CAMTP

Center for Applied Mathematics and Theoretical Physics
Univerza v Mariboru

11. Simpozij fizikov Univerze v Mariboru

Zbornik povzetkov

Hotel Piramida
Maribor, 6., 7. in 8. december 2012

Organizacija simpozija: CAMTP - Center za uporabno matematiko in teoretično fiziko, Univerza v Mariboru

Organizacijski odbor:
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Generalna sponzorja simpozija

PREDGOVOR

Naši Simpoziji fizikov Univerze v Mariboru, ali na kratko kar Božični simpoziji, imajo že tradicijo, saj imamo letos že enajstega po vrsti. Namen je strokovno druženje slovenskih fizikov, ob prisotnosti ter aktivni udeležbi nekaterih uglednih kolegov iz tujine kot častnih vabljenih gostov, pri čemer je srečanje že 2005 preraslo regionalne okvire in je postalo nacionalno srečanje. Letos imamo osem uglednih vabljenih predavateljev iz tujine, iz odličnih raziskovalnih skupin, tako da s tem ostajajo naša srečanja mednarodna. (Srečanje 2010, 9. po vrsti, je bilo izjemoma pretežno mednarodnega značaja, saj je bilo posvečeno Prof. Siegfriedu Grossmannu ob njegovem 80. življenjskem jubileju.) Srečanje je le ena od številnih dejavnosti CAMTP - Centra za uporabno matematiko in teoretično fiziko Univerze v Mariboru, ki sicer organizira kar šest serij mednarodnih znanstvenih srečanj. Glej **www.camtp.uni-mb.si**

Radi bi poudarili, da je naše srečanje posvečeno vsej fiziki, teoretični in eksperimentalni, pa tudi matematični fiziki in uporabni matematiki in vsem drugim temam, za katere je fizika pomembna, ali pa so pomembne za fiziko.

Vsa predavanja so na ravni kolokvijev, se pravi razumljiva za splošnega fizika, in zato še posebej primerna za študente, dodiplomske in podiplomske. Takšnih splošnih srečanj na področju fizike v svetu pravzaprav skorajda ni več, čeprav so po našem prepričanju pomembna za širjenje intelektualnega obzorja vseh fizikov. Kolegi iz tujine, dosedanji udeleženci, potrjujejo to stališče in cenijo naš znanstveni program. Simpozij daje priložnost mladim raziskovalcem, da predstavijo svoje delo ter se o svojih rezultatih pogovorijo z izkušenimi znanstveniki. S to dejavnostjo prispevamo tudi k popularizaciji fizike v naši družbi, na trajen način. Menimo, da je nujno poskrbeti za večjo popularizacijo naravoslovnih ved v naši družbi, in fizika igra pri tem ključno vlogo. Vsem dodiplomskim študentom dovoljujemo brezplačno udeležbo na vseh predavanjih, in s tem prispevamo k popularizaciji fizike ter k dodatnemu izobraževanju na tem področju.

Nenazadnje bi radi poudarili, da je naše druženje lahko pomemben prispevek pri nadaljnjih uspešnih aktivnostih mlade in uspešne Fakultete za naravoslovje in matematiko, ki jo vodi gospa Dekanica Prof.Dr. Nataša Vaupotič.

ORGANIZATORJA:
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FOREWORD

Our Symposia of Physicists at the University of Maribor, or shortly Christmas Symposia, already have a tradition, as this year it is already the 11th one. The purpose is the scientific socializing of Slovenian physicists along with the participation of some distinguished colleagues from abroad as our honorary guests. The Symposium in 2005 has already grown large by exceeding the regional boundaries and became a national meeting. This year we have eight invited speakers from abroad, from some best research groups, so that our meetings remain international. (The 9th Symposium 2010 was predominantly international, as it was dedicated to Professor Siegfried Grossmann on occasion of his 80th birthday.) The meeting is only one of the many activities of CAMTP, Center for Applied Mathematics and Theoretical Physics of the University of Maribor, which organizes six series of international scientific meetings. See **www.camtp.uni-mb.si**

We would like to stress that our meeting is devoted to the entire physics, theoretical and experimental, and also applied mathematics and to all other topics, for which physics is important, or they are important for physics.

All lectures are on the level of colloquia, thus understandable for a general physicist, and therefore particularly well suited for students, the undergraduate and graduate students. Such general meetings in the field of physics practically no longer exist in the world, although to our opinion they are important for the widening of the intellectual horizon of all physicists. Our colleagues from abroad, the participants so far, confirm our view and appreciate our scientific programme. The meeting is also an opportunity for the young researchers to present their work and discuss it with the experienced scientists. With this activity we also contribute to the promotion and the popularization of physics in our society. We are convinced that it is quite urgent to care about the more intense popularization of natural sciences in our society, and physics plays a key role in this context. All undergraduate students are welcome and can attend all the lectures of the conference free of charge. In this way we contribute to the popularization of physics and to the additional education in this field.

At the end we would like to stress that our gatherings can be an important contribution to the activities of the young and successful Faculty of natural sciences and mathematics of the University of Maribor under the leadership of the Dean Mrs. Prof. Dr. Nataša Vaupotič.

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Urnik 11. Simpozija fizikov Univerze v Mariboru

Četrtek, 6. december 2012	
Chair	Robnik
09:00-09:45	Prosen
09:45-10:30	Stöckmann
10:30-11:00	Manos
11:00-11:30	Coffee & Tea
11:30-12:15	Bonča
12:15-13:00	Fajfer
13:00-13:15	Zidanšek
13:15-15:00	Lunch
Chair	Bonča
15:00-15:45	Rotter
15:45-16:15	Žagar
16:15-16:45	Coffee & Tea
16:45-17:15	Stević
17:15-17:45	Čepič
17:45-18:15	Fregolente
18:15-18:45	Ferčec
19:30-20:30	Concert
20:30-22:30	Conference Dinner

Petek, 7. december 2012	
Chair	Prosen
09:00-09:45	Tsironis
09:45-10:30	Robnik
10:30-11:00	Batistić
11:00-11:30	Coffee & Tea
11:30-12:15	Schmelcher
12:15-13:00	Shudo
13:00-13:30	Repovš
13:30-15:00	Lunch
Chair	Korošak
15:00-15:45	Slak Rupnik
15:45-16:15	Marhl
16:15-16:45	Coffee & Tea
16:45-17:15	Fajmut
17:15-17:45	Gosak
17:45-18:15	Stožer
18:15-18:45	Svenšek
19:30-20:30	Concert
20:30-22:30	Conference Dinner

Sobota, 8. december 2012	
Chair	Tsironis
09:00-09:30	Vaupotič
09:30-09:45	Gornik
09:45-10:15	Rosina
10:15-10:45	Suslov
10:45-11:15	Ruffing
11:15-11:45	Coffee & Tea
11:45-12:15	Pažanin
12:15-12:45	Skačej
12:45-13:15	Trontelj
13:15-15:00	Lunch
Chair	Stöckmann
15:00-15:30	Prelovšek
15:30-16:00	Grozdanov
16:00-16:30	Rožič
16:30-16:40	Closing
16:40-20:30	Free time
20:30-24:00	Last Dinner

Naraščanje energije v časovno odvisnih biljardnih sistemih

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Energija časovno odvisnih sistemov se ne ohranja. Zanima nas pod kakšnimi splošnimi pogoji lahko energija časovno odvisnega sistema neomejeno narašča.

Časovno odvisni biljardi služijo kot preprosti modeli splošnejših časovno odvisnih sitemov, ki so zelo prikladni za numerično računanje. Numerični računi s časovno odvisnimi biljardi v splošnem kažejo, da povprečna hitrost ansambla, po velikem številu trkov, sledi potenčnemu zakonu $v \propto n^{\beta}$, kjer je n število trkov. Vrednost parametra β varira na intervalu med 0 in 1 in je odvisna od dinamičnih lastnosti *zamrznjenega* biljarda in od načina dihanja. V primeru popolnoma kaotičnih biljardov vidimo, da lahko ima β zgolj eno od treh vrednosti $\beta = 1/6,\ 1/4,\ 1/2$ [1,2], medtem ko je v sistemih mešanega tipa slika precej bolj zapletena [3,4].

Reference

[1] B. Batistić and M. Robnik, *J. Phys. A: Math. Theor.* **44** (2011), 365101

[2] B. Batistić and M. Robnik, in 8th International Summer School/Conference "Let's Face Chaos through Nonlinear Dynaimcs", Eds. M. Robnik and V. Romanovski, *AIP conf. proc.* **1469** (2012), 27

[3] F.Lenz, F. K. Diakonos and P. Schmelcher, *PRL* **100** (2008), 014103

[4] E. D. Leonel, D. F. M. Oliveira and A. Loskutov, *Chaos* **19** (2009), 033142

The energy growth in time-dependent billiard systems

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Energy of a time-dependent system is not conserved. The question is under which general conditions the energy of a time-dependent system grows infinitely.

Time-dependent billiards serve as simple models of general time-dependent systems, which are very suitable for numerical computations. Numerical calculations with time-dependent billiards in general show that the average velocity v of an ensemble, after a large number of collisions, follows the power law $v \propto n^{\beta}$, where n denotes the number of collisions. The value of the acceleration exponent β is restricted to the interval between 0 and 1 and depends on the dynamical properties of the *frozen* billiard as well as on the driving law. In the case of the fully chaotic time-dependent billiards the exponent β can be only one of three values 1/6, 1/4, 1/2 [1,2]. However, for the mixed type systems the picture is far more complicated [3,4].

References

[1] B. Batistić and M. Robnik, *J. Phys. A: Math. Theor.* **44** (2011), 365101

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[4] E. D. Leonel, D. F. M. Oliveira and A. Loskutov, *Chaos* **19** (2009), 033142

Neravnovesna dinamika več-delčnih sistemov

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Predstavil bom fundamentalno študijo ene in dveh vrzeli v t-J-Holsteinovem modelu pod vplivom zunanjega električnega polja. Ob upoštevanju kvantno mehanske narave problema sledimo časovnemu razvoju sistema začenši z osnovnim stanjem ko vključimo električno polje ob času nič ter vse do stacionarnega stanja. V primeru ene vrzeli opazimo adiabatski režim, kateremu sledi režim linearne $I-V$ karakteristike pri vmesnih električnih poljih [1,2]. Pri visokih poljih se sistem nahaja v režimu negativne diferencialne upornosti. Vezan par vrzeli (bipolaron) pod vplivom električnega polja razpade na dva neodvisna spinska polarona [3]. Odkrili smo različna univerzalna obnašanja sistema pri majhnih ter velikih časih merjenih od vključitve zunanjega električnega polja. Raziskal bom tudi relaksacijo s kratkim električnim pulzom vzbujenega Hoslteinovega polarona [4].

References

[1] M. Mierzejewski, L. Vidmar, J. Bonča, and P. Prelovšek, *Phys. Rev. Lett.* **106** 196401, (2011).

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[3] J. Bonča, M. Mierzejewski, and L. Vidmar, *Phys. Rev. Lett.* **109** 156404, (2012).

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Nonequilibrium dynamics of many-body systems

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I will present a fundamental study of one and two holes in the two dimensional t-J-Holstein model driven by the electric field. Taking fully into account quantum effects we follow the time-evolution of systems from their ground state as the electric field is switched on at $t = 0$, until they reach a steady state. In the single hole case adiabatic regime is observed followed by the positive differential resistivity at moderate fields where carrier mobility is determined [1,2]. At large field the system enters negative differential resistivity regime where current remains finite, proportional to $1/F$. I will also discuss the dissociation of a bound hole pair (bipolaron) under the influence of the external electric field [3]. Different universal behaviors are observed at short as well as long times after switching on the electric field. I will also present relaxation dynamics of a Holstein polaron after the excitation by a short electric pulse [4].

References

[1] M. Mierzejewski, L. Vidmar, J. Bonča, and P. Prelovšek, *Phys. Rev. Lett.* **106** 196401, (2011).

[2] L. Vidmar, J. Bonča, T. Tohyama, and S. Maekawa, *Phys. Rev. Lett.* **107** 246404, (2011).

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Kompleksne faze v plastno urejenih tekočih kristalih

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Tekoči kristali so snovi, ki imajo med trdno in tekočo fazo še vsaj eno fazo z lastnostmi kristalov in tekočin hkrati. Strukture tekoče kristalnih faz so kompleksne, saj se moduliranost orientacijskega reda lahko prepleta s kompleksnimi pozicijskimi redi. Prispevek je omejen na tekoče kristale, ki tvorijo plastne strukture. Opisala bom strukture nekaterih kompleksnih faz in predstavila njihov zvezni teoretični opis. Zvezni teoretični model ne more razložiti vzrokov za nastanek vseh faz. Diskretizacija zveznega modela pa ta problem razreši. V diskretnem modelu se interakcije med molekulami delijo na interakcije med molekulami v plasti in med molekulami različnih plasti. Kadar imajo interakcije med različnimi plastmi nasprotujoče si učinke, postanejo stabilne faze s kompleksnimi strukturami, katerih periode se lahko raztezajo preko mnogih plasti. V okviru diskretnega modela je bilo mogoče napovedati strukture nekaterih faz, ki so bile kasneje tudi eksperimentalno potrjene.

