Semiempirična teorija porazdelitve razmikov sosednjih nivojev izza BR režima: Modeliranje efektov tuneliranja in lokalizacije

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Klasična struktura hamiltonskih sistemov se odraža v statistiki energijskega spektra ustreznega Hamiltonovega operatorja. V tem kontekstu je najpomembnejša statistična mera porazdelitev razmikov med sosednjimi energijskimi nivoji, $P(S)$. Če je klasična dinamika sistema regularna, vemo, da je $P(S)$ Poissonova porazdelitev, prav tako vemo, da $P(S)$ ustreza GOE porazdelitvi, če je klasična dinamika sistema popolnoma kaotična. Zelo pomemben je razred mešanih sistemov, v katerih sobivata kaotična in regularna dinamika, za katere pa $P(S)$ ne razumemo najbolje. Radi bi dobili vpogled v problematiko mešanih sistemov preko konstrukcije ustreznega modela naključnih matrik. Posplošili bomo uveljavljeno teorijo Berryja in Robnika (**BR**), ki je točna v striktni semiklasični limiti, in ki jo lahko interpretiramo z dvo-bločnimi naključnimi matrikami, kjer en blok ustreza prostoru regularnih in drugi prostoru kaotičnih lastnih funkcij. Takšna klasifikacija stanj v semiklasični limiti je konsistentna s principom enakomerne semiklasične kondenzacije Wignerjevih funkcij na invariantne objekte v klasičnem faznem prostoru (The principle of uniform semiclassical condensation (PUSC)). Relativna velikost blokov ustreza relativnemu volumnu regularnega, oziroma kaotičnega faznega prostora. V originalni BR teoriji privzamemo za $P(S)$ Poissonovo porazdelitev za regularne nivoje in GOE porazdelitev za kaotične nivoje. V posplošitvi te slike zamenjamo GOE porazdelitev z Brodyjevo porazdelitvijo, s čimer vključimo v model dodaten parameter, ki kvantificira lokalizacijske efekte na kaotični komponenti; GOE v tem primeru ustreza popolnoma razlezenim (delokaliziranim) kaotičnim stanjem. Z naslednjo posplošitvijo kompenziramo klasifikacijo kvantnih stanj na osnovi semiklasične kondenzacije Wignerjevih funkcij (PUSC), s tem, da dopustimo šibko sklopitev dveh prvotno nesklopljenih matričnih blokov. Tako dobimo matrični model z dvema kvantnima parametroma (moč lokalizacije in tuneliranja) in enim klasičnim parametrom (relativna velikost regularnega/kaotičnega faznega prostora). Numerične rezultate primerjamo z uspešnim analitičnim teoretičnim modelom.

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Semiempirical theory of level spacing distribution beyond the BR regime: Modelling the localization and the tunneling effects.

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Classical structure of the Hamiltonian system reflects in the statistical properties of the energy spectrum of the corresponding quantum Hamilton operator. In this context the nearest energy level spacing distribution, $P(S)$, is the most important statistical measure. It is known that if the classical motion of a system is regular, $P(S)$ is the Poisson distribution, on the other hand, if the classical motion of a system is completely chaotic, $P(S)$ equals the statistics of the Gaussian orthogonal ensemble (GOE). There is also a large and very important class of mixed type systems, where regular and chaotic dynamics coexist, for which the properties of the $P(S)$ were understood only in the strict semiclassical limit. We try to get some general insight into this problem by constructing the proper random matrix model. The basic model generalizes the well established semiclassical theory of Berry and Robnik (**BR**), valid in the strict semiclassical limit, where the corresponding random matrix model is a two-block matrix, where one block corresponds to the regular and other one to the chaotic states. Such classification of states appears in the semiclassical limit as a consequence of the principle of uniform semiclassical condensation (PUSC) of Wigner functions of the eigenstates. The ratio between the sizes of the blocks equals the ratio between the phase space volumes occupied by the regular or chaotic orbits. The original assumption for the $P(S)$ of the chaotic and regular part of the spectrum is GOE and Poisson distribution, respectively. Generalization of this picture replaces the GOE distribution with Brody distribution bringing additional parameter which quantifies the effects of the localization of eigenstates on the chaotic part of the phase space. In this generalization GOE distribution corresponds to the limiting case of the totally extended (delocalized) chaotic states. Another generalization compensates the assumption of the validity of PUSC by introducing a weak coupling between the regular and chaotic block, which is interpreted as the tunneling effect. We end up with the random matrix model with two free parameters (localization and tunneling strength) and one fixed parameter (the size of the regular/chaotic phase space volume). We compare the numerical results with the rather successful analytical theoretical model.

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Bipolaron v t-J modelu sklopljen s longitudinalnimi in transferzalnimi kvantnimi mrežnimi nihanji

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Predstavil bom učinkovito numerično metodo za opis stanj ene in dveh vrzeli v antiferomagnetnem ozadju ob prisotnosti mrežnih prostostnih stopenj [1-4]. Metoda je definirana na neskončni mreži in omogoča izračun fizikalnih lastnosti pri poljubnih valovnih vektorjih v termodinamski limiti.
Z omenjeno metodo smo raziskali vpliv različnih polarizacij kvantnih vibracijskih stanj kisika na prostorsko simetrijo magnetnega bipolarona v t-J modelu. Linearna in kvadratna elektronsko fononska (EF) sklopitev na transferzalne vibracijske načine stabilizira $d-$simetrijo. Magnetno ozadje pomembno vpliva na nastanek $d-$simetije bipolarona. Z večanjem linearne elektronsko fononske sklopitve na longitudinalno polarizacijo se simetrija bipolarona spremeni iz $d-$ v $p-$. Pri tem se močno poveča efektivna masa bipolarona, ki postane anizotropna [4].

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Bipolaron in the $t-J$ model coupled to longitudinal or transverse quantum lattice vibrations

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I will present an efficient numerical method for the description of a single and two-hole motion in the antiferromagnetic background in the presence of lattice degrees of freedom. The method is free of finite-size effects and allows calculation of static and dynamic properties at an arbitrary wavevector in the thermodynamic limit [1-4]. Using newly developed method we explore the influence of two different polarizations of quantum oxygen vibrations on the spacial symmetry of the magnetic bipolaron in the context of the $t-J$ model. Linear as well as quadratic electron phonon (EP) coupling to transverse polarization stabilize $d-$wave symmetry. The existence of a magnetic background is essential for the formation of a $d-$wave bipolaron state. With increasing linear EP coupling to longitudinal polarization the symmetry of a d-wave bipolaron state changes to a p-wave. Bipolaron develops a large anisotropic effective mass [4].

