Spektralne funkcije in optična prevodnost v t-J-Holsteinovem modelu

JANEZ BONČA

Fakulteta za matematiko in fiziko, Univerza v Ljubljani, SI-1000 Ljubljana, Slovenija
J. Stefan Institu, SI-1000 Ljubljana, Slovenija
janez.bonca@ijs.si • www-f1.ijs.si/∼bonca

Predstavil bom učinkovito numerično metodo za opis stanj ene vrzeli v antiferomagnetnem ozadju ob prisotnosti mrežnih prostostnih stopenj. Metoda je definirana na neskobčni mreži in omogoča izračun fizikalnih lastnosti pri poljubnih valovnih vektorjih. Metodično povečevanje funkcijskega prostora vodi do rezultatov, ki so veljavni v termodinamski limiti. Izračunane spektralne funkcije v limiti močne sklopitve z mrežnimi nihanji dobro opišejo nenavadno obliko spektrov, izmerjenih z metodo ARPES na substanci $Ca_{2-x}Na_xCuO_2Cl_2$. Izračunali smo tudi trdnost naboja in optično prevodnost. Sklopitev z mrežnimi nihanji močno vpliva na koherentno gibanje vrzeli v fizikalno relevantnem režimu izmenjalne sklopitve. Optična prevodnost v režimu prehoda v močno sklopitev z mrežnimi nihanji vsebuje dva izrazita vrhova kar se ujema z meritvami.

Reference

[1] J. Bonča, S. Maekawa, and T. Tohyama, *Phys. Rev. B* **76** (2007) 035121.

[2] J. Bonča, S. Maekawa, T. Tohyama, and P. Prelovšek, *Phys. Rev. B* **77** (2008) 054519.

Spectral functions and optical conductivity of the t-J-Holstein model

JANEZ BONČA

Faculty of Mathematics and Physics, University of Ljubljana, SI-1000 Ljubljana, Slovenia
Institut J. Stefan, SI-1000 Ljubljana, Slovenia
janez.bonca@ijs.si • www-f1.ijs.si/∼bonca

I will present an efficient numerical method for the description of a single-hole motion in the antiferromagnetic background in the presence of lattice degrees of freedom. The method is free of finite-size effects and allows calculation of physical properties at an arbitrary wavevector. Methodical increase of the functional space leads to results that are valid in the thermodynamic limit. Calculated spectral functions in the strong coupling limit reproduce well the waterfall structure seen in ARPES spectra on $Ca_{2-x}Na_xCuO_2Cl_2$. We also compute the charge stiffness and optical conductivity. Coherent hole motion is most strongly influenced by the electron-phonon coupling within the physically relevant regime of the exchange interaction. Optical conductivity in the crossover to the strong coupling regime shows a two-peak structure in agreement with recent optical measurements.

References

[1] J. Bonča, S. Maekawa, and T. Tohyama, *Phys. Rev. B* **76** (2007) 035121.

[2] J. Bonča, S. Maekawa, T. Tohyama, and P. Prelovšek, *Phys. Rev. B* **77** (2008) 054519.

Termični spomin v spinskem sistemu

J. DOLINŠEK, M. JAGODIČ, Z. JAGLIČIĆ

Institut Jožef Stefan, Jamova 39, SI-1000 Ljubljana, Slovenija
IMFM Inštitut za matematiko, fiziko in mehaniko
Jadranska 19 SI-1000 Ljubljana, Slovenija

Poleg magnetnega in feroelektričnega spomina obstaja tudi termični spomin, kjer si sistem sklopljenih elektronskih spinskih magnetnih dipolnih momentov zapomni svojo "termično zgodovino" med ohlajanjem. Kadar pri zveznem ohlajanju snovi brez prisotnosti zunanjega magnetnega polja hlajenje za nekaj časa prekinemo (spinski sistem "staramo"), si spinski sistem zapomni temperaturo in čas prekinitve ohlajanja. Informacija se zapiše v elektronsko spinsko konfiguracijo in jo lahko "prečitamo" pri segrevanju vzorca z uporabo majhnega "čitalnega" magnetnega polja velikosti nekaj Oe. S pozitivnim termičnim ciklom lahko termični spomin spet izbrišemo in s tem "pomladimo" sistem (pojav je znan kot "pomladitev" ali "rejuvenacija"). Termični spomin obstaja v neravnovesnih (neergodičnih) spinskih sistemih in je bil doslej opažen v spinskih steklih, geometrijsko frustriranih antiferomagnetih ter v manjši meri v orientacijskih dielektričnih steklih in neurejenih feroelektrikih. V zadnjem času se je izkazalo, da je pojav zelo izrazit v kompleksnih kovinskih spojinah kot so Taylorjeve faze T-Al3(Mn,Pd,Fe) in dekagonalni kvazikristali d-Al-Mn-Fe [1].

Reference

[1] J. Dolinšek, J. Slanovec, Z. Jagličić, M. Heggen, S. Balanetskyy, M. Feuerbacher, K. Urban, *Phys. Rev. B* **77**, 064430 (2008).

Thermal memory in spin systems

J. DOLINŠEK, M. JAGODIČ, Z. JAGLIČIĆ

Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia
IMFM Institute for Mathematics, Physics and Mechanics
Jadranska 19 SI-1000 Ljubljana, Slovenija

Beside the magnetic and ferroelectric memory types, there exists also thermal memory, where the system of coupled electronic spin magnetic dipole moments remembers its thermal history during cooling. When a continuous cooling in the absence of an external magnetic or electric field is stopped for a period of time, the spin system "remembers" the stop temperature and the stop time it has spent at the constant stop temperature. This information is inscripted into the electronic spin configuration and can be retrieved at a later time by continuously heating the sample in the presence of a small "readout" magnetic field of magnitude of a few Oersted. A positive thermal cycle erases the thermally inscripted information. The phenomenon of thermal memory exists in out-of-equilibrium (nonergodic) spin systems and was so far experimentally observed in spin glasses, geometrically frustrated antiferromagnets and, to a smaller extent, in orientational dielectric glasses and disordered ferroelectrics. Recently, an especially strong memory effect was observed in T-Al3(Mn,Pd,Fe) complex metallic alloys, known as the Taylor phases, and decagonal quasicrystals d-Al-Mn-Fe [1].

References

[1] J. Dolinšek, J. Slanovec, Z. Jagličić, M. Heggen, S. Balanetskyy, M. Feuerbacher, K. Urban, *Phys. Rev. B* **77**, 064430 (2008).

Retrograde orbits in planetary systems

RUDOLF DVORAK

Institute of Astronomy
University of Vienna, Austria
dvorak@astro.univie.ac.at

It is known since long time that retrograde satellite orbits are more stable than prograde ones. The same is expected from retrograde planetary orbits. To clarify this different dynamical behaviour we have undertaken numerical simulations for retrograde orbits in our Solar system (for asteroids in the main belt) and also earth-like planets in multiplanetary systems. We will give some explanations for this difference for these kind of orbits for 'normal' orbits. In addition we treat the problem of retrograde planetary motion in mean motion resonances with numerical experiments and analytical considerations.

References

Gayon J and Bois E 2008 *Are retrograde resonances possible in multi-planet systems?* in *Astronomy and Astrophysics* **482** pp 665 -672

Kinoshita H and Nakai H 1988 *Note on secular perturbations between a retrograde body and a prograde body* in *Celestial Mechanics* **42** pp 279-292

Težki mezoni s pozitivno parnostjo v kiralni perturbacijski teoriji s težkimi mezoni

SVJETLANA FAJFER

Fakulteta za matematiko in fiziko, Univerza v Ljubljani in Institut J. Stefan
Jadranska 19, SI-1000 Ljubljana, Slovenia
svjetlana.fajfer@ijs.si

Predstavila bom kiralne efektivne teorije s težkimi mezoni, ki opišejo močno interakcijo težkih mezonov in lahkih psevdoskalarnih mezonov. Takšna efektivna teorija kombinira efektivno teorijo težkih kvarkov in kiralno perturbacijsko teorijo. Predstavila bom izračune kiralnih korekcij k močni sklopitveni konstanti, mešalni amplitudi mezonov $B_{d,s}$ in Isgur-Wise funkciji. V teh primerih smo ugotovili da težki mezoni prispevajo enako kot so korekcije mezonov K in η v kiralni perturbacijski teoriji. Zato predlagamo, da je pri izračunih na mreži potrebna ekstrapolacija fizikalnih rezultatov le v primerih ko je masa mezonov π manjsa od razlike mas težkih skalarnih in psevdoskalarnih mezonov.

Reference

[1] S. Fajfer, J.F. Kamenik, *Physical Review D* **74** (2006) 074023.

[2] D. Bećirević, S. Fajfer, J. F. Kamenik, *JHEP* **0706** (2007) 003.

[3] J.O. Eeg, S. Fajfer, J.F. Kamenik, *JHEP* **0707** (2007) 078.

[4] J.O. Eeg, S. Fajfer, J.F. Kamenik, *Physical Review D* **78** (2008) 074008.

Positive parity heavy mesons in heavy meson chiral perturbation theory

SVJETLANA FAJFER

physics Dept., University of Ljubljana and J. Stefan Institute
Jadranska 19, SI-1000 Ljubljana, Slovenia
svjetlana.fajfer@ijs.si

Chiral loop corrections to effective couplings describing strong interactions of two heavy mesons of even or odd parities and a light pseudoscalar meson are considered, within a framework which combines heavy quark effective theory and chiral perturbation theory. We consider chiral logarithmic corrections to strong couplings, B_d and B_s mixing amplitudes and to Isgur-Wise functions. In all three examples it was found that positive parity heavy mesons produce corrections which are competitive in size with the K- and eta-meson chiral logarithmic corrections. Therfore, we suggest that in the lattice studies one should use pion chiral logarithmic corrections in the extrapolation of the physical result, as long as the pion mass is much smaller than the mass gap between the scalar and pseudoscalar heavy-light mesons.