Reference

[1] H. Takezoe, E. Gorecka, M. Čepič, *Reviews of Modern Physics* **82** (2010) 897-937.

Complex phases in smectic liquid crystals

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Liquid crystals are materials that possess at least one additional phase between the solid crystalline phase and the liquid phase. This phase has properties of crystals and liquids at the same time. Structures of liquid crystalline phases are complex as a modulated orientational order of elongated molecules may intertwine with complex positional molecular order. The contribution is limited to liquid crystals, which form layered structures. Structures of several complex phases is described and the continuum theoretical model, which allows for description of these phases is presented. Unfortunately, the continuous model does not allow for structures of all observed phases. Discretization of continuous model has separated interactions to intralayer interactions i.e. to interactions between molecules within the layer, and to interlayer interactions i.e. to interactions between molecules, which are positioned in different layers. When interactions between different layers are competing, the phases with periods extending over more layers, are stabilized. This new approach has led to the prediction of new structures, which were later experimentally confirmed.

References

[1] H. Takezoe, E. Gorecka, M. Čepič, *Reviews of Modern Physics* **82** (2010) 897-937.

Higgs-ov bozon in iskanje fizike izven Standardnega modela

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Nedavno otkritje delca z maso 125 GeV, ki ima lastnosti Higgsovega delca na pospeševalniku LHC, v poskusih CMS in ATLAS, je eden od izjemno pomembnih dogodkov na področju fizike osnovnih delcev. Razložila bom vlogo Higgsovega delca v Standardnemu modelu, ter diskutirala možnosti vplivov fizike izven Standardnega modela na fiziko Higgsovega delca. Pri razpadu Higgsovega delca v dva gamma opaženo je odstopanje od napovedi Standardnega modela. Obstaja veliko predlogov za razlago odstopanja. Barvni skalarni delci so eni od možnih kandidatov. Eksperimentalni rezultati omejujejo sklopitveno konstanto teh delcev z Higgsovim, ter masa barvnih skalarjev mora biti nižja od 300 GeV. Takšna stanja so lahko prisotna v razširitvah Standardnega modela, kot so modeli poenotenja osnovnih interakcij.

Reference

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[2] I. Doršner, S. Fajfer and N. Košnik, *Phys. Rev. D* **86** (2012) 015013.

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[4] I. Doršner, S. Fajfer, J. F. Kamenik, N. Košnik, *Phys. Rev. D* **81** (2010) 055009.

Higgs boson and search for physics beyond Standard Model

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Recent discovery of a particle with the mass 125 GeV, having properties of the Higgs boson at LHC, the ATLAS and CMS experiments, is extremely important for particle physics community. I shall consider role of the Higgs boson within Standard Model and I plan to discuss possibilities of presence of Physics Behind SM in Higgs boson physics. In particular, the impact of colored scalars that can couple directly to matter fields on the recently measured H to gamma gamma excess is considered. Among all possible candidates only some colored scalar states can individually accommodate the excess and remain in agreement with all available data. Current experimental constraints require such colored states to have an order one coupling to the Standard Model Higgs and a mass below 300 GeV. These states can appear in some of extensions of the Standard Model with primary focus on scenarios of matter unification.

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Aspirinsko inducirana astma: modeliranje in simulacije zdravljenja

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Aspirinsko inducirana astma (AIA) se kaže pri pribl. 10% astmatikov po zaužitju nesteroidnega antirevmatika (NSAR), kot je npr. aspirin. Klinični znaki AIA so posledica napak v produkciji eikozanoidov levkotrienov in prostaglandinov v vnetnih celicah. V teh celicah izražena encima ciklooksigenaza 1 in 2 sta tarči NSAR. Nedavno je bilo pokazano, da obstaja močna zveza med pojavom aspirinsko inducirane astme in ekspresijo teh dveh encimov in encima sintaze levkotriena C4 v vnetnih celicah. V predstavitvi bom predstavil študij, ki na podlagi celostnega matematično-fizikalnega modeliranja in računalniških simulacij produkcije eikozanoidov v vnetnih celicah ob delovanju in odsotnosti NSAR povezuje različne klinične in neklinične eksperimentalne ugotovitve. Pristop k modeliranju tega biološkega sistema je nivojski, saj informacije črpa iz ekspresije genov za posamezne encime, molekularnih interakcij, farmakokinetike zdravil in njihovega vpliva v celici in vse povezuje v smislu napovedi učinkov na ravni organa. Model omogoča simulacijo delovanja različnih zdravil na molekularnem nivoju tako NSAR kot tistih za lajšanje kliničnih znakov astme, hkrati pa omogoča teoretično simulacijo varnega doziranja NSAR pacientom z AIA, s čimer ima model pomemben potencial za aplikacijo v klinični praksi.

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Aspirin induced asthma: modelling and simulations of treatment

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Aspirin induced asthma (AIA) is manifested in app. 10% of asthmatics after ingestion of non-steroidal anti-inflammatory drugs (NSAIDs). Clinical signs of AIA are the consequence of imparted production of eicosanoids leukotrienes and prostaglandins in inflammatory cells. In these cells enzymes cyclooxygenase 1 and 2 are the targets of NSAIDs. It has been recently shown that there exist a strong relationship between the occurrence of aspirin-induced asthma and the expressions of these two enzymes as well as of the enzyme leukotriene C4 synthase in inflammatory cells. In my talk I shall present our study that links various experimental approaches with mathematical modelling and computer simulations of eicosanoids production in inflammatory cells in the presence or absence of different NSAIDs. The modelling approach is systems biology approach in which the knowledge of enzyme gene expressions, molecular interactions, pharmacokinetics of drugs and their action on the molecular level as well as implications on the organ level are integrated. The model enables simulations of different NSAIDs as well as other drugs used in treatment of asthma acting on the molecular level. A computer simulation of a strategy for safe NSAIDs administration to aspirin-intolerant asthmatic patients is also proposed and evaluated in terms of clinical applicability.

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Izohronost centrov na centralnih mnogoterostih

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Singularna točka dvo-dimenzionalnega avtonomnega sistema navadnih diferencialnih enačb se imenuje center, če je njena okolica v celoti napolnjena z zaprtimi trajektorijami. Če se za nek sistem da ugotoviti, da ima center, se pojavi vprašanje, ali je center izohron, t.j. če imajo vse oscilacije enako periodo. Obravnavamo družino tri-dimenzionalnih sistemov s centralno mnogoterostjo napolnjeno z zaprtimi trajektorijami , t.j. sistem ima center na centralni mnogoterosti. Podamo kriterije za koeficiente sistema za razločevanje med primeri izohronih in primeri neizohronih oscilacij na centralni mnogoterosti.

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Isochronicity of centers on center manifolds

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A singular point of a two-dimensional autonomous system of ODEs is called a center if it has a neighborhood wholly filled with closed trajectories. If for some system it is possible to determine that it has a center, then it appears the question whether the center is isochronous, that is, whether all oscillations have the same period. We study a family of three dimensional systems with center manifolds filled with closed trajectories, that is, the systems have center on center manifolds. We give criteria on the coefficients of the system to distinguish between the cases of isochronous and non-isochronous oscillations on the center manifolds.

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Dinamične lastnosti disipativnega Fermi-Ulamovega modela

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Enrico Fermi je z namenom, da bi pojasnil visoke energije kozmičnih delcev, predlagal preprost model, kjer se nabiti delci pospešujejo s pomočjo močnih časovno odvisnih magnetnih polj [1]. Najbolj raziskana verzija modela je preprost Fermi-Ulamov model (FUM). V tem modelu se klasični delec giblje med, in elastično odbija od, dveh navpičnih sten. Ena od sten miruje med tem ko se druga periodično premika. Model lahko enostavno posplošimo na bolj kompleksne časovno odvisne sisteme. V faznem prostoru, ki je mešanega tipa, vidimo kaotično komponento znotraj katere so regularni KAM otoki in invariantne krivulje, ki omejujejo naraščanje energije. S pomočjo invariantnih krivulj lahko pojasnimo skalirne zveze, ki veljejo za povprečno hitrost in varianco hitrosti v kaotičnem nizko energijskem območju. Če v tem modelu predpostavim neelastične trke, omenjeno mešano strukturo faznega prostora nadomestijo atraktorji. Odvisno od začetnih pogojev in kontrolnih parametrov lahko vidimo kaotični atraktor, ki ga karakterizira pozitiven Lyapunov eksponent. Z ustreznim spreminjanjem kontrolnega parametra lahko uničimo kaotični atraktor zaradi krize roba, nakar se atraktor spremeni v kaotični tranzient. S hkratnim spreminjanjem parametra disipacije in parametra, ki omogoča prehod iz integrabilnosti v neintegrabilnost in s pomočjo Lyapunovih eksponentov za klasifikacijo območij s kaotično in regularno dinamiko, študiramo strukturo parametričnega prostora [2].

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Some dynamical properties of a dissipative Fermi-Ulam model

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As an attempt to describe the high energy cosmic rays, Enrico Fermi [1] proposed a very simple model. In his original formalism, he argued that a charged particle could be accelerated by intense time-dependent magnetic fields. One of the most studied versions of the problem is the well known Fermi-Ulam model (FUM). The simplicity of this model is such that it allows immediate generalizations for more complex time-dependent Hamiltonian systems. The model is described as being a classical particle confined between and bouncing two rigid walls, in which one of them is fixed and the other one moves periodically in time. In the non-dissipative version of the problem, all the collisions with the two walls are assumed to be elastic. The phase space presents mixed structure in the sense that, depending on the combinations of control parameters and initial conditions, both invariant spanning curves, chaotic seas and Kolmogorov-Arnold-Moser (KAM) islands are all observed. It is worth to emphasize that the presence of the invariant spanning curves limit the energy gain of the bouncing particle in the chaotic sea. It also implies that the chaotic low energy region might be described using a scaling function for both the average velocity as well as the variance of the average velocity. On the other hand, the introduction of inelastic collisions on this model is enough to destroy such a mixed structure and the system exhibits attractors. Depending on the initial conditions and control parameters, one can observe a chaotic attractor characterized by a positive Lyapunov exponent. By a suitable control parameter variation, the chaotic attractor might be destroyed via a crisis event. After the destruction, the chaotic attractor is replaced by a chaotic transient. Additionally, by changing simultaneously the dissipation parameter and the parameter which controls the transition from integrability to non-integrability and by using the Lyapunov exponents in order to classify regions with chaotic and regular behaviour we have also studied the structure of the parameter-space [2].

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Teoretično obravnavanje frekvence faznega načina nihanja molekul z ukrivljeno sredico v smektični A fazi za tanke celice

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Leta 2011 so odkrili tekočekristalne materiale, ki tvorijo feroelektrične plastne strukture, v katerih molekule v povprečju niso nagnjene na smektično plast. Tako imenovano ortogonalno feroelektrično smektično tekočekristalno fazo $SmAP_F$ so opazili v tekočih kristalih, ki jih tvorijo nesimetrične molekule z ukrivljeno sredico, ki imajo v repu vgrajene silicijeve atome [1]. Ortogonalna feroelektrična smektična teko čekristalna faza je feroelektrični material z najvišjo do sedaj opaženo simetrijo. V prispevku podrobno predstavimo teoretično obravnavo prostorske ureditve molekul v celici ter odziv molekul na zunanje polje. Predvsem nas zanima razlaga nepričakovanega dielektričnega odziva v statičnem zunanjem električnem polju. Z naraščujočim zunanjim poljem se namreč frekvenca faznega načina nihanja zmanjšuje.

Sistem opišemo s prosto energijo, ki vsebuje energijski prispevek zaradi prostorskih deformacij v smeri ureditve molekul, električne energije zaradi spontane polarizacije ter električne energije v zunanjem polju. V $SmAP_F$ so dolge osi molekul poravnane v smeri pravokotno na smektične plasti, ki jih tvorijo molekule. Smer kratke osi molekule je pravokotno glede na dolgo os in kaže v smeri ukrivljenosti molekule. Hkrati kratka os določa tudi smer lokalne polarizacije, ki se s krajem lahko spreminja. Za naš primer je ključna kombinacija med pahljačasto in upogibno deformacijo povprečne smeri kratkih osi. V izmeničnem zunanjem polju na tekoči kristal delujemo na dva načina: zanihamo smer kratke osi molekul (fazni na v cin nihanja) in lokalno večamo in manjšamo stopnjo urejenosti elektri v cnih dipolov ter s tem velikost lokalne polarizacije (amplitudni način nihanja). V kolikor je elastična konstanta za upogibno deformacijo veliko manjša od elastične konstante za pahljačasto deformacijo (značilnost tekočih kristalov iz molekul z ukrivljeno sredico), s teoretičnim modelom napovemo manjšanje frekvence faznega načina nihanja z večanjem stacionarnega zunanjega polja, če pa sta vrednosti primerljivi (zna v cilnost tekočih kristalov iz paličastih molekul), se frekvenca povečuje.