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Nonisochronicity of planar Hamiltonian systems with even degree nonlinearities

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Problems of center and isochronicity are important for investigation of qualitative properties for planar verctor fields. Some nice results were obtained in the 1960's and 1970's and at present these problems are once again attracting considerable interest (see [1-7] and reference therein). Recently, much attention has been paid to conditions for isochronicity of the centers of planar polynomial Hamiltonian systems. There is a question given in [5] that "Is there a planar polynomial Hamiltonian system of even degree which has an isochronous center?". We answer a weak version of this question, proving that there is no planar polynomial Hamiltonian system with only even degree nonlinearities having an isochronous center at the origin, and generalize it to some analytical Hamiltonian systems.

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Leptokvarki pri nizkih energijah

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Leptokvarki so delci, ki imajo lastnosti leptonov in kvarkov. Srečamo jih lahko v razširitvah standardnega modela v teorijah poenotenja osnovnih interakcij. Lahko provzročijo prehiter razpad protona. V primeru da so relativno lahki, lahko vplivajo na fiziko kvarkovskih okusov pri nizkih energijah. Sistematično študiramo vpliv leptokvarkov na šibke razpade čarobnih, čudnih, in lahkih mezonov. Pred nekaj meseci so v ameriškem nacionalnem laboratoriju Fermilab opazili, da je v produkciji kvarka top in antitop v trkih proton-antiproton izmerjena asimetrija naprej-nazaj prevelika v primerjavi z napovedjo standardnega modela. Poskušamo razlagati opaženo asimetrijo s pomočjo izmenjave leptokvarkov.

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Leptoquarks phenomenology at the low-energies

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Leptoquarks are particles behaving as quarks and leptons, which arise in the extensions of the standard model like unifying theories of the basic interactions. They might cause a too fast proton decay. In the case that they are relatively light they might influence flavour physics at low energies. We study constraints on the leptoquarks couplings coming from the charm, strange and light nonstrange meson weak decays. Recently in american national Laboratory Fermilab it was observed that in the proton antiproton collisions when top anitop quarks are produced, there is a discrepancy between standard model and experimental value of the forward-backward asymmetry. We explain this asymmetry by assuming leptoquark exchange.

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Fermi acceleration, Suppression of Fermi acceleration and scaling in a two-dimensional non-integrable time-dependent billiard.

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The interest in understanding the dynamics of billiard problems becomes in earlies 1927 when Birkhoff [1] introduced a system to describe the motion of a free particle inside a closed region with which the particle suffers elastic collisions. Inside the billiard, a point particle of mass m moves freely along a straight line until it hits the boundary. After the collision, it is assumed that the particle is specularly reflected. In our work, we revisit the problem of a classical particle bouncing inside a periodically time varying Oval billiard. The problem is described using a four dimensional mapping for the variables velocity of the particle; time immediately after a collision with the moving boundary; the angle that the trajectory of the particle does with the tangent at the position of the hit; and the angular position of the particle along the boundary. Our main goal is to understand and describe the behaviour of the particle's average velocity (and hence its energy) as a function of the number of collisions with the boundary. It was recently shown for a time dependent oval billiard that, in certain cases under the breathing perturbation, the particle does not exhibit unlimited energy growth [2]. As we shall show in our work, the breathing geometry can indeed lead the particle to experience Fermi acceleration. However, the slope of growth is rather smaller as compared to the non breathing case. The small growing exponent for the average velocity was the main reason to conclude that Fermi acceleration was not observed in the breathing case. Our results reinforce the Loskutov-Ryabov-Akinshin (LRA) conjecture [3]. Scaling Properties are also considered. After confirming the existence the mechanism of Fermi acceleration we introduced inelastic collision into the model [4]. We observe that dissipation causes a drastic consequence on the velocity's behaviour. We observed that for short times, the deviation of the average velocity as well as its energy grows according to a power law and suddenly it bends towards a regime of saturation for long enough values of time [5]. It must be emphasized that different values of dissipation generate different behaviours, such kind of behaviours can be usually described using scaling approach. We observed that depending on what kind of dissipation we introduce one can observe different asymptotic behaviors including transients, attracting fixed points and locking, chaotic attractors and even crisis events as the damping coefficients are varied [6].

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Quantum Optics and Quantum Information with Nuclear Spins in Quantum Dots

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Nuclear spins are among the most promising systems to store and manipulate quantum information. However, in quantum dots, they have mainly been seen as a noisy environment for qubits based on the electron spin. Recent advances in the experimental control of electron spins in quantum dots have paved the way towards preparing, measuring and manipulating the nuclear spins in a quantum dot *using* the hyperfine interaction. We study theoretically polarization, measurement and gate operation for nuclear spins in qunatum dots. In particular, we show that certain fundamental model Hamiltonians from quantum optics can be realized in these systems and used to implement effects like superradiance or certain quantum information protocols.

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Quantum Optomechanics & Hybrid Systems

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I shall discuss the current state and prospects of performing quantum optical experiments with opto-mechanical systems, that are systems where a nano- or micromechanical resonator is coupled via radiation pressure to single modes of optical or MW cavity fields. The recently observed regime of strong optomechanical coupling paves the way towards a plethora of quantum optical protocols for quantum state engineering of mesoscopic, mechanical degrees of freedom. I will discuss in particular a protocol for quantum teleportation of states of light onto a mechanical resonator, and possible setups for hybrid approaches interfacing optomechanical systems with single atoms and atomic ensembles. I will conclude with an outlook on the possibilities which will open up in a regime of super-strong optomechanical coupling based on near field gradient forces.

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Mrežni modeli beta celic

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Sladkorna bolezen (tipa 1) je posledica autoimunega uničenja beta celic v Langerhansovih otočkih trebušne slinavke, pri čemer se drastično zmanšanje izločanja inzulina pokaže šele, ko je večina beta celic uničenih. Sklopitev med beta celicami in bogata inervacija otočkov skupaj tvorijo kompleksno mrežo medcelične komunikacije, ki zagotavlja koordinirano izločanje inzulina in je odporna na napake v normalnih pogojih, kar je siceršnja značilnost različnih celičnih procesov, ki pa kažcjo podobno skalno ncodvisno strukturo v mrcžncm opisu, občutljivo na usmcrjene napade na najbolj povezane vozle mreže. Predstavili bomo uporabo prostorsko vpetih kompleksnih mrež za kvantifikacijo vloge citoarhitekture endokrinega tkiva pri napredujočem propadanju beta celic. Pokazali bomo, da se kompleksnost tkiva, izražena kot funkcija korelacije med vozli mreže, hitro manjša ob usmerjenih napadih v heterogenih mrežnih strukturah ter kaže povečano odpornost v bolj homogenih strukturah. To nam lahko pomaga pri nadaljnjem razumevanju mehanizma nastanka in dinamike napredovanja sladkorne bolezni.