Reference

[1] S. Fajfer, J.F. Kamenik, *Physical Review D* **74** (2006) 074023.

[2] D. Bećirević, S. Fajfer, J. F. Kamenik, *JHEP* **0706** (2007) 003.

[3] J.O. Eeg, S. Fajfer, J.F. Kamenik, *JHEP* **0707** (2007) 078.

[4] J.O. Eeg, S. Fajfer, J.F. Kamenik, *Physical Review D* **78** (2008) 074008.

Delocalization of wavepackets in disordered nonlinear systems

SERGEJ FLACH

Max-Planck-Institut für Physik komplexer Systeme
Nöthnitzer Str. 38, D-01187 Dresden, Germany
flach@pks.mpg.de www.pks.mpg.de/ flach

Linear disordered systems allow for Anderson localization. Then all eigenstates are localized, and an initially localized wave packet will not spread beyond the localization volume of the linear system. Adding nonlinearities leads to an interaction of eigenstates. The question is therefore, whether the wave packet will spread or stay localized. I will show that the wave packet can spread in three different regimes. All of them show subdiffusion, while some allow also for partial localization due to selftrapping. The subdiffusive spreading is universal and characterized by the second moment growing algebraically in time, with exponent 1/3 for one-dimensional systems with cubic nonlinearity. It is due to a finite number of modes which stay resonant and are responsible for weak chaos inside the packet.
I will discuss higher spatial dimensions, address the spreading in the presence of a nonzero thermal background, and the speeding up of the spreading process by ramping the nonlinearity strength in time.

References

[1] S. Komineas, G. Kopidakis, S. Flach and S. Aubry, *Phys. Rev. Lett.* **100**, 084103 (2008).

[2] S. Flach, D. O. Krimer and Ch. Skokos, arXiv:0805.4693 (2008).

[3] R. A. Vicencio and S. Flach, arXiv:0809.2115 (2008).

[4] S. Flach, S. Komineas, D. O. Krimer and Ch. Skokos, in preparation.

Fourier's law by two stage thermalization

THOMAS GILBERT

Center for Nonlinear Phenomena and Complex Systems
Université Libre de Bruxelles, C. P. 231, Campus Plaine, B-1050 Brussels, Belgium
thomas.gilbert@ulb.ac.be • http://homepages.ulb.ac.be/˜tgilbert

I will report on some new developments regarding the problem of characterizing the process of heat transfer from first principles and argue that there is hope to achieve such an understanding for a particular class of insulating materials known as aerogels, *i.e.* gels whose liquid component has been removed. Heat conductivity is a number that characterizes heat transfer in solid materials and measures the heat current resulting from the application of a small temperature difference across the solid. For most solids the theoretical computation of this number is a very challenging task. The models I shall describe capture the properties of materials which possess both the spatial structure of solids and collisional dynamics of gases. I will discuss the conditions under which the heat conductivity of these materials can be universally expressed in terms of the frequency of collisions between gas particles. This universality manifests itself when the gas particles are individually trapped in a porous solid material and only rarely collide with each other, mostly rattling around their traps. Importantly, this result is independent of the trapping mechanism.

References

[1] P. Gaspard and T. Gilbert, *Heat conduction and Fourier's law by consecutive local mixing and thermalization*, Phys. Rev. Lett. **101** (2008) 020601.

[2] P. Gaspard and T. Gilbert, *Heat conduction and Fourier's law in a class of many particle dispersing billiards* New J Phys **10** (2008) 103004

[3] T. Gilbert and R. Lefevere, *Heat conductivity from molecular chaos hypothesis in locally confined billiard systems*, Phys. Rev. Lett. (2008) *in press.*

[4] P. Gaspard and T. Gilbert, *On the derivation of Fourier's law in stochastic energy exchange systems*, arxiv:0809.3967

Biljardi s trdimi stenami in z enosmernim transportom

MARTIN HORVAT

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

V biljardih z enosmernim klasičnim transportom fazni prostor razpade na tri klasično invariantne in disjunktne podprostore, ki pripadajo naprej-potujočim delcem, nazaj-potujočim delcem in družini periodičnih obrit, ki loči oba prejšnja prostora. Klasični transport vzdolž neke smeri analiziramo s pomočjo t.i. modela skakanja. Ta poenostavljena slika omogoča enostavno tipiziranje transporta. V kvantni sliki je klasični enosmerni transport kršen s tuneliranjem preko družine periodičnih orbit med preostalima invariantnima podprostoroma. Omenjeno tuneliranje je merjeno v sipalni sliki in je šibko, a ima zanimive posledice za statistiko lastih energij biljardov. Leta niha med statistikama, ki sta tipični za kvantne sisteme pripadajoč klasično kaotičnim sistemom s simetrijo z ozirom na obrat casa in sistemom brez te simetrije.

Reference

[1] Horvat M in Prosen T 2007 The bends on a quantum waveguide and cross-products of Bessel functions *J Phys. A: Math. Theor.* **40** 6349-6379

[2] Prosen T, Veble G in Robnik M 2007 Expanded boundary integral method and chaotic time-reversal doublets in quantum billiards *New. J. Phys.* **9** 15

[3] Gutkin B 2007 Dynamical breaking of time reversal symmetry *J. Phys. A: Math. Theor.* **40** 761-769

Unidirectional hard-wall billiards

MARTIN HORVAT

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

In the billiards with the classical unidirectional transport the phase-space decomposes into three disjoint subspaces associated to the forward traveling particles, backwards traveling particles and to the family of bouncing-ball orbits, which separate both previous subspaces. The classical transport along one direction of travel is analysed using the so-called jump model. In this picture we can easily classify transport properties in unidirectional billiard. In the quantum picture the unidirectional transport is violated due to the tunneling over the bouncing ball orbits between the other two classical invariant manifolds. This tunneling is analysed using the scattering techniques and is quite weak. Nevertheless it has interesting consequences for the statistics for eigenenergies. This is found to be a hybrid between statistics typical for quantum systems that correspond to classically chaotic systems with the time-reversal symmetry and to the systems no such symmetry.

References

[1] Horvat M and Prosen T 2007 The bends on a quantum waveguide and cross-products of Bessel functions *J Phys. A: Math. Theor.* **40** 6349-6379

[2] Prosen T, Veble G and Robnik M 2007 Expanded boundary integral method and chaotic time-reversal doublets in quantum billiards *New. J. Phys.* **9** 15

[3] Gutkin B 2007 Dynamical breaking of time reversal symmetry *J. Phys. A: Math. Theor.* **40** 761-769

Occupation statistics of an atomic Bose-Einstein condensate in a double well trap

TSAMPIKOS KOTTOS

Max-Planck Institute for Dynamics and Self-Organization, D-37073 Goettingen, Germany, and
Department of Physics, Wesleyan University, Middletown CT-06459, USA
tkottos@wesleyan.edu http://www.wesleyan.edu/physics/tkottos/

We study the occupation statistics $P(n)$ of a Bose-Einstein condensate consisting of N particles loaded in a double-well trap with inter-site coupling K. Two dynamical scenaria are investigated: a)wavepacket dynamics and b) linear variation of the bias between the on-site energies of the two wells. In the latter case, as we increase the driving rate of the bias, we resolve three different regimes: quantum adiabatic, diabatic, and sudden. We find that during the adiabatic to diabatic crossover, many-body Landau- Zener transitions play a dominant role, resulting in oscillations of the second moment of the occupation statistics. In contrast, the crossover to the sudden regime is characterized by a broad distribution $P(n)$ which is reflected in a global maximum of the second moment.

References

[1] M. Hiller, T. Kottos and D. Cohen, *Europhys. Lett.*, **82** (2008) 40006.

[2] M. Hiller, T. Kottos and D. Cohen, *Phys. Rev. A*, **78** (2008) 013602.

[3] K. Smith-Mannschott, M. Chuchem, M. Hiller, D. Cohen, T. Kottos, in preparation (2008)

Dinamika v diskretnih kvadratičnih sistemih v ravnini, ki ustrezajo algebram z enodimenzionalnim idealom

MILAN KUTNJAK

Fakulteta za elektrotehniko, računalništvo in informatiko
Univerza v Mariboru, Smetanova 17, SI-2000 Maribor, Slovenia
milan.kutnjak@uni-mb.si •
http://www.mp.feri.uni-mb.si/osebne/kutnjak/mkutnjak.html

Predstavljeni bodo nekateri rezultati v zvezi z dinamiko v diskretnih homogenih kvadratičnih sistemih v ravnini

$$\begin{array}{l} x_{k+1} = a_1 x_k^2 + 2b_1 x_k y_k + c_1 y_k^2 \\ y_{k+1} = a_2 x_k^2 + 2b_2 x_k y_k + c_2 y_k^2 \end{array} ; \quad a_i, b_i, c_i \in \mathbb{R}, \quad i = 1, 2$$

kjer pripadajoča algebra

$*$	$\vec{e}_1$	$\vec{e}_2$
$\vec{e}_1$	$a_1\vec{e}_1 + a_2\vec{e}_2$	$b_1\vec{e}_1 + b_2\vec{e}_2$
$\vec{e}_2$	$b_1\vec{e}_1 + b_2\vec{e}_2$	$c_1\vec{e}_1 + c_2\vec{e}_2$

; $\quad a_i, b_i, c_i \in \mathbb{R}, \quad i = 1, 2$

vsebuje enodimenzionalni ideal. Zvezo med homogenimi kvadratičnihmi sistemi in dvodimenzionalnimi komutativnimi algebrami je vpeljal že Markus [2] (izčrpne informacije o tej tematiki in virih v zvezi z njo najdemo v Walcherjevi monografiji [3]). Tak algebrični pristop nam pomaga pojasniti dinamiko v ustreznem kvadratičnem sistemu. Pri tem ima pomembno vlogo struktura algebre same, ter obstoj posebnih elementov, kot so na primer nilpotenti in idempotenti. Znano je, da je dinamika v takih sistemih lahko kaotična [1]. Najpreprostejši primer je dinamika kompleksnega kvadriranja, ki je na robu množice vseh omejenjih orbit kaotična.
V tem poročilu bomo obravnavali dinamiko diskretnih kvadratičnih sistemov v ravnini kjer pripadajoča algebra vsebuje ideal napet na nilpotent $\vec{n}$ ($\vec{n} \cdot \vec{n} = \vec{0}$) oziroma na idempotent $\vec{p}$ ($\vec{p} \cdot \vec{p} = \vec{p}$). Pokazali bomo, da je dinamika v prvem primeru trivialna, v slednjem pa je lahko kaotična.