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Theoretical study of the dielectric response in thin cells of ferroelectric Smectic A phase made of bent-core liquid crystals

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The orthogonal ferroelectric Smectic-A phase ($SmAP_F$) made of asymmetric bent-core molecules with a carbosilane terminal group was recently discovered [1]. This phase presents the highest symmetry layered ferroelectric possible and the highest symmetry ferroelectric material found to date. In this contribution we present theoretical modelling of the structure and response of the $SmAP_F$ phase in the confined geometry and focus especially on the unexpected dielectric response observed under the DC bias electric field: phase mode frequency decreases if external bias field increases.

The system is described by the free energy density which contains the elastic and electrostatic contribution. The electrostatic part describes polarization self-interaction and coupling of polarization with the static external bias electric field. The elastic contribution describes the splay and bend deformation in the direction of molecular orientation. To present an average orientation of the bent-core molecules in a small volume we define long molecular axes which are on average perpendicular to smectic layers and short molecular axes which are perpendicular to the long axes and point into the direction of the molecular bend. The average local direction of the short axes is also the direction of the local polarization. An external AC electric field has two effects on liquid crystal molecules: it oscillates the direction of the short molecular axes (phase mode) and the order of molecular alignment, thus oscillating the magnitude of polarization (amplitude mode). If the bend elastic constant is much smaller than the splay elastic constant (the case of bent-core molecules) then the theoretical modelling predicts the reduction of the phase mode frequency with increasing external bias DC field. If the values of both elastic constants are comparable (the case of rod-like molecules) then the phase mode frequency increases with increasing bias field.

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Modeliranje sezonskih prilagoditev cirkadianih ritmov z modifikacijami strukture mednevronskih povezav v suprakiazmatičnem jedru

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Cirkadiani ritmi regulirajo časovno koordinacijo notranjih bioloških procesov, ki uravnavajo dnevne fiziološke ritme in vedenje številnih različnih organizmov. Pri sesalcih se 24-urni ritem uravnava v suprakiazmatičnem jedru (SCN) v hipotalamusu, ki ima funkcijo cirkaidnega vzpodbujevalnika. SCN sestavljajo med seboj povezani nevroni, katerih električno aktivnost in sinhronizacijo z 24-urnim ciklom uravnava izmenjavanje dneva in noči. Poleg tem vsakodnevnim spremembam v svetilnosti, se cirkadiani ritmi morajo prilagoditi tudi spreminjanju dolžine dneva zaradi menjave letnih časov. Eksperimentalno je bilo pokazano, da je porazdelitev električne aktivnosti nevronov v SCN-u poleti znatno širša kot pozimi [1]. Poleg tega je znano, da se znotrajcelična signalizacija posameznih nevronov v SCN-u tekom leta ne spreminja, pač pa naj bi te sezonske spremembe oziroma prilagoditve cirkadianih ciklov bile posledica modifikacij v medceličnih povezavah med nevroni. Za preučevanje vloge organizacije citoarhitekture med nevroni v SCN-u, smo izdelali matematični model, ki celostno opisuje delovanje SCN-a. Naše teoretične napovedi so pokazale, da je sezonska prerazporeditev električne aktivnosti nevronov neposredno povezana s spremembami v strukturi nevronske mreže. Prav tako se je izkazalo, da so spremembe v vzorcih nevronske aktivnosti povezane z lastnostmi mreže malega sveta, ki karakterizirajo medcelično komunikacijo v SCN-u

[2].

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Understanding Seasonal Adaptations of Circadian Clocks through the Lens of the Network Structure of the Suprachiasmatic Nucleus

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Circadian clocks drive the temporal coordination of internal biological processes, which in turn determine daily rhythms in physiology and behavior in the most diverse organisms. In mammals, the 24-hour timing clock resides in the suprachiasmatic nucleus (SCN) of the hypothalamus. The SCN is a network of interconnected neurons that serves as a robust self-sustained circadian pacemaker. The electrical activity of these neurons and their synchronization with the 24-hour cycle is established via the environmental day and night cycles. Apart from daily luminance changes, the dynamics of circadian rhythms needs to be adapted to day length changes between summer and winter as well. It has been observed experimentally, however, that the dynamics of individual neurons of the suprachiasmatic nucleus (SCN) does not change as the seasons change. Rather, the seasonal adaptation of the circadian clock is hypothesized to be a consequence of changes in the intercellular dynamics, which leads to a phase distribution of electrical activity of SCN neurons that is narrower in winter and broader during summer [1]. By developing a mathematical model of the SCN architecture, we explore in depth the role of the structure of this important neuronal network. We show that the redistribution of the neuronal activity during winter and summer can be explained by structural changes of the network. Interestingly, the alterations of the electrical activity patterns can

be related with small-world properties of our proposed SCN network [2].

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Izpeljava hidrodinamike iz kvantne teorije polja

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Hidrodinamika je področje polno zanimivih pojavov, ki je v zadnjem času pritegnilo veliko pozornosti s strani visokoenergetske fizike. Eden izmed razlogov za to je, da nam omogoča opis kolektivnih stanj kvark-gluonske plazme, kar je pomembno za razumevanje poskusov v LHC-ju in v RHIC-u. Drugi razlog je njena tesna povezanost s teorijami gravitacije in teorijo strun, ki je zrastla iz dualnosti AdS/CFT ter teorije črnih lukenj. Če znamo nek fizikalni sistem opisati z mikroskopsko kvantno teorijo polja, potem bi morala hidrodinamika postati efektivni opis tega sistema pri nizkih energijah. Ta efektivna teorija bi morala vsebovati ohranjen tok ter tenzor energije in gibalne količine v obliki vrste z naraščajočo stopnjo odvodov, znano iz fenomenološke teorije hidrodinamike. Težava nastopi, ker je kvantna teorija polja izražena v jeziku Lagrangeve funkcije, ki ni primerna za opis sistemov z izgubo energije ter posledično pojavov kot sta difuzija in viskoznost. Da omogočimo opis takšnih pojavov, lahko kvantno teorijo polja izrazimo s formalizmom "Closed-Time-Path" (CTP) Schwingerja in Keldiša, pri katerem podvojimo število polj in uporabimo dve časovni premici. Predstavil bom formalizem CTP ter kako nam omogoča izpeljavo hidrodinamike kot efektivne teorije pri nizkih energijah z disipacijo. Po splošni obravnavi se bom osredotočil na primer kvantne elektrodinamike. Prav tako bom predstavil tudi povezavo med hidrodinamiko in gravitacijo, ter omenil nekaj posledic, ki bi jih formalizem CTP lahko imel za kvantno teorijo gravitacije.

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Deriving hydrodynamics from quantum field theory

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Hydrodynamics is a rich and fascinating subject, which has recently attracted much attention from the high energy physics community. One reason is that it allows us to describe the collective behaviour of quark-gluon plasmas, relevant for experiments at the LHC and RHIC. Another reason is its deep connection with theories of gravity and string theory coming from the AdS/CFT correspondence as well as black hole physics. Given a microscopic quantum field theory description of a system, hydrodynamics should arise as a low energy effective field theory. The effective theory should then reproduce the usual phenomenological derivative expansion of the conserved current and the stress-energy tensor. The problem, however, arises from the fact that quantum field theory is formulated in a Lagrangian language, which is unable to generate dissipative effects such as diffusion or viscosity. To account for dissipation, we can re-formulate quantum field theory in a Closed-Time-Path (CTP) formalism of Schwinger and Keldysh through a doubling of degrees of freedom and the use of two time axes. I will present the CTP formalism and discuss how it enables us to derive hydrodynamics as a low energy effective theory with dissipative effects. After a general discussion, I will focus on the example of Quantum Electrodynamics. I will also present the connection between hydrodynamics and gravity, and discuss some implications the CTP formalism might have on quantum gravity.

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Dinamična lokalizacija v kaotičnih sistemih: spektralna statistika in mera lokalizacije v brcanem rotorju kot paradigma za časovno odvisne ter časovno neodvisne sisteme

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Proučujemo kvantno mehaniko brcanega rotorja v klasično povsem kaotičnem režimu, v domeni semiklasičnega vedenja, sledeč pionirskemu delu F. Izraileva iz poznih 1980. let, predvsem (1990 *Phys. Rep.* **196** 299). Uporabimo enega od njegovih N-dimenzionalnih modelov (1988 *Phys. Lett. A* **134** 13) za različne $N \leq 4000$, ki v limiti $N \to \infty$ stremi k kvantiziranemu brcanemu rotorju, in za veliko različnih vrednosti parametra brcanja $K \geq 5$. Opišemo vidike dinamične lokalizacije kot paradigmo časovno odvisnih ter časovno neodvisnih (avtonomnih) povsem kaotičnih sistemih in/ali v sistemih mešanega tipa (generični Hamiltonovi sistemi). Potem ko potrdimo rezultate Izraileva, bistveno izboljšamo natančnost numeričnih računov, ki nas vodi do naslednjih zaključkov. (C1) Porazdelitev razmikov med sosednjimi nivoji lastnih faz (ali lastnih kvazi-energij) je dobro opisana z Brodyijevo porazdelitvijo, nekoliko bolje kot z drugimi predlaganimi modeli, za različne vrednosti Brodyjevega eksponenta $\beta_{\rm BR}$ od 0 (Poisson) do 1 (GOE/COE), odvisno od stopnje dinamične lokalizacije. V limiti $N \to \infty$ in za fiksno lokalizacijsko dolžino l_∞ imamo zmerom Poisson, tudi če smo v klasično povsem kaotičnem režimu. (C2) Proučujemo lastne funkcije Floquetovega operatorja in karakteriziramo njihove lokalizacijske lastnosti uporabljajoč Izrailevovo informacijsko entropijsko mero, ki opisuje stopnjo dinamične lokalizacije lastnih funkcij, ki je po normiranju označena z $\beta_{\rm loc}$, in je na intervalu $[0, 1]$. Potrdimo Izrailevov rezultat, da sta parameter odbijanja med sosednjimi nivoji $\beta_{\rm BR}$ and $\beta_{\rm loc}$ skoraj linearno povezana, blizu identitete, čeprav vidimo

nekaj razpršenosti podatkov. (C3) Pokažemo obstoj skalirnega zakona med $\beta_{\rm loc}$ ter relativno lokalizacijsko mero $\Lambda = l_\infty/N$, ki ga napoveduje Izrailev. (C4) Menimo, in imamo evidenco, da se lahko uporabi podobna analiza tudi v primeru dinamične lokalizacije v časovno neodvisnih (avtonomnih) Hamiltonovih sistemih, kakor n.pr. v biljardih mešanega tipa (Batistić and Robnik 2010,2012), kjer je veljavnost Brody-ijeve porazdelitve potrjena z visoko stopnjo natančnosti za lokalizirana kaotična lastna stanja, vključno z najbolj izrazitim režimom $\beta_{\rm BR} \approx 0.5$, ki vidno odstopa od Poissona ter GOE/COE.

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Dynamical localization in chaotic systems: spectral statistics and localization measure in kicked rotator as a paradigm for time-dependent and time-independent systems

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We study the quantum mechanics of the kicked rotator in the classically fully chaotic regime, in the domain of the semiclassical behaviour, following the pioneering works of F. Izrailev from the late 1980s, especially (1990 *Phys. Rep.* **196** 299). We use one of his N-dimensional models (1988 *Phys. Lett. A* **134** 13) for various $N \leq 4000$, which in the limit $N \to \infty$ tends to the quantized kicked rotator, and for many different values of the kick parameter $K \geq 5$. We describe the features of dynamical localization as a paradigm for other both time-dependent and time-independent (autonomous) fully chaotic or/and mixed type (generic) Hamiltonian systems. After confirmi ng Izrailev's results we significantly improve the accuracy of the numerical calculations, giving rise to the following conclusions: (C1) The level spacings distribution of the eigenphases (or quasienergies) is very well described by the Brody distribution, somewhat better than by other proposed models, for various Brody exponents $\beta_{\rm BR}$ from 0 (Poisson) to 1 (GOE/COE), depending on the strength of the dynamical localization. In the limit $N \to \infty$ and fixed finite localization length l_∞ we have always Poisson, even if we are in the classically fully chaotic regime. (C2) We study the eigenfunctions of the Floquet operator and characterize their localization properties following Izrailev's information entropy measure describing the degree of dynamical localization of the eigenfunctions, which after normalization is given by $\beta_{\rm loc}$ on the interval $[0, 1]$. We confirm Izrailev's result that the level repulsion parameter $\beta_{\rm BR}$ and $\beta_{\rm loc}$ are almost linearly related,

close to the identity line, although there is some scattering of the data. (C3) We show the existence of a scaling law between $\beta_{\rm loc}$ and the relative localization length $\Lambda = l_\infty/N$, which is predicted by Izrailev. (C4) We believe and have evidence that a similar analysis of the dynamical localization applies also in time-independent (autonomous) Hamilton systems, like in mixed type billiards (Batistić and Robnik 2010,2012), where the Brody distribution is confirmed to a very high degree of precision for localized chaotic eigenstates including in the most pronounced regime with $\beta_{\rm BR} \approx 0.5$, away from Poisson and GOE/COE.

