CAMTP

Center for Applied Mathematics and Theoretical Physics
Univerza v Mariboru

5. Simpozij fizikov Univerze v Mariboru

Zbornik povzetkov

Hotel Piramida
Maribor, 14., 15. in 16. december 2006

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

Urednika:
prof. dr. Marko Robnik, CAMTP
prof. dr. Dean Korošak, Katedra za aplikativno fiziko, Fakulteta za gradbeništvo

PREDGOVOR

Naši Simpoziji fizikov Univerze v Mariboru, ali na kratko kar Božični simpoziji, imajo že tradicijo, saj imamo letos že petega po vrsti. Namen je strokovno druženje slovenskih fizikov, ob prisotnosti ter aktivni udeležbi nekaterih kolegov iz tujine kot častnih vabljenih gostov, pri čemer je lansko srečanje preraslo regionalne okvire in je postalo nacionalno srečanje. Srečanje poteka v okviru dejavnosti CAMTP - Centra za uporabno matematiko in teoretično fiziko, organizatorja pa sva skupaj s Prof.Dr. Deanom Korošakom.

Letos si organizatorji in udeleženci štejemo v čast, da bodo med nami, kot častni vabljeni predavatelji, naši najbolj ugledni in najstarejši fiziki, Predsednik SAZU Prof.Dr. Boštjan Žekš, Akad.Prof.Dr. Robert Blinc, in drugi, in nadvse ugledni gostje iz tujine, kjer bi med najstarejšimi omenil Prof.Dr. Siegfrieda Grossmanna z Univerze v Marburgu, Nemčija.

Rad bi poudaril, 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. S to dejavnostjo prispevamo tudi k popularizaciji fizike v naši družbi, na trajen način, in ne le zgolj v okviru leta 2005, ki je bilo svetovno leto fizike. 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 rad poudaril, da je naše druženje lahko pomemben prispevek pri samo-organiziranju fizikov znotraj nove Fakultete za naravoslovje in matematiko, ki je v letu 2006 uradno zaživela, kar je seveda velik uspeh Pedagoške fakultete ter Univerze v Mariboru, katere vodstvu čestitamo k temu dogodku in izražamo upanje, da bo nova fakulteta bistveno prispevala k povezavi fizikov na Univerzi v Mariboru, v smislu delitve pedagoških ter znanstveno raziskovalnih dejavnosti ter rednega strokovnega druženja v obliki kolokvijev itd.

Prof.Dr. Marko Robnik
— Direktor CAMTP —
— Direktor 5. Simpozija —

Seznam udeležencev 5. Simpozija fizikov Univerze v Mariboru

akad. prof. dr. Robert Blinc
Institut Jožef Stefan

prof. dr. Tassos Bountis
University of Patras

dr. Anamarija Borštnik Bračič
FS, Univerza v Ljubljani

prof. dr. Gvido Bratina
Univerza v Novi Gorici

mag. Xingwu Chen
CAMTP, Univerza v Mariboru

mag. Vitaliy Cherkaskiy
Kharkov Institute of Physics and Tehnology

prof. dr. Bruno Cvikl
FG, Univerza v Mariboru

doc. dr. Jure Dobnikar
Institut Jožef Stefan

prof. dr. Rudolf Dvorak
University of Vienna

akad. prof. dr. Igor Grabec
FS, Univerza v Ljubljani

prof. dr. Siegfried Grossmann
Philipps-University

dr. Martin Horvat
FMF, Univerza v Ljubljani

prof. dr. Dean Korošak
FG, Univerza v Mariboru

prof. dr. Peter Križan
FMF, Univerza v Ljubljani

Martin Vodopivec
FMF, Univerza v Ljubljani

prof. dr. Aleksander Zidanšek
MPŠ, Institut Jožef Stefan

prof. dr. Primož Ziherl
FMF, Univerza v Ljubljani

prof. dr. Tomaž Zwitter
FMF, Univerza v Ljubljani

dr. Tomaž Žagar
GEN energija d.o.o., Krško

akad. prof. dr. Boštjan Žekš
MF, Univerza v Ljubljani

dr. Marko Žnidarič
FMF, Univerza v Ljubljani

prof. dr. Slobodan Žumer
FMF, Univerza v Ljubljani

Urnik 5. Simpozija fizikov Univerze v Mariboru

Četrtek, 14. december 2006	
Chair	Robnik
09:00-10:00	Žekš*
10:00-11:00	Grossmann*
11:00-11:30	tea, coffee
11:30-12:30	Blinc*
12:30-13:30	Grabec*
13:45-15:00	lunch
Chair	Blinc
15:00-16:00	Plessas*
16:00-16:30	tea, coffee
16:30-17:30	Prosen*
17:30-18:00	Stepišnik*
18:00-18:15	Perc
18:15-18:30	Marčič
20:00-	concert and dinner

*vabljeno predavanje/invited lecture

Urnik 5. Simpozija fizikov Univerze v Mariboru

Petek, 15. december 2006	
Chair	Stepišnik
09:00-10:00	Dvorak*
10:00-10:30	Trontelj*
10:30-11:00	Šmit*
11:00-11:30	tea, coffee
11:30-12:00	Cvikl*
12:00-12:30	Bratina*
12:30-13:30	Križan*
13:45-15:00	lunch
Chair	Trontelj
15:00-16:00	Romanovski*
16:00-16:30	tea, coffee
16:30-17:00	Žnidarič
17:00-17:30	Veble
17:30-18:00	Zidanšek*
18:00-18:30	Dobnikar
20:00-	dinner

*vabljeno predavanje/invited lecture

Urnik 5. Simpozija fizikov Univerze v Mariboru

Sobota, 16. december 2006	
Chair	Šmit
09:00-10:00	Bountis*
10:00-11:00	Zwitter*
11:00-11:30	tea, coffee
11:30-12:30	Ziherl*
12:30-13:00	Žagar
13:00-13:30	Horvat
13:30-15:00	lunch
Chair	Grossmann
15:00-15:30	Muševič*
15:30-15:45	Kutnjak
15:45-16:00	Borštnik Bračič
16:00-16:30	tea, coffee
16:30-17:30	Ruffing*
17:30-18:00	Žumer*
20:00-	dinner

*vabljeno predavanje/invited lecture

Feroelektrični fazni prehodi: prehodi red nered ali nestabilnost anharmonske kristalne mreže?

ROBERT BLINC

Institut J. Stefan Ljubljana, Slovenia
robert.blinc@ijs.si • www.ijs.si

Stabilno stanje feroelektričnega sistema določa minimum termodinamskega potenciala. V najpreprostejšem primeru je to kar prosta energija, ki je podana z: F=U-TS. Tu je U interakcijska energija sistema, S entropija, T pa temperatura. Prvi člen, to je interakcijska energija U, minimizira prosto energijo, ko je sistem urejen. Drugi člen, ki je sorazmeren temperaturi, pa minimizira prosto energijo, ko je sistem neurejen in je entropija maksimalna. Pri ohlajanju pride pri določeni vmesni temperaturi do faznega prehoda iz neurejene v urejeno fazo.

Feroelektrični fazni prehodi se delijo na dva razreda: 1.na prehode vrste red nered, kjer je entropijska sprememba pri faznem prehodu znatna, in 2.na prehode, ki jih povzroča nestabilnost anharmonske kristalne mreže, kjer je entropijska sprememba pri faznem prehodu majhna in kjer nestabilno mrežno nihanje (mehki fonon) zamrzne pri kritični temperaturi. Klasični primer za prehode vrste red nered je družina kristalov vrste $KH_2\ PO_4$, kjer imajo protoni dve ravnovesni legi v vodikovih vezeh, ki povezujejo PO_4 tetradre. V visoko temperaturni fazi so protoni neurejeni, v nizko temperaturni fazi pa zamrznejo v eni izmed dveh možnih ravnovesnih leg. Klasični primer za prehode, ki jih povzročajo mehki fononi, pa naj bi bili perovskitni kristali vrste $BaTiO_3$.

Že pred več kot dvajsetimi leti je A. Müller s pomočjo meritev elektronske paramagnetne resonance na kristalu $BaTiO_3$ dopiranim z Mn^{4+}, Cr^{3+} in Fe^{3+} vzbudil resen dvom v to teorijo. Rezultati so namreč pokazali, da naj bi Mn^{4+}, Cr^{3+} in Fe^{3+} , ki zamenjujejo Ti ion, ne bili na centralnem mestu sredi kisikovega oktaedra, temveč naj bi ležali izven centralne lege. Vendar teh rezultatov niso jemali povsem resno, ker naj bi dopiranje kristala spremenilo njegove lastnosti. Naše NMR meritve ^{47}Ti in ^{49}Ti , ki so opravljene na čistem monokristalu $BaTiO_3$, pa so povsem jasno pokazale, da že v kubični paraelektrični fazi Ti ioni skačejo med osmimi necentralnimi legami.

Fazni prehod je tako tu kombinirane narave, saj je zamrznjenje mehkega fonona povezano z ureditvijo Ti ionov. Podobne rezultate smo dobili v primeru $SrTiO_3$ in z ^{18}O obogačenim $SrTiO_3$.

Order - disorder versus displacive behaviour of ferroelectric perovskites

ROBERT BLINC

J. Stefan Institute Ljubljana, Slovenia
robert.blinc@ijs.si • www.ijs.si

Whereas the first microscopic theory of $BaTiO_3$ was based on order-disorder behavior, later on $BaTiO_3$ has been considered as a classiacal example of displacive soft mode transitions, which can be described by anharmonic lattice dynamics. Already more than twenty years ago, electron paramagnetic resonance (EPR) measurements performed on Mn^{4+}, Cr^{3+}, and Fe^{3+} doped $BaTiO_3$ by Müller et. al. seriously questioned the pure displacive character of the phase transitions. Recently, the problem has been studied by quadrupole perturbed ^{47}Ti and ^{49}Ti NMR. It was clearly shown that the Ti sits off-center not only in the tetragonal but also in the cubic phase. This off-center scenario confirms theoretical studies which showed a combined displacive and order-disorder character of the transitions in $BaTiO_3$. The model clearly shows the characteristics of a displacive transition, but with a simultaneous partial ordering of the Ti subsystem as an additional order-disorder feature. Similar results were obtained for $SrTiO_3$ and ^{18}O enriched $SrTiO^3$. Here we present quadrupole perturbed ^{17}O NMR data of both $BaTiO_3$ and $SrTiO_3$ which throw some new light on the role of the oxygen network as well as the A and B ions at the phase transitions in ABO_3 perovskite lattices.