Reference

[1] M. Kutnjak, *Nonlinear Phenom. Complex Syst.* **10** (2007) 176-179.

[2] L. Markus, *Ann. Math. Studies* **45** (1960) 185-213.

[3] S. Walcher, Algebras and Differential Equations, Hadronic Press, Inc., Palm Harbor, 1991.

On dynamics in planar discrete quadratic systems corresponding to algebras containing a one-dimensional ideal

MILAN KUTNJAK

Faculty of Electrical Engineering and Computer Science
University of Maribor, Smetanova 17, SI-2000 Maribor, Slovenia
milan.kutnjak@uni-mb.si •
http://www.mp.feri.uni-mb.si/osebne/kutnjak/mkutnjak.html

We consider the dynamics in those special cases of quadratic homogeneous discrete dynamical systems

$$\begin{array}{l} x_{k+1} = a_1 x_k^2 + 2b_1 x_k y_k + c_1 y_k^2 \\ y_{k+1} = a_2 x_k^2 + 2b_2 x_k y_k + c_2 y_k^2 \end{array} ; \quad a_i, b_i, c_i \in \mathbb{R}, \quad i = 1, 2$$

in which the corresponding algebra contains some nontrivial one-dimensional ideal. The correspondence between homogeneous dynamical systems and two-dimensional commutative algebras

$*$	$\vec{e}_1$	$\vec{e}_2$
$\vec{e}_1$	$a_1\vec{e}_1 + a_2\vec{e}_2$	$b_1\vec{e}_1 + b_2\vec{e}_2$
$\vec{e}_2$	$b_1\vec{e}_1 + b_2\vec{e}_2$	$c_1\vec{e}_1 + c_2\vec{e}_2$

; $\quad a_i, b_i, c_i \in \mathbb{R}, \quad i = 1, 2$

was introduced by Markus [2] (an extended list of references may be found in Walcher's monograph [3]). Algebraic concepts (such as structure of algebra and existence of special elements like idempotents and nilpotents) help us to study the dynamics of the corresponding discrete homogeneous quadratic maps. It is well-known that such systems can exhibit chaotic behavior [1]. The simplest example is the complex-squaring map, which exhibits chaotic behavior on the unit circle which is the boundary, ∂B, of the set of all points with bounded forward orbits.

In this report we will consider the dynamics in all planar cases which correspond to an algebra with an ideal spanned by vector $\vec{p}$ or $\vec{n}$, where $\vec{p}$ and $\vec{n}$ stand for two important special algebraic elements which affect strongly on the dynamics. These special elements are idempotents (i.e. elements defined by $\vec{p} \cdot \vec{p} = \vec{p}$) and nilpotents of rank two (i.e. elements defined by $\vec{n} \cdot \vec{n} = \vec{0}$). We show that in the cases where the ideal is spanned by a nilpotent $\vec{n}$ the dynamics is trivial. However, in cases where the ideal is spanned by an idempotent $\vec{p}$ the dynamics is much more interesting (even chaotic).

References

[1] M. Kutnjak, *Nonlinear Phenom. Complex Syst.* **10** (2007) 176-179.

[2] L. Markus, *Ann. Math. Studies* **45** (1960) 185-213.

[3] S. Walcher, Algebras and Differential Equations, Hadronic Press, Inc., Palm Harbor, 1991.

O izreku Kaplana in Yorka v kvadratičnih sistemih

MATEJ MENCINGER

Fakulteta za gradbeništvo
Univerza v Mariboru, Smetanova 17, SI-2000 Maribor, Slovenia
IMFM, Jadranska 19, SI-1000 Ljubljana, Slovenia
matej.mencinger@uni-mb.si •
http://www.fg.uni-mb.si/matematika/MatejM.htm

Med homogenimi kvadratičnimi sistemi in neasociativnimi algebrami je bijektivna zveza, ki jo omogoča desna stran sistema. Pripadajoče množenje $*$ v algebri je z desno stranjo Q enolično definirano s formulo $x * y = \frac{1}{2}\left(Q\left(x+y\right) - Q\left(x\right) - Q\left(y\right)\right)$. Zato je takšen algebraični pristop uporaben tako za kvadratične sistema NDE $x' = Q\left(x\right)$, kot tudi za ustrezne diskretne sisteme $x_{k+1} = Q\left(x_k\right)$; $x_k \in \mathbb{R}^n$. V zveznih sistemih je koordinatno izhodišče vedno totalno degenerirana kritična točka. V diskretnih sistemih pa je le-to vedno stabilno. V ravnini pri zveznih sistemih seveda ni kaotičnega obnašanja, kar pa za diskretni primer ni res (najpreprostejši primer za obstoj kaosa v takih sistemih je preslikava, ki ustreza množenju kompleksnih števil). V tem poročilu bomo sledili Markusovi izvirni ideji [2] in razložili kako so bili (do linearne ekvivalence natrančno) klasificirani ravninski sistemi. Korenine do (algebrske) klasifikacije so dvostranske. Prvič, vsak homomorfizem iz ene algebre v drugo je povezan z obstojem linearne preslikave, ki ohranja rešitve iz ene pripadajoče algebre v drugo. Posledično pomeni obstoj izomorfizma med dvema algebrama obstoj linearne ekvivalence med pripadajočima sistemoma. To opraviči algebrski prisop pri klasificiranju kvadratičnih sistemov. Drugi rezultat, ki je Markusu omogočil izvršiti klasifikacijo algebrer (in sistemov) v ravnini pa je rezultat Kapana in Yorka [1], ki pravi, da vsaka končnodimenzionalna realna algebra premore bodisi projektorje bodisi nilpotente reda 2. Poleg obstoječe Markusove klasifikacije v ravnini je bila narejena tudi delna klasifikacija sistemov v 3D prostoru (glej [3,4]). V tem poročilu bomo prikazali osnovne ideje algebrske klasifikacije v ravnini.

Reference

[1] J. L. Kaplan and J. A. Yorke, *Nonlinear Anal.* **3** (1979) L49-L51.

[2] L. Markus, *Ann. Math. Studies* **45** (1960) L185-L213.

[3] M. Mencinger, *Nonlinearity* **16** (2003) L201-L218.

[4] M. Mencinger and B. Zalar, *Commun. Algebra* **33** (2005) L807-L828.

On the Kaplan-Yorke result in quadratic systems

MATEJ MENCINGER

Faculty of Civil Engineering
University of Maribor, Smetanova 17, SI-2000 Maribor, Slovenia
IMFM, Jadranska 19, SI-1000 Ljubljana, Slovenia
matej.mencinger@uni-mb.si •
http://www.fg.uni-mb.si/matematika/MatejM.htm

There is a one-to-one correspondence between homogeneous quadratic systems and nonassociative commutative finite dimensional real algebras. It is the right hand side of the system which allows us to introduce the algebraic concept into the dynamical system. The corresponding algebra multiplication $*$ is uniquely defined by $x * y = \frac{1}{2}\left(Q\left(x+y\right) - Q\left(x\right) - Q\left(y\right)\right)$. Therefore, this kind of algebraic approach is applicable for quadratic systems of ODEs $x' = Q\left(x\right)$, as well as for the discrete quadratic systems $x_{k+1} = Q\left(x_k\right)$; $x_k \in \mathbb{R}^n$. The origin is always a total degenerate critical point in the continuous case on one hand, and is (trivial) stable in the discrete case on the other hand. There is no chaotic behavior in $\mathbb{R}^2$ in the continuous case on one hand, and it is well known that there is a chaotic behavior in some discrete cases on the other hand.

In this report we will follow the original Markus idea [2] and explain how the planar systems were classified up to a linear equivalence. The origin of (algebraic) classification is two-sided. Firstly, every algebra homomorphism from one algebra to another is associated with the existence of a linear solution preserving map which preserves the solutions from one corresponding system to another. Consequently, the existence of an algebra isomorphism between two algebras imply the linear equivalence of two corresponding systems. This justifies the algebraic approach when classifying the quadratic systems. Secondly, the fact that every finite dimensional real algebra contains either idempotents or nilpotents of rank two (i.e. the Kaplan-Yorke result [1]) enabled Markus to do the algebraic classification based on the number of idempotents and nilpotents of rank two. A partial algebraic classification in 3D space was done in [3,4]. In this report I am going to present the basic ideas of the classification in the plane.

References

[1] J. L. Kaplan and J. A. Yorke, *Nonlinear Anal.* **3** (1979) L49-L51.

[2] L. Markus, *Ann. Math. Studies* **45** (1960) L185-L213.

[3] M. Mencinger, *Nonlinearity* **16** (2003) L201-L218.

[4] M. Mencinger and B. Zalar, *Commun. Algebra* **33** (2005) L807-L828.