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Patološke spremembe topologije medceličnih povezav med gladkimi mišičnimi celicami v pljučnih arterijah pod kronično hipoksičnimi pogoji

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Motnje vaskularnega tonusa igrajo ključno vlogo pri razvoju pulmonarne hipertenzije. Eksperimentalne meritve kontrakcij gladkih mišičnih celic v pljučnih arterijah podgan dokazujejo, da inhibicija medcelične komunikacije ne vpliva na lastnosti kontrakcije celic normoksičnih podgan, ki so stimulirane s KCl. Po drugi strani pa v celicah podgan obolelih za kronično hipoksijo, v katerih pride do kontrakcije pri znatno nižjih nivojih stimulacije, inhibitorji presledkovnih stikov zatrejo ta hipersenzibilen odziv. Zavoljo pojasnitve eksperimentalnih rezultatov in raziskav podrobnosti narave medceličnih povezav med gladkimi mišičnimi celicami smo izdelali mrežni model citoarhitekture pljučne arterije, v katerem vozli predstavljajo posamezne gladke

mišične celice, povezave pa medcelično komunikacijo. Dinamiko posameznih celic dirigira matematični model, ki vključuje vse relevantne elemente napetostno-odvisne Ca^{2+} signalizacije. V skladu z eksperimentalnimi dognanji smo v model vključili tudi variabilnost gladkih mišičnih celic, ki je predvsem odraz porazdelitve prevodnosti K^+ kanalov. Medcelična komunikacija temelji na difuziji Ca^{2+} in električni sklopitvi, pri čemer je povezanost celic določena s topologijo mreže, ki jo tvorijo presledkovni stiki. Model predvideva, da se eksperimentalne meritve lahko razložijo le s spremembami topološke organiziranosti medcelične komunikacije, medtem ko količina oziroma izraženost posameznih presledkovnih stikov ni ključnega pomena. Izkaže se, da medcelične povezave med gladkimi mišičnimi celicami v pljučnih arterijah normoksičnih podgan tvorijo učinkovito mrežo, ki ima lastnosti kompleksnih mrež. Po drugi strani ima topologija medceličnih povezav v tkivu podgan obolelih za kronično hipoksijo lastnosti preproste naključne geometrične mreže. Hipersenzibilni odziv gladkih mišičnih celic pod kronično hipoksičnimi pogoji tako povežemo z reorganizacijo v smislu zmanjšanja kompleksnosti medceličnih povezav.

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Pathological Changes of the Cellular Network Topology of Pulmonary Artery Smooth Muscle under Chronic-Hypoxic Conditions

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Pulmonary vascular tone is of major importance in pulmonary hypertension. Experiments on rat intrapulmonary arteries (IPA) showed that the IPA contractile sensitivity to KCl is modified by gap-junction inhibition under pathological chronic-hypoxic conditions and not under normoxic conditions. In order to explain these experimental results, we make use of computational modeling approach. We consider the cytoarchitecture of the IPA as a spatial network model in which nodes represent individual smooth muscle cells (SMCs) and the links signify intercellular communication.The dynamics of single cells includes all crucial elements of voltage-dependent Ca^{2+} signaling. The inter-individual cell-to-cell variability is taken into account by distributing the reversal potentials for K^+, which is in accordance with

experimental observations. The communication between cells occurs via Ca^{2+} diffusion and electrical coupling. Model predictions indicate that the experimental results can be explained by modifications in the topology of the cellular network. Moreover, changes in gap-junction amount do not considerably affect the observed behavior of the tissue. We show that for normoxic conditions the tissue of IPA is characterized by a complex intercellular network, whereas for pathological chronic-hypoxic conditions there is a loss of the complexity in the network topology. This indicates to be the main reason for the observed pathological hyper-sensitive responses of the IPA.

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Tok mikropolarne tekočine skozi cev

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Model mikropolarne tekočine je bistvena posplošitev dobro poznanega Navier - Stokesovega modela, ki upošteva mikrostrukturo tekočine. Opisuje obnašanje številnih realnih tekočin (npr. polimerizacijske suspenzije, tekoče kristale, motne tekočine, živalsko kri itd.) bolje kot klasični model. Namen tega predavanja je predstaviti nedavne rezultate o asimptotični aproksimaciji toka mikropolarne tekočine skozi tanko (ali dolgo) cev s krožnim prerezom. Začnemo z obravnavanjem nestisljive mikropolarne tekočine, ki teče skozi popolnoma ravno pipo in najdemo učinkovito obnašanje toka preko stroge asimptotične analize glede na debelino cevi. Ker inženirska praksa zahteva intenzivno poznavanje tokov ukrivljene cevi, razširimo našo analizo do primera splošne ukrivljene cevi s poljubno osrednjo krivuljo. Z uporabo ukrivljenih koordinat in dvo-skalirne asimptotske tehnike eksplicitno konstruiramo približek, ki potrdi učinke tekoče mikrostrukture in zvitja cevi. Določimo natančno utemeljitev dobljenega učinkovitega modela z dokazom ustrezne ocene napake. Nenazadnje še študiramo prenos reaktivne stopljene snovi skozi valjasto cev napolnjeno z mikropolarno tekočino v navzočnosti kemijske reakcije. Formalno razvijemo asimptotični model, ki eksplicitno prikazuje učinke kemije in mikrostrukture tekočin na stopljeno razpršitev.

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On the micropolar fluid flow through a pipe

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The micropolar fluid model is an essential generalization of the well-established Navier-Stokes model which takes into account the microstructure of the fluid. It describes the behavior of numerous real fluids (e.g. polymeric suspensions, liquid crystals, muddy fluids, animal blood, etc.) better than the classical model. The aim of this talk is to present recent results about asymptotic approximation of the micropolar fluid flow through a thin (or long) pipe with circular cross-section. We begin by considering an incompressible micropolar fluid flowing through an undeformed straight pipe and find the effective behavior of the flow via rigorous asymptotic analysis with respect to the pipe's thickness. Since engineering practice requires extensive knowledge of curved-pipe flows, we extend our analysis to the case of general curved pipe with an arbitrary central curve. Using curvilinear coordinates and two-scale asymptotic technique, we construct the approximation explicitly acknowledging the effects of fluid microstructure and pipe's distortion. We provide the rigorous justification of the obtained effective model by proving the corresponding error estimate. Last but not least, we study the transport of a reactive solute through a cylindrical pipe filled with micropolar fluid and in the presence of chemical reaction. We formally derive the asymptotic model showing explicitly the effects of chemistry and fluid microstructure on the solute dispersion.

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Hadronske resonance v kromodinamiki na mreži

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Predstavila bom kako se izračuna maso in razpadno širino Γ hadronskih resonanc *ab initio*. Hadronske resonance so tisti hadroni, ki lahko razpadejo preko močne interakcije, in predstavljajo veliko večino vseh hadronov. Resonance se tvorijo pri sipanju dveh stabilnih hadronov, in potem razpadejo hitro z razpadnim časom $\tau = \hbar/\Gamma$. Doslej je bila v literaturi iz prvih načel določena le masa in širina resonance ρ, ki se tvori pri sipanju $\pi\pi \to \rho \to \pi\pi$. Za nobeno drugo od številnih hadronskih resonanc doslej masa in širina nista bili izračunani *ab initio*. Skupaj s sodelavci smo poleg procesa $\pi\pi \to \rho \to \pi\pi$ [1], prvi simulirali sipanje $K\pi$ [2] in $D\pi$ [3] ter določili lastnosti resonanc, ki se pri tem tvorijo. Pri izračunu smo uporabili kromodinamiko na mreži. To je edina neperturbativna metoda, ki temelji neposredno na kromodinamiki, torej na osnovni teoriji močne interackije med kvarki in gluoni. Neperturbativna metoda je potrebna, ker jakost močne interakcije med kvarki v hadronih onemogoča perturbativni razvoj po ustrezni sklopitveni konstanti.

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Hadronic resonances in Quantum ChromoDynamics on the lattice

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I shall present the calculation of the mass and the decay width Γ of a hadronic resonance *ab initio*. Hadronic resonances are those hadrons that can decay via the strong interaction, and they represent most of the hadron states. The resonances are formed for example in the scattering of two stable hadrons, and then decay quickly with the lifetime $\tau = \hbar/\Gamma$. Among all the hadronic resonances, only the decay width of the ρ resonance, which appears in the scattering $\pi\pi \to \rho \to \pi\pi$, has been calculated from first-principles up to now. The width of no other resonance has been determined *ab initio*. We have simulated the scattering $\pi\pi \to \rho \to \pi\pi$ [1], and for the first time also the scattering $K\pi$ [2] and $D\pi$ [3], and we have determined the properties of the resonances that form in these scattering channels. Our calculation is done using Quantum ChromoDynamics (QCD) on the lattice, which represents the only non-perturbative method that is based directly on QCD - that is the basic theory of strong interactions between quarks and gluons. The nonperturbative method is essential since the strength of the strong interaction between quarks in hadrons does not allow the perturbative expansion in the strong coupling constant.

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Neravnovesna stacionarna stanja robno-gnanih odprtih kvantnih verig

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Obravnavali bomo splošen neravnovesni pristop k problemu kvantnega transporta v eni dimenziji. Zamislimo si močno korelirano kvantno verigo s popolnoma koherentno dinamiko, ki jo ženemo stran od ravnovesja z Lindbladovimi disipatorji, ki delujejo le na prostostnih stopnjah na robu verige. Z drugimi besedami, inkoherentni procesi so dobvoljeni le na robu verige in ti ženejo sistem stran od ravnovesja. Neravnovesno stanje s tokom potem aproksimiramo kot stacionarno stanje ustrezne markovske master enačbe [1].

V predavanju bom orisal nekaj zanimivih rezulatov, ki smo jih nedavna dobili v tej smeri. Prvič, z uporabo numeričnih metod inspiriranih z metodo renormalizacijske grupe na gostotni matriki najdemo primere difuzijskega transporta v povsem čistih in celo Bethe-ansatz integrabilnih močno koreliranih sistemih kot sta npr. anizotropna Heisenbergova veriga XXZ spinov 1/2 in enodimenzionalen fermionski Hubbardov model.

Drugič, pod močno neravnovesnimi robnimi pogoji lahko najdemo primere točnih analitičnih rešitev [2], ki opisujejo stacionarna stanja z anomalnimj transportnimi lastnostmi. Na primer, pokažemo lahko,da je za Heisenbergov XXZ model z ekstremnim neravnovesnim robnim pogojem stacionarni gostotni operator končne verige n spinov - do normalizacijske konstante - polinom stopnje $2n-2$ v sklopitveni konstanti. V izotropnem primeru najdemo kosinusni spinski profil, $1/n^2$ skaliranje spinskega toka ter spin-spin korelacije dolgega reda. Še več, perturbacijska verzija našega nastavka [3] nam da novo kvazi-lokalno ohranjeno količino anizotropnega Heisenbergovega modela s pomočjo katere lahko rigorozno [4] ocenimo spinsko Drudejevo utež (balistični transportni koeficient) v 'easy-plane' režimu.

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Non-equilibrium steady states of boundary-driven open quantum chains

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We will discuss a general non-equilibrium setup by which one can approach the quantum transport problem in one dimension. One considers a strongly interacting quantum chain with fully coherent bulk dynamics and driven out of equilibrium in terms of Lindblad dissipators which only act on degrees of freedom near the boundary, i.e. at the ends of the chain. Non-equilibrium state carrying the physical currents is then approximated as the steady state of the corresponding Markovian master equation [1].

In this talk I will describe several interesting results which have recently been obtained along these lines. Firstly, using numerical methods inspired by the density matrix renormalization group, one can - quite remarkably - find examples of diffusive transport in clean, and even Bethe-ansatz integrable, strongly interacting systems (at high-temperature near-equilibrium conditions), such as the Heisenberg XXZ spin 1/2 chain and the one-dimensional fermionic Hubbard model.

Secondly, under far from equilibrium conditions, one can find several exact analytical solutions [2] which describe steady states with anomalous transport properties. For example, in the Heisenberg XXZ chain under extreme boundary driving we show that the steady-state density operator of a finite system of size n is – apart from a normalization constant – a polynomial of degree $2n-2$ in the coupling constant. In the isotropic case we find cosine spin profiles, $1/n^2$ scaling of the spin current, and long-range correlations in the steady state. Furthermore, the perturbative (weak coupling) version of our ansatz [3] is used to derive a novel pseudo-local conservation law of the anisotropic Heisenberg model, by means of which we rigorously estimate [4] the spin Drude weight (the ballistic transport coefficient) in the easy-plane regime. This closes a long standing question in strongly correlated condensed matter physics.