Stability and Chaos in Multi-Dimensional Hamiltonian Systems and Symplectic Maps

TASSOS BOUNTIS

CRANS - Center for Research and Applications of Nonlinear Systems
Department of Mathematics University of Patras, Rion, Patras
26500 Greece
bountis@math.upatras.gr • www.math.upatras.gr/ bountis

The connection between local and global stability of motion of N - degree of freedom Hamiltonian systems will be discussed, in an attempt to understand the thermodynamic limit, where $N \to \infty$ and statistical mechanics is expected to take over from classical mechanics. I will focus on Simple Periodic Orbits (SPOs), i.e. periodic solutions with all degrees of freedom oscillating in phase (or out of phase) and with equal characteristic frequencies. In the case of the Fermi - Pasta - Ulam (FPU) lattice, I shall explain how the stability of these SPOs is related to the breakdown of FPU recurrences and discuss how the study of SPOs can shed light on the transition to large scale chaotic behavior characterized by invariant spectra of Lyapunov exponents. I will then report on a recent discovery of a very efficient spectrum of indices, called the $GALI_k, k = 1, 2, .., 2N$, which can efficiently distinguish ordered from chaotic motion and identify the dimensionality of quasiperiodic orbits in conservative dynamical systems. I will apply this index not only to Hamiltonian systems, but also to 2N - dimensional symplectic maps, which are of interest in accelerator dynamics.

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References

[1] C. Antonopoulos, T. Bountis and Ch. Skokos, *Int. J. Bifurc. Chaos Journal of Bifurc. Chaos* **16** No. 6 (2006) 1777-1793.

[2] C. Antonopoulos and T. Bountis, *Phys. Rev. E* **73** (2006) p. 056206.

[3] T. Bountis, *Nonlinear Phenomena and Complex Systems* **9**, No. 3 (2006) 209 - 239.

Statistično modeliranje dvodimenzionalnih kaotičnih polj

ANAMARIJA BORŠTNIK BRAČIČ in IGOR GRABEC

Katedra za sinergetiko, Fakulteta za strojništvo
Univerza v Ljubljani, Aškerčeva 6, SI-1000 Ljubljana, Slovenija
anamarija.bracic@fs.uni-lj.si • www.fs.uni-lj.si/lasin/

V predavanju bom predstavila, kako z metodo neparametričnega statističnega modeliranja napovemo časovni razvoj deterministčnega kaotičnega polja. Metoda temelji na predpostavki, da se pri časovnem razvoju polja njegove statistične lastnosti ne spremenijo. Z analizo polja v preteklosti lahko pridobimo informacijo o relacijah med vrednostmi polja v sosednjih oziroma časovno zaporednih točkah. Na podlagi iskanja podobnosti med trenutnim vektorjem stanja in različnimi vektorji stanja v preteklosti lahko s poznavanjem relacij med sosednjimi vektorji stanja napovemo vrednost polja v naslednjem časovnem intervalu.

Pri predstavitvi metode bom posebno pozornost namenila načinu vzorčenja polj in pokazala, kakšen način vzorčenja vodi k najbolj učinkovitem napovedovanju polj. Uporabljeno metodo bom ilustrirala na zgledu diskretnega modela kaotične mrežno povezane mape.

Reference

[1] S. Mandelj, I. Grabec, E. Govekar, *International Journal of Bifurcation and Chaos* **14** No.6 (2004) 2011-2025.

[2] I. Grabec, *European Physical Journal B* **48** No. 2 (2005) 279-289.

[3] I. Grabec, S. Mandelj, *Progress of Theoretical Physics Supplement* **150** (2003) 81-88.

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Statistical modeling of two dimensional chaotic fields

ANAMARIJA BORŠTNIK BRAČIČ and IGOR GRABEC

Chair of Synergetics, Faculty of Mechanical Engineering
University of Ljubljana, Aškerčeva 6, SI-1000 Ljubljana, Slovenia
anamarija.bracic@fs.uni-lj.si • www.fs.uni-lj.si/lasin/

Non-parametric statistical modeling is a powerful tool for predicting evolution of deterministic chaotic fields. It is based on assumption that statistical properties of deterministic chaotic fields remain unchanged as the field evolutes with time. An analysis of field patterns in the past enables us to extract relations between values of field in neighboring points in space as well as in time. Based on similarities between the present field pattern and field patterns extracted from the past data, the field value in the next time step can be successfully predicted.

In my presentation a special attention will be paid to the optimization of field pattern sampling. It will be shown how to sample a set of patterns, which gives the highest quality field prediction. The proposed method will be illustrated on a model of chaotic discrete coupled map lattice.

References

[1] S. Mandelj, I. Grabec, E. Govekar, *International Journal of Bifurcation and Chaos* **14** No.6 (2004) 2011-2025.

[2] I. Grabec, *European Physical Journal B* **48** No. 2 (2005) 279-289.

[3] I. Grabec, S. Mandelj, *Progress of Theoretical Physics Supplement* **150** (2003) 81-88.

[4] S. Mandelj, I. Grabec, E. Govekar, *International Journal of Bifurcation and Chaos* **11** (2001) 2731-2738.

Nadzorovana rast organskih polprevodniških slojev

GVIDO BRATINA

Univerza v Novi Gorici
Vipavska 13, 5001 Nova Gorica
bratina@p-ng.si • www.p-ng.si

Tanki sloji organskih polprevodnikov predstavljajo novo paradigmo na področju elektronskih in optoelektronskih sestavnih delov, saj na primer omogočajo izdelavo večbarvnih zaslonov na gibkih podlogah. Razumevanje mehanizmov, ki uravnavajo rast organskih polprevodniških slojev v začetnih fazah je ključno za razumevanje elektronskih in optičnih lastnosti slojev. V predavanju bodo predstavljeni rezultati eksperimentov s katerimi smo preiskali morfološke značilnosti tankih slojev treh tehnološko zelo pomembnih organskih polprevodnikov: 3,4,9,10-perilendianhidrida tetrakarboksilne kisline (PTCDA), pentacena in rubrena, v območju debelin pod eno molekularno plastjo. Rezultati kažejo, anomalno spreminjanje velikosti otokov na PTCDA. Primerjava rasti pentacena in rubrena na stopničastih safirnih podlogah pa kaže na pomembno vlogo molekularne konformacije na morfologijo slojev.

Controlled growth of thin organic semiconductor layers

GVIDO BRATINA

University of Nova Gorica
Laboratory for epitaxy and nanostructures, Vipavska 13, 5001 Nova Gorica
bratina@p-ng.si • www.p-ng.si

Organic semiconductors represent a new paradigm in the field of advanced electronic and optoelectronic devices. They promise the fabrication of e. g. multicolor displays on flexible substrate. Understanding of the mechanisms that govern the initial stages of growth of organic semiconductor layers is important for understanding the electronic and optical properties of these material systems. The presentation will cover the experimental results of investigations of morphology of thin layers of three technologycally relevant organic semiconductors: 3,4,9,10-perylenetetracarboxylicacid dianhidride (PTCDA), pentacene, and rubrene. Our results show an anomalous scaling behavior of PTCDA in a submonolayer coverages. The comparison of initial stages of growth of pentacene and rubrene on stepped sapphire surfaces indicate an important role of molecular conformation on thin film morphology.

O električnih lastnostih po metodi ioniziranih skupkov izvedenega vzorca dvoplastne Al/PTCDA(800nm)/CuPc(1200nm)/ITO strukture organskih polprevodnikov kot zaporne diode

BRUNO CVIKL IN MATJAŽ KOŽELJ, DEAN KOROŠAK

Katedra za aplikativno fiziko, Fakulteta za gradbeništvo
Univerza v Mariboru, Smetanova ulica 17, SI-2000 Maribor,
Slovenija
J. Stefan Institute, Ljubljana, Jamova 39, Slovenija
cvikl@uni-mb.si • www.fg.uni-mb.si

Zaporna dioda je iz anorganskih polprevodnikov izvedena p-n tunelska dioda, za katero je značilno da, ob pogoju, da je dopiranje z p- in n- nečistočami blizu območja degeneracije, prične električni tok v določenem območju zaporne napetosti naglo eksponentno naraščati in presega eksponentno rast v prevodni smeri zunanje napetosti [1].

Tokovna, I U, pri sobni temperaturi izmerjena, karakteristika naravno starane dvoplastne AL/PTCDA(800nm)/CuPc(1200nm)/ITO strukture organskih polprevodnikov izraža pri napetosti U = - 10 V izrazito rast (absolutne) vrednosti toka, ki spominja na Zenerjev pojav. Za podrobnejčo proučitev tega, še neobjavljenega, pojava organskih polprevodnikov so meritve kapacitete-napetosti zapisane strukture podale [2,3] vrednosti parametrov, ki omogočajo izračun notranjega električnega polja ter potencialne energije vrzeli, t.im. HOMO transportnega pasu, dane polprevodniške strukture. Slednja je kvadratna funkcija prostorske koordinate, katere maksimalna vrednost in lega temena parabole zavisita od vrednosti zunanje napetosti. Za U = 0 je maksimum pri 41 V (relativno na poljubno aditivno konstanto) s temenom na približni oddaljenosti 1150 nm od Al katode.

V predstavitvi bo podan kvalitativni opis naravno starane, zaporne, dvoplastne

AL/PTCDA(800nm)/CuPc(1200nm)/ITO strukture organskih prevodnikov v skladu z meritvami. Tako I-U kot C-U lastnosti navedene strukture je moč razložiti na osnovi možne plazovite multiplikacije nosilcev naboja (t.j. vrzeli), pri čemer je mogoče zanemariti pojav tuneliranja nosilcev v strukturi sami. Prikazano bo kako je vrednost napetosti, pri kateri prične tok v zaporni smeri zunanje napetosti močno naraščati, enolično določena z vrednostjo odgovarjajoče napetosti naraščanja toka v prevodni smeri in od razlike izstopnega dela vrzeli, Al in ITO elektrod. Na osnovi izvedenih zaključkov to delo tako podaja zaznavno podporo nedavnega doprinosa [3] k osvetlitvi lastnosti meritev kapacitete-napetosti organskih polprevodniških struktur.

Reference

[1] S. M. Sze, *Physics of Semiconductor Devices, 2-nd Edition*, John Wiley and Sons, New York 1981, p. 96.

[2] B. Cvikl, M.Koželj, D. Korošak, R. Jecl, *J. Appl. Phys.* **99** (2006) 023704-1.