Networking beta-cells

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Destruction of pancreatic islet beta-cells by targeted autoimmune attack progressively leads to diabetes, with a rapid onset in the impairment of insulin release only after most of the cells within the islet have already been destroyed. Coupling between beta-cells and rich innervation of islets together form complex cell-to-cell communication network that ensures coordinated insulin release and sustains tolerance to random errors under normal glycemic conditions. Network theory helped uncover the common scale-free structure of different cellular processes in living organisms that is robust against random errors but highly sensitive to targeted attacks on most connected nodes. Here we explore the use of spatial complex networks to quantify the functional role of endocrine pancreatic tissue architecture in the progression of beta-cells destruction towards diabetes. We show that the tissue complexity, expressed as the function of node-node link correlations of the underlying network, decays extremely fast under targeted attacks on beta-cells in islets with heterogeneous network structure, whereas the more homogeneously organized islets displayed increased tolerance to progressive beta-cell death. This may help to understand the onset and the pathogenesis of diabetes and may indicate that the longer survival of the tissue is a result of transition in tissue complexity.

Projekt Belle II

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V prispevku bom najprej obdelal nekaj novejših rezultatov raziskav, ki smo jih s sodelavci opravili na spektrometru Belle. Obravnavali bomo motivacijo za naslednjo generacijo poskusov v fiziki mezonov B in D, ter govorili o novem projektu, ki ga v ta namen pripravljamo na pospeševalniku KEKB.

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The Belle II Project

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The talk will first review some recent highlights of measurements of B meson properties that have been carried out by the Belle collaboration. We will discuss the motivation for a future Super B factory at KEK, as well as the requirements for the detector and for the accelerator. Finally, the present status of the project will be presented together with the plans for the future.

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Computing hadron properties ab initio

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Most of the observable matter in the universe is made out of hadrons, the constituents of the atomic nuclei. The building blocks are quarks and gluons and the quantum field theory describing their interaction is Quantum Chromodynamics (QCD). Among the puzzles that theory should explain, is the problem of confinement, why quarks and gluons are bound to hadrons. Due to fundamental diseases of continuum QCD, the theory has to be regularized and the formulation on a space-time lattice provides such a tool. The lattice approach allows one to solve the high dimensional quantization integrals on large computers. This way we can compute masses and other properties of baryons and mesons. In my talk I plan to give a survey on some of these concepts and results.

Resolving the structure of hadrons

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Presently it represents a big challenge to describe and understand the composite structure of hadrons on the basis of quantum chromodynamics (QCD). Along several distinct methods one attempts to explain the electroweak hadron form factors and the extended structure of the hadron-hadron interaction vertices. I shall discuss the insights that have been gained until now into electromagnetic and axial form factors of the nucleons, the electric radii and magnetic moments of the nucleons and the light as well as strange ground-state hyperons, the axial charges of the nucleon and of nucleon resonances, and finally the microscopic structures of the pion-nucleon as well as pion-Delta interaction vertices. All results stem as direct predictions from the relativistic constituent quark model and will be compared to what is so far known from other effective theories, such as the Dyson-Schwinger approach, and from lattice QCD calculations.

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Vpliv osmotskega tlaka na pakiranje DNK in stabilnost kapside preprostih virusov

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Opisal bom problem pakiranja DNK v kapsidi bakteriofaga. Pokazal bom, da se da ta problem sformulirati v okviru modela nematske nanokapljice. Pogoj za elastično ravnovesje se da zapisati v obliki prvega integrala EL enačb in podaja napetostno ravnovesje v sistemu. Če rešimo ta pogoj za gostoto DNK dobimo enačbo stanja za njeno enkapsidacijo, ki dobro opisuje eksperimentalne rezultate tudi v primeru polivalentnih protiionov. Opisal bom tudi vpliv osmotskega tlaka na prazne kapside in pokazal, da obstaja kritični osmotski tlak, ki destabilizira kapsido in vodi k zapletenemu scenariju razpada kapside.

Effects of osmotic stress on DNA packing and capsid stability in simple viruses

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I will address the problem of DNA packing in the bacteriophage capsid. I will show that it can be formulated in the framework of a liquid crystalline nematic nanodrop model. The elastic equilibrium condition can be written as a first integral of the EL equations and gives the elastic stresses in the system. Solving the first integral for the DNA density field leads to the encapsidation equation of state that compares well with osmotic stress experiments and predicts the ejection characteristics in the presence of polyvalent counterions. I will also discuss the effects of osmotic stress on empty viral capsids and show that there exists a critical value of the osmotic stress that destabilizes the capsid. The rupture scenario is quite complicated but depends on a single dimensionless parameter.

Spinski in toplotni transport v spinskih verigah

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Spinske verige predstavljajo zanimive kvantne sisteme velikega števila delcev, ki so dejansko realizirani v novih materialih. Kljub dolgi zgodovini Heisenbergovega modela ostaja odprtih nekaj bistvenih teoretičnih vprašanj, zlasti v povezavi s transportom pri končnih temperaturah. Eksperimenti v zadnjem obdobju kažejo na izredno dolge proste transportne poti in na močan vpliv nečistoč pri nizkih temperaturah. Podan bo pregled teoretičnega razumevanja transporta v čistih in neurejenih spinskih verigah. Spinska togost pri $T > 0$ bo prikazana v povezavi z integrabilnostjo Heisenbergovega anizotropnega modela. Analiziran bo medsebojni vpliv elektronskih korelacij in slučajne statične neurejenosti v povezavi z možno večdelčno Andersonovo lokalizacijo. Pokazano bo tudi, da ena sama nečistoča spremeni statistiko nivojev in privede do nekoherentnega transporta pri $T > 0$, v nasprotju z obnašanjem fermionov brez interakcije.

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Spin and thermal transport in spin chains

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Spin chains represent interesting quantum many-body systems, well realized in several novel materials. In spite of long history of the prototype Heisenberg model there are several challenging theoretical questions, in particular regarding the finite-temperature transport in such systems. Recent experiments on thermal conduction in such materials reveal very long mean free transport path and impurity dominated transport at low temperatures. The theoretical understanding of transport in clean and disordered spin chains will be reviewed in the talk. Finite $T > 0$ spin stiffness will be discussed in connection with the integrability of the anisotropic Heisenberg model. The interplay of electron correlations and random static disorder will be analysed with respect to possible many-body Anderson localization. It will be also shown that a single static impurity introduced in a such a chain at $T > 0$ leads to a change of level statistics and to an incoherent transport, in contrast to the system of noninteracting fermions.