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Teorija vozlov in fizika

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Predstavili bomo osnovne pojme matematične teorije vozlov in jo pojasnili na nekaterih fizikalnih primerih. Nato si bomo ogledali kratek animiran film o vozlih, s posebnim poudarkom na tem, kako izgleda hiperbolični komplement vozla.

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Knot theory and physics

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We shall present the fundamental concepts of the mathematical theory of knots and illustrate it on some examples from physics. Then we shall present a short animated movie on knots, with special emphasis on how hyperbolic knot complements looks like.

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Uporaba WKB metode v 1D časovno odvisnih nelinearnih Hamiltonovih oscilatorjih

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Najprej podamo pregled WKB teorije za 1D časovno odvisni linearni oscilator, sledeč originalnemu članku (Robnik in Romanovski 2000), kjer smo nelinearno rekurzivno formulo rešili eksaktno in eksplicitno, v zaključeni obliki, do vseh redov. Tudi na kratko pregledamo osnovne rezultate o statističnih lastnostih 1D časovno odvisnega linearnega oscilatorja, še prav posebej časovni razvoj porazdelitve energije. Nato predstavimo preprost pristop v duhu WKB teorije, z namenom dobiti približne analitične rešitve za določen razred časovno odvisnih nelinearnih 1D Hamiltonovih oscilatorjev. Primer homogenih potenčnih potencialov je rešen v zaključeni obliki v vodilnem redu. Natančnost aproksimacije je presenetljivo dobra in jo ilustriramo na primeru kvartičnega oscilatorja. Pričakujemo, da je metoda uporabna pri obravnavi statističnih lastnosti dinamičnih količin (kot sta denimo energija in adiabatska invarianta) v nelinearnih oscilatorjih, ter pri številnih drugih aplikacijah v nelinearnih oscilatorjih.

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WKB approach applied to 1D time-dependent nonlinear Hamiltonian oscillators

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First we review the WKB theory for 1D time-dependent linear oscillator, following the original paper of Robnik and Romanovski (2000), where the nonlinear WKB recursion relation has been solved exactly and explicitly, in closed form, to all orders. We also briefly review the basic results on the statistical properties of 1D time-dependent linear oscillator, in particular the time evolution of the energy distribution. Then we present a simple WKB-like approach to obtain approximate analytic solutions to a certain class of time-dependent nonlinear 1D Hamiltonian oscillators. The case of homogeneous power law potentials is solved explicitly in closed form in the leading order. The accuracy of the approximation is surprisingly good and we illustrate it in case of the quartic oscillator. The method is expected to be useful in treating the statistical properties of the dynamical quantities (like energy and adiabatic invariant) in nonlinear oscillators, and many other applications in nonlinear oscillators.

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Ali je pionski oblak privatna last konstituentnega kvarka ali občinska last nukleona?

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Pomembno vlogo pionskega oblaka v nukleonu vidimo pri magnetni polarizabilnosti, electroekscitaciji, spinskih lastnostih nukleona in, v zadnjem času, pri globoko neelastičnem sipanju (npr. pri produkciji nevtronov v smeri naprej pri trkih elektrona na protonu pri 300 GeV, merjenih v kolaboracijah H1 and ZEUS na DESY).

Pojavi se vprašanje, ali dobimo boljši opis, če pripišemo vsakemu konstituentnemu kvarku svoj lastni pion, ali če dodatne pione priklopimo neposredno na goli nukleon. Ker se seštevajo (interferirajo) amplitude pionov iz različnih kvarkov, se zdita obe sliki enakovredni. Vendar vzamemo v približku le vodilno večpionsko konfiguracijo, zato sta opisa različna, podobno kot pri primerjavi sklopitvs jj in LS v jedrski fiziki. Pokazali bomo, da dá opis s "privatnim pionom" boljše ujemanje raznih količin z eksperimentalnimi vrednostmi.

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Is the pion cloud a private property of constituent quarks or a communal property of the nucleon?

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The importance of the pion cloud in the nucleon has been demonstrated in the study of the magnetic polarizabilities, electroexcitation, spin properties of the nucleon and, more recently, in deep inelastic scattering (for example the forward neutron production in the ep collisions at 300 GeV measured by the H1 and ZEUS Collaborations at DESY). The question arises whether it is a better picture that each constituent quark contains its own pion cloud or that the additional pions are coupled directly to a bare nucleon. Since the amplitudes of pions from different quarks add up (interfere) both pictures seem equivalent. If one takes, however, only the leading multipion configuration the descriptions differ, like in comparing jj and LS coupling in nuclear physics. We show that it is the "private pion" description which gives a better agreement of different observables with experiment.

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Generiranje delcem podobnih sipanlnih stanj v valovnem transportu

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Govoril bom o naših izsledkih v povezavi s transportom valov skozi kompleksne sisteme, kjer sipalna stanja kažejo trajektorijam podobne vzorce [1]. Ta sipalna stanja imajo dobro definiran sipalni časovni zamik in deterministično prepustnost blizu 0 ali 100%. Predstavil bom metodo kako generirati ta stanja, ki bazira izključno na sipalni matriki sistema, ki smo jo numerično implementirali za balistične in neurejene sipalce. Zaključil bom z diskusijo o možni realizaciji naših idej z elektro-magnetnimi ali akustinimi valovi in o možnih aplikacijah, kot na primer, fokusiranje valov in varna nizko energijska komunikacija [2].

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Generating particle-like scattering states in wave transport

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I will speak about our work on scattering states which display trajectory-like wave function patterns in wave transport through complex systems [1]. These beam-like scattering states feature the dual property of having a well-defined scattering delay time and deterministic transmission close to 0 or 100%. An operational protocol for generating these states is put forward which is based solely on a system's scattering matrix and which we implemented numerically for ballistic and disordered scattering landscapes. I will conclude by a discussion of envisioned realizations of our ideas with electromagnetic or acoustic waves with possible applications like wave focusing and secure/low-power communication [2].

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Elektrokaloriki: materiali za aplikacijo v hladilnih in grelnih napravah nove generacije

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Elektrokaloriki, materiali katerih temperatura se spreminja s spreminjajočim se električnim poljem oz. električno napetostjo, so izjemnega pomena za energijsko učinkovite in tehnološko sprejemljive tehnologije. Namreč v zadnjem času so vedno večje potrebe po energijskih proizvodnih kapacitetah in s tem posledično povečanje obremenitve okolja. Kot protiutež temu se že pojavljajo npr. energijske nalepke, a največ bo zagotovo pripomogla nova tehnologija. Omenjeni materiali so dobri izolatorji in so uporabni za številne aplikacije, kot npr. hlajenje v mikroelektroniki, senzorji, aktuatorji, v hladilnikih v gospodinjstvu, v toplotnih črpalkah, itd. Prednost elementov, narejenih iz takšnih materialov pa se odraža v preprostem delovanju, večji energijski učinkovitosti, so okolju in ljudem prijaznejši, itd. Pojav v teh materialih se imenuje elektrokalorični (EK) pojav. Dosedanje napovedi izjemno velikega EK pojava v anorganskih in organskih materialih temeljijo na posrednih meritvah električne polarizacije [1, 2]. V našem primeru pa smo omenjeni pojav izmerili neposredno [3]. V predavanju bom predstavila elektokalorični pojav, njegovo uporabnost in dobljene rezultate naših raziskav.

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Electrocalorics: materials for application in cooling and heating new generation devices

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Electrocalorics, materials that exhibit a temperature change under an applied/removed electric field, are very important and attractive for more energy effiecient and environmentally acceptable technologies.As known, in recent times the needs around energy capacities for production increase, and consequently there is a pressure on the environment. Some measures, like for instance, the energy labeling have already been taken to reduce energy consumption, but the real solution could be found in the development of new technologies. Electrocalorics are good insulators and they can be useful for various applications like cooling in microelectronics, sensors, actuators, in household refrigerators, in heat pumps, etc. Advantages of the elements made from such materials could be simple design, more energy efficient, more environmentally friendly, etc. This interesting phenomenon in mentioned materials is called electrocaloric effect (ECE).The recent predictions of the giant ECE in inorganic and organic materials based on indirect measurements of the electric polarization [1, 2]. In our case this effect was measured directly [3]. In this presentation the electrocaloric effect and its applications will be disscused and a review of our research work in this field will be given.

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Kvantne diferenčno-diferencialne enačbe

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Diferencialne enačbe, ki vsebujejo parameter procesa skaliranja so običajno navedene kot kvantne diferenčno-diferencialne enačbe. Predstavljene so nekatere njihove uporabnosti na diskretnih modelih Schrödingerjeve enačbe in pokazane njihove bogate in včasih tudi nepričakovane analitične strukture. Raziskan je Liejev algebraični koncept za dobljene osnovne diskretizacije, ki posplošijo koncept deformiranih Heisenbergovih algeber od Juliusa Wessa. Te so prav tako povezane z algebraičnimi fundacijami kvantnih grup v duhu Ludwiga Pittnerja. Raziskani so nekateri trenutni problemi osnovnih enačb razlike. Izvedene so nekatere uporabnosti v diskretni Schrödingerjevi teoriji in predstavljene nekatere spektralne lastnosti nastalih operatorjev, tudi v primeru Schrödingerjevih operatorjev z osnovnimi premik-potenciali in v primeru diferenčno-diferencialnih operatorjev osnovnega stanja. Za nastale sisteme ortogonalne funkcije je pojasnjen koncept podedovane ortogonalnosti. Rezultati v tem delu so večinoma povezani z nedavnim delom s Sophio Roßkopf in Lucio Birk.

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Quantum Difference–Differential Equations

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Differential equations which contain the parameter of a scaling process are usually referred to by the name Quantum Difference–Differential Equations. Some of their applications to discrete models of the Schrödinger equation are presented and some of their rich, filigrane and sometimes unexpected analytic structures are revealed. A Lie-algebraic concept for obtaining basic adaptive discretizations is explored, generalizing the concept of deformed Heisenberg algebras by Julius Wess. They are also related to algebraic foundations of quantum groups in the spirit of Ludwig Pittner. Some of the moment problems of the underlying basic difference equations are investigated. Applications to discrete Schrödinger theory are worked out and some spectral properties of the arising operators are presented, also in the case of Schrödinger operators with basic shift–potentials and in the case of ground state difference–differential operators. For the arising orthogonal function systems, the concept of inherited orthogonality is explained. The results in this talk are mainly related to a recent joint work with Sophia Roßkopf and Lucia Birk.

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Citosolni kalcij, membranski potencial in uravnavana eksocitoza celic beta v tkivnih rezinah trebušne slinavke

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Celice beta otočkov trebušne slinavke tvorijo komplekse funkcionalne sincicije preko katerih nadzirajo membranski potencial, citosolni kalcij, ki končno proži uravnavano eksocitozo hormona inzulina. Dogovorjeni model opisane aktivacije celice beta vključuje zaprtje od ATP-odvisnih kalijevih kanalov zaradi presežkov ATP, depolarizacijo plazemske membrane in vdor kalcijevih ionov skozi napetostno-občutljive kalcijeve kanale (VACCs) kar sproži od kalcija-odvisne procese uravnavane eksocitoze. Recentni rezultati našega laboratorija, kjer uprabljamo preparat svežih tkivnih rezin trebušne slinavke; nove metode izbora za preučevanje fiziologije celic beta v njihovem obicajnem celično-socialnem okolju,so pokazali, da so lahko druge molekularne entitete poleg VACCs pomembne ali celo poglavitne pri nadzoru citosolnega kalcija in tako uravnavane eksocitoze inzulina. Nadalje, odvisnost eksocitotskega procesa od kalcija je zelo odvisna od fosforilacijskega statusa v citosolu in se lahko hitro spremeni med fiziološko aktivacijo celic beta.

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Cytosolic calcium, membrane potential and regulated exocytosis of beta cells in fresh pancreatic tissue slices

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Beta-cells in pancreatic islets form complex functional syncytia to control membrane potential, cytosolic calcium that eventually drives regulated exocytosis of insulin. A consensus model along this beta-cell activation pathway includes closure of ATP-dependent potassium channels due to excess ATP, plasma membrane depolarization and influx of calcium into the cytosol through voltage-activated calcium channels (VACCs) to trigger calcium-dependent processes of regulated exocytosis. Recent results from our laboratory using fresh pancreas slices, a novel method of choice to study the physiology of beta-cells still embedded in their normal cellulo-social context; suggest an important or even dominant role of molecular entities other than VACCs in controlling cytosolic calcium and thus exocytosis of insulin. In addition, calcium-dependence of the exocytotic process itself depends strongly on phosphorylation status within the cytosol and can rapidly change during the physiological activation of the beta-cells.

