two features which leads to two diï¬€erent types of inequalities - these inequalities are violated by quantum mechanics. Crucially, as we shall rigorously demonstrate in this proceedings that in the latter case, no realist model is required to be violated for showing the quantum contextuality. Specifically, using the measurements pertaining to a suitable Mach-Zehnder type setup, this quantum mechanical effect of contextuality between the path and the polarization degrees of freedom of a polarized photon can be demonstrated - an effect that holds good for the product as well as the entangled states.

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***Quantum technologies and quantum computing: superconducting quantum bits as simulators of atoms interacting with fields***

**Abstract:**
Recent experimental developments in the field of superconducting electronics have enabled us to access a level of unprecedented control over these systems, at the level of single

quanta. Superconducting qubits fabricated with modern nanolithography techniques behave as artificial atoms: their energy levels can be calculated and measured spectroscopically. When irradiated with pulsed microwaves, these systems exibit typical quantum-optics phenomena, such as Rabi oscillations and Ramsey interference fringes. There has been also significant progress in recent years towards understanding the sources of decoherence in these devices. Therefore, superconducting qubits are excellent candidates for building future quantum computers. In this talk, I will give a brief overview of the progress in the field. Then I will describe our recent experiments on the stationary and dynamical Autler-Townes effect. I will show that, based on the operation of a qubit as a three-level system, it is possible to build devices such as quantum switches, operating with quantum fidelities of the order of 95%. I will then describe the simulation of an NMR effect, motional averaging, that was done recently in our group. I will show that an alternative description of this effect is as Landau-Zener interference with dressed states.

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***Competition of different coupling schemes in atomic nuclei***

**Abstract**
One of the most important and difficult tasks of nuclear physics at present is to explore nuclei far from the stability line, where new phenomena not taken into account by current nuclear models are anticipated. These may change dramatically standard concepts in nuclear physics. In a recent work the low-lying yrast states in self-conjugate N=Z nucleus 92Pd were measured for the first time[1]. Shell model calculations using realistic interactions reveal that a phase transition from normal superfluidity, which is dominated by like-particle isovector pairing (or seniority) coupling, to a novel spin-aligned neutron-proton coupling scheme may have occurred in this nucleus[1,2]. This structure is different from the ones found in the ground and low-lying yrast states of all other even-even nuclei studied so far. The low-lying spectrum of excited states generated by such correlated neutron-proton pairs has two distinctive features: i) the levels are almost equidistant at low energies and ii) the transition probability is approximately constant and strongly selective. This unique mode is shown to replace normal isovector pairing as the dominating coupling scheme in N = Z nuclei approaching the doubly-magic nucleus 100Sn.

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***Statistical ensemble in-equivalence in star matter***

Statistical ensemble in-equivalence is defined as the dependence of the observed physics on the externally applied constraints. From a conceptual point of view, it is a particularly interesting issue as it
prevents the use of standard thermodynamics. From the phenomenological point of view, it is

associated with phase transitions taking place in systems with long-range interactions.

One example corresponds to finite systems where phase separation is trivially quenched by conservation laws, leading to thermodynamical anomalies.

We shall discuss the case of stellar baryonic matter at sub-saturation densities. There, the microscopic dishomogeneities and Coulomb interaction lead to ensemble in-equivalence, making the supernovae matter the first physical example of such a phenomenon at the thermodynamical limit.

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***Cooperative interaction of n radiators with quantum cavity field***

**Abstract:**
An exact analytical approach to study the time evolution of the interaction between a system of N two level atoms with single mode cavity field it is proposed. Supposing that at the initial moment the system of radiators is prepared in a superposition of states [1,2], the wave functions of atom-field interaction for three and four atoms are presented exactly. In the case of the odd number of atoms in the cavity the quantum Rabi frequencies have non zero values, otherwise one zero value of quantum Rabi frequency is characteristic for the even number of atoms.

It was shown that with increasing of the odd number of atoms the nonzero quantum Rabi frequencies increase in the system too. It is established that one atom have one quantum Rabi frequency, three atoms have two frequencies, fife atoms- three. For even numbers of atoms the zero value of eigenstates of radiators in interaction with single cavity mode is observed. In this case the number of collective level in the system is odd and the trapping states of the atoms in the cavity are possible.

From analytic solutions follows that it is possible to realize the micro maser regimes for three atoms choosing the flying time for which the radiators pass totally in the ground state. It is established the dependence of the fling time on the number of atoms and cavity state for which the atomic ensemble comes back to its initial state.