[3] B. Cvikl, M.Koželj, D. Korošak, R. Jecl, *J. Appl. Phys.* submitted.

On the backward diode electrical characteristic of the ionized cluster beam deposited Al/PTCDA(800nm)/CuPc(1200nm)/ITO bilayer organic structure

BRUNO CVIKL AND MATJAŽ KOŽELJ, DEAN KOROŠAK

Chair of Applied Physics, Faculty of Civil Engineering
University of Maribor, Smetanova ulica 17, SI-2000 Maribor,
Slovenia
J. Stefan Institute, Ljubljana, Jamova 39, Slovenia
cvikl@uni-mb.si • *www.fg.uni-mb.si*

The backward diode refers to the p-n tunnel diode fabricated from the inorganic semiconductors characterized by the fact that, providing the p and n doping concentrations are nearly degenerate, the current in the reverse direction of the externally applied bias exhibits a strong exponential growth that considerably exceeds the rapid growth of current for forward biases [1].

The room temperature current-voltage, I U, characteristics of our, naturally aged, bilayer AL/PTCDA(800nm)/CuPc(1200nm)/ITO organic semiconductor structure exhibit, at around U = -10 V of applied bias, behavior that strongly resemble the typical Zener effect. In order to investigate this, so far an unreported feature, the room temperature capacitance voltage, C-U, characteristics were measured that provide [2,3] the parameters that enable the spatial dependence of the resulting electric field as well as the respective hole potential energy within the structure, the HOMO transport band, to be calculated. It turns out to be a parabolic function of the space coordinate with its maximum value as well as its position within the structure to be bias dependent. For U = 0 its maximum value is 41 eV (as described in terms of an arbitrary additive constant) and it is centered at about 1150 nm from the Al cathode.

In this work the qualitative description of the backward, naturally aged, bilayer, AL/PTCDA(800nm)/CuPc(1200nm)/ITO, organic semiconductor structure will be

presented and shown to be in full agreement with the experiment. It will be shown that the I-U and C-U characteristics of this particular organic bilayer structure may be understood on the basis of the possible avalanche multiplication of charge carriers without invoking any tunneling effect whatsoever. In particular, it will be shown how the turn-on bias voltage of the backward current is uniquely determined from the experimentally determined turn-on voltage in forward bias and the difference of the work functions of the electrodes. The presented work consequently may serve as an additional support of the recent approach [3] towards the illumination of the capacitance voltage characteristics of the organic semiconductor structures.

References

[1] S. M. Sze, *Physics of Semiconductor Devices, 2-nd Edition*, John Wiley and Sons, New York 1981, p. 96.

[2] B. Cvikl, M.Koželj, D. Korošak, R. Jecl, *J. Appl. Phys.* **99** (2006) 023704-1.

[3] B. Cvikl, M.Koželj, D. Korošak, R. Jecl, *J. Appl. Phys.* submitted.

Nenavadne faze paramagnetnih koloidov

Jure Dobnikar

Institut Jožef Stefan, Jamova 39, Ljubljana, Slovenia
jure.dobnikar@ijs.si

Dušan Babič, Natan Osterman, Blaž Kavčič, Igor Poberaj
Univerza v Ljubljani, Ljubljana, Slovenia

in Primož Ziherl
Univerza v Ljubljani, Ljubljana, Slovenia
Institut Jožef Stefan, Jamova 39, Ljubljana, Slovenia

Eksperimentalno in numerično smo preučevali kvazidvodimenzionalne strukture paramagnetnih koloidov. Koloidi so omejeni med stekleni steni, katerih razmik je malo večji od premera koloidov, tako da je njihova medseojna interakcija odvisna od razdalj v ravnini xy in tudi od z koordinate koloidov. S spreminjanjem razmika med stenama lahko dobimo popolnoma odbojne dipolarne inerakcije, dipolarne interakcije z zmanjšanim odbojem pri majhnih razdaljah, pa tudi privlačne interakcije, ko je razmik dovolj velik. Preučevali smo sisteme s popolnimi odbojnimi interakcijami. Ob spreminjanju jakosti zunanjega magnetnega polja in gostote koloidov smo opazili vrsto različnih struktur, od tekoče in heksagonalne faze do kvadratne in verižne faze ter faz, kjer osnovni gradniki niso posamezni koloidi, temveč njihovi skupki. Podobna stanja že nekaj časa opažajo v 2D sistemih z različnimi modelskimi potenciali, naše delo pa je njihova prva eksperimentalna uresničitev.

Exotic phases of q paramagnetic colloids

Jure Dobnikar

Institut Jožef Stefan, Jamova 39, Ljubljana, Slovenia
jure.dobnikar@ijs.si

Dušan Babič, Natan Osterman, Blaž Kavčič, Igor Poberaj
Univerza v Ljubljani, Ljubljana, Slovenia

and Primož Ziherl
Univerza v Ljubljani, Ljubljana, Slovenia
Institut Jožef Stefan, Jamova 39, Ljubljana, Slovenia

We have studied quasi 2D systems of paramagnetic colloids experimentally and numerically. The colloids were bound to a region between two planparallel walls with the spacing slightly larger than the colloidal diameter. The collid-colloid interaction thus depends on the xy distance and on the z coordinates of the colloids. By varying the wall spacing we can realize purely dipolar repulsive interactions, repulsive interactions with reduced strength at small distances and also attractive interactions between colloids. Limiting ourselves to the purely repulsive potentials we have varied the magnetic field strength and the colloidal density and observed a number of different phases, from liquid and hexagonal, to quadratic, lamellar and phases where the building blocks were clusters of colloids rather than single colloids. Similair phases have been found in many simulations with toy-model potentials, but this work is the first experimental realization of such phases.

Terrestrial Planets in Extrasolar Planetary Systems

RUDOLF DVORAK

AstroDynamicsGroup, Institute for Astronomy
University of Vienna, Türkenschanzstrasse 17, A-1180 Vienna
dvorak@astro.univie.ac.at • www.astro.univie.ac.at/adg

Today there are about 200 extrasolar planets in 156 extrasolar systems confirmed. We have observational evidence for planets from 7 (Gliese 876 d) earth masses (like Uranus) up to several Jupiter masses. It means that up to now no Earth-like planet was found in the Solar environment. To ensure that an orbit of such a planet is stable in the so-called habitable zone (=HZ)[1] around a host star in a planetary systems with Jupiterlike planets there a different possible configurations:

- a hot Jupiter moves very close to the central star
- a large planet orbits moves far enough outside the HZ such it does not perturb the motions of a terrestrial planet inside the HZ
- When 'Jupiter' itself moves inside the HZ a terrestrial planet may be in the the so-called coorbital motion; it means it can be a satellite or a Trojan planets.

In this new investigation we study in real multiplanetary systems the stable regions for possible terrestrial Trojans in the HZ.

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[1] roughly speaking where water can be in a liquid state (Kasting 1991)

Statistično modeliranje fizikalnih zakonov

IGOR GRABEC

Fakulteta za strojništvo
Univerza v Ljubljani, Aškerčeva 6, SI-1000 Ljubljana, Slovenia
igor.grabec@fs.uni-lj.si • www.fs.uni-lj.si/lasin

Predmet obravnave je statistično modeliranje fizikalnih zakonov na osnovi izmerjenih podatkov o medsebojno povezanih fizikalnih spremenljivkah. Modeliranje se začne s statistično oceno gostote porazdelitve povezane verjetnosti (GPV) opazovanih spremenljivk. GPV je statistično opisana z jedrsko cenilko. Jedro je opisano s sipalno funkcijo inštrumenta in centrirano na eksperimentalnih podatkih. Na osnovi GPV je opredeljena povezana entropija informacije, ki predstavlja kompleksnost opazovanega pojava. Z njo je vpeljana medsebojna informacija merjenih spremenjivk in redundanca povezane meritve. Napaka ocene povezane verjetnosti v povprečju pada, redundanca meritve pa narašča z naraščajočim številom podatkov. Vsota napake ocene in redundance meritve ima zato minimum, s katerim je opredeljen optimalni model GPV. Kot optimalna cenilka relacije med merjenimi spremenljivkami je izpeljano pogojno povprečje, ki je enostavno izraženo z merskimi podatki. Pogojno povprečje predstavlja ne-parametrično regresijo in je splošno uporabno v statističnem modeliranju naravnih zakonov. Njegova uporabnost je prikazana na modeliranju turbulentnih polj v fiziki, predikciji odzivov pacientov na prejeta zdravila v medicini in napovedovanju časovnih vrst v ekonomiji.

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Statistical modeling of physical laws

IGOR GRABEC

Faculty of Mechanical Engineering
University of Ljubljana, Aškerčeva 6, SI-1000 Ljubljana, Slovenia
igor.grabec@fs.uni-lj.si • www.fs.uni-lj.si/lasin

Statistical modeling of experimental physical laws in terms of measured data about joint physical variables is treated. The modeling starts by the statistical estimation of joint probability density function (PDF) of observed variables. The PDF is expressed by the kernel estimator. The kernel is described by the instrument scattering function that is centered at measured data. Based upon joint PDF the entropy of experimental information is defined. It represents the complexity of the observed phenomenon and is applied in the definition of mutual information and redundancy of experimentation. The error of PDF estimation on average decreases, while redundancy increases with the number of acquired data. Hence, the sum of estimation error and redundancy exhibits a minimum by which an optimal model of PDF is determined. As an optimal estimator of relations between simultaneously measured variables the conditional average is derived. Conditional average is simply expressed by measured data and represents a non-parametric regression that is generally applicable in statistical modeling of natural laws. Its applicability is demonstrated on modeling of turbulent fields in physics, prediction of patient response to drug administration in medicine and forecasting of time series in economy.

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Deterministic law, chaos, and fractality

On recent results for the Lorenz model

SIEGFRIED GROSSMANN

Fachbereich Physik
Philipps-University, Renthof 6, 35032 Marburg, Germany
grossmann@physik.uni-marburg.de • *www.physik.uni-marburg.de*

Despite well established classical equations of motion many phenomena in nature seem to be unpredictable, but at the same time may also show beautiful regular or fractal structures. Causality even in classical mechanics is restricted by the unavoidably limited knowledge of the initial conditions. A paradigm showing all these features is the Lorenz model, originally meant to understand the transition to Rayleigh-Benard convective turbulence. The wonderful richness of its solutions in the various ranges of its full two-dimensional parameter space is presented and analysed. Sequences of regular periodic motions, well ordered in fractal sets, are nested into chaotic ranges and vice versa. Some of the structures can be understood in analytically tractable approximations.