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Obrat toka kot posledica interakcije v časovno odvisnih mrežah

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Raziskave na področju ragelj in usmerjenih tokov v časovno odvisnih mrežah žanjejo veliko pozornost, tako v klasični kot kavntni dinamiki. Klasični efekt raglje se nanaša na ne-interagirajoče delce v časovno odvisnem sistemu in bazira na zlomu prostorske in časovne simetrije. Zanima nas ekspanzija močno interagirajočega sistema delcev v časovno odvisnih mrežah. Pokažemo, da lahko v toku časa interakcije dolgega dosega povzročijo zaporedno preklapljanje smeri toka razredčenega plina delcev. Ti obrati toka bazirajo na splošnem mehanizmu, ki zaradi interakcije vodi do akumulacije delcev v regularnih območjih ustreznega enodelčnega faznega prostora in sinhronizacije gibanja posameznih delcev ter povečanja izkoristka Hamiltonskih ragelj.

Drugi del govora bom posvetil novemu pristopu h konceptu simetrije, ki ga najdemo povsod v fiziki in drugod. V izoliranem sistemu tipično predpostavimo, da neka simetrija velja za celoten sistem ali pa je ni. Toda v naravi pogosto opazimo, da simetrija približno velja lokalno a ne globalno. Kot prvi korak k temu problemu, uvedemo concept simetrije parnosti v prostorskih domenah (lokalna parnost) in raziskujemo njen vpliv na transportne lastnosti 1d aperiodičnih potencialov. Pokažemo, da če lokalna parnost šibko komutira s Hamilonjanom, to povzroči stanja, ki ustrezajo lokalni parnosti in imajo tok enak 0 ali pa popolnoma prepustna stanja z verjetnostno gostoto, ki sledi lokalni simetriji potenciala. Analiziramo vlogo lokalne simetrije parnosti, ki nastopa na različnih prostorskih skalah in jo apliciramo na resonančno sipanje. Naša odkritja ilustriramo z aplikacijo na zaporedje potencialnih barier s predpisanimi transportnimi lastnostmi.

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Interaction-induced Current Reversal in Spatiotemporally Driven Lattices

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Ratchets and directed currents in driven lattices are a topical field of research, both for classical as well as quantum dynamics. The 'classical' ratchet effect which is based on breaking certain symmetries in time and space typically refers to a non-interacting particle system in a structured and time-driven environment. We investigate here the expansion of strongly interacting particle systems in driven lattices. It is demonstrated that long-range interactions can cause, as time evolves, consecutive reversals of directed currents for dilute ensembles of particles. These current-reversals are based on a general mechanism which leads to an interaction-induced accumulation of particles in the regular regions of the underlying single-particle phase space and to a synchronized single-particle motion as well as an enhanced efficiency of Hamiltonian ratchets.

The second part of the talk is dedicated to a new approach to the concept of symmetry which is ubiquitous in physics and several other disciplines. Typically we assume in isolated systems that a symmetry holds for the complete system or not. However, in nature we often observe that a symmetry is approximately valid locally but not globally in space. As a first step to address this problem, we therefore introduce the concept of parity symmetry in restricted space domains, i.e. local parity, and explore its impact on the transport properties of one-dimensional aperiodic potentials. We show that weak commutation of combined local parity operations with the Hamiltonian induces states which either exhibit definite local parity and zero current or are totally transmitting with probability density following local symmetries of the potential. The role of local parity symmetries occurring on different spatial scales is analyzed and applied to resonant scattering. Our findings are illustrated through application to potential barrier arrays with prescribed transport features.

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Uvod v eksaktno WKB analizo

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WKB (Wentzel-Kramers-Brillouin) metoda je pogosto uporabljena tehnika za izračun asimptotskih rešitev navadnih ali parcialnih diferencialnih enačb z majhnim ali velikm parametrom [1]. Kakorkoli, WKB reštve so v najboljšem primeru asimptotske in v splošnem diveregentne, izaradi česar je težko dokazati njeno pravilnost. WKB rešitve lahko zamenjujemo v parametričnem porostoru le na hevristični način, saj asimptotska vrsta ne zajema eksponentno majhnih členov. To nam onemogoča, da bi aplicirali WKB metodo na diferencialne enačbe višjih redov in nelinearne diferencialne enačbe.

Predstavil bom zadnja spoznanja na področju eksaktne WKB metode, kjer lahko divergentne vrste obravnavamo analitično s pomočjo Borel-Laplacove resumacije in kjer lahko pravilno zaobjamemo tudi eksponentno majhne člene [2]. Kot aplikacijo bom pokazal, da lahko s pomočjo eksaktne WKB metode rešimo problem večnivojskega ne-adiabatskega prehoda, ki je star problem že od Landau-Zener-Stueckelberg [3-5].

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An introduction to exact WKB analysis

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The WKB (Wentzel-Kramers-Brillouin) method is a widely used technique to obtain asymptotic solutions of ordinary (and partial) differential equations with a small (or large) parameter [1]. However, WKB solutions are asymptotic at most and divergent in general, so rigorous mathematical arguments verifying its validity have been difficult to build. In particular, since controlling the exponentially small terms are usually beyond the treatment of asymptotic series, switching of WKB solutions in a parameter space could be made only in a heuristic manner. This prevents, for example, from applying the WKB method to higher-order differential equations and nonlinear differential equations. We here give a brief introduction to recent developments of the exact WKB method (resurgent theory, exponential asymptotics), in which divergent series are treated analytically via the Borel-Laplace resummation and exponentially small terms can be handled in an appropriate way [2]. As an application, we will show that the multilevel non-adiabatic transition problem, a long standing problem since Landau-Zener-Stueckelberg [3-5], could be solved by following the recipe developed in the exact WKB method [6-7].

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Molekulsko modeliranje tekočekristalnih elastomerov

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Tekočekristalni elastomeri (TKE) so mehki funkcionalni materiali iz šibko povezanih polimernih mrež z vgrajenimi tekočekristalnimi molekulami. Te materiale zato odlikuje izrazita sklopitev med makroskopsko deformacijo in orientacijsko tekočekristalno ureditvijo. Ker je na slednjo moč vplivati z zunanjimi dražljaji (temperaturo, električnim poljem ali ultravijolično svetlobo), so TKE obetavni za uporabo kot senzorji in aktuatorji [1].

V predavanju bom predstavil obsežne molekulske simulacije nabreklih TKE. Obravnavani simulirani poskusi vključujejo obnašanje TKE pri spreminjanju temperature, odziv na obremenitev s silo ter obnašanje v zunanjem električnem polju. Simulacije Monte Carlo so do sedaj potrdile obstoj izotropne, nematske in smektične faze, pa tudi prehod iz izotropne v nematsko fazo, ki ga sproži zunanja obremenitev [2]. Transverzalno električno polje lahko nadalje izzove vrtenje tekočekristalnega direktorja, kar privede do tvorbe orientacijskih progastih domen [3].

Rezultate simulacij je mogoče uporabiti tudi za napoved izbranih eksperimentalnih opazljivk, na primer razsežnosti vzorca, specifične toplote, spektrov devterijeve magnetne resonance in intenzitete sipane rentgenske svetlobe.

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Molecular modeling of liquid crystal elastomers

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Liquid crystal elastomers (LCE) are soft functional materials consisting of weakly crosslinked polymer networks with embedded liquid crystalline (mesogenic) molecules. Consequently, LCE are characterized by a pronounced coupling between macroscopic strain and orientational mesogenic order. As the latter can be controlled by external stimuli such as temperature, electric field, or ultraviolet light, LCE have great potential for application as sensors and actuators [1].

In this talk large-scale molecular simulations of swollen LCE will be presented. The simulated experiments include temperature scans, stress-strain runs, and the application of an external electric field. So far, isostress Monte Carlo simulations of LCE have been capable of reproducing isotropic, nematic and smectic phases, as well as a stress-induced isotropic-to-nematic transition [2]. Moreover, a transversal electric field has been seen to induce nematic director rotation resulting in orientational stripe domains [3].

The rather extensive simulation output can also be used to predict selected experimental observables, such as LCE sample dimensions, specific heat, deuterium magnetic resonance spectra, and scattered X-ray patterns.

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Linearne diferenčne enačbe in deljivost

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Diferenčne enačbe so se pojavile dolgo nazaj in predstavljajo številne uporabnosti v drugih vejah znanosti (glej npr. [1]). Eno izmed prvih srečanj, ponavadi implicitno, matematikov s pojmov zaporedja običajno nastopi v nekaterih problemih v elementarni teoriji števil. Namreč, mnoge knjige problemov vsebujejo probleme glede deljivosti zaporedja celih števil, danega z eksplicitno formulo $a(n)$, $n \geq k$, kjer je k fiksno celo število. V tem predavanju bo predstavljena preprosta uporabna metoda, ki za velik razred zaporedij celih števil pokaže, kdaj so vsi njihovi členi deljivi z naravnim številom $m \neq 1$.

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Linear difference equations and divisibility

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Difference equations have appeared long time ago and have numerous applications in other branches of science (see, e.g. [1]). One of the first encounters, usually implicit, of mathematicians with the notion of sequences traditionally appears in some problems in elementary number theory. Namely, many problem books contain problems regarding divisibility of integer sequences given by an explicit formula $a(n)$, $n \geq k$, where k is a fixed integer. In this talk we present an easy applicable method which, for a large class of integer sequences, shows when all their terms are divisible by a natural number $m \neq 1$.

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Orjaški valovi: od 2d elektronskega plina do ekonomije

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Valovi, ki se propagirajo skozi nehomogeni medij kažejo neregularne vzorce tako v prostoru kot času. Lord Raylight je že ob koncu 19. stoletja, s predpostavko naključne superpozicije ravnih valov, predvidel eksponentno zmanjševenje verjetnostne gostote za intenziteto valov, $p(I) \sim \exp(I)$, kjer je intenziteta I proporcionalna kvadratu višine vala. Že dolgo vemo, da Raylightova napoved močno podceni verjetnost za zelo visoke valove. Splošna razlaga je nelinearnost, ampak slikanje elektronskega toka skozi naključni potencial kaže, da je lahko takšno razhajanje znatno že v linearnem režimu [1].

S študijem stacionarnega valovnega polja in transportov mikrovalov preko naključno postavljenih sipalcev kaže [2], da veliko odstopanje od Raylightovega zakona obstaja že v linearnem režimu, ki se ga ne da razložiti z obstoječimi teorijami. Torej je razumevanje linearnega režima nujno za pravilno razlago pojava orjaških valov. Enaka opažanaja kot za valove, ki se propagirajo skozi naključno potencialno polje, vidimo tudi pri razširjanju zvoka skozi turbulentni zrak in porazdelitvi tveganja na trgu delnici [3], kar nakazuje na univerzalnost pojava v zelo različnih sistemih.

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Freak waves: from 2d electron gases to economics

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Waves propagating through an inhomogeneous medium produce patterns irregular in space and time. Assuming a random superposition of plane waves, Lord Rayleigh predicted already at the end of the 19th century an exponential decay for the probability density of wave intensities, $p(I) \sim \exp(-I)$, where the intensity I is proportional to the square of the height of the wave. It had been known for many years, however, that Rayleigh's law severely underestimates the probability for waves with extreme heights. The common explanation is nonlinearity, but imaging of the electron flow in a random potential [1] suggests that such deviations may already be present and significant in the linear regime. In a study of both stationary wave fields and transient transport of microwaves through an arrangement of randomly distributed scatterers we showed [2] that huge deviations from Rayleigh's law do exist already in the linear regime, which cannot be accounted for by existing theories. Thus, an understanding of the linear regime is essential for the proper interpretation of freak waves. The same intensity distributions found in the wave propagation through random potential landscapes are observed, too, in the propagation of sound through turbulent air, and in the risk distribution of portfolios on the stock market [3], suggesting universal features present in very different systems.

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Funkcionalna povezanost v Langerhansovih otočkih v tkivnih rezinah trebušne slinavke miši

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Teorija kompleksnih mrež je dala nova orodja za študij strukture in delovanja kompleksnih sistemov. Posebno zanimiva v tem pogledu je analiza bioloških sistemov, saj so strukturni principi kompleksnih mrež prisotni na vseh nivojih organizacije živih organizmov. Predstavili bomo mrežno upodobitev Langerhansovih otočkov, mikroorganov, ki so sestavljeni iz do nekaj tisoč celic beta, ki izločajo inzulin v odvisnosti od znotrajceličnega kalcija. Fizično vpete električno sklopljene celice beta smo funkcionalno povezali na osnovi korelacij med časovnimi poteki od kalcija odvisne fluorescence v posameznih celicah. Aktivnost celic smo posneli s pomočjo konfokalne mikroskopije z laserskim skenerjem v Langerhansovih otočkih v tkivnih rezinah trebušne slinavke miši. Tako konstruirane funkcionalne mreže smo analizirali v luči znanih strukturnih in fiziolo skih lastnosti Langerhansovih otočkov. Zasledujoč časovno evolucijo mrež ob stimulaciji z glukozo smo pokazali, da so celice bolj korelirane v času stimulacije kot v obdobju, ko niso stimulirane. Največja stopnja

korelacije je bila vidna v obdobju aktivacije in deaktivacije, ko se celice odzivajo na glukozni dražljaj. Med aktivnostjo je stopnja koreliranosti bila izrazito odvisna od evklidske razdalje med celicami, kar potrjuje v predhodnih raziskavah oblikovano hipotezo, da sinhronizacijo celic beta zagotavljajo kalcijevi valovi, ki se širijo od celice do celice. Najpomembnejša ugotovitev našega dela je, da funkcionalne mreže kažejo lastnosti malega sveta, kar namiguje na možnost, da celice beta v Langerhansovem otočku ne tvorijo preproste geometrijske mreže, kot se je predvidevalo doslej, ampak so povezane na funkcionalno bolj učinkovit način. Rezultati, ki jih bomo predstavili, zato podpirajo obstoječe znanje fiziologije celic beta z novega, mrežnega vidika, hkrati pa osvetljujejo funkcionalno urejenost sincicija celic beta v novi luči in kažejo, da ta ni tako preprosta, kot se je mislilo doslej.