Anorganske molekularne žice na poti v molekularno elektroniko

DRAGAN MIHAILOVIC

Odsek za kompleksne snovi
Institut Jozef Stefan, Jamova 39, SI-1000 Ljubljana, Slovenia
dragan.mihailovic@ijs.si •complex.ijs.si

Hiter razvoj nanotehnologije vodi do zahtev po vedno novih enodimenzionalnih materialih z novimi funkcionalnimi lastnostmi. Nedavno so se nanožice na osnovi molibdena žvepla in joda[1] izkazale kot zelo perspektiven nov tovrsten material z izjemno funkcionalnostjo na molekularni ravni. Omenjene nanožice imajo povsem edinsteveno strukturo, ki omogoča da se skupki molibdena vežejo preko anionskih mostičkov v dolge gibke verige[2]. Te hkrati kažejo zelo velike Youngove module[3] in nelinearne mehanske in elektronske lastnosti[4,5]. Zelo šibka sklopitev med posameznimi polimernimi verigami znotraj kristaliničnih svežnjev posameznih žic omogoča opazovanje fundamentalnih elektronskih in magnetnih lastnosti enodimenzionalnih sistemov. Sposobnost kovalentne vezave na koncih posameznih žic preko sulfidnih vezi na molekularna stikala in zlate kontakte[6] omogoča njihovo uporabo za električne povezave v molekularni elektroniki. Samourejanje žic z vozlišči iz zlatih nanodelcev vodi v samo-organizirana kritična vezja, podobna kot tvorijo neuronske mreže v možganih. V predavanju bom nakazal pot za njihovo uporabo pri izgradnji molekularnega računalnika.

References

[1] D.Vrbanic et al. *Nanotechnology* **15** (2004) 635-638.

[2] D.Mihailovic, *Progress in Materials Science*, Published online (2008) doi:10.1016/j.pmatsci.2008.09.001.

[3] A.Kis et al.,*Small* **3**(2007) 1544.

[4] I.Vilfan and D.Mihailovic, *Phys. Rev.B* **74** (2006) 235411-1.

[5] I.Popov et al., *Phys. Rev.Lett.* **99** (2007) 085503.

[6] M.Ploscaru,*Nano Letters* **7** (2007) 1445-1448.

Inorganic Molecular Wires on the Road to Molecular Electronics

DRAGAN MIHAILOVIC

Department of Complex Matter
Jozef Stefan Instiute, Jamova 39, SI-1000 Ljubljana, Slovenia
dragan.mihailovic@ijs.si • complex.ijs.si

The rapid development of nanotechnology has lead to demands on new one-dimensional materials with new functional properties. Most recently inorganic molecular wires - particularly molybdenum halide or chalcogenide cluster polymers[1] - have emerged as a new type of one-dimensional materials with remarkable molecular-scale functionality [2]. These molecular wires are unique in terms of structure and molecular properties, setting them apart from the plethora of nanowires and nanotubes discovered in recent years. Their one-dimensional polymer structure gives rise to some very unusual physical properties. Anionic bridges which bind Mo clusters together into one-dimensional chains are extraordinarily strong, yet highly deformable, giving rise to exceptionally high YoungOs moduli[3] and nonlinear mechanical and electronic properties respectively[4,5]. The very weak interaction between individual polymer chains within crystalline bundles leads to observation of extreme one-dimensional electronic and magnetic character. The connectivity of the molecular wire ends to gold nanoparticles and surfaces with covalent bonds [6] and good electronic coupling enable self-assembled molecular-scale electrical connections to be made between individual molecules, which opens the way to a wide variety of diverse applications in molecular and gas sensing and potentially revolutionary applications in molecular electronics.

References

[1] D.Vrbanic et al. *Nanotechnology* **15** (2004) 635-638.

[2] D.Mihailovic, *Progress in Materials Science*, Published online (2008) doi:10.1016/j.pmatsci.2008.09.001.

[3] A.Kis et al.,*Small* **3**(2007) 1544.

[4] I.Vilfan and D.Mihailovic, *Phys. Rev.B* **74** (2006) 235411-1.

[5] I.Popov et al., *Phys. Rev.Lett.* **99** (2007) 085503.

[6] M.Ploscaru,*Nano Letters* **7** (2007) 1445-1448.

Proti kooperaciji v igri dileme zapornika s pomočjo koevolucije

MATJAŽ PERC

Oddelek za fiziko, Fakulteta za naravoslovje in matematiko
Univerza Maribor, Koroška cesta 160, SI-2000 Maribor, Slovenija
matjaz.perc@uni-mb.si • www.matjazperc.com

Predstavil bom problem evolucije kooperacije v igri dileme zapornika kjer so na začetku vsi igralci povezani zgolj s svojimi štirimi najbližjimi sosedi. Če sočasno z evolucijo strategij omogočimo, da igralci tvorijo nove povezave, se možnost preživetja kooperatorjev zviša, tudi če so skušnjave za defekcijo velike. Ta koevolucijski proces rezultira v zelo heterogenih interakcijskih mrežah, katerih porazdelitev je najbolje opisana z eksponentnim fitom.

Reference

[1] A. Szolnoki and M. Perc, *New J. Phys.* **10** (2008) 043036

[2] M. Perc and A. Szolnoki, *Phys. Rev. E* **77** (2008) 011904

[2] A. Szolnoki, M. Perc, and Z. Danku, *Europhys. Lett.* (2008) sprejeto

Towards cooperation in the prisoner's dilemma game via coevolution

MATJAŽ PERC

Department of Physics, Faculty of Natural Sciences and Mathematics
University of Maribor, Koroška cesta 160, SI-2000 Maribor, Slovenia
matjaz.perc@uni-mb.si • www.matjazperc.com

The evolution of cooperation in the prisoner's dilemma game shall be discussed, where initially all players are linked via a regular graph, having four neighbors each. If, simultaneously with the strategy evolution, players are allowed to make new connections the survival of cooperators shifts towards high temptations to defect. Moreover, this coevolutionary process results in highly heterogeneous interaction networks with an exponential fit best characterizing their degree distribution.

References

[1] A. Szolnoki and M. Perc, *New J. Phys.* **10** (2008) 043036

[2] M. Perc and A. Szolnoki, *Phys. Rev. E* **77** (2008) 011904

[2] A. Szolnoki, M. Perc, and Z. Danku, *Europhys. Lett.* (2008) accepted

Classification of baryon ground and resonant states

WILLIBALD PLESSAS

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

Results from a systematic study of baryon properties within the framework of relativistic constituent-quark models will be reviewed. They concern in particular the spectroscopy of all light and strange baryons, the baryon electromagnetic and weak form factors, the hadronic decays of baryon resonances and the structure of their rest-frame wave functions. The combined insight into these properties, together with the presently available phenomenological data, leads to a new and extended classification scheme into spin-flavor multiplets for all of the established light and strange baryon ground and resonant states.

References

[1] K. Berger, R.F. Wagenbrunn, and W. Plessas, *Phys. Rev. D*, **70** (2004) 094027.

[2] K. Glantschnig, R. Kainhofer, W. Plessas, and R.F. Wagenbrunn, *Eur. Phys. J. A*, **23** (2005) 507.

[3] T. Melde, W. Plessas, and R.F. Wagenbrunn, *Phys. Rev. C*, **72** (2005) 015207; ibid. **74** (2006) 069901.

[4] T. Melde, K. Berger, L. Canton, W. Plessas, and R.F. Wagenbrunn, *Phys. Rev. D*, **76** (2007) 074020.

[5] T. Melde, W. Plessas, and B. Sengl, *Phys. Rev. C*, **76** (2007) 025204.

[6] B. Sengl, T. Melde, and W. Plessas, *Phys. Rev. D*, **76** (2007) 054008.

[7] T. Melde, W. Plessas, and B. Sengl, *Phys. Rev. D*, **77** (2008) 114002.

Van der Waalsove interakcije med ogljikovimi nanocevkami

RUDOLF PODGORNIK

Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
rudolf.podgornik@fmf.uni-lj.si • www.fmf.uni-lj.si

Predstavil bom Lifšicovo teorijo van der Waalsovih interakcij med makroskopskimi telesi in pokazal, kako jo lahko uporabimo za izračun van der Waalsovih interakcij med anizotropnimi cilindri. Obravnaval bom dielektrične spektre enostenskih ogljikovih nanocevk in pokazal, kako se njihove strukturne lastnosti kažejo v značilnostih interakcij med njimi.

Reference

[1] Rick F. Rajter, Rudi Podgornik, V. Adrian Parsegian, Roger H. French, and W. Y. Ching: van der Waals London dispersion interactions for optically anisotropic cylinders: Metallic and semiconducting single-wall carbon nanotubes, PHYSICAL REVIEW B 76, 045417 2007.

[2] Rick Rajter, Roger H. French, Rudi Podgornik, W. Y. Ching, and V. Adrian Parsegian, Spectral mixing formulations for van der Waals London dispersion interactions between multicomponent carbon nanotubes, JOURNAL OF APPLIED PHYSICS 104, 053513 (2008).

Van der Waals interactions between carbon nanotubes

RUDOLF PODGORNIK

Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
rudolf.podgornik@fmf.uni-lj.si • www.fmf.uni-lj.si

I will present the Lifshitz theory of van der Waals interactions between macroscopic bodies and show how it can be applied to calculations of van der Waals interactions between anisotropic cylinders. I will discuss the ab initio dielectric spectra of single walled carbon nanotubes and show how the structural properties of nanotubes transpire on the characteristics of the interactions between them.

References

[1] Rick F. Rajter, Rudi Podgornik, V. Adrian Parsegian, Roger H. French, and W. Y. Ching: van der Waals London dispersion interactions for optically anisotropic cylinders: Metallic and semiconducting single-wall carbon nanotubes, PHYSICAL REVIEW B 76, 045417 2007.