The behavior of quantum fluctuations of photon numbers and atomic inversion during the collective absorption and radiation is exactly analytically and numerically studied.
The exact quantum solutions for these q-bits formed from two-level atoms can be used in quantum processing of information encapsulated in the initial states of atomic ensemble and cavity field.

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***The quantum diffusion approach in reactions with heavy ions at sub-barrier energies***

**Abstract**
With the quantum diffusion approach the behavior of capture cross sections and mean-square angular momenta of captured systems are revealed in the reactions with deformed and spherical nuclei at sub-barrier energies. The calculated results are in a good agreement with existing experimental data. With decreasing bombarding energy under the barrier the external turning point of the nucleus-nucleus potential leaves the region of short-range nuclear interaction and action of friction. Because of this change of the regime of interaction, an unexpected enhancement of the capture cross section is expected at bombarding energies far below the Coulomb barrier. This eï¬€ect is shown its worth in the dependence of mean-square angular momentum of captured system on the bombarding energy. From the comparison of calculated capture cross sections and experimental capture (fusion) cross sections, the importance of quasiï¬ssion near the entrance channel is shown for the actinide-based reactions and reactions with medium-heavy nuclei at sub-barrier energies.

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***BCS-BEC crossover in density imbalanced electron-hole layers***

**Abstract**
We study excitonic condensation in a semiconducting electron-hole bilayer system with unequal layer densities at zero temperature. Using mean-field theory we solve the BCS gap equations numerically and investigate the effects of intra- and inter-layer interactions. We analyze the stability of the Sarma phase with **k**,-**k** pairing by calculating the superfluid mass density and also by checking the compressibility matrix. We find that with bare Coulomb interactions the superfluid density is always positive in the Sarma phase, due to a peculiar momentum structure of the gap function originating from the singular behavior of the Coulomb potential at zero momentum and the presence of a sharp Fermi surface. Introducing a simple model for screening, we find that the superfluid density becomes negative in some regions of the phase diagram, corresponding to an instability towards a Fulde-Ferrel-Larkin-Ovchinnikov (FFLO) type superfluid phase. Thus, intra-layer interaction and screening together can lead to a rich phase diagram in the BCS-BEC crossover regime in electron-hole bilayer systems.

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***An Improved Approach to Polaron Transport in Organic Molecular Crystals***

**Abstract**
Improved results have been obtained on the temperature dependence of transport properties of an extended Holstein molecular crystal model incorporating simultaneous diagonal and off-diagonal exciton-phonon coupling. The Hamiltonian is partially diagonalized by a canonical transformation and the optimal coefficients for the canonical transformation are determined in a self-consistent manner. Calculated transport properties exhibit substantial corrections on those obtained previously by Munn and Silbey for a wide range of temperatures thanks to the numerically exact evaluation and added momentum-dependence of the transformation matrix.

Results of the diffusion coefficient in the moderate and weak coupling regime show distinct band-like and hopping-like transport features as a function of temperature.

## *Posters*

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***Isovector pairing effect on the moments of inertia of proton-rich heated nuclei***

**Abstract**
The perpendicular and parallel moments of inertia [1] are calculated as a function of the temperature by taking account the isovector pairing. The used single-particle energies are those of a deformed Woods-Saxon mean-field. The obtained results are compared to their homologues of the conventional Finite Temperature BCS (FTBCS) theory. With this aim, the generalized gap equations [2,3] have been solved for even-even heated deformed nuclei such as Z=30-38 and N-Z=0, 2, 4. The isovector pairing effect leads to a change in the behavior as well as a non-negligible discrepancy between the perpendicular and parallel moments of inertia values calculated within the two models when $T<T_{cnp}$ ($T_{cnp}$ being the critical temperature beyond which the neutron-proton gap parameter vanishes). Beyond this temperature, a discrepancy between the two models persists. It is due to the shift of the critical temperatures of the proton ($T_{cpp}$) and neutron systems ($T_{cnn}$) when evaluated with and without inclusion of the isovector pairing effect.

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***Extracting additional information from small-angle scattering data for deterministic fractals***

**Abstract**
The scattering intensities from deterministic fractals obey the generalized power low behavior with minima and maxima superimposed on a power law decay. It is shown that the minima and maxima are damped with increasing polydispersity of the fractal sets; however, they remain quite pronounced even at sufficiently large values of polydispersity. We study and analyze the scattering curves in the momentum space. In the fractal region, the curve I(q)qD is found to be approximately log-periodic with the period equal to the scaling factor of fractal; here D and I(q) are the fractal dimension and the scattering intensity, respectively. In particular, the positions of deepest minima and highest maxima are log-periodic, and their number coincides with the number of fractal iterations. The minima and maxima positions are explicitly estimated by relating them to the pair distance distribution in the real space.