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Serpentinasti biljardi v klasični in kvantni sliki

MARTIN HORVAT

Fakulteta za matematiko in fiziko
Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenia
martin.horvat@fmf.uni-lj.si • http://chaos.fiz.uni-lj.si

Predstavil bom specifičen razred dvodimenzionalnih biljardnih verig sestavljen iz ravnih in zavitih odsekov valovoda. Klasični delci v takšni vegi ne morejo spremeniti smer potovanja vzdolž verige. To lastnost imenujemo enosmerni transport. Ogledali si bomo dinamične in transportne lastnosti skozi verigo z uporabo modelov skakanja. Serpentinast biljard v kvantni sliki diskuritamo v okviru sipalnega formalisma. V kvantni sliki je enosmerni transport kršen in posledično refleksija je različna od nič. Refleksijo podrobneje preučimo v različno oblikovanih serpentinastih biljardih, kjer odkrijemo možnost lokalizacije v naključnih kanalih. Ogledamo si tudi energijski spekter v zaprtih serpentinastih biljardov, ki je sestavljen iz bližnjih parov nivojev. Ugotovimo, da so ti pari nivojev, zaradi neničelne refleksije, razcepljene semiklasične degeneracije med levo in desno potujočimi valovi. V serpentinastem biljardu brez geometričnih simetrij so razdalje med sosednjimi pari porazdeljene po Wignerjevi porazdelitvi. Dodatno si ogledamo korespondenco med kvantnim in klasičnim sipanjem vzdolž kanala na presečni ploskvi, kjer klasični sistem predstavimo z verjetnostno porazdelitvijo in kvantni sistem z Wignerjevo funkcijo.

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Serpent billiards in classical and quantum picture

MARTIN HORVAT

Faculty of matematics and physics
University in Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
martin.horvat@fmf.uni-lj.si • http://chaos.fiz.uni-lj.si

I will present a specific two-dimensional billiard chain composed of straight and bended sections of a wave-guide in which classical particle can not change its direction of travel. We call this property uni-directional transport. We review dynamical and transport properties through serpent billiards by using the so called jump model approach. In the quantum picture the unidirectional transport is violated and consiquently the reflection is non-zero. The latter is studied in differently shaped serpent billiards and find indication for localization in randomly composed billiards. We also take a look at the spectrum of closed serpent billiards. The latter are composed of pairs of levels. These pairs are, due to non-zero reflection, split semi-classical degeneracy between left and right propagating waves. The distance between neighbouring pairs in non-symmetrical billiards follow the Wigner distribution. In addition we discuss the correspondence between classical and quantum scattering along the channel on the surface-of-section, where classical system is represented by the probability distribution and quantum by the Wigner function.

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Redki razpadi mezonov B

PETER KRIŽAN

Fakulteta za matematiko in fiziko, Univerza v Ljubljani
Institut J. Stefan, Ljubljana
peter.krizan@ijs.si • www-f9.ijs.si/ krizan/pk.html

V predavanju bom predstavil nekaj izbranih študij redkih razpadov mezonov B. Razlagi motivacije, iskanju signalov fizikalnih procesov, ki jih ne moremo zadovoljivo popisati v okviru Standardnega modela, teorije osnovnih delcev in njihovih interakcij, bo sledil pregled najbolj zanimivih rezultatov meritev s spektrometrom Belle. Govoril bom o meritvi razpada $B \to \tau\nu$, iskanju znakov za prehod $B \to K^{(*)}\nu\nu$, meritvi simetrije naprej-nazaj v končnem stanju $K^* l^- l^+$ in meritvi kršitve simetrije CP v prehodih $B \to X^s\gamma$. Predstavil bom tudi načrte za bodočnost, povezane s t.i. Super tovarno mezonov B.

Rare B decays

PETER KRIŽAN

Fakulteta za matematiko in fiziko, Univerza v Ljubljani
Institut J. Stefan, Ljubljana
peter.krizan@ijs.si • www-f9.ijs.si/ krizan/pk.html

The talk will present some selected studies of rare B decays. We will first discuss the motivation, search for phenomena which cannot be accommodated in the Standard model, the theory of elementary particles and their interactions. We will then present the measurements of $B \to \tau\nu$ decays with the Belle spetrometer, as well as searches for $B \to K^{(*)}\nu\nu$ transitions, measurements of forward-backward asymmetry in the $K^* l^- l^+$ final state, and CP violation in $B \to X^s\gamma$ decays. We will also discuss plans for the future Super B factory and report on possible improvements in particle identification methods.

O kaotični dinamiki na posplošeni Juliajevi množici, ki izvira iz diskretnega homogenega kvadratnega sistema v ravnini

MILAN KUTNJAK[1], MATEJ MENCINGER[2]

[1] *Univerza v Mariboru, FERI, Maribor, Slovenija*
milan.kutnjak@uni-mb.si
[2] *Univerza v Mariboru, FG, Maribor in IMFM, Ljubljana, Slovenija*
matej.mencinger@uni-mb.si

Predstavljeni bodo nekateri rezultati v zvezi z dinamiko v diskretnih homogenih kvadratičnih sistemih oblike (1), ki so v enolični zvezi s komutativnimi (neasociativnimi) algebrami, ki so podane s tabelo množenja (2). V (1) in (2) so $a_{1,2}$, $b_{1,2}$ ter $c_{1,2}$ realni parametri.

$$\begin{aligned} x_{k+1} &= a_1 x_k^2 + 2b_1 x_k y_k + c_1 y_k^2 \\ y_{k+1} &= a_2 x_k^2 + 2b_2 x_k y_k + c_2 y_k^2 \end{aligned}$$

$\circ$	e_1	e_2
e_1	$a_1e_1 + a_2e_2$	$b_1e_1 + b_2e_2$
e_2	$b_1e_1 + b_2e_2$	$c_1e_1 + c_2e_2$

Znano je, da je dinamika kompleksnega kvadriranja (ki je poseben primer kvadriranja iz zgornje tabele za $a_1 = 1$, $b_1 = a_2 = c_2 = 0$, $c_1 = -1$, $b_2 = 2$) na robu množice vseh omejenjih orbit (t.j. na Juliajevi množici) kaotična. Zaradi velikega nabora parametrov v zgornji tabeli pričakujemo podobno dinamiko tudi pri nekaterih drugih sistemih. Najprej se lotimo sistema, ki je z algebrskega stališča najbolj podoben algebri kompleksnih števil. Dokažemo, da je v pripadajočem sistemu dinamika na robu množice vseh omejenih orbit (t.j. na posplošeni Juliajevi množici) kaotična.

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On chaotic dynamics on generalized Julia set arising from discrete quadratic homogeneous systems in the plane

MILAN KUTNJAK[1], MATEJ MENCINGER[2]

[1] *University of Maribor, Maribor, Slovenia*
milan.kutnjak@uni-mb.si
[2] *University of Maribor, Maribor and IMFM, Ljubljana, Slovenia*
matej.mencinger@uni-mb.si

We will present some results concerning the dynamics of homogeneous discrete quadratic systems (1) which are in one-to-one correspondence with the commutative (nonassociative) algebra-family given by the multiplication table (2). Here $a_{1,2}$, $b_{1,2}$ and $c_{1,2}$ are some real-valued parameters.

$$\begin{aligned} x_{k+1} &= a_1 x_k^2 + 2b_1 x_k y_k + c_1 y_k^2 \\ y_{k+1} &= a_2 x_k^2 + 2b_2 x_k y_k + c_2 y_k^2 \end{aligned}$$

$\circ$	e_1	e_2
e_1	$a_1e_1 + a_2e_2$	$b_1e_1 + b_2e_2$
e_2	$b_1e_1 + b_2e_2$	$c_1e_1 + c_2e_2$

It is well known that the dynamics of the complex squaring map (which is included in the above family for $a_1 = 1$, $b_1 = a_2 = c_2 = 0$, $c_1 = -1$, $b_2 = 2$) is chaotic on the boundary of the set of all bounded orbits. Since the complex squaring is algebraically just one of many possible squarings (denoted by $\circ$ in the above table) we expect that in many systems the behavior on the boundary of the set of bounded orbits (i.e. the generalized Julia set) is chaotic, as well. We use the Markus classification of real-commutative-2D-algebras to determine (algebraically) the most similar system and prove that the dynamics on it's generalized Julia set is chaotic.

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Vpliv polja vacuuma na comptonovo sipanje

MILAN MARČIČ

Univerza v Mariboru
Fakulteta za strojništvo, Smetanova 17, SI-2000 Maribor, Slovenia
milan.marcic@uni-mb.si • www.fs.uni-mb.si

Predstavljen je izračun sipanja fotona na elektronu ob upoštevanju statinega in dinaminega polja vacuuma [1, 2, 3, 4, 5, 6]. Polje vacuuma je določeno s konfiguracijo prostora med dvema nenabitima prevodnima paralelnima ploščama, ki mirujeta (statično polje vacuuma) ali pa se enakomerno gibljeta eno od druge. Korekcijski členi v izračunani S-matriki in sipalnem preseku za Comptonovo sipanje predstavljajo vpliv statičnega in dinamičnega polja vacuuma.

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Influence of vacuum field on compton scattering

MILAN MARČIČ

University of Maribor
Faculty for Mechanical Engineering, Smetanova 17
SI-2000 Maribor, Slovenia
milan.marcic@uni-mb.si • www.fs.uni-mb.si

We present the calculation of the photon-electron scattering by taking into account both the static and the dynamic vacuum fields [1, 2, 3, 4, 5, 6]. The vacuum field is represented by the configuration of the space between two uncharged conducting parallel plates which can be at rest (static vacuum field) or moving from each other at a constant velocity (dynamic vacuum field). Correction terms in the computed S-matrix and scattering cross section for Compton scattering manifest the influence of the static and dynamic vacuum field.

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Samourejanje nematskih koloidov

IGOR MUŠEVIČ

Institut Jožef Stefan, Jamova 39, 1000 Ljubljana
Fakulteta za matematiko in fiziko, Univerza v Ljubljani, Jadranska 19, 1000 Ljubljana, Slovenia
igor.musevic@ijs.si

Nematski koloidi so disperzije mikrometrskih delcev v nematskih tekočih kristalih, ki kažejo nenavadne lastnosti samourejanja v pravilnih geometrijskih vzorcih. Za takšno vedenje so odgovorne sile, ki jih med delci posreduje tekoči kristal. Te sile imenujemo strukturne in so posledica orientacijske urejenosti tekočih kristalov ter deformacije urejenosti tekočega kristala v bližini koloidnih delcev. Dolgo časa je bilo znano, da se nematski koloidi spontano združujejo v enodimenzionalne verige, prav tako so bile znane dvodimenzionalne urejene strukture na meji med tekočim kristalom in izotropno tekočino. Do bistvenega napredka v razumevanju narave samourejanja nematskih koloidov so privedle nedavne raziskave, ki so pokazale, da nematski koloidi spontano tvorijo tudi pravilne dvodimenzionalne strukture, ki so izredno močno vezane. S tem se je odprla nova pot do samourejanja koloidov v fotonskih 3D-kristalih, kažejo pa se tudi nove zanimive poti izdelave metamaterialov s postopkom samourejanja nanodelcev.