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Kvantni fazni prehod daleč od ravnovesja

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V predavanju bom orisal splošen pristop k eksplicitnemu računanju *neravnovesnih stacionarnih stanj* in *razpadnih načinov* končnih vendar morda velikih mnogo-delčnih kvantnih sistemov, ki so lahko sklopljeni z okolico (npr. s termičnimi, kemičnimi ali magnetnimi rezervoarji) [1]. S pomočjo koncepta kvantizacije v Liouiville-Fockovem prostoru operatorjev bomo izračunali neravnovesno stacionarno stanje v odprti končni, a dolgi Heisenbergovi XY spinski verigi ($s = 1/2$), ki je zgolj na koncih priključena na dva rezervoarja [2]. Predstavili bomo numerično in teoretično evidenco za obstoj *kvantnega faznega prehoda daleč od ravnovesja* s spontanim nastankom reda dolgega dosega v spin-spin korelacijskih funkcijah, ki ga karakterizira tudi prehod od intenzivne do ekstenzivne operatorske entropije prepletenosti. Na koncu bomo podali preprosta hevristično razlago te nove vrste kvantnega faznega prehoda v duhu teorij povprečnega polja, in opozorili na mnoga preostala zanimiva odprta vprašanja.

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Quantum phase transition far from equilibrium

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In this talk it will bc shown how to addrcss cxplicit computation of *non-cquilibrium steady states* and *decay modes* of finite but large many-body quantum systems which may be coupled to some external reservoirs [1]. Using the concept of quantization in the Liouville-Fock space of operators we shall then compute the non-equilibrium steady state in an open Heisenberg XY spin 1/2 chain of finite but large size coupled to Markovian baths at its ends [2]. We present numerical and theoretical evidence of a *far from equilibrium quantum phase transition* with spontaneous emergence of long-range order in spin-spin correlation functions, characterized by a transition from saturation to linear growth with size of entanglement entropy in operator space. A simple heuristic mean-field description of this new type of quantum phase transition will be given, however many exciting questions still remain open.

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Pristop k reševanju polinomskih sistemov

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Eden od problemov, ki se pogosto pojavi v raziskavah različnih matematičnih modelov v fiziki, tehniki in drugih znanostih je problem reševanja sistema polinomov

$$f_1(x_1, \ldots, x_n) = 0, \ldots, f_m(x_1, \ldots, x_n) = 0. \tag{1}$$

Obravnavali bomo zahtevnost tega problema in predstavili metodo za reševanje sistema (1) z uporabo kongruenc po praštevilu. Ta pristop deluje posebej efektivno v primeru, ko so $f_1, \ldots, f_m$ homogeni ali kvazi-homogeni polinomi.

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An approach to solving systems of polynomials

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One of problems frequently arising in studies of various phenomena in physical, technical and other sciences is the problem of solution of polynomial system

$$f_1(x_1, \ldots, x_n) = 0, \ldots, f_m(x_1, \ldots, x_n) = 0. \qquad 1$$

In this talk we discuss the difficulty of this problem and present a method to solve system (1) using calculations modulo a prime number. The approach works especially efficiently in the case when $f_1, \ldots, f_m$ are homogeneous or quasi-homogeneous polynomials.

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Ogromen elektrokalorični pojav v anorganskih in organskih feroelektričnih materialih

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Elektrokalorični pojav je definiran kot segrevanje ali ohlajanje elektrokaloričnega materiala pri povečanju ali zmanjšanju električnega polja pod adiabatnimi pogoji. Pojav je velikega pomena za aplikacijo v hladilnih in grelnih napravah nove generacije, ki bi bile okolju prijaznejše. Dosedanje napovedi ogromnega elektrokaloričnega pojava v anorganskih in organskih materialih temeljijo izključno na posrednih meritvah električne polarizacije in ne na neposrednih meritvah elektrokaloričnega pojava samega [1, 2]. V našem primeru pa smo ta pojav na omenjenih materialih izmerili neposredno. Dobljeni rezultati so primerljivi z rezultati posrednih meritev. V predavanju bom predstavila elektrokalorični pojav, njegovo uporabnost in pokazala rezultate naših neposrednih meritev.

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Giant electrocaloric effect in inorganic and organic ferroelectric materials

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Electrocaloric effect (ECE) or adiabatic change of temperature is defined as the heating or cooling of electrocaloric material due to the applied electrical field under adiabatic conditions, and it is of great importance for application in cooling or heating devices of new generation, which would be friendlier for environment. Recent predictions of the existence of the giant ECE in inorganic and organic materials are based solely on the indirect measurements of the electric polarization and not on direct measurements of the ECE itself [1, 2]. In our case, this effect was measured directly and the observed magnitude of ECE is consistent with recent predictions. In this lecture ECE and its application will be disscused and a review of recent direct measurements of the ECE in inorganic and organic materials will be given.

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Some Recent Developments in Quantum Oscillator Algebras and Basic Ghost States

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Some recent developments in the area of quantum oscillator algebras are presented. Their filigrane function spaces are looked at in greater detail and particular properties of related complete and incomplete function systems are elucidated.

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Dinamika možganov

ALISON HALE,[1] JANEZ JAMŠEK,[2] BOJAN MUSIZZA,[3] SAMO RIBARIČ[4] IN ANETA STEFANOVSKA[1]

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Predstavili bomo rezultate študije delovanja možganov pri kateri smo uporabili metode nelinearne dinamike in ugotovili značilne razrede deterministične in stohastične dinamike, ki se jasno razlikujejo v budnem stanju in v anesteziji. V budnem stanju pri ljudeh obstajajo interakcije med visokofrekvenčnimi valovi električne aktivnosti možganov (20-80 Hz), medtem ko so valovi na nizkofrekvenčnem področju (0.5-20 Hz) nesklopljeni. Nasprotno, v anesteziji so visokofrekvenčni valovi nepovezani, medtem ko obstaja vzročna povezanost med nizkofrekvenčnimi valovi. Pokazali bomo tudi vpliv različnih anestetikov in razliko v možganski dinamiki pri ljudeh in podganah.

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Brain dynamics

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We study brain functionality using newly developed nonlinear dynamics techniques, thereby revealing distinct classes of deterministic and stochastic dynamics in the brain that differ between the awake state and anaesthesia. In the awake state in humans, interactions exist between the high frequency (20-80 Hz) brainwaves, but not between low frequency (0.5-20 Hz) brainwaves. Conversely in anaesthesia the high frequency brainwaves are disorganised, whereas low frequency brainwaves are interacting. We discuss the effects of different anaesthetics in humans and rats.