Generalized self-similar Vicsek fractal (GSSVF) with controllable fractal dimension is introduced, and its scattering properties are studied to illustrate the above conclusions.

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***Propagation of a laser pulse train under electromagnetically induced transparency conditions***

**Abstract:**
We investigate the spatio-temporal dynamics of short laser pulse train propagating in an absorbing medium under the conditions of electromagnetically induced transparency.

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***Nonlinear effects in the theory of super-radiance and superconductivity***

**Abstract**
In this reports it is proposed the non-linear cooperative interaction between the quasi-spins through the vibration states of thermostat (the large system with big degree of freedom).

As an example is studied the cooperative interaction between the cooper pairs through the non-linear lattice vibration in single and two-phonon exchange processes between the electrons.

The similar problem it is proposed for quasi-spin systems used in the description of super-radiance and ferromagnetism. In the case of super-radiance phase transition of the radiators cooperatively interact between them in two and single photon exchange processes.

It is observed that exchange integral between the quasi-particles (electron, optical dipoles, spins etc.) depends on the temperature. This temperature dependence of exchange integral between the quasi-particles drastically changes the second order diagram as this is demonstrated in paper [1, 2]. Unlike the approach proposed in papers [1, 2], in this report it is takes into account the non-linear vibration of thermostat modes (phonon, optical modes etc.). It is observed that this effect influence the temperature dependence of the order parameter in the second order phase transition like superconductivity, super-radiance, ferromagnetism, etc.

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***Energy transfer between two centers of radiation localized in two cavities connected through evanescent field***

**Abstract**
The energy transfer between two radiators localized in the spherical cavities in interaction through evanescent field is investigated. In the good cavity limits the exact solution of SchrÃ¶dinger equation for this system was obtained. The interesting problem appears, when one atom excitation in one cavity is transferred to second atom from other cavity. The dynamic of this energy transfer was analytically and numerically studied.

The similar problem is studied in the bad cavity limit, when the life time of photons in the cavity is smaller then the decay time of excited atoms. In this case the entanglement state between the atoms was analytically demonstrated. The exact solution of master equation of damped quantum oscillators, describes the behavior of quantum radiators (atoms, quantum dots) in the process of discreet absorption and emission of cavity photons. The quantum description of such systems opens the new possibilities in the processing of quantum information from two optical cavities.

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***Ab initio investigation of point-like defects formation energy and charge transport in AlN nanowires***

**Abstract**
The influence of intrinsic and some extrinsic point-like defects on the charge transport properties of atomic-sized wurtzite AlN wires coupled to Al(111) bulk contacts is investigated at low temperatures using Green-Keldysh formalism.

We find that the conduction of the wide band-gap semiconductor wire is essentially enhanced by the presence of surface states. Point defects related to atoms chemically bound inside the wire are more effective in controlling the charge transport, but their formation energy is higher, as compared to atoms bound on the surface.

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***Nonadiabatic generation of spin currents in a quantum ring with Rashba and Dresselhaus spin-orbit interactions***

**Abstract**
Spin and charge currents are shown to be non-adiabatically induced in a mesoscopic ring endowed with spin-orbit interaction (SOI) under the application of a two-component, spatially asymmetric terahertz laser pulse. The internal phase difference $\phi$ between the laser components is considered a parameter of the problem. The spin-orbit interaction is linear in the electron momentum and consists of a superposition of Rashba (R) and Dresselhaus (D) terms. The equation of motion for the density operator is solved numerically and the solution is used to calculate the time-dependent charge and spin currents as functions of the relative phase of the pulses and of the SOI strength. Our results indicate that the persistent charge current that is established within the ring is essentially independent of the strength of SOI, a foreseeable outcome on account of the spin-symmetric characteristic of the charge response. The interplay between the R and D components of SOI generate some interesting features of the spin response. Since the two SOI interactions rotate by precession the electron spins in opposite directions, when both are present their interference induces a beating pattern of the spin current. This result suggests a nutation of the electron spin between the precession axes.