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Self-Assembly in Nematic Colloids

IGOR MUŠEVIČ

Jožef Stefan Institute, Jamova 39, 1000 Ljubljana
Faculty of Mathematics and Physics, University of Ljubljana,
Jadranska 19, 1000 Ljubljana, Slovenia
igor.musevic@ijs.si

The ability to generate regular spatial arrangements of particles on different length scales is one of the central issues of the "bottom-up" approach in nanotechnology. Current techniques rely on single atom or molecule manipulation by the STM and colloidal particle manipulation by laser or optoelectronic tweezers, microfluidics, optofluidics and micromanipulation. Of particular interest is self-assembly, where the pre-determined spatial arrangements of particles, such as 3D photonic crystals, could be realized spontaneously. Dispersions of particles in liquid crystals show several novel classes of anisotropic forces between inclusions, which result in an amazing diversity of assembled patterns, such as linear chains and 2D photonic crystals of microspheres. The forces between the particles in nematic colloids are extremely strong and long-range, resulting in ten thousands stronger binding compared to the binding in water based colloids. The mechanisms of self-assembly in nematic colloids are discussed, showing this is a novel paradigm in colloidal science, which can lead to new approaches to colloidal self-assembly for photonic devices.

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Nepredvidljivost kot učinkovit promotor kooperacije v družbi

MATJAŽ PERC

Oddelek za Fiziko, Pedagoška fakulteta
Koroška cesta 160, SI-2000 Maribor, Slovenija
matjaz.perc@uni-mb.si

Nepredvidljivost je nekaj vsakdanjega v življenju. V okviru evolucijske teorije iger bom pokazal, da je slednja učinkovit promotor kooperacije v družbi. Predstavil bom inovativno združitev evolucijske teorije iger in stohastike, ki vodi v zanimivo in bogato interdisciplinarno navezavo fizike, sociologije in ekonomije.

Več informacij dostopnih via: *http://fizika.tk/*

Unpredictability as a potent promoter of cooperation in society

MATJAŽ PERC

Department of Physics, Faculty of Education
Koroška cesta 160, SI-2000 Maribor, Slovenia
matjaz.perc@uni-mb.si

Unpredictability is omnipresent in everyday life. Within the framework of evolutionary game theory, I will show that the latter is an effective promoter of cooperation in society. I will outline an innovative merging of evolutionary game theory and stochasticity, leading to an interesting and fruitful interdisciplinary collaboration of physics, sociology and economics.

More information available via: *http://fizika.tk/*

Baryon properties in relativistic constituent quark models

WILLIBALD PLESSAS

Theoretical Physics, Institute of Physics
University of Graz, Universitätsplatz 5, A-8010 Graz, Austria
plessas@uni-graz.at

At low- and intermediate energies baryons are considered as consisting of three constituent quarks. They can be effectively described within relativistic constituent quark models. In this approach one is able to incorporate the relevant symmetries required by quantum chromodynamics as well as special relativity. It turns out that the spectroscopy of all known baryons can be reproduced in close agreement with phenomenology. In addition, a variety of baryon reactions can be described too.

I shall start with explaining the fundamentals of relativistic constituent quark models in the framework of Poincaré-invariant quantum mechanics. I shall then address the various dynamical concepts that distinguish modern constituent quark models and show their performances along the spectroscopy of baryons with flavors up, down, strange, and charm. In this context I shall highlight some striking properties of baryon spectra such as the systematics in their level orderings and also the issue of quantum-chaotic behaviour. The wave functions stemming from constituent quark models can further be employed to calculate baryon reactions. I shall review the covariant description of electroweak processes leading to the electromagnetic and axial form factors of the nucleons as well as other baryon ground states. Finally, first covariant results for different mesonic decay modes of baryon resonances will be presented. I shall end with an outlook to challenging problems in the future research on baryon physics.

Ali je časovna zahtevnost klasičnih simulacij kvantnih sistemov povezana z integrabilnostjo?

TOMAŽ PROSEN

Oddelek za fiziko, Fakulteta za matematiko in fiziko
Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenija
tomaz.prosen@fmf.uni-lj.si • http://chaos.fiz.uni-lj.si

Študirali smo učinkovitost simulacij časovnega razvoja lokalnih kvantnih opazljivk in termičnih kvantnih stanj z metodo časovno odvisne gostotno-operatorske renormalizacijske grupe (tDMRG) v generični družini kvantnih spinskih verig na prehodu med integrabilnim režimom in režimom kvantnega kaosa. Kvantna stanja oz. opazljivke učinkovito predstavimo s pomočjo matrično - produktnega nastavka z matrikami dimenzije $D_\epsilon(t)$, tako da je časovni ravoj dolge verige natančen znotraj napake ϵ do časa t.

Ugotovili smo, da računski resursi klasične simulacije npr. dimenzija $D_\epsilon(t)$ narašča *eksponentno* $D_\epsilon(t) \propto \exp(\mathrm{h}\, t)$, razen v primeru, ko je sistem ekzaktno integrabilen, tedaj pa opazimo *polinomsko* naraščanje. Eksponent h ponuja privlačno možnost definicije kvantnega kaosa preko algoritmične kompleksnosti.

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[1] T. Prosen and M. Žnidarič, Is efficiency of classical simulations of quantum dynamics related to integrability?, preprint `quant-ph/0608057`

[2] A. J. Daley, C. Kollath, U. Schollwöck and G. Vidal, Time-dependent density-matrix renormalization-group using adaptive effective Hilbert spaces, *J. Stat. Mech.* (2004) P04005

Is efficiency of classical simulations of quantum systems related to integrability

TOMAŽ PROSEN

Department of Physics, Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
tomaz.prosen@fmf.uni-lj.si • http://chaos.fiz.uni-lj.si

Efficiency of time-evolution of quantum observables, and thermal states of quenched hamiltonians, is studied using *time-dependent density matrix renormalization group* method in a family of generic quantum spin chains which undergo a transition from integrable to non-integrable - quantum chaotic case as control parameters are varied. Quantum states (observables) are represented in terms of matrix-product-operators with rank $D_\epsilon(t)$, such that evolution of a long chain is accurate within fidelity error ϵ up to time t.

We find that rank generally increases *exponentially* $D_\epsilon(t) \propto \exp(\mathrm{h}\, t)$, unless the system is integrable in which case we find *polynomial* increase. The exponent h offers an attractive possibility to define quantum chaos thru classical algorithmic complexity of its simulation.

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[1] T. Prosen and M. Žnidarič, Is efficiency of classical simulations of quantum dynamics related to integrability?, preprint `quant-ph/0608057`

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Izohronost via Urabejev kriterij

VALERY G. ROMANOVSKI

CAMTP - Center za uporabno matematiko in teoretično fiziko
Univerza v Mariboru, Krekova 2, SI-2000 Maribor, Slovenia
Valery.Romanovsky@uni-mb.si • www.camtp.uni-mb.si

Predlagamo novo metodo preučevanja izohronih nihanj v nekaterih sistemih navadnih diferencialnih enačb, katere je mogoče reducirati na enačbe drugega reda $\ddot{x} + f(x)\dot{x}^2 + g(x) = 0$. Metoda temelji na Urabejevem kriteriju izohronosti periodičnih nihanj sistema $\ddot{x} + g(x) = 0$. S pomočjo te metode smo našli vse potrebne pogoje za izohronost kubičnega dvodimenzionalnega sistema navadnih diferencialnih enačb odvisnega od šestih parametrov. Za vse izohrone sisteme v tej družini smo našli natančne izraze za Urabejevo funkcijo.

Reference

[1] M. Urabe, The potential force yielding a periodic motion whose period is an arbitrary continuous function of the amplitude of the velocity. *Arch. Rational Mech. Anal.* **11** (1962) 27–33.

[2] M. Robnik and V.G. Romanovski, On Urabe's criteria of isochronicity.*J. Phys. A* **32** (1999) 1279-1283

[3] A. R. Chouikha, Isochronous Centers of Liénard Type Equations and Applications (2004) http://front.math.ucdavis.edu/math.DS/0410022

[4] A. R. Chouikha, V. G. Romanovski, X. Chen, Isochronicity of analytic systems via Urabe's criterion (2006), submitted to Journal of Physics A

Isochronicity via Urabe's Criterion

VALERY G. ROMANOVSKI

CAMTP - Center for Applied Mathematics and Theoretical Physics
University of Maribor, Krekova 2, SI-2000 Maribor, Slovenia
Valery.Romanovsky@uni-mb.si • www.camtp.uni-mb.si

Based on Urabe's criteria for the isochronicity of periodical solutions of the equation $\ddot{x}+g(x)=0$ we propose a method for studying isochronous oscillations in some systems of ODE reducible to the equation $\ddot{x}+f(x)\dot{x}^2+g(x)=0$. It is applied to obtain the necessary and sufficient conditions for isochronicity of a cubic two-dimensional autonomous system depending on six parameters. For all isochronous systems in this family the Urabe function is explicitly constructed.

References

[1] M. Urabe, The potential force yielding a periodic motion whose period is an arbitrary continuous function of the amplitude of the velocity. *Arch. Rational Mech. Anal.* **11** (1962) 27–33.

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On an Adaptive Grid in Numerical Schrödinger Theory

ANDREAS RUFFING

Fakultät für Mathematik, Technische Universität München
Boltzmannstraße 3, D-85747 Garching, Germany

CAMTP - Center for Applied Mathematics and Theoretical Physics
University of Maribor, Krekova 2, SI-2000 Maribor, Slovenia

ruffing@ma.tum.de • www.camtp.uni-mb.si

An adaptive grid is discussed in context of numerical investigations for some standard candidate potentials in Schrödinger theory. The analysis behind is shortly reviewed and some concrete results on finding eigenvalues are provided.