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Stationary distributions in reaction kinetics

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The most often used continuous time discrete state stochastic model of chemical reactions is defined in full generality. Next, general evolution equations for the most important quantities (such as absolute probabilities, moments, generating functions) will be given. Then we turn to the detailed investigation of the stationary distribution, and discuss uni- and multimodality and their relevance in applications as e.g. in the theory of chirality or nucleation. It turns out that these properties are closely related to the structure of the state space. In connection with stationary distributions two other important notions also emerge: product form of the distribution and the notion of detailed balance. Finally, we show an interesting application of the results of deterministic reaction kinetics in the theory of stochastic processes enlightening the importance of necessary and sufficient conditions of detailed balance.

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Renesansa magnetometrov z magnetooptičnim senzorjem

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Pare alkalnih kovin, ki jih optično črpamo so izredno občutljive za prisotno magnetno polje in to od statičnega magnetnega polja do polj s frekvenco krog 1 MHz ter so zato potencialno izjemen senzor za merjenje magnetnega polja. Tako so jih uporabili v nekdanji Sovjetski zvezi v prvih satelitih za meritve magnetnih polj v medplanetarnem prostoru. Poznani so prvi poskusi uporabe teh magnetometrov v zgodnjih 70 letih za meritev magnetnega polja, ki spremlja elektrofiziološko aktivnost srca (MKG). Vendar takrat občutljivost magnetometrov s parami alkalnih kovin (MPAK) ni bila primerljiva z občutljivostjo rf SQUID, ki jih je uvedel J.E. Zimmerman. Od tistih začetkov optičnih magnetometrov so oboji MPAK in SQUID magnetometri dosegli nove meje občutljivosti. Danes je njihova občutljivost primerljiva, lahko celo rečemo, da je izračunana teoretična občutljivost kalijevega MPAK boljša. Tak MPAK - pogosto vzamemo kalijeve pare - uporablja trdni uglasljiv diodni laser za vzbujanje K atomov v takoimenovani K celici in drug uglasljiv diodni laser, ki je pravokoten na prvega, da zazna spremembo zasuka polarizacijske ravnine, ki je sorazmerna s prisotno spremembo magnetnega polja. Ravno uglasljivi trdni diodni laserji nam omogočajo, da lahko pomerimo tudi spremenljiva magnetna polja (do frekvence okrog 1 MHz)z izjemno visoko občutljivostjo. Izračuni, simulacije in tudi že eksperimenti kažejo, da lahko pomerimo npr. šibke nizkofrekvenčne dušikove jedrsko kvadrupolne resonančne (NQR) signale bolj uspešno kot s klasično metodo. To so predvsem dušikovi signali, ki pripadajo različnim prepovedanim snovem (narkotiki eksplozivi in podobno).
Načrtali in zgradili smo MPAK s kalijevimi parami in opravili smo že nekaj testnih meritev. Rezultati so pričakovano dobri. Občutljivost našega magnetometra je v področju belega šuma pri okrog 5 fT/SQRT(Hz). Zaznani magnetni signal pri 37 kHz je imel pri amplitudi 100 fT šum od 10 do 20 fT. Pričakujemo, da bomo lahko izboljšali dosežene rezultate za faktor 2 do 4. Potem bomo lahko poskusili z detekcijo šibkih nizkofrekvenčnih dušikovih NQR signalov.

The Renesance of Magnetometers with Magnetooptical Sensors

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Optically pumped alkaline metal vapor offers with its high sensitivity to measured magnetic field in the low frequency range from dc to about 1 MHz a good possibility for magnetic sensor. That was exploited in the early magnetometers used in space research (mainly in the Soviet Union). Also some attempts were made in 70-ties of previous century to detect with these sensors the heart signals (MCG). However, their sensitivity was in those days not comparable to that of the rf SQUID, designed by J. E. Zimmerman. Since these early years of optical magnetometers both, SQUID magnetometer and optically pumped alkaline vapor magnetometer (OPAVM) reached new limits. Today, they are on the way to be of comparable sensitivity. Theoretically, the calculated sensitivity of OPAVM reaches even better result. Atomic vapor (for instance potassium vapor) magnetometer of high sensitivity uses tunable solid state diode laser for the excitation of potassium atoms in the sensing cell and a tunable solid state diode laser to detect the change of polarization plane rotation, which is proportional to alteration in the measured magnetic field. These tunable solid state lasers enabled us to go beyond the measurements of static (dc) magnetic field to extremly sensitive ac magnetic field measurements (up to 1 MHz range). The calculated, simulated and experimental results demonstrate that the atomic vapor magnetometer can be successfully used for the detection of ^{14}N NQR signal belonging to different illicit materials, as well as for magnetoencefalographic (MEG) experiments. We shall report here on our experiments with potassium vapor magnetometer.
We have constructed a potasium OPAVM and currently we are testing the system. The present results are encouraging the sensitivity of our OPAVM is in the white noise region at about 5 fT/SQRT(Hz); the detected test rf magnetic signal at 37 kHz with amplitude of 100 fT had noise of 10-20 fT and we expect an improvement for a factor of 2 or 4 is possible. We will then be able to apply the measuring system to detect the weak low frequency ^{14}N NQR signals.

Labirinti v tankih filmih smektičnega tekočega kristala

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Predstavila bom raziskavo v prostostoječih tankih filmih smektičnega tekočega kristala, v katerem se pri zniževanju temperature površina naguba. Nagubanje površine je periodično in zato se periodično spreminja tudi debelina smektičnega filma. Tako v filmu nastane labirintna struktura [1] hribov in dolin. Nestabilnost v debelini filma se pojavi spontano, pojav je obrnljiv. Labirinte smo opazili tako v tankih kot debelih filmih, širina labirintne poti pa je odvisna od temperature in od debeline filma.
Vzorce smo opazovali z mikroskopom med prekrižanima polarizatorjema in v odbiti svetlobi. Primerjava meritev pokaže, da je debelina filma sklopljena z orientacijo molekul. V področjih, kjer se debelina povečuje ali zmanjšuje, je usmerjenost molekul konstantna, nato pa se na vrhu hriba ali doline zavrti za 180 stopinj.
Smektični tekoči kristali, v katerih smo opazili pojav, so zgrajeni iz dimernih molekul. Z rentgenskim sipanjem smo ugotovili, da molekule tvorijo inerkalirano strukturo, tako da je debelina smektične plasti enaka polovici dolžine dimera. Zaradi tega je gostota plasti na površini manjša kot gostota notranjih plasti. Za molekule je ugodneje, če so bližje skupaj, kar se zgodi pri nagubanju površinske plasti. Prostorsko spreminjanje debeline filma je povezano s tvorbo defektov v notranjosti filma.
S teoretično oceno, ki temelji na kontinuumskem modelu [2] za opis smektičnih tekočih kristalov, lahko pokažemo, da pri določeni temperaturi sistem več pridobi, če zmanjša površinsko energijo in naguba površinsko plast, kot izgubi zaradi nastanka dodatnih defektov v notranjosti filma.
Predlagani mehanizem za nastanek labirintov je splošen, zato predpostavljamo, da je proces možen v vseh sistemih, kjer je gostota ob površini bistveno manjša kot v notranjosti vzorca.