[2] Rick Rajter, Roger H. French, Rudi Podgornik, W. Y. Ching, and V. Adrian Parsegian, Spectral mixing formulations for van der Waals London dispersion interactions between multicomponent carbon nanotubes, JOURNAL OF APPLIED PHYSICS 104, 053513 (2008).

Quantifying cross-correlations using local and global detrending approaches

BORIS PODOBNIK

Physics Department, Faculty of Civil Engineering
University of Rijeka, V. Cara Emina 5, Rijeka, Croatia
bp@phy.hr

Real-world data often exhibit long-range correlations combined with deterministic periodic trends. We introduce a new method, the cross-correlations test $Q_{\rm CC}$, for quantifying the long-range cross-correlations between two time series. If there are no cross-correlations between two time series, the cross-correlations test follows approximately the $\chi^2(m)$ distribution, where m is the number of degrees of freedom. If the cross-correlations test exceeds the critical value of the $\chi^2(m)$ distribution, then we say that the cross-correlations are significant. In addition to long-range cross-correlations, deterministic sinusoidal trends also affect the cross-correlations test. We show that a global detrending approach is effective for investigating cross-correlations of the underlying stochastic process. We show that if a Fourier phase-randomization procedure is carried out on a power-law cross-correlated time series, the cross-correlations practically vanish and the cross-correlations statistic test is substantially reduced compared to the case before Fourier phase randomization. We propose that both the cross-correlations test and the detrended cross-correlation analysis method should be used in order to confirm the existence of cross-correlations between two different time series. We also study the effect of periodic trends on systems with long-range power-law auto-correlations and with long-range power-law cross-correlations. We find that periodic trends can severely affect the quantitative analysis of long-range correlations, leading to crossovers and other spurious deviations from power laws. We show that both local and global detrending approaches together with phase randomization should be applied to properly uncover long-range power-law auto-correlations and cross-correlations in the random part of the underlying stochastic process.

References

[1] B. Podobnik and H.E. Stanley, *Phys. Rev. Lett.*, **100** (2008) 084102.

[2] J. Hosking, *Biometrika*, **68** (1981) 165.

[3] G. M. Ljung and G. E. P. Box, *Biometrika*, **65**, (1978) 297.

[4] C.-K. Peng *et al.*, *Phys. Rev. E*, **47** (1993) 3730.

[5] K. Hu, P.Ch. Ivanov, Z. Chen, P. Carpena, H.E. Stanley, *Phys. Rev. E*, **64** (2001) 011114.

[6] P. Ch. Ivanov, *et al.*, *Nature* , **383**, (1996) 323.

[7] Y. Ashkenazy *et al.*, *Phys. Rev. Lett.*, **86**, (2001) 1900.

Slow decay of acoustic waves due to viscoelastic boundaries

GEORG PROPST

Institute for Mathematics and Scientific Computing
Karl-Franzens University Graz, Austria
georg.propst@uni-graz.at www.uni-graz.at/georg.propst/

We consider the linear wave equation on a bounded domain $\Omega \subset R^3$ with convolution boundary conditions (cf.[1])

$$\begin{aligned} p_{tt}(t,x) - \Delta p(t,x) &= 0, \qquad x \in \Omega, \\ \frac{\partial p}{\partial n}(t,x) + \int_{-\infty}^{t} a(t-s)\, p_t(s,x)\, ds &= 0, \qquad x \in \partial\Omega. \end{aligned}$$

It is shown, that under physically reasonable conditions on the kernel a, all solutions tend to 0, as $t \to \infty$. The method is to use the Arendt-Batty-Lyubic-Vu theorem for C_0 semigroups (cf.[2]). However, the decay can be arbitrarily slow. This is established for one- two- and three-dimensional examples by proving eigenvalues that are arbitrarily close to the imaginary axis. The talk summarizes the results of [3], [4].

References

[1] G.Propst and J.Prüss, On wave equations with boundary dissipation of memory type, *Journal of Integral Equations and Applications,* **8** (1996), 99–123.

[2] W.Arendt, C.J.K.Batty, M.Hieber and F.Neubrander, *Vector-Valued Laplace Transforms and Cauchy Problems* (Birkhäuser, Basel 2001).

[3] W.Desch, E.Fašangová, J.Milota and G.Propst, Stabilization through viscoelastic boundary damping, in preparation.

[4] W.Desch, E.Fašangová, J.Milota and G.Propst, Spectrum of a viscoelastic boundary damping model, in preparation.

Točno reševanje master enačbe za odprte večdelčne kvantne sisteme in kvantni fazni prehod daleč od ravnovesja

TOMAŽ PROSEN

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

Predstavil bom obravnavo odprtih večdelčnih kvantnih sistemov z master enačbo v markovski aproksimaciji, t.j. Lindbladovo enačbo. Orisal bom novo analitično metodo, ki nam je omogočila točno rešitev Lindbladove enačbe za nekatere večdelčne kvantne sisteme, npr. za odprto XY spinsko verigo, ter predstavil nekaj vznemirljive nove fizike, ki nam jo te rešitve razkrijejo.

Reference

[1] T. Prosen, *New Journal of Physics*, **10** (2008) 043026.

[2] T. Prosen in I. Pižorn, *Physical Review Letters*, **101** (2008) 105701.

Exact solutions of master equations for open many-body quantum systems and quantum phase transition far from equilibrium

TOMAŽ PROSEN

Faculty of mathematics and physics
University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
tomaz.prosen@fmf.uni-lj.si • chaos.fmf.uni-lj.si

We shall discuss theoretical treatment of open many-particle quantum systems in terms of the master equations in the Markovian approximation, namely the Lindblad equation. I will outline a new analytical technique which enables us to exactly solve the Lindblad equation for certain many-particle quantum systems, e.g. for the open XY spin chain, and present some exciting new physics contained in these solutions.

References

[1] T. Prosen, *New Journal of Physics*, **10** (2008) 043026.

[2] T. Prosen and I. Pižorn, *Physical Review Letters*, **101** (2008) 105701.

Tekočekristalni senzor za biološke molekule

MIHA RAVNIK[1] in SLOBODAN ŽUMER[1,2]

[1] *Fakulteta za matematiko in fiziko, Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenija*

[2] *Institut Jožef Stefan, Jamova 39, SI-1000 Ljubljana, Slovenija*

miha.ravnik@fmf.uni-lj.si • http://softmatter.fmf.uni-lj.si/

V sodelovonju z raziskovalnima skupinama na Brown University, ZDA, in Rhode Island Memorial Hospital, ZDA, razvijamo nematski tekočekristalni senzor za detekcijo razvejanih bioloških molekul, kot je LPS, ki je odgovorna za okužbo s salmonelo [1]. Senzor temelji na kvadratnih mikrometrskih čašah napolnjenih z nematskim tekočim kristalom, kjer pride zaradi interakcije med tekočim kristalom in biomolekulami na zgornji prosti površini senzorja do spremembe optične polarizacijske slike [2]. Iz primerjave eksperimentalnih slik s simuliranimi lahko s senzorjem detektiramo način urejanja na zgornji površini (pravokotno, vzporedno ali degenerirano vzporedno) ter tudi podamo oceno moči interakcije. Numerično modeliranje služi kot orodje za optimizacijo in rezumevanje parametrov senzorja. Senzor pri koncentracijah biomolekul, ki so primerljive s fiziološkimi, zanimivo deluje na strukturnem prehodu nematskega tekočega kristala, kar mu daje dobro občutljivost [3].

Reference

[1] M. K. McCamley, G. P. Crawford, M. Ravnik, S. Žumer, A. W. Artenstein, S. M. Opal, *Appl. Phys. Lett.* **91**, 141916 (2007).

[2] J. M. Brake, M. K. Daschner, Y. Y. Luk, and N. L. Abbott, *Science* **302**, 2094 (2003).

[3] M. K. McCamley, G. P. Crawford, M. Ravnik, S. Žumer, v pripravi.

Nematic liquid crystal biosensor

MIHA RAVNIK[1] and SLOBODAN ŽUMER[1,2]

[1] *Faculty of Mathematics and Physics, University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia*
[2] *Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia*
miha.ravnik@fmf.uni-lj.si • http://softmatter.fmf.uni-lj.si/

Liquid crystal biosensor is developed in collaboration with the research groups from Brown University, USA, and Rhode Island Memorial Hospital, USA. The goal is to detect large biomolecules in blood, like LPS, which is released into the bloodstream in case of sepsis. [1]. Sensor is based on micron-sized square wells filled with a nematic liquid crystal, where liquid crystal-biomolecule interaction at the top free surface triggers changes in the optical polarization micrographs [2]. Using comparison between experimental and calculated micrographs, type and strength of surface interaction can be detected. Numerical modeling is used as a tool for optimization and development of sensor parameters. Interestingly, at biomolecular concentrations close to physiological values, sensor can operate on a structural transition of the nematic liquid crystal ordering, which gives good sensor sensitivity [3].

References

[1] M. K. McCamley, G. P. Crawford, M. Ravnik, S. Žumer, A. W. Artenstein, S. M. Opal, *Appl. Phys. Lett.* **91**, 141916 (2007).

[2] J. M. Brake, M. K. Daschner, Y. Y. Luk, and N. L. Abbott, *Science* **302**, 2094 (2003).

[3] M. K. McCamley, G. P. Crawford, M. Ravnik, S. Žumer, to be submitted.