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NMR meritve dinamike molekularne difuzije skozi porozno snov in dinamike utekočinjene sipke snovi

JANEZ STEPIŠNIK

Oddelek za fiziko, FMF
Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenia
Janez.Stepisnik@fmf.uni-lj.si • www.fmf.uni-lj.si

NMR eksperimentalna tehnika moduliranih gradientov omogoča direktne meritve spektra enodelčnih korelacij hitrosti, ki so ključne za opis dinamičnih sistemov[1,2]. CPMG vlak radiofrekvenčnih sunkov, ki deluje na spine v stalnem magnetnem polju, je uspešna različica te metode [3,4], ki odlično dopolnjuje metodo neelastičnega sipanja nevtronov s frekvenčnim območjem nad 10 MHz. Meritve na z vodo omočenem silikatnem prahu so dale spekter, ki vsebuje informacije o omejeni diffuziji vode kot tudi o strukturi poroznega sredstva. Meritve na sipki snovi utekočinjeni s prepihavanjem zraka, pa so pokazale, da hitrostna avtokorelacija ne pojema eksponencialno, kar predpostavljaja večina teorij, temveč kaže izrazit prehod iz balističnega v subdifuzni in difuzni režim v daljših časovnih intervalih. Tehnika deluje tudi z metodo NMR v šibkem magnetnem polju [5].

Reference

[1] J.Stepišnik, *Progress in NMR Spectroscopy* **17** (1985) 187-209.

[2] P.T. Callaghan, J. Stepišnik, *Advances in Magnetic and Optical Resonance*, Academic Press, London, New York **19** (1996) 324-397.

[3] S.Lasič, J. Stepišnik, A, Mohorič, I. Serša and G. Planinšič, *Europhys. Lett.* **75** (2006) 887-893.

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NMR measurement of molecular diffusion dynamics in porous media and dynamics of fludized granular system

JANEZ STEPIŠNIK

Physics Department, FMF
University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
Janez.Stepisnik@fmf.uni-lj.si • www.fmf.uni-lj.si

Modulated gradient spin echo is a novel measuring technique to get directly the single particle velocity autocorrelation spectra [1,2], a key quantity to describe system dynamics. CPMG train of radiofrequency pulses applied to spins in constant magnetic field gradient is an efficient variant of this method[3,4] with the frequency range between a few Hz to about 100 kHz that perfectly completes the neutron nonelastic scattering method having the frequency range above 10 MHz. The measurement of diffusion in water-saturated pulverized silica gives the spectrum that provides comprehensive information about the molecular restricted motion as well as about the structure of porous medium. The measurements on the air-fluidized granular systems give the velocity autocorrelation function that differs from the commonly anticipated exponential decay but clearly show transitions from ballistic, through sub-diffusion and into diffusion regimes of grain motion. The method works with the low-field NMR as well[5].

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[1] J.Stepišnik, *Progress in NMR Spectroscopy* **17** (1985) 187-209.

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[5] J. Stepišnik, *Nature* **439** (2006) 799-801.

Določanje koncentracijskih profilov z diferencialno metodo PIXE

Ž. ŠMIT[1], I. LANGUS, B. ŠEME, T. TRČEK-PEČAK, K. KAVKLER, M. URŠIČ

[1] *Fakulteta za matematiko in fiziko, Jadranska 19, SI-1000 Ljubljana*
Institut Jožef Stefan, Jamova 39, P.O.B. 3000, SI-1001 Ljubljana
ziga.smit@fmf.uni-ml.si • www.fmf.uni-lj.si

Diferencialna metoda PIXE temelji na obsevanju vzorcev s protoni različnih energij. Ti nato vzbujajo karakteristične rentgenske žarke v različnih globinah, kar lahko izkoristimo za določitev porazdelitve elementov po globini vzorca. Ker pa pridelki rentgenskih žarkov vsebujejo najmočnejsi prispevek z območja tik pod površino, so dekonvolucijski algoritmi za določitev koncentracij že v osnovi nestabilni. V tem prispevku poročamo o izdelavi preprostega in stabilnega dekonvolucijskega algoritma, pri katerem inverzijo matrike nadomestimo z iskanjem minimuma χ^2. Meritve smo opravili na tandemskem pospeševalniku Instituta Jožef Stefan. Glede na metodo, kako smo normalizirali spektre, lahko razdelimo vzorce v tri skupine: kovinske predmete s spremenjeno površino ter kovinske pigmente na freskah in na oljnih slikah. Kovinski vzorci ne vsebujejo lahkih elementov, tako da zaznamo rentgenske žarke vseh sestavin. V oljnih slikah pa imamo opravka z organskimi spojinami, ki jih v rentgenskem območju ne vidimo, tako da za normalizacijo uporabljamo signal argonove črte iz zraka. Pri freskah pa so pigmenti vezani v apnenec, ki ga spoznamo po kalcijevih črtah, tako da lahko te meritve obdelamo na oba načina in tako napravimo preizkus metode.

Concentration profile studies by the differential PIXE method

Ž. ŠMIT[1], I. LANGUS, B. ŠEME, T. TRČEK-PEČAK, K. KAVKLER, M. URŠIČ

[1] *Faculty of Mathematics and Physics, Jadranska 19, SI-1000 Ljubljana*
Jožef Stefan Institute, Jamova 39, P.O.B. 3000, SI-1001 Ljubljana
ziga.smit@fmf.uni-mj.si • www.fmf.uni-mj.si

The method of differential PIXE is based on irradiation of the sample surface by energetic protons of different energies. The protons then excite characteristic X-rays at different depths, which may then reveal the elemental distribution at different regions below surface. However, as the X-ray yields from the outmost sample surface represent the strongest contribution to the total X-ray yield, the de-convolution algorithms are inherently unstable. In the present approach, a robust and stable algorithm was constructed that replaced the matrix inversion by a simple min χ^2 problem. The measurements were performed at the Tandetron accelerator of the Jožef Stefan Institute in Ljubljana. From the point of spectra normalization, three different types of targets were used: plated metals, frescoes, and oil paintings. Metals contain no light Z elements that could not be detected through their characteristic X-rays. Oil paintings contain organic matrix, i.e. elements invisible in X-rays, so the proton dose was determined using the argon signal from the air. In frescoes, the pigments are imbedded in limestone matrix that can be probed by calcium X-rays. The fresco measurements were then used for monitoring the efficiency of both methods.

Dolga pot jedrske kvadrupolne resonančne (JKR) spektroskopije do aplikacij

ZVONKO TRONTELJ

IMFM Inštitut za matematiko, fiziko in mehaniko
Jadranska 19 SI-1000 Ljubljana, Slovenija
zvonko.trontelj@fmf.uni-lj.si • www.fiz.uni-lj.si/bio

JKR spektroskopija kot del NMR spektroskopije je poznana od leta 1951, ko sta Dehmelt in Krueger naredila prve uspešne eksperimente. Energijski razcep med kvadrupolnimi nivoji in seveda tudi resonančna frekvenca sta sorazmerna komponentam tenzorja kvadrupolnega momenta jedra in tenzorja gradienta električnega polja na mestu jedra. Električno okolje ustvarijo elektroni, ki so v bližini jedra s kvadrupolnim momentom. To zadnje dejstvo je jasno nakazovalo analitsko uporabnost metode, saj so molekule, oziroma atomi, v katerih je prisotno neko jedro s kvadrupolnim momentom, od snovi do snovi v različnem elektronskem okolju in je zato JKR resonančna frekvenca karakteristična za vsako posamezno snov, ki ima jedra s kvadrupolnim momentom. Kljub tej analitski možnosti metode je bila pot do uspešnih aplikacij zelo dolga. Pokazal bom, kako so (smo) premagali nekatere težave na poti do uporabe JKR spektroskopije. Obravnavali bomo detekcijo dušikovih (^{14}N) JKR frekvenc v nekaterih prepovedanih snoveh in v nekaterih zdravilih, kar pomeni dobro perspektivo za JKR spektroskopijo kot metodo detekcije prepovedanih snovi na kritičnih krajih in metodo odkrivanja polimorfizma v farmacevtskih proizvodih.

Reference

[1] H. G. Dehmelt and H. Krueger, *Naturwiss.* **37** (1950) 111.

[2] J. Lužnik, J. Pirnat, V. Jazbinšek, T. Apih, A. Gregorovič, R. Blinc, J. Seliger, Z.Trontelj, *Appl. Phys. Letters* **89** (2006) 123509.

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A long way of Nuclear Quadrupole Resonace (NQR) spectroscopy towards applications

ZVONKO TRONTELJ

IMFM Institute for Mathematics, Physics and Mechanics
Jadranska 19 SI-1000 Ljubljana, Slovenia
zvonko.trontelj@fmf.uni-lj.si • www.fiz.uni-lj.si/bio

The NQR spectroscopy as a part of NMR spectroscopy is known since 1950 when Dehmelt in Krueger accomplished first successful NQR measurements. Splitting between the quadrupole energy levels, as well as the resonance frequency are proportional to components of tensor of nucleus' quadrupole moment and of tensor of electric field gradient at the place of nucleus. Electrons, situated in the vicinity of nucleus with quadrupole moment, are responsible for the electric environment. The NQR spectroscopy is therefore potentially a valuable analitical tool. Namely, molecules and atoms with quadrupolar nuclei are in each chemical compound in different electric environment, hence they experience different NQR frequencies. The NQR frequency is characteristical for each chemical compound, provided it contains nuclei with quadrupole moment. Howewer, the way to apply NQR as a suitable tool was difficult and long. We will demonstrate how some difficulties were solved. We will consider the detection of nitrogen (^{14}N) NQR frequencies in some illicit materials and in some drugs. The two applications of NQR spectroscopy as a method for the detection of illicit materials at some critical locations and the method for proving the presence of polymorphic structure in pharmaceutical products demonstrate the power of NQR spectroscopy for some important applications.

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Van der Waalsova interakcija in robni elementi

GREGOR VEBLE

Fakulteta za Matematiko in Fiziko, oddelek za fiziko
Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenija
in
CAMTP - Center za uporabno matematiko in teoretično fiziko
Univerza v Mariboru, Krekova 2, SI-2000 Maribor, Slovenija
gregor.veble@fmf.uni-lj.si • www.camtp.uni-mb.si/~veble/

Predstavil bom metodo za izračun neaditivnih Van der Waalsovih interakcij med dielektriki poljubnih oblik. Metoda je prikladna za geometrije, kjer je dielektrični odziv skoraj povsod konstanten in so meje med dielektriki ostre. Za te geometrije lahko namreč prostorske operatorje, ki določajo prosto energijo sistema [1], prepišemo na operatorje, ki počivajo le na mejah dielektrikov. Z redukcijo problema s treh na dve dimenziji in nato z diskretizacijo mej na trikotne robne elemente postane račun numerično obvladljiv. Metodo bom predstavil na problemu dveh dielektričnih krogel ter na samointerakciji enoosnega elipsoida.