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Labyrinths in free standing smectic liquid crystal films

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I will present a study of thin free standing films made of intercalated smectic liquid crystal in which, upon lowering the temperature, the minimal surface area condition is broken1. A periodic modulation of the film thickness is obtained and a labyrinth structure of crests and valleys [1] is formed. The thickness instability occurs spontaneously at a threshold temperature within the smectic phase. Labyrinths were observed both in thin and thick films. The width of the labyrinthine path depends on the temperature and the thickness of the film.
Comparing the textures observed in the reflected light and the light transmitted between crossed polarisers it is found that the film thickness variation is coupled to the spatial variation of the molecular orientation. In the regions with thickness gradient the molecular orientation is uniform and on the top of the hills or bottom of the valleys it rotates by 180 degrees.
The observed phenomenon is associated to the difference in the mass density at the surface and in the bulk. In the intercalated systems the surface layers are essentially "half empty", so they tend to increase the mass density in the surface layer by tilting it. Tilting can be achieved by the undulation of the whole film (and keeping the film thickness constant) or by the insertion of additional layers close to the surface [2] (and modulate the film thickness) and thus undulate only the layers close to the surface. This leads to the formation of edge defects. Theoretical estimates show that at a certain temperature the system reduces the free energy by enlarging the sloped regions more than it pays for the formation or the elongation of the edge dislocation lines associated with increasing the sloped areas.
The proposed mechanism for labyrinth formation is general and it should be valid for any lamellar phase in which the surface density is lower than in the bulk.
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Aerodinamična optimizacija letalskih površin

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Aerodinamično oblikovanje letal poteka na različnih nivojih kompleksnosti. Prične se z načrtovanjem dvodimenzionalnih krilnih profilov, nato z oblikovanjem posameznih aerodinamičnih površin, kot sta krilo in trup, na koncu pa se ob upoštevanju medsebojnih vplivov komponent analizira in oblikuje celotno letalo. Pri vsakem od teh korakov je mogoče uporabiti optimizacijske metode, s katerimi površine prilagodimo danim zahtevam.
Na primerih bom predstavil nekaj pristopov, ki se na podjetju Pipistrel uporabljajo pri načrtovanju letal. Za potrebe izdelave laminarnih profilov, ki dobro ustrezajo izbranim režimom leta, uporabljamo metodo za dvodimenzionalno optimizacijo oblike krilnega profila. Ta počiva na posebej izbranem funkcionalu tlačne porazdelitve, ki ob minimizaciji daje profile z laminarnim obtekanjem v mejni plasti. Ti profili se nato uporabijo pri optimizaciji kril in propelerjev, ki je zasnovana na izračunu sil in induciranih hitrosti z metodo vzgonske črte. S spreminjanjem dolžine in naklona profilov lahko minimiziramo upor pri željeni vrednosti vzgona. Na koncu bom predstavil še "ročno" optimizacijo oblike stika med krilom in trupom s polno CFD ("Computational Fluid Dynamics", računska dinamika fluidov) simulacijo.

Reference

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Aerodinamic optimisation of aircraft surfaces

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Aerodynamic aircraft design is performed at various levels of complexity. It begins with the design of two-dimensonal wing sections, then by designing individual surfaces such as the wings and the body, and in the end the interactions between various components are taken into account when designing and analysing the whole aircraft. During each of theses steps, optimisation methods may be used that help adapt the various surfaces to the given design demands.
By using examples, I will demonstrate certain approaches that are used during Pipistrel aircraft design. To design laminar wing sections that well fit the required flight parameters, we use a two-dimensional automatic optimisation method. It is based on a specially chosen functional of the pressure distribution that, when minimised, gives wing sections with laminar flow in the boundary layer. These sections are then used in the optimisation of wings and propellers, which is based on the calculation of forces and induced velocities by using the lifting line theory. By varying the chord and angle of attack of the individual sections we can minimize drag at given lift. In the end I will demonstrate the "manual" optimisation of the wing-body junction by using full CFD (Computational Fluid Dynamics) simulations.

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Nova stanja v fononski spektralni funkciji Holsteinovega polarona

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Holsteinov model je eden najpreprostejših modelov v fiziki trdne snovi, ki sklaplja prostostne stopnje nosilcev naboja in atomskih nihanj. Kljub njegovi preprostosti točna rešitev razen limitnih primerov ni znana. S pomočjo različnih analitičnih in numeričnih približkov se dobro razume lastnosti osnovnega stanja modela, torej nastanek polarona [1], medtem ko so lastnosti vzbujenih stanj poznane le delno [2]. Analiza vzbujenih stanj je motivirana z računom fononske spektralne funkcije [3], ki je eksperimentalno merljiva količina. Poleg iz literature znanega pasu enofononskih vzbujenih stanj polarona, kjer je dodatna fononska ekscitacija nevezana, smo z numeričnim računom opazili še tri ločene, dobro skonvergirane vrhove, ki imajo med seboj različne lastnosti. Dve stanji imata disperzijo in ustrezata vezanima stanjema polarona in fonona z energijama nad in pod polaronsko-fononskim kontinuumom, medtem ko je tretje stanje nedisperzivno.

Reference

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[2] O. S. Barišić, *Physical Review B* **73** (2006) 214304-214315.

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Emergence of novel states in the Holstein polaron phonon spectral function

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Holstein model is one of the simplest models in solid state physics, which couples charge carriers and atomic vibrational degrees of freedom. Despite its simplicity, an exact solution of the model aside from some limiting cases is still unknown. Many analytical as well as numerical methods have provided a fair understanding of its ground state properties, i.e., the formation of a polaron [1]. However, the properties of excited states are only partially understood [2]. We gain the insight of the excited states by calculating numerically the phonon spectral function [3], which is in principle an experimentally measurable quantity. Beside the well-known one-phonon excitations of the polaron, where the additional phonon excitation is unbound, we observe three separate, well converged peaks with distinct properties. Two of these three states are coherent and correspond to bonding and antibonding states, while the third state is dispersionless.

References

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Karakterizacije Hilbertovega prostora

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Naslednji rezultat sta dokazala P. Jordan in J. von Neumann [1] (glej posplošitev v [2] in [4]).

Naj bo X realen ali kompleksen normiran prostor. Denimo, da je za vsak par $x, y \in X$ izpolnjeno

$$\| x + y \|^2 + \| x - y \|^2 = 2 \| x \|^2 + 2 \| y \|^2 .$$

V tem primeru obstaja na X skalarni produkt. Norma, ki jo ta skalarni produkt generira, sovpada z dano normo na X.