Nekaj novih rezultatov o adiabatskih invariantah v časovno odvisnem linearnem oscilatorju

MARKO ROBNIK

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

Teorija adiabatskih invariant v neavtonomnih hamiltonskih sistemih ima dolgo zgodovino ter številne pomembne aplikacije v številnih vejah fizike, vendar je le redko osnovana na rigoroznih rezultatih. Pomembna je za razumevanje asimptotskega (dolgoročnega) vedenja dinamičnih sistemov. Obravnavali bomo primer linearnega oscilatorja, katerega frekvenca je poljubna funkcija časa, kar je v splošnem ekzaktno nerešljiv problem. Gledali bomo razvoj energije začetnega mikrokanoničnega ansambla začetnih pogojev and izpeljali porazdelitveno funkcijo končnih energij, ki se izkaže, da je univerzalna porazdelitev, katere funkcionalne lastnosti niso odvisne od podrobnosti sistema, razen parametrov poreazdelitve kot je prvi moment (končna povprečna energija) in varianca itd. To vprašanje je tesno povezano s problemom ohranitve adiabatskih invariant. Teorija je zanimiva po matematični plati, saj vsebuje elemente teorije dinamičnih sistemov, teorije verjetnosti, diskretne matematike (diferenčnih enačb) in WKB teorije.

Reference

[1] M. Robnik and V. G. Romanovski, *Journal of Physics A: Mathematical & General* **39** (2006) L35-L41.

[2] M. Robnik and V. G. Romanovski, *Open Sys. & Information Dyn.* **13** (2006) 197-222.

[3] M. Robnik and V. G. Romanovski, *Journal of Physics A: Mathematical & General* **39** (2006) L551-L554.

[4] A. V. Kuzmin and M. Robnik, *Reports on Math. Phys.* **60** No. 1 (2007) 69-84.

[5] M. Robnik and T. A. Wood, *Nonlinear Phenom. in Complex Syst.* **9** (2006) 141-149.

Some new results on the adiabatic invariants in time-dependent linear oscillator

MARKO ROBNIK

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

The theory of adiabatic invariants in nonautonomous Hamiltonian systems has a long history and important applications in many different branches of physics, but is rarely based on rigorous results. It is important for the understanding of the asymptotic (long term) behaviour of dynamical systems. We shall treat the case of the linear oscillator with its frequency being an arbitrary function of time, which is in general a nonsolvable problem. We study the energy evolution of an initial microcanonical ensemble of initial conditions and derive the distribution of the final energies, which turns out to be a universal distribution, whose functional properties do not depend on any details of the system, except for the parameters of the distribution function like the first moment (the final average energy) and the variance etc. This question is closely related to the problem of the preservation of the adiabatic invariant. The theory is interesting also from the mathematical point of view, as it comprises elements of the theory of dynamical systems, probability theory, discrete mathematics (difference equations) and WKB theory.

References

[1] M. Robnik and V. G. Romanovski, *Journal of Physics A: Mathematical & General* **39** (2006) L35-L41.

[2] M. Robnik and V. G. Romanovski, *Open Sys. & Information Dyn.* **13** (2006) 197-222.

[3] M. Robnik and V. G. Romanovski, *Journal of Physics A: Mathematical & General* **39** (2006) L551-L554.

[4] A. V. Kuzmin and M. Robnik, *Reports on Math. Phys.* **60** No. 1 (2007) 69-84.

[5] M. Robnik and T. A. Wood, *Nonlinear Phenom. in Complex Syst.* **9** (2006) 141-149.

Limitni cikli v kubičnem sistemu NDE

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

Predstavil bom metodo za pridobitev zgornje meje števila limitnih ciklov, katere se pojavijo po malih motnjah iz singularnega centra ali fokusa. Metoda temelji na kompleksifikaciji dvo-dimenzionalnega realnega sistema navadnih diferencialnih enačb in na natančnem študiju ideala generiranega z fokusnimi količinami sistema na osnovi uporabe algoritmov računske komutativne algebre.
Predstavil bom tudi primer kubičnega sistema z 12 limitnimi cikli relativno velikega obsega.

Reference

[1] V. Levandovskyy, V. Romanovski, D. S. Shafer, *Journal of Differential Equations* **246** (2009) 1274-1287.

[2] L. A. Cherkas, V. Romanovski and Y. Xing, Limit cycles and centers in a cubic planar system, submitted to International Journal of Bifurcations and Chaos.

[3] V. Romanovski and D. Shafer, "The center and cyclicity problems: a computational algebra approach", Birkhäuser Boston, 2009 (in press)

Limit cycles in cubic systems of ODE's

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

We present a method to obtain an upper bound for the number of limit cycles which appear after small perturbation from a singular point of center or focus type. The method is based on complexification of plane real system of ordinary differential equations and the detail study of the ideal generated by the focus quantities of the system using algorithms of computational commutative algebra.
We also give an example of a cubic system with twelve limit cycles of relatively large size.

References

[1] V. Levandovskyy, V. Romanovski, D. S. Shafer, *Journal of Differential Equations* **246** (2009) 1274-1287.

[2] L. A. Cherkas, V. Romanovski and Y. Xing, Limit cycles and centers in a cubic planar system, submitted to International Journal of Bifurcations and Chaos.

[3] V. Romanovski and D. Shafer, "The center and cyclicity problems: a computational algebra approach", Birkhäuser Boston, 2009 (in press)

Macroscopic quantum phenomena and atomic Bose-Einstein condensates

LUCA SALASNICH

CNR-INFM, CNISM and Department of Physics "Galileo Galilei" University of Padova, Via Marzolo 8, I-35131 Padova, Italy
luca.salasnich@cnr.it www.padova.infm.it/salasnich/

In the first part of the talk I shall discuss the Bose-Einstein condensation and its implications for macroscopic quantum phenomena like superfluidity and superconductivity. In the second part I shall analyze the properties of Bose-Einstein condensates made of ultracold alkali-metal atoms. In particular, I shall introduce and discuss the Gross-Pitaevskii equation, which is the main tool for an accurate description of static and dynamical properties of these Bose condensates under an external confinement.

References

[1] C.J. Pethick and H. Smith, *Bose-Einstein condensation in dilute gases* (Cambridge Univ. Press, Cambridge 2001).

[2] A.J. Leggett, *Quantum liquids. Bose condensation and Cooper pairing in condensed-matter systems* (Oxford Univ. Press, Oxford, 2006).

[3] L. Salasnich, A. Parola, and L. Reatto, *Phys. Rev. Lett.*, **91** (2003) 080405.

[4] L. Salasnich and B.A. Malomed, *Phys. Rev. A*, **74** (2006) 053610.

[5] L. Salasnich, N. Manini, and F. Toigo, *Phys. Rev. A* **77** (2008) 043609.

Ali lahko spekter lastne difuzije vode razkrije skrivnosti mokrote?

JANEZ STEPIŠNIK, IGOR SERŠA in ALEŠ MOHORIČ
Fakulteta za matematiko in fiziko, Univerze v Ljubljani in Institut J. Stefan, Ljubljana
Janez.Stepisnik@fmf.uni-lj.si • www.fmf.uni-lj.si

Voda je ena od najpomembnejših snovi na zemlji, katere lastnosti so pomembne za mnoge fizikalne, kemične, biološke in geološke procese. Zgradba in dinamika mreže vodikovih vezi določa edinstvene lastnosti vode. Njihovo razumevanje je še vedno od nerešenih ugank znanosti v zadnjem stoletju. Čeprav urejenost dolgega dosega v vodi še nima jasne eksperimentalne potrditve, pa njeni modeli izhajajo v glavnem iz množice teoretičnih simulacij[1,2]. Lastnosti molekularnih interakcij so skrite tudi v spektru avtokorelacij hitrosti molekul. Novo metodo magnetne resonance z moduliranimi efektivnimi gradienti magnetnega polja[3,4] smo uporabili za meritev nizkofrekvenčnega dela avtokorelacijskega spektra vode. Posebnost nove metode je neposredna meritev spektra hitrostnih korelacij z modulacijo faze spinov na osnovi konstantnega gradienta magnetnega polja in zaporedja radiofrekvenčnih pulzov, ki tudi določa frekvenčni doseg meritev. Spektri dobljeni pri različnih temperaturah kažejo nenavadno upadanje pri nizkih frekvencah. Pojasnili smo jih s sklopitvijo difundirajočih molekul na migotajoče privlačne centre v strukturi mreže vodikovih vezi. Rezultati modela se lepo prilagajajo meritvam in dokazujejo, da so meritve prva neposredna potrditev vpliva mreže vodikovih vezi na translacijsko gibanje molekul v vodi. Oblika spektrov pa daje tudi mero urejenosti mreže pri različnih temperaturah.

References

[1] A. Luzar and D. Chandler, *Nature (London)* **379** (1996) 55 57.

[2] M. Schulz, S. Stepanow and S. Trimper, *Europhys. Lett.* **54** (4)(2001) 424 429.

[3] S. Lasič, J. Stepišnik, A. Mohorič, I. Serša and G. Planinšič, *Europhys. Lett,* **75** (2006) 887893.

[4] J. Stepišnik, S. Lasič, A. Mohorič, I. Serša and A. Sepe, *Magn. reson. imag.* bf 25 (2007) 517-520.

Can self-diffusion spectrum of water reveal wet secrets?

JANEZ STEPIŠNIK, IGOR SERŠA and ALEŠ MOHORIČ
Faculty of mathematics and physics, University of Ljubljana and Institute J. Stefan, Ljubljana
Janez.Stepisnik@fmf.uni-lj.si • www.fmf.uni-lj.si

Water is one of the most important compounds on the earth, where its properties are essential to many physical, chemical, biological, and geological processes. The structure and dynamics of the hydrogen-bonding network in water are what makes water unique. Its understanding is one of the most intriguing scientific questions in the last 100 years. Although the long-range structure of water has never been clearly experimentally determined, its models lean mostly against the theoretical simulations that have not yet comprehensive experimental conformation. As the molecular velocity autocorrelation spectrum (VAS) hides the details of molecular interactions, we use the novel NMR technique of modulated gradient spin echo to measure the low frequency range of VAS of bulk water at different temperatures. The method is unique one to allow direct measurement of spectrum in the frequency range determined by the rate of spin phase modulation by using the constant magnetic field gradient and the sequence of radiofrequency pulses. Obtained spectra show unusual decline at low frequency that can be explained and fitted by the calculation based on the coupling of diffusing water molecules to the flickering attractive points in the hydrogen bond network. Thus, these results seem to be the first direct experimental observation of the effect of hydrogen bonding to the molecular translational dynamics in water, where the shapes of spectra also provide a measure of network ordering at different temperatures.