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***Ab initio vibrational and thermal properties of AlN nanowires under axial stress***

**Abstract**
As a wide band-gap semiconductor, AlN is being considered as a possible candidate for the next generation of chemical sensors and electronic, optoelectronic or field emission nano-devices. Not only are its intrinsic properties appropriate for such uses, but its successful synthetisation into low dimensional structures has already been proven. In this study we obtain the relaxed configuration, phononic dispersions, density of states and lattice thermal transmission coefficient of some selected AlN nanowires with diameters on the order of few nanometers. Such structures experience a dimension-dependent phase transition from their wurtzite configuration with [001] orientation along the nanowire axis to a graphene-like structure with stacked planes along the [001] axis. In our study we have pointed out that this transition can be induced by external stress. The dependence of the thermal properties of such structures with externally applied forces are of practical importance since electronics suffer from tensional or compressional stress caused by either thermal or mechanical fluctuations; nanowires similar to the ones presented here, if contained in these devices (especially if they would be used as bridging elements between microscopic contacts or as nanosensors), would suffer a dramatic change in properties when acted upon by forces in the order of a few nN.

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***Spin current noise and spin conductance through a quantum dot in the Kondo regime***

**Abstract**
We analyze the equilibrium frequency-dependent spin current noise and spin conductance through a quantum dot in the local moment regime. Spin current correlations behave markedly differently from charge correlations. Equilibrium spin correlations are characterized by two universal scaling functions in the absence of an external field: one of them is related to charge correlations, while the other one describes cross-spin correlations. We characterize these functions using a combination of perturbative and non-perturbative methods. We find that at low temperatures spin cross-correlations are suppressed at frequencies below the Kondo scale, TK, and a dynamical spin accumulation resonance is found at the Kondo energy, Ï‰ âˆ¼ TK . At higher temperatures, T > TK , surprising low-frequency anomalies related to overall spin conservation appear in the spin noise and spin conductance, and the Korringa rate is shown to play a distinguished role. The transient spin current response also displays universal and singular properties.

**Belabbas Mohamed**

***The neutron-proton pairing effect on some nuclear statistical quantities in N=Z even-even systems***

**Abstract**
The infuence of the isovector neutron-proton (np) pairing effect on nuclear statistical quantities is studied in N=Z even-even systems. Expressions of the energy,the entropy, and the heat capacity are established using a recently proposed temperature-dependent isovector pairing gap equations. They generalize the conventional finite temperature BCS (FTBCS) ones. The model is first numerically tested using the schematic one-level model. As a second step, realistic cases are considered using the single-particle energies of a deformed Woods-Saxon mean field.

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***Reduction of ballistic spin scattering in a spin-FET using stray electric fields***

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**Abstract**
The practical realization of the spin field effect transistor (spin-FET) suggested by Datta and Das [1] in the 90's was first met with serious challenges concerning the efficient spin injection using metallic ferromagnetic contacts and the attainment of the ballistic regime. Since then, a number of studies, both theoretical and experimental reported significant progress. Recently, the electrical control in a spin-FET using Rashba spin-orbit (SO) coupling was achieved in the

experimental setup of Koo et al. [2]. From the theoretical point of view, some performance limitations were predicted, which are due to the inter-band ballistic scattering and spin interference effects in the large SO coupling regime [3]. The quasi-bound states which appear as a consequence of the Rashba SO coupling, introduce a strongly irregular behaviour of the spin-FET conductance at large Rashba parameter. Moreover, the presence of the bulk inversion asymmetry, i.e. the Dresselhaus SO coupling, may compromise the spin-valve effect even at small values of the Rashba parameter. However, by introducing stray electric fields in addition to the SO couplings, we show that the effect of the SO induced quasi-bound states can be tuned. The oscillations of the spin-resolved conductance become smoother, resulting the possibility to control the spin-FET characteristics. For the calculations we employ a multi-channel scattering formalism, based on the R-matrix method extended to spin transport, in the presence of Rashba and Dresselhaus SO couplings.

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***Exact solution of Weiss transcendental equation of ferromagnetism***

**Abstract**

Weiss equation of ferromagnetism, central to the mean field approach, is solved exactly. The magnetization is expressed as a power series in J/T and H/T, where the exchange integral J characterizes the magnetic interaction between z nearest neighbors in the molecular field approximation, T is the temperature and H is the external field. In this contribution, the authors follow closely the method developed by Siewert and Essing, taking advantage of the possibility of doing cumbersome analytic calculations using Mathematica.