Rezultat, ki smo ga pravkar zapisali, karakterizira predhilbertov prostor med vsemi normiranimi prostori. Naslednji rezultat karakterizira Hilberov prostor med vsemi normiranimi prostori [3].

Naj bo X realen ali kompleksen normiran prostor in $L(X)$ algebra vseh omejenih linernih operatorjev na X. Denimo, da je na podalgebri $B(X) \subset L(X)$, ki vsebuje vse operatorje s končnodimenzionalno zalogo vrednosti in identični operator I, definirana involucija $A \mapsto A^*$. Denimo, da je za vsak operator $U \in B(X)$ z lastnostjo $U^*U = UU^* = I$ izpolnjeno $\| U \| = 1$. V tem primeru obstaja na X skalarni produkt $(.,.)$, pri čemer velja:
(i) X opremljen s skalarnim produktom $(.,.)$ je Hilbertov prostor.
(ii) Norma, ki jo generira skalarni produkt $(.,.)$ sovpada z dano normo na X.
(iii) Involucija $A \mapsto A^*$ sovpada z adjungiranjem glede na skalarni produkt $(.,.)$.

Reference

[1] P. Jordan, J. von Neumann, *On inner product in linear metric spaces, Ann. Math. (II S.) 36* (1935) 719-723.

[2] S. Kurepa, *The Cauchy functional equation and scalar product in vector spaces, Glasnik matematičko-fizički i astronomski, 19* (1964) 23-35.

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Characterizations of Hilbert space

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The result below was proved by P. Jordan and J. von Neumann [1] (see [2] and [4] for generalizations).

Let X be a real or complex normed space. Suppose that the relation

$$\| x + y \|^2 + \| x - y \|^2 = 2 \| x \|^2 + 2 \| y \|^2$$

holds for all pairs $x, y \in X$. In this case there exists an inner product on X such that the corresponding norm is equal to the given norm.

The result above characterizes pre-Hilbert space among all normed spaces. The next result characterizes Hilbert space among all normed spaces [3].

Let X be a real or complex normed space and let $L(X)$ be the algebra of all bounded linear operators on X. Suppose there exists an involution $A \mapsto A^*$ on a subalgebra $B(X) \subset L(X)$ which contains all bounded linear operators with finite-dimensional range and the identity operator I. Suppose that $\| U \| = 1$ for each operator $U \in B(X)$ with the property $UU^* = U^*U = I$. In this case there exists an inner product $(.,.)$ on X such that the following holds:
(i) X equipped with the inner product $(.,.)$ is a Hilbert space.
(ii) The norm which corresponds to the inner product $(.,.)$ coincides with the given norm on X.
(iii) The involution $A \mapsto A^*$ coincides with the adjoint operation with respect to the inner product $(.,.)$.

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Bright solitons, self-organized structures, and pitchfork bifurcations in dipolar Bose-Einstein condensates

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In condensates of chromium atoms, which possess large dipole moments, two interactions compete with each other, the short-range van der Waals interaction and the long-range dipole-dipole interaction. The experimental possibility of manipulating the s-wave scattering length via Feshbach resonances allows for tuning the relative strengths of the interactions and of studying new phenomena in these condensates in the different regimes. These phenomena include:
1) *The existence of two-dimensional bright solitons in dipolar gases;* by 3d numerical simulations we have pinned down the physical parameters where in a real experiment with chromium condensates such bright solitons could be observed.
2) *The formation of structured "blood-cell-shaped" condensates* close to the stability threshold, associated with a roton instability; by realistic 3d simulations of multilayer stacks of dipolar condensates, in which these effects are enhanced, we have given guidance to experimentalists in which ranges of the condensate parameters there is a chance of detecting signatures of structured ground states and the roton instability.
3) *Complex non-linear collapse dynamics;* applying the method of coupled Gaussian wave packets we have been able to clarify the theoretical nature of the collapse mechanism: On the route to instability the condensate passes through a pitchfork bifurcation, where itself turns unstable while two stable branches are born on forkarms, before it finally vanishes in a tangent bifurcation. Compared to numerical calculations with imaginary time evolution, which only work for stable solutions, Gaussian wave packets are superior in that they are capable of producing both stable and unstable stationary solutions, and thus of giving access to yet unexplored regions of the space of solutions of the Gross-Pitaevskii equation.

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Experiment and the Foundations of Quantum Physics

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In the early days of quantum physics "gedanken experiments" played a crucial role in discussing its conceptional implications. This is exemplified by the debate between Albert Einstein and Niels Bohr. Due to technical progress gedanken experiments have become real experiments beginning around 1970. This includes matter wave interferometry with electrons and neutrons, experiments on entanglement of photons and tests of the linearity of quantum mechanics. Most interestingly and unexpectedly these experiments gave rise to the new field of quantum information science signified by such concepts as quantum cryptography, quantum teleportation and quantum computation. While these ideas promise to replace if not all but certainly significant parts of today's information technology, they also gave rise to new fundamental experiments. In the talk I will review the historical development briefly and then focus on most recent fundamental experiments and address some of the open questions and issues.

Recycling as an Option of Used Nuclear Fuel Management Strategy

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The use of Nuclear Technology for Energy production is expanding worldwide. This is in response to continuous growth of the worlds demand for energy, in particular CO2-free energy. Energy Supply faces the challenges of climate change, public acceptance, limited natural resources, and economic viability. Nuclear Energy provides a more suitable solution than other energy production options because in addition to providing a stable base-load and being CO2-free, Nuclear is a recyclable energy. Back-end policy is one of the major topics that utilities have to face when managing a new nuclear project. What will be done with the used fuel? is a key question, especially in terms of public acceptance. Countries that had previously postponed this topic now have to rethink the best solution for complete sustainable nuclear power.
We will evaluate and propose practical solutions for mid-term issues on Used Nuclear Fuel (UNF) Management for strategies. Different scenarios for UNF management will be presented, where UNF recycling (as MOX, for Mixed Oxied fuel, and ERU, for Enriched Reprocessed Uranium) should be considered.
The feasibility of the Used Nuclear Fuel Recycling in connection with advanced recycling reactors and international initiatives, and the nuclear industry ecosystem dealing with general information such as todays international trends, the Nuclear Renaissance, the worldwide evolution of the Back-End policies will be addresed, as well as how secondary resources, such as recycling of nuclear material, are supporting the Nuclear Renaissance after decades of helping bridge the gap between primary resources and utilities requirements. We will also present the different options available for Used Nuclear Fuel (UNF) management of recyclable fissile and fertile materials contained in used nuclear fuel and describe the implementation of the different scenarios in the Slovenian context.
Recycling spent fuel offers real advantages when compared to direct disposal. Given the current volatility of enriched uranium prices, used fuel is regarded more and more as a complementary and valuable energy resource. Natural resources savings reinforce the economic interest. Final waste management (reduction in volume by 5 and of radiotoxicity by 10 of the final waste) and the highest standards in terms of health, safety, and environmental protection are favourable for back-end policy change world-wide.
Recycling is a flexible solution that takes into account the installed power and nuclear policies of each country. A country owning only one nuclear plant may benefit from recycling just as well as countries with several tens of nuclear plants. Various multinational programs make it possible for a country with limited installed power to take part in a larger world-wide nuclear program dealing with long term resources for future generation reactors as well as final waste disposal.