Reference

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Van der Waals interaction and boundary elements

GREGOR VEBLE

Faculty of Mathematics and Physics, department of physics
University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
in
CAMTP - Center for Applied Mathematics and Theoretical Physics
University of Maribor, Krekova 2, SI-2000 Maribor, Slovenia
gregor.veble@fmf.uni-lj.si • www.camtp.uni-mb.si/~veble/

I will present a method to calculate non-additive Van der Waals interactions between dielectrics of arbitrary shapes. The method is suitable for geometries where the dielectric response is constant almost everywhere, and where the dielectric boundaries are sharp. For these geometries one can reduce the operators acting on the whole space to operators that reside only on the dielectric boundaries. By reducing the problem from three to two dimensions and performing a discretisation of the boundaries into triangular boundary elements, the calculation becomes numerically tractable. I will present the method on the case of two dielectric spheres and the self interaction of an ellipsoid.

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Multifunkcijske okolju prijazne naprave

ALEKSANDER ZIDANŠEK

IJS - Institut Jožef Stefan in Mednarodna podiplomska sola Jožefa Stefana
Jamova 39, SI-1000 Ljubljana, Slovenia
aleksander.zidansek@ijs.si • www.ijs.si

in

DIMITRIJ NAJDOVSKI

X3data in Mednarodna podiplomska sola Jožefa Stefana
Novi trg 6, SI-1000 Ljubljana, Slovenia

Predstavljeni bodo primeri uporabe fizike za uveljavljanje novih okolju prijaznih tehnologij. Še posebej bodo izpostavljeni nekateri inovativni pristopi na področju večfunkcionalnih naprav, ki poleg svoje osnovne funkcije služijo tudi kot vir obnovljive energije. Primer tak sne naprave je protivetrna ograja na avtocesti, ki vključuje sonne fotovoltai cne celice in piezoelektrične elemente za pretvorbo sončne oziroma mehanske energije v električno.

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[1] A. Zidanšek, R. Blinc and D. Najdovski, New technologies for energy savings in traffic. V: KOLENC, Jurij (ur.). Mednarodno srečanje Promet v funkciji gospodarskega in trajnostnega razvoja, Ljubljana-Portorož, 12.-13. maja 2005. Zbornik referatov. Portorož Fakulteta za pomorstvo in promet (2005), str. 200-207.

Multifunctional environmentally friendly devices

ALEKSANDER ZIDANŠEK

JSI - Institute J. Stefan Institute and J. Stefan International Postgraduate School
Jamova 39, SI-1000 Ljubljana, Slovenia
aleksander.zidansek@ijs.si • www.ijs.si

and

DIMITRIJ NAJDOVSKI

X3data and J. Stefan International Postgraduate School
Novi trg 6, SI-1000 Ljubljana, Slovenia

Some applications of physics in implementation of new environmentally friendly technologies shall be discussed. Innovative approaches in multifuncional devices will be presented, which in addition to their primary function also serve as a source of renewable energy. An example of such a device is a highway wind barrier with embedded photovoltaic solar cells and piezoelectric devices for conversion of solar and mechanical energy into electric energy.

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Agregati lipidnih vesiklov

PRIMOŽ ZIHERL

Fakulteta za matematiko in fiziko, Univerza v Ljubljani
Jadranska 19, SI-1000 Ljubljana, Slovenia
Institut Jožef Stefan
Jamova 39, SI-1000 Ljubljana, Slovenia
primoz.ziherl@ijs.si • www-f1.ijs.si/˜ziherl

Teoretični opis lipidnih vesiklov, zasnovan na upogibni energiji membrane, lahko z efektivnim adhezijskim členom dopolnimo, da opiše tudi agregate teh preprostih umetnih tvorb, ki uspešno reproducirajo številne morfološke vidike preprostih bioloških celic. Ključni elementi mehanike agregatov se pokažejo že pri dubletu: v režimu šibke adhezije je stik med vesikloma raven, pri velikih vrednostih adhezijske konstante pa sigmoiden s po eno evaginacijo in komplementarno invaginacijo na vsakem od vesiklov, kar se lepo ujema z eksperimentalno opaženimi oblikami agregatov eritrocitov in pojasnjuje nekatere lastnosti večceličnih agregatov, kot so rouleauji eritrocitov. Podobno obnašanje zasledimo tudi pri dvorazsežnih vesiklih, kjer je z variacijskim reševanjem modela mogoče raziskati celoten stabilnostni diagram agregatov, ki vsebuje poleg prostih vesiklov tudi neskončne kolumnarne ter ploskovite agregate. Ti rezultati osvetlijo geometrijo kvazidvorazsežnih tkiv, kakršna so epitelijska.

Aggregates of lipid vesicles

PRIMOŽ ZIHERL

Faculty of mathematics and physics, University of Ljubljana
Jadranska 19, SI-1000 Ljubljana, Slovenia
Jožef Stefan Institute
Jamova 39, SI-1000 Ljubljana, Slovenia
primoz.ziherl@ijs.si • www-f1.ijs.si/~ziherl

The theoretical model of lipid vesicles based on the membrane bending energy can be extended by an effective adhesion term to describe aggregates of these artifical objects which reproduce much of the morphology of simple biological cells. The salient mechanical features of aggregates become apparent in an aggregate as simple as the doublet: The contact zone is flat at small adhesion strenghs, wheras at large strengths it is sigmoidally curved with one evagination and a matching invagination. The calculated doublet shapes are in good agreement with the experimentally observed erythrocyte aggregates, and the sigmoidal contact zone explains certain aspects of multicellular aggregates such as erythrocyte rouleaux. Similar behavior is found in two-dimensional vesicles where a variational approach can be used to analyze the complete stability diagram, which includes free vesicles and both columnar and sheet-like infinite aggregates. These results elucidate the geometry of quasi-twodimensional tissues such as epithelia.

Fizika zvezd in dinamika Galaksije

TOMAŽ ZWITTER

Fakulteta za matematiko in fiziko Univerze v Ljubljani
tomaz.zwitter@fmf.uni-lj.si • www.fiz.uni-lj.si/astro

Svetloba zvezd prihaja iz njihovih atmosfer in tako razkriva njihovo temperaturo, kemijsko sestavo, gravitacijsko sesedenost, vrtenje in hitrost približevanja oz. oddaljevanja. Večina teh informacij je merljiva le spektroskopsko, v posebnih primerih prekrivalnih dvojnih zvezd pa lahko izračunamo tudi njihovo maso in fizično velikost. Predstavil bom prve rezultate projekta RAVE (www.rave-survey.org), doslej najobsežnejše spektroskopske raziskave gibanja in fizikalnih lastnosti zvezd v naši Galaksiji. Omenil bom tudi vznemirljivo možnost, da se je zaradi majhnih medsebojnih motenj zvezd mogoče vprašati, ali so te zvezde v naši Galaksiji tudi nastale, ali izvirajo od drugod. Ker je naša Galaksija le ena od številnih podobnih v vesolju, so ugotovitve zanimive tudi za študij nastanka galaksij v splošnem. Taka lokalna kozmologija bo v naslednjem desetletju z meritvami satelita Gaia Evropske vesoljske agencije vedno pomembnejša.

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Stellar Physics and Dynamics of the Galaxy

TOMAŽ ZWITTER

Faculty of Mathematics and Physics
University of Ljubljana
tomaz.zwitter@fmf.uni-lj.si • www.fiz.uni-lj.si/astro

Light from a star originates in its atmosphere. So it reveals the effective temperature, chemical composition, local gravity, rotation and radial velocity of the atmosphere. In a special case when the star is a member of an eclipsing binary, also the mass and radius can be accurately determined. Most of this information is gathered by spectroscopy methods. This is also the core of the largest and ongoing spectroscopic survey of stars in our Galactic neighborhood, the RAdial Velocity Experiment (RAVE, www.rave-survey.org). A fraction of the stars measured by the survey has a straight-forward dynamical history. Small density of perturbers allows us to infer the origin of these stars, were they born in our Galaxy or elsewhere. Our Galaxy is a very typical spiral galaxy in the Universe. So the observations which can be (at present) obtained only for our Galaxy have a more general significance. It is expected that the European Space Agency's mission Gaia, which will be launched in 2012, will only increase the importance of this approach, which is usually referred to as local cosmology.

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Konkurenčnost jedrske energije v Sloveniji

TOMAŽ ŽAGAR

GEN energija, d.o.o.
Cesta 4. julija 42, SI-8270 Krško, Slovenia
tomaz.zagar@gen-energija.si • www.gen-energija.si

Po letošnjem poročanju medijev v Sloveniji in Evropi lahko sklepamo, da politika in gospodarstvo spet razmišljata o gradnji novih jedrskih elektrarn. Kaj stoji za tem novim gibanjem? Ali je to posledica ekonomskih gibanj, ali pa je to povezano z vse večjo skrbjo za okolje ali pa je potrebo po jedrski energiji prinesla vse večja želja po trajnostnem razvoju?

Ko pogledamo vse faktorje vidimo, da je ponoven interes za jedrsko energijo povzročila kombinacija mnogih faktorjev. Med njimi bom v predavanju obdelal skrb za trajnostni razvoj in pogled na jedrsko energetiko z vseh treh stališč trajnostnega razvoja (ekologija, družbeni vpliv in ekonomija). Obdelal bom tudi vpliv jedrske energetike na problem globalnega ogrevanja ozračja in v zadnjem času tudi vse bolj pomembno vprašanje varnosti oskrbe z energijo in energetske neodvisnosti.

Za konec pa bom predstavil še pogled v prihodnost jedrske energetike preko IV. generacije reaktorjev pa vse do fuzijskih elektrarn.

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Prospects for Nuclear Energy in Slovenia

TOMAŽ ŽAGAR

GEN energija, d.o.o.
Cesta 4. julija 42, SI-8270 Krško, Slovenia
tomaz.zagar@gen-energija.si • www.gen-energija.si

In this last year media coverage in Slovenia and in Europe gave the impression that the nuclear power is coming back. What is driving this new interest? Is the driving force behind this renewal of interest just economy, is this driving force environment, or is this driving force need for sustainable development?