References

[1] A. Luzar and D. Chandler, *Nature (London)* **379** (1996) 55 57.

[2] M. Schulz, S. Stepanow and S. Trimper, *Europhys. Lett.* **54** (4)(2001) 424 429.

[3] S. Lasič, J. Stepišnik, A. Mohorič, I. Serša and G. Planinšič, *Europhys. Lett,* **75** (2006) 887893.

[4] J. Stepišnik, S. Lasič, A. Mohorič, I. Serša and A. Sepe, *Magn. reson. imag.* bf 25 (2007) 517-520.

Magnetne lastnosti nekaterih multiferoikov

ZVONKO TRONTELJ

IMFM Inštitut za matematiko, fiziko in mehaniko
Jadranska 19 SI-1000 Ljubljana, Slovenija
zvonko.trontelj@fmf.uni-lj.si • http://fizika.imfm.si

Multiferoiki - materiali, ki kažejo tako feroelektrične kot feromagnetne lastnosti in pogosto tudi opazno sklopitev med električno polarizacijo in magnetizacijo, so danes predmet intenzivnih raziskav vsepovsod. Pričakuje se, da bomo uspeli s temi materiali povečati gostoto spominskih elementov v informacijsko - komunikacijski - tehnologiji (ICT). Ko bo potekal zapis preko magnetnih lastnosti in branje preko električnih lastnosti novega spominskega elementa, bomo imeli možnost večje gostote podatkov, saj branje s pomočjo električnega polja povzroči manjšo energijsko disipacijo v primeri z doslej uporabljenim tokom, oziroma magnetnim poljem.
Podal bom pregled raziskav magnetnih lastnosti nekaterih oksidnih multiferoikov, ki smo jih izvedli v zadnjih dveh letih v Centru za magnetna merjenja (CMag) v Ljubljani: $Pb(Fe_{1/2}Nb_{1/2})O_3$ - (PFN), $0.8Pb(Fe_{1/2}Nb_{1/2})O_3$ - $0.2Pb(Mg_{1/2}W_{1/2})O_3$ - (0.8PFN-0.2PMW), (0.3PFN - 0.7PMW), (PFW). Obravnavali bomo tudi material, kjer je bil kisik nadomeščen s fluorom: $K_3Fe_5F_{15}$ - (KFeF).
Multiferoični materiali so so bili tako monokristali (KFeF, PFN), polikristali (KFeF, PFN), keramika (0.8PFN - 0.2PMW, 0.3PFN - 0.7PMW, PFW). Magnetne meritve M(T), M(H), dc in ac magnetno susceptibilnost smo izvedli na komercialnem SQUID magnetometru QD-MPMS-XL5, v laboratorijih na IJS so naredili dielektrične in Moessbauerjeve meritve.
Pri večini raziskovanih materialov so feroelektrični in feromagnetni fazni prehodi precej vsaksebi na temperaturni skali. Temu primerno so tudi sklopitve med električno polarizacijo in magnetizacijo šibke, velikokrat le v drugem redu (P^2M^2). Določili smo efektivni magnetni moment in velikost magnetno urejenih skupkov. Nekateri omenjeni materiali kažejo relaksorske lastnosti, kar smo opazili tako pri magnetnih kot pri dielektričnih meritvah.

Reference

[1] J.F. Scott, *Science* **315** (2007) 954.

Magnetic Properties of some Multiferroics

ZVONKO TRONTELJ

IMFM Institute for Mathematics, Physics and Mechanics
Jadranska 19 SI-1000 Ljubljana, Slovenia
zvonko.trontelj@fmf.uni-lj.si • http://fizika.imfm.si

Multiferroics are materials which demonstrate both, ferroelectric and ferromagnetic properties. Often, the coupling between electric polarization and magnetization is observed. That is the reason for intense research work on this substances supported by the expectation to obtain with them memory elements with higher density of information. With the magnetic field for writing and with the electric field (voltage) for reading we expect smaller dissipation of energy and this way a possible higher density of information.

The results of last two years magnetic research on some oxide type of multiferroics in Ljubljana Centre for magnetic measurements (CMag) will be presented. We studied $Pb(Fe_{1/2}Nb_{1/2})O_3$ - (PFN), $0.8Pb(Fe_{1/2}Nb_{1/2})O_3$ - $0.2Pb(Mg_{1/2}W_{1/2})O_3$ - (0.8PFN-0.2PMW), (0.3PFN - 0.7PMW), (PFW). We shall also mention the case where oxygen was replaced by fluorin: $K_3Fe_5F_{15}$ - (KFeF).

These materials were in a form of sigle crystals (KFeF, PFN), polycrystalline powder (KFeF, PFN) and ceramics (0.8PFN - 0.2PMW, 0.3PFN - 0.7PMW, PFW). Magnetic measurements M(T), M(H), dc and ac magnetic susceptibility were performed with a commercial SQUID magnetometer QD-MPMS-XL5. Dielectric and Moessbauer measurements were done at J. Stefan institute.

Materials which we studied have ferroelectric and ferromagnetic phase transitions at temperatures that are quite far apart. Consequently, the coupling between electric polarization and magnetization is expected to be weak. We observed in some cases a second order coupling (P^2M^2). The effective magnetic moment and the size of ordered magnetic clusters was determined. Some samples clearly show magnetic relaxor properties as well as dielectric relaxor properties revealed from ac magnetic and electric susceptibility measurements.

References

[1] J.F. Scott, *Science* **315** (2007) 954.

Quantum communication in theory and experiment

RUPERT URSIN

IQOQI - Institute for Quantum Optics and Quantum Information Austrian Academy of Sciences, Boltzamnng. 3, A-1090 Vienna, Austria

Rupert.Ursin@univie.ac.at • www.quantum.at

Ever since its invention in the 1920s, quantum physics has given rise to countless discussions about its meaning and about how to interpret the theory correctly. These discussions focus on issues like the Einstein-Podolsky-Rosen paradox, quantum nonlocality the role of measurement in quantum physics. In recent years, however, research into the very foundations of quantum mechanics has also led to a new field - quantum information technology.
I will present some of the recent real world demonstrations of quantum communication as well as the proposals to perform experiments with entangled photons on the International Space Station (ISS).

References

[1] A. Einstein, B. Podolsky, and N. Rosen, Can quantum-mechanical description of physical reality be considered complete? *Phys. Rev.*, **47** (10):777–780, May 1935.

[2] J. S. Bell. *Speakable and Unspeakable in Quantum Mechanics*. Cambridge UP, Cambridge, 1987.

[3] A. Zeilinger. A foundational principle for quantum mechanics. *Found. Physics*, **29**:631, 1999.

[4] N. Gisin, G. Ribordy, W. Tittel, and H. Zbinden. Quantum cryptography. *Rev. Mod. Phys.*, **74** (1):145–195, Mar 2002.

[5] T. Schmitt-Manderbach, H. Weier, M. Fuerst, R. Ursin, F. Tiefenbacher, T. Scheidl, J. Perdigues, Z. Sodnik, C. Kurtsiefer, J. G. Rarity, A. Zeilinger, and H. Weinfurter. Experimental demonstration of free-space decoy-state quantum key distribution over 144 km. *Phys. Rev. Lett.*, **98**:010504, 2007.

[6] R. Ursin, F. Tiefenbacher, T. Schmitt-Manderbach, H. Weier, T. Scheidl, M. Lindenthal, B. Blauensteiner, T. Jennewein, J. Perdigues, P. Trojek, B. Oemer, M. Fuerst, M. Meyenburg, J. Rarity, Z. Sodnik, C. Barbieri, H. Weinfurter, and A. Zeilinger. Entanglement-based quantrum communication over 144 km. *Nature Physics*, **3**:481 – 486, 2007.

[7] R. Ursin, T. Jennewein, J. Kofler, J. M. Perdigues, L. Cacciapuoti, C. J. de Matos, M. Aspelmeyer, A. Valencia, T. Scheidl, A. Fedrizzi, A. Acin, C. Barbieri, G. Bianco, C. Brukner, J. Capmany, S. Cova, D. Giggenbach, W. Leeb, R. H. Hadfield, R. Laflamme, N. Lutkenhaus, G. Milburn, M. Peev, T. Ralph, J. Rarity, R. Renner, E. Samain, N. Solomos, W. Tittel, J. P. Torres, M. Toyoshima, A. Ortigosa-Blanch, V. Pruneri, P. Villoresi, I. Walmsley, G. Weihs, H. Weinfurter, M. Zukowski, and A. Zeilinger. Space-quest: Experiments with quantum entanglement in space. *arXiv:0806.0945*, 2008.

Bananski tekoči kristali

NATAŠA VAUPOTIČ

Fakulteta za naravoslovje in matematiko
Univerza v Mariboru, Koroška 160, SI-2000 Maribor, Slovenia
natasa.vaupotic@uni-mb.si • www.fnm.uni-mb.si

Predstavila bom osnovne lastnosti tekočih kristalov, ki jih tvorijo ukrivljene molekule. Posebnost t.i. bananskih tekočih kristalov je v tem, da molekule, ki so v osnovi nekiralne, tvorijo kiralne strukture. Zlom kiralne simetrije vodi do nastanka številnih eno, dvo in tridimenzionalnih struktur. Bananski tekoči kristali so pomembni tako s stališča bazičnih raziskav kot tudi za aplikacije. Zaradi velike optične aniozotropije so zanimivi za uporabo v tekočekristalnih preklopnikih, izdelujejo se ?e prvi prototipi celic. V predavanju bom predstavila modeliranje tekočih kristalov v ograjenih in neograjenih vzorcih ter njihovo odzivanje na zunanja polja. Teoretične napovedi bom povezala z eksperimentalnim delom na tem področju.