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Functional Connectivity in Islets of Langerhans from Mouse Pancreas Tissue Slices

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Complex network theory has provided new tools for studying the structure and function of complex systems. A particularly attractive avenue in this context is the analysis of biological systems, since structural principles of complex networks have been identified at all scales of functioning of living organisms. Here, we propose a network representation of islets of Langerhans, microorgans that consist of up to several thousand electrically coupled beta cells that secrete insulin in a calcium-dependent manner. Physically embedded and electrically coupled beta cells are functionally connected on the basis of correlations between calcium dynamics of individual cells, obtained by means of confocal laser-scanning calcium imaging in islets from acute mouse pancreas tissue slices. Obtained functional networks are analyzed in the light of known structural and physiological properties of islets. Focusing on the temporal evolution of the network under stimulation with glucose, we show that the dynamics

are more correlated under stimulation than under non-stimulated conditions. In particular, the highest overall correlation, largely independent of Euclidean distances between cells, is observed in the activation and deactivation phases when cells are driven by the external stimulus. Moreover, we find that the range of interactions in networks during activity shows a clear dependence on the Euclidean distance, lending support to previous observations that beta cells are synchronized via calcium waves spreading throughout islets. Most interestingly, the functional connectivity patterns between beta cells exhibit small-world properties, suggesting that beta cells do not form a homogeneous geometric network but are connected in a functionally more efficient way. Presented results provide support for the existing knowledge of beta cell physiology from a network perspective and shed important new light on the functional organization of beta cell syncitia whose structural topology is probably not as trivial as believed so far.

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Stisnjena stanja minimalne nedoločenosti za atome in fotone v votlini

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Opisali bomo stisnjena stanja minimalne nedoločenosti za linearno Planckovo nihanje v kvantni mehaniki. Ta so izpeljana z delovanjem ustrezne maksimalne kinematične invariantne grupe na rešitev osnovnega stanja. Pokazali bomo, da produkt spremenljivk doseže minimalno vrednost 1/4 samo v primerih, da je ena spremenljivka minimum in druga je maksimum, ko nastopi stiskanje ene izmed spremenljivk. Posplošena zaporedna stanja so eksplicitno konstruirana in obravnavana je tudi njihova Wignerjeva funkcija. Pokriti koeficienti med stisnjenimi ali posplošenimi harmoničnimi in Fockovimi stanji so eksplicitno določeni v členih hipergeometričnih funkcij. Ustrezne statistike fotonov so obravnavane in omenjena je tudi uporaba v kvantni optiki in v kvantni elektrodinamiki v votlini. Najdene so tudi eksplicitne rešitve Heisenbergovih enačb za operatorje radiacijskega polja s stiskanjem.

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The Minimum-Uncertainty Squeezed States for Atoms and Photons in a Cavity

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We describe the minimum-uncertainty squeezed states for the linear Planck oscillator in quantum mechanics. They are derived by the action of corresponding maximal kinematical invariance group on the standard ground state solution. We show that the product of the variances attains the required minimum value 1/4 only at the instances that one variance is a minimum and the other is a maximum, when the squeezing of one of the variances occurs. The generalized coherent states are explicitly constructed and their Wigner function is studied. The overlap coefficients between the squeezed, or generalized harmonic, and the Fock states are explicitly evaluated in terms of hypergeometric functions. The corresponding photons statistics are discussed and an application to quantum optics and cavity quantum electrodynamics is mentioned. Explicit solutions of the Heisenberg equations for radiation field operators with squeezing are found.

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Modeliranje bakterije *Proteus mirabilis* kot aktivni tekočekristalni sistem

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Spregovoril bom o modeliranju eksperimenta M. Matsushite et al. [1], ki opazuje dinamične lastnosti prehodnih časovno-krajevnih vzorcev kolonije bakterije *Proteus mirabilis*, ki se razvija na površini hranilnega želatine – agarja. Pojav modeliramo kot primer gnanega (aktivnega) tekočekristalnega sistema z dinamično preferirano smerjo [2]. V eksperimentu opazijo različne vzorce: od potujočih prog do naraščajočih in pojemajočih tarč in rotirajočih spiral. Slednje so le ene ročnosti, kar kaže na to, da sistem ni le mikroskopsko, ampak tudi makroskopsko kiralen. Vzorci so optične narave, saj se ob spremembi smeri opazovanja urejeno in ponovljivo spreminjajo. Prvotno so jih pojasnjevali kot pojav moiré, kar pa ne zadošča. Za vzorce je značilno, da so prehodne narave, kar pomeni, da obstajajo le dinamično, statičnih konfiguracij, ki so sicer značilne za običajne tekočekristalne sisteme, pa ne opazimo. Zaradi tega sistema ne opišemo s statično, pač pa z dinamično preferirano smerjo, ki je v tem primeru makroskopska hitrost bakterij. Sistem tako kaže nematsko urejanje le, dokler je v gnanem dinamičnem stanju, ko pa dinamika zamre, tudi ureditev izgine. Poleg nematskega urejanja model zajema tudi reakcijo, ki opisuje rast bakterij, transport ter efektivno energijsko bilanco, ki prek prehoda iz izotropne v nematsko fazo in obratno določa velikost hitrostnega ureditvenega parametra.

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Modeling *Proteus mirablis* as an active LC system

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We model the experiment of M. Matsushita et al. [1] on the dynamical properties of transient spatio-temporal patterns in bacterial colony of *Proteus mirabilis* as an example of a driven liquid crystal system with a dynamical preferred direction [2]. In the experiment spatio-temporal patterns emerge inside the bacterial colony on the surface of nutrient-rich agar medium. Various propagating stripe-like patterns are observed, as well as expanding/shrinking targets and rotating spirals. The latter show only one hand, which evidences that the system is not only microscopically but also macroscopically chiral. The patterns are due to an optical effect as they change in a regular and reproducible manner when the angle of observation is altered. Originally they were explained as a moir-type effect, which however is unclear. The characteristic feature of the patterns is that they are transient, i.e., they only exists while they are dynamic, whereas no static structures are observed as they normally are in regular liquid crystal systems. Therefore the system is modeled by a dynamic preferred direction, which differs from the usual nematic director in that it is a rate – in our case the macroscopic velocity of the bacteria. Hence it exhibits nematic like ordering only when the system is in a driven dynamic state, and vanishes otherwise. Besides nematic features the model includes a reaction equation describing the growth of the bacteria, transport, and an effective energy balance that determines the magnitude of the velocity order parameter by controling the isotropic-nematic transition.

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Študij počasne magnetne dinamike v multiferoikih iz družine $K_3Fe_5F_{15}$

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$K_3Fe_5F_{15}$ je multiferoik in spada v družino $K_3M^{II}_3M^{III}_2F_{15}$. M^{II}_3 and M^{III}_2 označujeta prehodno kovino (Fe, Mn, Co, Cr). Magnetizacijo smo pomerili med ogrevanjem predhodno v magnetnem polju 0 ohlajenega vzorca (ZFC) in med ohlajanjem vzorca v končnem magnetnem polju (FC). Te meritve kažejo na prisotnost magnetnega prehoda v $K_3Fe_5F_{15}$, $K_3Fe_3Cr_2F_{15}$ and $K_3Cu_3Fe_2F_{15}$. Poleg tega smo pomerili magnetno relaksacijo kot funkcijo temperature takoj po preklopu magnetnega polja od vrednosti H v -H. Opazili smo počasno - časovna skala je 1 ura - spreminjanje magnetizacije, ki ga dobro opišemo z logaritemsko časovno odvisnostjo za vse 3 omenjene vzorce v širokem razponu temperatur in magnetnih polj. Sklepamo, da je prisotna porazdelitev magnetnih momentov skladno z anizotropnimi barierami, ki preprečujejo reorientacijo magnetnih momentov. Vpeljali smo model termično aktiviranih magnetnih momentov področij, ki so porazdeljena glede na bariere. Tako lahko razumemo odvisnost relaksacijskih parametrov od temperature in magnetnega polja. Dimenzije teh magnetnih področij so v obsegu do nekaj 10 nanometrov.

Research of slow magnetic dynamics in multiferroics of $K_3Fe_5F_{15}$ family

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$K_3Fe_5F_{15}$ is a multiferroic material belonging to the $K_3M^{II}_3M^{III}_2F_{15}$ family. M^{II}_3 and M^{III}_2 denote a transition metal (Fe, Mn, Co, Cr). Zero-field cooled (ZFC) and field cooled (FC) magnetization measured as a function of temperature demonstrates magnetic transition in $K_3Fe_5F_{15}$, $K_3Fe_3Cr_2F_{15}$ and $K_3Cu_3Fe_2F_{15}$. Complementary to this, the magnetic behavior below the magnetic transition was studied via magnetic relaxation at different temperatures after switching magnetic field from H to $-H$. A slow change of magnetization on the hours time scale was observed and it was best described by a logarithmic time dependence for all three compounds over a broad temperature and field range. It follows that a distribution of magnetic moments over anisotropy barriers, which block the magnetic moments against reorientation, is present. We introduced a model of thermal activation of the magnetic moments of regions distributed over the barriers to describe the temperature and field dependence of the relaxation parameters. The dimensions of these magnetic regions were estimated to be of nanometer size.

Nelinerna stanja v $\mathcal{PT}-$simetričnih metamaterialih

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Sintetični sistemi z enakimi vnosi in izgubami tvorijo $\mathcal{PT}-$simetrične materiale, ki jih opišemo z nehermitskimi Hamiltoniani in kažejo fazni prehod med ekzaktno in zlomljeno fazo kot funkcijo moči vnosa/izgub [1]. Obravnavamo $\mathcal{PT}-$simetrični metamaterial sestavljen iz magnetno sklopljenih dimerov, ki predstavljajo resonatorje v obliki prekinjenega kroga (SRR), kjer eden izgublja in drugi v enaki meri pridobiva. Nelinearnos veplejemo z Esakijevimi diodami. Na enak način kot pri ekvivalentni vezavi [3], razširjeni na $\mathcal{PT}-$dimerske verige, je dinamika naboja q_n akumulirana na kondenzatorju $n-$tega SRR opisana z

$$\lambda'_M \ddot{q}_{2n} + \ddot{q}_{2n+1} + \lambda_M \ddot{q}_{2n+2} + q_{2n+1} = \varepsilon_0 \sin(\Omega\tau) - \alpha q_{2n+1}^2 - \beta q_{2n+1}^3 - \gamma \dot{q}_{2n+1} \tag{1}$$

$$\lambda_M \ddot{q}_{2n-1} + \ddot{q}_{2n} + \lambda'_M \ddot{q}_{2n+1} = \varepsilon_0 \sin(\Omega\tau) - \alpha q_{2n}^2 - \beta q_{2n}^3 + \gamma \dot{q}_{2n} \tag{2}$$

kjer so λ_M, λ'_M koeficienti magnetne interakcije, α in β so brezdimenzijski koeficienti nelinearnosti, γ je koeficient črpanja/izgub ($\gamma > 0$), ε_0 je amplituda zunanje napetosti, med tem ko sta Ω in τ njena frekvenca in karakteristični čas normalizirana na LC resonančno frekvenco ω_0 in inverzno LC frekvenco ω_0^{-1}, kjer je $\omega_0 = 1/\sqrt{LC_0}$ in C_0 kapacitivnost.

Brez nelinearnosti, pri fiksnih λ_M, λ'_M, pasovna širina kot funkcija γ kaže $\mathcal{PT}-$ fazni prehod in spremembo pasu. Prisotnost nelinearnosti lahko inducira nelinearne lokalizirane načine v obliki diskretnih dihalcev z večjim deležem celotne energije koncentrirane na dveh sosednjih mestih [3]. $\mathcal{PT}-$ simetrični nelinearni metamateriali se lahko uporabljajo za dinamično nastavljanje v območju modificiranega pasu in za preklapljanje v zlomljeno fazo.