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***Resonance tunneling***

**Abstract**

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***How to distinguish indistinguishable particles and to generate entanglement between them.***

**Abstract**
We distinguish identical particles through their extrinsic physical properties and operationally with an operator of measure selective $M_m$, the permutation operator P and $M_m$ don't commute. In a system of two identical particles $[M_m,P_{12}]\neq 0$. These operators of measures selective $M_m$ are defined as local operators if they act on physical systems of distinguishable particles, but when $M_m$ acting on the Hilbert sub-space of a system with a constant number of indistinguishable particles they can generate entanglement in the system. In a system of 2 particles, an operator $M_m$, that distinguishes particle, doesn't generate entanglement in the system if $M_m P_{12}|\psi\rangle = 0$, for all $|\psi\rangle = (1/\sqrt{2})[|\psi\rangle_{fermion} + |\psi\rangle_{boson}]$. Otherwise when $M_m P_{12}|\psi\rangle \neq 0$, the extrinsic physical properties are not good quantum numbers to distinguish identical particles because they can generate entanglement.

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***Thermal conductance of a two-channel Kondo model***

**Abstract**
A theory of thermal transport in a two-channel Kondo system, such as the one formed by a small quantum dot coupled to two leads and to a larger dot, is formulated. The interplay of the two screening constants allows an exploration of the Fermi liquid and non-Fermi liquid regimes. By using analytical, as well as numerical, renormalization group methods, we study the temperature dependence of the thermal conductance and the Lorentz number. We find that in the low-temperature limit, the Lorentz number attains its universal value, irrespective of the nature of the ground state.

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***Evaluation of the beta decay half-lives with inclusion of the neutron-pr proton***

**Abstract**
The study of the beta transitions (in both forms) is a good probe for the study of nuclear structure. Although the mechanism of the latter is - in principle- well known, their study is still limited due to the various interactions which may occur. Moreover, it is expected that the neutron-proton (np) pairing plays a significant role in this kind of transitions [1]. However, np pairing is often treated within the BCS approach of which the non-conservation of the particle-number is the main drawback [2]. The goal of the present work is thus to study the particle-number fluctuations, which are inherent to the BCS theory, in the isovector case, on the beta decay half-lives. With this aim, we have first established the expressions of the transition probabilities, of Fermi as well as Gamow-Teller types, which strictly conserve the particle-number. They have been numerically calculated for some transitions of isobars such as N=Z.

The obtained results are compared, on the one hand, to values obtained before the projection, and on the other hand by considering only the pairing between like-particles. We have then studied the effect of the deformation (and specially the elongation) of the mother-nucleus on this physical observable.

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***Generation of photon pairs in hyper-Raman Effects and it's connection with transitions symmetries***

We propose the new interaction picture of hyper-Raman process in which two quanta from pumping field are absorbed an other two entangled photons are generated, following the modern experimental description of two photon generation of light observed in paper [1]. We obtained the effective interaction Hamiltonian for this process.

This model Hamiltonian was obtained for 39K atoms used in experiment and contains the operator which describes this process of simultaneously annihilation and creation of photon in hyper-Raman process [1,2]. The symmetry of this Hamiltonian can be reduced to *su(2)* algebra in which the Casmir vector of quasi momentum of two fields is conserved.

The new method of elimination of atomic operators is proposed for the description of the stabilisation process of such quantum generators of coherent entangled photons [3]. The quantum correlations between pump and generation field are established [4]. The relaxation of the system in coherent states of bimodal field is demonstrated using quasi-classical limit. The experimental situation for the observation of such correlations between the pump and emission field in hyper-Raman process is proposed. The possibilities of observation of cross-correlation between the pump field and generation field are analysed. The interesting limit of nonlinear operators belonging to *su(2)* to the linear operators of *su*(1,1) algebra is discussed.

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***Preparing isolated vibrational wave packets by light-induced molecular potentials with chirped laser pulses***

**Abstract**
Quantum control of cold atomic and molecular gases using lasers and magnetic fields is the basis for the new research field of the ultra-cold coherent physics. We investigate the use of chirped laser pulses to prepare specific vibrational wave packets by controlling the tunneling

dynamics in the 0g-(6s,6p3/2) double well potential of Cs2 molecule. Such a possibility to manipulate the population dynamics appears in a pump-dump scheme designed to form cold molecules in a gas of cold cesium atoms by photoassociation of two cesium atoms in the 0g-(6s,6p3/2) electronic state coupled with a3Î£u+ (6s,6s) electronic state. We show that a dump pulse acting on the 0g-(6s,6p3/2) barrier can be used to control the tunneling and to capture population in the inner well in deep vibrational levels out of tunneling resonances.

Controlling the phase or amplitude of the vibrational states composing a wave packet, as well as the isolation and quantification of a vibrational wave packet are research subjects interesting the control of decoherence and the implementation of quantum information processing.