Renewed interest in nuclear power is combined effect of different concerns. Concern of global warming and concerns about limited natural resources are maybe the two mayor driving forces. However, concerns about security of supply and economical concerns are also important and should not be forgotten.

What might nuclear power look like in the future? We shall see Generation IV reactors and in distant future we can also expect fusion power plants.

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Mehanske lastnosti fosfolipidnih mehurčkov in enostavnih bioloških membran

BOŠTJAN ŽEKŠ

Inštitut za biofiziko Medicinske fakultete Univerze v Ljubljani
Lipičeva 2, 1000 Ljubljana, Slovenija
predsednik@sazu.si

Opisane bodo osnovne elastične lastnosti fosfolipidnih membran in predstavljen bo model sklopljenih plasti, ki upošteva, da je membrana sestavljena iz dveh tekočih plasti. Predstavljen bo fazni diagram možnih oblik fosfolipidnih mehurčkov v odvisnosti od vrednosti njihovih geometrijskih parametrov: prostornine mehurčka, ploščine membrane in razlike ploščin obeh membranskih plasti. Potem bo predstavljeno nekaj analiz takih sistemov:

- Ko so fosfolipidni mehurčki v vodni raztopini, fosfolipidne molekule izhlapevajo iz zunanje plasti in zato zmanjšujejo razliko ploščin ter spreminjajo obliko mehurčka. Opaženo zaporedje oblik lahko razložimo z modelom sklopljenih plasti.
- Zunanje izmenično električno polje deformira pri nizkih frekvencah okrogle mehurčke v prolatno obliko, ki pa pri višjih frekvencah postane oblatna. Tudi to lahko popišemo z modelom, če upoštevamo še dielektrično anizotropijo membrane.
- Z dodatki ustvarimo v membrani pore in študiramo transportne lastnosti na posameznem mehurčku. Spreminjanje oblik mehurčkov opazujemo s faznokontrastnim mikroskopom in ga teoretsko popišemo.
- Obstajajo izmerjene porazdelitve raznih molekul po deformirani membrani rdeče krvne celice, ki se jih da razumeti, če upoštevamo, da ima ta membrana še tretjo plast (membranski skelet), ki pa ni tekoča, ampak lahko prenaša strižne obremenitve. Določili smo ustrezno konstitutivno relacijo.

Mechanical properties of phospholipid vesicles and of simple biological membranes

BOŠTJAN ŽEKŠ

Institute of Biophysics, Faculty of Medicine, University of Ljubljana
Lipičeva 2, 1000 Ljubljana, Slovenija
predsednik@sazu.si

Basic elastic properties of phospholipid membranes will be described and the bilayer couple model will be reviewed, which takes into account that the membranes are composed of two liquid layers. The phase diagram of possible shapes of phospholipid vesicles will be presented as a function of geometrical parameters of the vesicle: vesicle volume, membrane area and area difference of the two layers. After that some specific studies on such systems will be presented:

- When phospholipid vesicles are in the water solution, the phospholipid molecules evaporate from the outer layer, decreasing the area difference and changing the vesicle shapes. The observed sequence of shapes can be described by the bilayer couple model.
- The external alternating electric field deforms at low frequencies spherical vesicles into prolate forms, which become oblate at large frequencies. The model accounts for observed deformations, but the dielectric anisotropy of the membrane must be taken into account.
- Pores are created in the mebrane and the transport properties are studied on a single vesicle. The shape of the vesicle is observed in the phase contrast microscope and descibed theoretically.
- Experimentally determined molecular distributions on stretched red blood cell membranes are explained by taking into consideration the third, skeleton layer of the membrane, which is not liquid, but provides elastic resistance to shear deformations. Corresponding constitutive relation is obtained.

Prepletenost kvantnih stanj

MARKO ŽNIDARIČ

Fakulteta za matematiko in fiziko
Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenia
marko.znidaric@fmf.uni-lj.si • chaos.fiz.uni-lj.si

Asher Peres je nekoč prepletenost kvantih stanj označil kot tisti trik, ki omogoča "kvantnim čarovnikom", da počnejo reči, ki jih navadni čarovniki ne morejo. Takšni kvantni čarovniški triki so, na primer, teleportacija, kvantna varna komunikacija ali pa kvantno računanje. V predavanju bom predstavil različne vidike prepletenih kvantnih stanj: za kaj so sploh uporabna ter kako jih dobimo. V določenih postopkih so posebej zanimiva nakljucna kvantna stanja, podobno kot so v klasičnem svetu pomembna naključna števila. Opisal bom razne postopke, kako takšna naključna stanja učinkovito generiramo, ter kakšna je njihova prepletenost. Uporabnost prepletenih kvantnih stanj pa ima tudi svojo ceno - so zelo občutljiva za motnje iz okolice. Proces, pri katerem se zaradi sklopitve z okolico ta prepletenost izgubi, imenujemo dekoherenca.

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Entanglement of quantum states

MARKO ŽNIDARIČ

Fakulteta za matematiko in fiziko
Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenia
marko.znidaric@fmf.uni-lj.si • chaos.fiz.uni-lj.si

Asher Peres once characterized entanglement as the trick that enables "quantum magicians" to produce phenomena that cannot be imitated by classical magicians. Such quantum tricks are for instance teleportation, quantum secure communication or quantum computation. I shall present different aspects of entangled states: what are they useful for and how can they be produced. For certain applications random quantum states are of special interest, similarly as random numbers are important in classical world. I will describe several procedures how such random states can be produced and how to quantify their entanglement. The usefulness of entanglement though has its price - entangled states are very sensitive to perturbations from the environment. The process in which the entanglement is lost is called decoherence.

References

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Modeliranje koloidnih struktur, ki so prepletene z nematskimi disklinacijami

SLOBODAN ŽUMER in MIHA RAVNIK

Oddelek za fiziko, Fakulteta za matematiko in fiziko
Univerza v Ljubljani, Jadranska 19, 1000 Ljubljana, Slovenija
slobodan.zumer@fmf.uni-lj.si

Opisal bom naše nove simulacije koloidnih struktur v nematikih, ki so konfinirani v tanki nematski plasti. Fenomenološki pristop nam omogoča izračun tenzorskega polja nematskega parametra urejenosti in določitev disklinacijskih linij v takem sistemu. Preverili smo vplive ograditve in zunanjih polj. Uspelo nam je napovedati obstoj cele vrste novih koloidnih struktur, ki so prepletene z disklinacijskimi linijami in so zato še posebej močno vezane. Do sedaj so bile opaž ene le strukture z lokaliziranimi disklinacijskimi linijami, šele naj novejši eksperimenti skupine profesorja Muševiča potrjujejo naše napovedi.

Modeling of colloidal structures entangled by nematic defect lines

SLOBODAN ŽUMER in MIHA RAVNIK

Department of Physics, Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, 1000 Ljubljana, Slovenia
slobodan.zumer@fmf.uni-lj.si

Our recent simulations of defects and colloidal structures in spatially confined nematic liquid crystals will be described. New theoretical predictions based on phenomenological approaches will be contrasted with the latest experimental studies. Inter-colloidal couplings in a nematic are effectively many-body interactions that are particularly sensitive to the confinement and external fields. Their complexity leads to numerous nematic and colloidal structures not present in simple liquids where van der Waals and electrostatic interactions are dominant. Here we focus on one- and two-dimensional colloidal structures. Number of stable and metastable colloidal super structures and their dependence on the confinement and external fields will be shown. We show that in these structures colloidal particles can be coupled also by an entangled network of delocalized disclination lines. Such a coupling is string-like and is therefore much more robust as compared to an interaction based on an array of localized disclinations.

5. Simpozij fizikov Univerze v Mariboru

Koncert
14. december 2006, ob 20h v Kavarni Art Hotela Piramida, Maribor

Barbara Novak, klavir
Mojca Sok, flavta

Program:
F. Schubert: Sonate in A minor "Arpeggione",1.st - Allegro moderato

M. Ravel: Pavane pour une infante defunte

G. Schocker: Musique Francaise
1. Cafe music
2. Chanson
3. Dans le pays

Pianistka Barbara Novak je končala program glasbene gimnazije na SGBŠ v Mariboru pri prof. Elizabeti Berglez ter študij klavirja nadaljevala na Akademiji za glasbo v Ljubljani, kjer je letos z odliko diplomirala v razredu prof. Andreja Jarca. Izpopolnjevala se je na mednarodnih mojstrskih tečajih pri S. Gadzijevu, V. Lobanovu, J. Perryju, A. Serdarju, J. Siirali, R. Kinki, C. Boginu in večkrat pri K. H. Kammerlingu v Lindau, kjer je prejela nagrado za mlado obetavno pianistko. Kot solistka je nastoplala z orkestrom SGBŠ Maribor ter z Mariborskim godalnim orkestrom, solistično in v komornih zasedbah koncertirala po Sloveniji ter snemala za Radio Maribor. Je dvakratna nagrajenka državnih tekmovanj ter zmagovalka mednarodnega klavirskega tekmovanja v Genovi in mednarodnega tekmovanja komornih skupin v Heerlenu na Nizozemskem. Za svoje umetniške dosežke je prejela plaketo Dr. Roman Klasinc, ki jo podeljuje SGBŠ Maribor. V času šolanja je bila Zoisova štipendistka, leta 2005 pa je prejela še Yamahino štipendijo. Pred kratkim je uspešno izvedla Rapsodijo na Paganinijevo temo Sergeja Rahmaninova z orkestrom SNG Maribor. To šolsko leto hodi na mojstrsko izpopolnjevanje k prof. C. Boginu v Italiji.

Mojca Sok se je rodila na Ptuju. Flavto se je pričela učiti v razredu prof. N. Franjkovič. Po končani Glasbeni gimnaziji v Mariboru je šolanje nadaljevala na Akademiji za glasbo v Ljubljani pri prof. F. Ruplu, kjer je leta 2004 z odliko diplomirala. Leta 2001 je na Tekmovanju mladih slovenskih glasbenikov v kategoriji 3.a prejela srebrno plaketo in 3.nagrado. Sedaj je študentka podiplomskega študija pri prof. Mateju Zupanu. V času šolanja je bila Zoisova štipendistka, udeleževala se je številnih seminarjev in poletnih šol pri priznanih profesorjih, kot so: G. Hoyos, B. Fromanger, R. Ghiani, A. Nicolet in L. Kovasc. Redno je zaposlena kot profesorica flavte na Glasbeni šoli Karol Pahor Ptuj, sodeluje pa tudi v orkestrih Slovenske filharmonije in Mariborskega simfoničnega orkestra.


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