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Nonlinear modes in $\mathcal{PT}-$symmetric metamaterials

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Synthetic systems with matched gain and loss may form parity-time ($\mathcal{PT}$)-symmetric metamaterials described through non-hermitian Hamiltonians and showing a phase transition in between an exact and a broken phase as a function of the gain/loss power [1].The $\mathcal{PT}-$symmetry breaking has been experimentally observed in optical lattices [2]. We introduce a $\mathcal{PT}$-symmetric metamaterial consisted of split-ring resonator (SRR) dimers, one with loss and the other with equal amount of gain, coupled magnetically while nonlinearity and gain are introduced through tunnel Esaki diodes. Within the framework of the equivalent circuit model [3], extended for the $\mathcal{PT}-$ dimer chain, the dynamics of the charge q_n accumulated in the capacitor of the $n-$th SRR is governed by

$$\lambda'_M \ddot{q}_{2n} + \ddot{q}_{2n+1} + \lambda_M \ddot{q}_{2n+2} + q_{2n+1} = \varepsilon_0 \sin(\Omega\tau) - \alpha q_{2n+1}^2 - \beta q_{2n+1}^3 - \gamma \dot{q}_{2n+1} \tag{3}$$

$$\lambda_M \ddot{q}_{2n-1} + \ddot{q}_{2n} + \lambda'_M \ddot{q}_{2n+1} = \varepsilon_0 \sin(\Omega\tau) - \alpha q_{2n}^2 - \beta q_{2n}^3 + \gamma \dot{q}_{2n} \tag{4}$$

where λ_M, λ'_M are the magnetic interaction coefficients, α and β are dimensionless nonlinear coefficients, γ is the gain/loss coefficient ($\gamma > 0$), ε_0 is the amplitude of the external driving voltage, while Ω and τ are the driving frequency and temporal variable, respectively, normalized to the inductive-capacitive (LC) resonance frequency ω_0 and inverse LC resonance frequency ω_0^{-1}, respectively, $\omega_0 = 1/\sqrt{LC_0}$ with C_0 being the linear capacitance.

In the absense of nonlinearity, for fixed λ_M, λ'_M, the bandwidths as a function of the gain/loss parameter γ show the onset of the $\mathcal{PT}-$ phase transition and a resulting band modification. The presense of noninearity may induce nonlinearly localized modes in the form of discrete breathers with the largest part of the total energy concentrated into two neighboring sites belonging to the same gain/loss dimer [3]. The $\mathcal{PT}-$ symmetric nonlinear metamaterial may be used for dynamic tuning in the range of the modified band and switching to the broken phase.

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Optične lastnosti feromagnetnih tekočin: kobaltovi nanodelci razpršeni v organsko topilo

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Feromagnetne tekočine (ferofluidi) so homogene koloidne disperzije nanodelcev v tekočem gostitelju. Raziskave ferofluidov so intenzivne že od 70. let prejšnjega stoletja, ker so idealni za aplikacije v optičnih tehnologijah, npr. za hitra stikala, preklopnike, nastavljive fazne retarderje idr. (glej npr. [1] in tam navedene reference). Vzrok za široko uporabnost ferofluidov je v tem, da že z relativno majhnimi zunanjimi magnetnimi polji dosežemo veliko linearno in krožno optično anizotropijo.

V predavanju bomo predstavili raziskave Faradayevega (inducirana optična aktivnost) in Voigtovega pojava (inducirana dvolomnost) v ferofluidu, ki ga tvorijo kobaltovi nanodelci s premerom okoli 10 nm, razpršeni v dielektrično organsko tekočino (npr. toluen ali cikloheksan). Nanodelci so feroelektrični in monodomenski. Volumski delež nanodelcev v raztopini je reda 10^{-5}.

Kot, za katerega se zasuče polarizacija pri Faradayevi rotaciji, smo merili v odvisnosti od velikosti in koncentracije nanodelcev, velikosti zunanjega magnetnega polja in valovne dolžine svetlobe. Eksperimentalne rezultate smo primerjali s teoretično napovedjo. Izpeljali smo efektivni dielektrični tenzor za ferofluid, pri čemer smo upoštevali termodinamične lastnosti koloidne raztopine. Predlagani pristop omogoča določitev magnetnega momenta in plazemske frekvence posameznega nanodelca, in iz tega debelino nemagnetne površinske plasti feromagnetnih nanodelcev [2].

Model, ki dobro opiše Faradayevo rotacijo, predvidi za nekaj redov velikosti manjšo inducirano dvolomnost, kot jo opazimo eksperimentalno. To nakazuje, da so v raztopini prisotne tudi verige nanodelcev. Dokler je koncentracija verig majhna

v primerjavi s koncentracijo nanodelcev, verige ne vplivajo na velikost Faradayeve rotacije, imajo pa izjemen vpliv na dvolomnost. Dvolomnost se povečuje z večanjem zunanjega magnetnega polja, kar se v obstoječih raziskavah pripisuje povečanju dolžine verig z večanjem zunanjega magnetnega polja. Pokazali smo, da lahko v zelo razredčenih raztopinah eksperimentalne meritve odvisnosti dvolomnosti od volumskega deleža nanodelcev in zunanjega polja razložimo, če predpostavimo, da se tvorijo samo verige dveh nanodelcev (dimeri). Dvolomnost je eksponentno odvisna od volumna nanodelcev in kvadratno od volumskega deleža [3]. Pri Faradayevi rotaciji je slednja odvisnost linearna [2]. Eksperimentalni rezultati potrjujejo teoretične napovedi [4], da lahko v razredčeni raztopini pričakujemo le dimere.

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Optical properties of ferrofluids: cobalt nanoparticles dispersed in organic solvents

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Ferromagnetic fluids (ferrofluids) are homogeneous colloidal dispersions of ferromagnetic nanoparticles dispersed in a liquid carrier. Ferrofluids are extensively studied, because they are ideal for applications in optical technology as fast shutters, switches, tunable phase retarders, etc., since, due to the magnetic nature of the compounds, large linear and circular optical anisotropy can be induced by applying relatively small external magnetic fields (see e.g. [1] and references therein).

In the talk we will present a study of Faraday effect (induced optical activity) and Voigt effect (induced birefringence) in a composite material made of cobalt nanoparticles embedded in a dielectric liquid host. Nanoparticles have a diameter of approximately 10 nm and are in the monodomain ferromagnetic state. The volume fraction of the nanoparticles is of the order of 10^{-5}.

Faraday rotation angle is measured as a function of the external magnetic field, varying the size and concentration of nanoparticles and the wavelength of light. A nonlinear dependence of the optical rotation on magnetic field resulting from the reorientation of nanoparticles is observed. To analyse the experimental results an effective dielectric tensor of the composite material into which the thermodynamic properties of the system are incorporated was constructed. The proposed approach enables quantitative determination of the magnetic moment and the plasma frequency of a single nanoparticle, and from this the size of the nonmagnetic shell of magnetic nanoparticles [2].

The model that describes well Faraday rotation does not give a satisfactory expla-

nation of the induced birefringence; the model predicts birefringence that is orders of magnitude smaller than the observed one. This suggests that chains of nanoparticles are also present in the dispersion. Chains do not affect the magnitude of the Faraday effect as long as their concentration is small compared to the concentration of monomers, however they have a huge effect on the magnitude of birefringence. Birefringence increases with increasing magnetic field, which is usually attributed to the growth of the chain length with increasing external magnetic field. We show that in dilute solutions the experimental results of the dependence of the birefringence on the volume fraction of nanoparticles and on the external magnetic field can be explained by assuming that only dimers of nanoparticles are formed. The birefringence depends exponentially on the volume of nanoparticles and it is quadratic in volume fraction as opposed to the Faraday effect that is linear in the volume fraction [3]. These results confirm previous theoretical considerations [4] assuming the density functional approach that predicts that chains of only two particles can be expected in dilute solutions.

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Teraherčna spektralna karakterizacija farmacevtske učinkovine v komercialnih zdravilih

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Teraherčna časovno ločljiva spektroskopija (THz-TDS) se uveljavlja v praksi za pridobivanje spektralnih podatkov različnih materialov kot so eksplozivi, farmacevtske in biološke snovi. V THz frekvenčnem območju te snovi kažejo karakteristične spektralne linije, pretežno zaradi kolektivnih vibracijskih stanj in intermolekularnih vibracijskih stanj. Zato je THz-TDS obetavna metoda predvsem na področju farmacevtske industrije, kajti z njo je mogoče pridobiti številne uporabne informacije o vsebnosti aktivnih učinkovin in njihovi porazdelitvi v farmacevtskih tabletah [1-2]. THz-TDS omogoča neposredno določitev absorpcijskih koeficientov in lomnih količnikov brez Kramers-Kronigove analize [3]. V tem prispevku predstavljamo zmožnosti THz-TDS pri detekciji in identifikacije enake učinkovine v različnih komercialno dobavljivih farmacevtskih tabletah. Metodo smo testirali z izbiro različnih vzorcev komercialnih tablet z aktivno učinkovino paracetamol, za katere smo na osnovi meritev izračunali absorpcijske spektre in jih med seboj primerjali. Predstavljamo tudi geometrijo izvajanja spektroskopskih meritev in metode računanja optičnih konstant ter rezultate analize farmacevtskih tablet z enako aktivno učinkovino.

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Terahertz spectral characterisation of active substance in commercial pharmaceutical tablets

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Terahertz time-domain spectroscopy (THz-TDS) is commonly used to acquire spectral data of different materials such as explosives, pharmaceutical and biological compounds, which exhibit characteristic spectral features in the THz frequency range mainly due to collective vibrational modes and intermolecular vibrational modes. Therefore, THz-TDS has great potential in pharmaceutical industry, because it provides useful information for recognition of the active substance and its distribution within the pharmaceutical tablets [1-2]. THz-TDS allows the direct determination of the absorption coefficients and the refractive indices without the need for a KramersKronig analysis [3]. Here we present the capability of the THz-TDS to detect and identify the same active substance in various commercial pharmaceutical tablets. We tested the method for selected several samples of commercial tablets with paracetamol as active pharmaceutical ingredient and compared the absorption spectra of all samples. We also present the measurement geometry used for collecting THz spectral data, calculation methods, and results of the analysis of the observed pharmaceutical tablets.

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Energetska pismenost in Svet energije

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Z uporabo zakona o ohranitvi energije so v praktinem življenju velike težave. Kljub temu, da se zakon o ohranitvi energije v skladu z učnim načrtom obravnava že v osnovni šoli, pa ga ne uporabljamo pri različnih razpravah o energiji v vsakdanjem življenju. Čeprav vemo, da energije ne moremo ustvariti iz nič, bi pri njeni rabi najraje videli, da bi imeli čim več za manj ali celo zastonj. Kadar se v medijih ali politiki razvname razprava o energetiki, se javnost obnaša, kot da še nikoli ni slišala za osnovne pojme zakona o ohranitvi energije. Energetska pismenost povprečnega državljana Slovenije je zelo slaba! Energetska pismenost je relativno nov pojem, ki nam pove ali znamo osnovne fizikalne zakone o energiji prenesti in uporabiti v vsakdanjem življenju. Z njim opišemo znanja kot so: od kje energija, za kaj in koliko energije potrebujem, znam kredibilno oceniti podatke o energiji in moči, znam slediti toku energije in kredibilno odločati o vprašanjih s tega področja. V predavanju bo osvetljen problem energetske pismenosti s konkretnimi primeri iz modernih vprašanj energetskih pretvorb kot so sončne elektrarne, jedrske elektrarne, hidroelektrarne in vprašanj obnovljivih virov na sploh. Da bi izboljšali energetsko pismenost in učiteljem ter profesorjem fizike (in naravoslovja) ponudili dodatno orodje na tem področju, smo pripravili v GEN energiji multimedijsko, interaktivno razstavo Svet energije. S primeri iz razstave bo oplemeniten tudi zaključek predavanja. Če kje, potem v energetiki velja There si no such thing as free lunch.

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Energy Literacy and The World of Energy

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In our everyday life there are big problems with implementing the law of conservation of energy. Even though it is included in the school curriculum as early as in primary school in Slovenia for example, we do not regularly implement it in different discussions on energy. It is obvious that energy cannot be created from nothing. Nevertheless, everybody wants to use as much energy as possible for less money, or even for free. Whenever there is a debate about energy in the media or among politicians, people behave as if they have never heard anything about the physical energy conservation laws. Energy literacy of an average citizen in Slovenia is very low! Energy literacy is a relatively new expression telling us if we are able to practice the basic physical laws of energy in our daily life. Energy literacy talks about our knowledge about the following: where energy comes from, why and how much energy we need, can we really evaluate information about energy and power, can we truly follow the flow on energy and decide about these issues correctly. The lecture will highlight the topic of energy literacy, giving a lot of explanations about the modern energy transformations, such as solar plants, nuclear power plants, hydro power plants as well as renewable sources in general. In order to improve energy literacy and offer additional materials in this field to physics teachers and professors (as well as to natural science teachers) our company GEN energija has made a multimedia, interactive exhibition called The World of Energy. For the conclusion you will be able to see some examples from the exhibition. If anywhere, this is true for the field of energy technology: There is no such thing as free lunch.

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