Reševanje problemov kvantnih nečistoč

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Modeli kvantnih nečistoč se pojavljajo na različnih področjih fizike, denimo kot modeli magnetnih neč istoč v notranjosti kovin in na njihovih površinah, kot modeli kvantnih pik in ostalih nanostruktur, ter kot efektivni modeli v teoriji dinamičnega povprečnega polja (DMFT) za opis močno koreliranih elektronskih sistemov. Predstavil bom nekaj novosti pri reševanju tovrstnih modelov z metodo numerične renormalizacijske grupe (NRG), predvsem nov postopek za diskretizacijo kontinuuma stanj prevodniških elektronov, ki bistevno izboljša konvergenco metode. Pokazal bom, kako lahko z opisanimi izboljšavami dobimo spektralne funkcije z visoko energijsko ločljivostjo, ter pokazal nekaj primerov uporabe na področju fizike močno koreliranih sistemov.

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Solving quantum impurity problems

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Quantum impurity problems appear in different areas of physics, for example as models of magnetic defects inside metal samples or on their surfaces, as models of quantum dots and other nanostructures, or as effective models in the dynamical mean-field theory (DMFT) for describing strongly correlated electron systems. I will present some recent developments in solving such models using the numerical renormalization group (NRG) technique, in particular a new method for the discretization of the continuum of conduction-band electron states which significantly improves the convergence of the method. I will demonstrate how these improvements allow computation of spectral functions with high energy resolution, and I will present some succesful applications in the field of strongly correlated systems.

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Dinamika večdelčnih kvantnih sistemov

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Fizika točno rešljivih integrabilnih sistemov je dobro razumljena. Na drugi strani pa vemo o močno koreliranih sistemih, kjer točna rešitev ni možna, veliko manj. Za takšne sisteme običajni teoretični pristopi odpovejo, tako da se moramo zateči k numeričnim in eksperimentalnim metodam. Kljub temu so v eni dimenziji lastnosti osnovnih stanj znane, predvsem po zaslugi uspešnih preturbacijskih metod in pa tudi učinkovite numerične renormalizacijske grupe. O bolj kompleksnih stanjih kot so osnovna, na primer o ravnovesnih stanjih pri končni temperaturi ali pa celo o neravnovesnih stanjih, pa je znanega veliko manj. Nedavno se je pojavila nova numerična metoda imenovana časovno odvisna renormalizacijska grupa, s katero lahko v nekaterih primerih študiramo veliko večje sisteme, kot je bilo to možno do sedaj. Predstavil bom znane eksperimentalne in teoretične rezultate za 1D kvantne sisteme, ter nekaj novih izsledkov. Med drugim bom omenil transportne lastnosti, ter vlogo integrabilnosti in kaosa pri "izpeljavi" statistične mehanike iz mikroskopskih zakonov.

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Dynamics of one-dimensional many-body quantum systems

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Exactly solvable systems are well understood. Much less in known on the other hand for systems of strongly interacting particles. There, standard theoretical tools usually fail and one has to resort to numerical or experimental studies. Limiting to one-dimensional systems, properties of ground states and states at low temperatures are extensively explored thanks to successfull perturbative methods and to an efficient numerical density renormalization group. However, finite temperature equilibrium properties or even more so non-equilibrium dynamics is rather unexplored. Recently a new numerical method called time-dependent density matrix renormalization group method has been suggested which in some cases enables to study much larger systems. I will review known theoretical and experimental facts about 1D quantum systems and then present some new findings. These will include discussion of transport properties and the role of integrability or chaos in deriving statistical mechanics.

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Rešitev XY spin 1/2 verige s termalnimi rezervoarji

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Rešitev modela odprete XY spin 1/2 verige v Lindbladovem približku enačb gibanja je omogočila odkritje neravnovesnega kvantnega faznega prehoda v spinsko-spinskih korelacijah pri končni temperaturi [1,2]. Pokazal bom, da obstaja neravnovesni kvantni fazni prehod tudi v primeru termalnih rezervoarjev, ki jih v najenostavnejšem modelu opišemo s pomočjo Redfieldove enačbe gibanja. Formalna rešitev obeh modelov (z Lindbladovo in Redfieldovo enačbo gibanja) s pomočjo formalizma tretje kvantizacije (ali kvantizacije v Liouvillovem prostoru operatorjev) je identična. Ravno tako lahko v obeh primerih fazo magnetnih korelacij dolgega dosega okarakteriziramo s hiperobčutljivostjo neravnovesnega stacionarnega stanja na parametre modela. Obravnaval bom različne entropije, energijsko gostoto in lokalni spin, ki prav tako kažejo kritično obnašanje. Zanimivo je tudi obnašanje toplotnega toka, kjer opazimo negativno diferencialno toplotno prevodnost in nemonotono odvisnost toplotnega toka od jakosti sklopitve s termalnimi rezervoarji.

Reference

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[2] T. Prosen and I. Pižorn, *Phys. Rev. Lett.* **101**, 105701 (2008).

Exact solution of thermally driven open XY spin 1/2 chain.

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Using the quantization in the Liouville space of operators (third quantization) to solve the open XY spin 1/2 chain with Lindblad driving, a non-equilibrium phase transition in the spin-spin correlations at finite temperature was discovered [1,2]. However, it was unclear that this transition persists in a more realistic Redfield driving. This is shown as the minimal model of the thermal driving of one-dimensional problems quadratic in majorana fermions and is also exactly solvable using the same formalism of the third quantization. In both cases (of non-thermal local Lindblad as well as of thermal Redfield driving) the phase of long-range magnetic correlations can be characterized by hypersensitivity of the non-equilibrium-steady state to external (bath or bulk) parameters. Various entropies, local energy density and local spin expectation values also reveal possible criticality. Studying the heat transport, we find negative differential thermal conductance for sufficiently strong thermal driving, as well as non-monotonic dependence of the heat current on the strength of the bath coupling.

References

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