Reference

[1] D. Pociecha, N. Vaupotič, E. Gorecka, J. Mieczkowski in K. Gomola, *J. Mater. Chem.* **18** (2008) 881-885.

[2] N. Vaupotič, M. Čopič, E. Gorecka in D. Pociecha *Phys. Rev. Lett.* **98** (2007) 247802-1-247802-4.

[3] E. Gorecka, N. Vaupotič in D. Pociecha *Chem. Mater.* **19** (2007) 3027-3031.

[4] N. Vaupotič *Ferroelectrics* **344** (2006) 151-159.

[5] N. Vaupotič in M. Čopič *Phys. Rev. E* **72** (2005) 031701-1-031701-4.

[6] E. Gorecka, N. Vaupotič, D. Pociecha, M. Čepič in J. Mieczkowski *ChemPhysChem* **6** (2005) 1087-1093.

[7] N. Vaupotič, V. Grubelnik in M. Čopič *Phys. Rev. E* **62** (2000) 2317-2323.

[8] N. Vaupotič, S. Kralj, M. Čopič in T. J. Sluckin *Phys. Rev. E* **54** (1996) 3783-3791.

Liquid Crystals made of Bent-core Molecules

NATAŠA VAUPOTIČ

Faculty for Natural Sciences and Mathematics
Univerza v Mariboru, Koroška 160, SI-2000 Maribor, Slovenia
natasa.vaupotic@uni-mb.si • www.fnm.uni-mb.si

Basic properties of liquid crystals made from bent-core molecules will be presented. The astonishing property of these, so called banana liquid crystals, is formation of chiral structures from achiral molecules. This breakdown of chiral symmetry leads to the formation of several one, two and three-dimensional structures. Bent-core liquid crystals are important from the basic and the applicative point of view. Because of their large optical anisotropy they are potentially applicable for liquid crystal displays, the first prototypes are already being tested. In the talk I will present modelling of bent-core liquid crystals in bulk and in confined geometries and their response to external fields. Theoretical predictions will be compared to the experimental work in this field.

References

[1] D. Pociecha, N. Vaupotič, E. Gorecka, J. Mieczkowski and K. Gomola, *J. Mater. Chem.* **18** (2008) 881-885.

[2] N. Vaupotič, M. Čopič, E. Gorecka and D. Pociecha *Phys. Rev. Lett.* **98** (2007) 247802-1-247802-4.

[3] E. Gorecka, N. Vaupotič and D. Pociecha *Chem. Mater.* **19** (2007) 3027-3031.

[4] N. Vaupotič *Ferroelectrics* **344** (2006) 151-159.

[5] N. Vaupotič and M. Čopič *Phys. Rev. E* **72** (2005) 031701-1-031701-4.

[6] E. Gorecka, N. Vaupotič, D. Pociecha, M. Čepič and J. Mieczkowski *ChemPhysChem* **6** (2005) 1087-1093.

[7] N. Vaupotič, V. Grubelnik and M. Čopič *Phys. Rev. E* **62** (2000) 2317-2323.

[8] N. Vaupotič, S. Kralj, M. Čopič and T. J. Sluckin *Phys. Rev. E* **54** (1996) 3783-3791.

Rob kaosa v mejni plasti

GREGOR VEBLE

Univerza v Novi Gorici, Vipavska c. 13, SI-5000 Nova Gorica
Pipistrel d.o.o. Ajdovščina, Goriška c. 50a, SI-5270 Ajdovščina
FMF, Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana
CAMTP, Univerza v Mariboru, Krekova 2, SI-2000 Maribor, Slovenija
gregor@pipistel.si • www.pipistrel.si

Mejna plast je v dinamiki fluidov osnovnega pomena pri razumevanju upora in separacije toka od površine. Z mejno plastjo označimo tisti del tekočine ob steni, v katerem hitrost preide od hitrosti stene do hitrosti okoliške tekočine. Pri določeni debelini mejne plasti gibanje tekočine v njej preide iz urejenega, laminarnega v turbulentno, kaotično. Prehod ni posledica linearne nestabilnosti laminarnega toka, pač pa poteka preko sedelne točke. Prikazal bom numerične izračune mejne plasti na meji med kaosom in urejenostjo. Relativni atraktor je v tem primeru periodična orbita. Iz lastnosti meje je mogoče bolje razumeti prehod iz laminarnega v turbulentni tok.

Reference

[1] J.D. Skufca, J.A. Yorke in B. Eckhardt, *Physical Review Letters* **96** (2006) 174101.

[2] T.M. Schneider, B. Eckhardt in J.A. Yorke *Physical Review Letters* **99** (2007) 034502.

[3] C. Canuto, A. Quarteroni, M. Y. Hussaini in T. Zang, *Spectral Methods in Fluid Mechanics* (1988) Springer-Verlag, New York.

Edge of chaos in the boundary layer

GREGOR VEBLE

University of Nova Gorica, Vipavska c. 13, SI-5000 Nova Gorica
Pipistrel d.o.o. Ajdovščina, Goriška c. 50a, SI-5270 Ajdovščina
FMF, University of Ljubljana, Jadranska 19, SI-1000 Ljubljana
CAMTP, University of Maribor, Krekova 2, SI-2000 Maribor,
Slovenia
gregor@pipistel.si • www.pipistrel.si

The boundary layer is of fundamental importance in understanding drag and flow separation in fluid dynamics. It denotes the part of the fluid near the wall where the velocity transitions from the wall velocity to the surrounding fluid velocity. At a certain boundary layer thickness the motion transitions from a laminar, ordered flow to a turbulent, chaotic one. The transition is not a consequence of a linear instability of the laminar flow, but rather occurs via a saddle-point. I will show numerical calculations of the boundary layer flow on the edge between chaos and order. The relative attractor turns out to be a periodic orbit. From the properties of the edge one can better understand the transition from the laminar to the turbulent flow.

References

[1] J.D. Skufca, J.A. Yorke and B. Eckhardt, *Physical Review Letters* **96** (2006) 174101.

[2] T.M. Schneider, B. Eckhardt and J.A. Yorke *Physical Review Letters* **99** (2007) 034502.

[3] C. Canuto, A. Quarteroni, M. Y. Hussaini and T. Zang, *Spectral Methods in Fluid Mechanics* (1988) Springer-Verlag, New York.

Bulk Metallic Glasses: Properties, Application and Examples

MAGDALENA WENCKA

Jožef Stefan Institute, Jamova 39, SI 1000 Ljubljana, Slovenia

Bulk Metallic Glasses (BMG) are metastable solids without structural long-range order. The first BMG (Au-Si), in micrometers dimensions, was produced by Pol Duwez over forty years ago from eutectic liquid cooled with the rate of 106 K/s. The application of lower cooling rates (0.1-100 K/s) enabled production of BMGs of larger size (up to centimeters). The amorphous atomic structure of BMGs provides the origin of many technologically advantageous mechanical properties of the material: strength two times higher than that of the stainless steel but the BMGs are lighter, hardness - especially for surface coatings, toughness - more fracture resistant than ceramics, elasticity - high yield strength, and low electrical and thermal conductivity. BMGs are corrosion-resistant materials, too. The superior mechanical, electrical and thermal properties of the BMGs are largely a consequence of the unordered structure with various bonding lengths and nonperiodic positions of the atoms.

The application of BMGs is very broad, ranging from military and aerospace materials to medical applications (knee-replacement devices), consumer electronics (rolling-up laptops) and sporting goods (tennis rackets). The BMGs can be used as hydrogen-storage materials, too. The hydrogen can be stored in the micro-cracks and voids in the material, and the hydrogen atomic diffusion may be observed using Nuclear Magnetic Resonance (NMR) technique. The influence of the hydrogen content on the hydrogen diffusion in the Zr-based metallic glasses will be discussed in particular.

References

[1] M. Telford, *Materials Today*, March, 36 (2004).

[2] M. Li, J. Eckert, L. Kecskes, J. Lewandowski, *J. Mater. Res.* **22**, 255 (2007).

[3] T. Apih, M. Bobnar, J. Dolinšek, L. Jastrow, D. Zander, U. Köster, *Solid State Commun.* **134**, 337 (2005).

Playing billiards with light: Quantum chaos in optical microcavities

JAN WIERSIG

Institute for Theoretical Physics
Otto-von-Guericke University, D-39016 Magdeburg, Germany
jan.wiersig@ovgu.de
www.uni-magdeburg.de/itp/condmat1/condmat1.html

Optical microcavities are important for a wide range of research areas and applications [1], such as ultra-low threshold lasers and single-photon sources. In the nonlinear dynamics and quantum chaos community microdisk cavities with deformed cross-sectional shape attracted considerable attention since they can be used to study the ray-wave correspondence in open systems in direct comparison to experiments [2,3]. In this talk we discuss two aspects: (i) avoided resonance crossings [4,5] and (ii) the influence of the chaotic repeller on the far-field emission pattern [6].

References

[1] K. J. Vahala, *Nature* **424**, 839 (2003).

[2] J. U. Nöckel and A. D. Stone, *Nature* **385**, 45 (1997).

[3] C. Gmachel *et al.*, *Science* **280**, 1556 (1998).

[4] J. Wiersig, *Phys. Rev. Lett.* **97**, 253901 (2006).

[5] J. Unterhinninghofen, J. Wiersig, and M. Hentschel, *Phys. Rev. E* **78**, 016201 (2008).

[6] J. Wiersig and M. Hentschel, *Phys. Rev. Lett.* **100**, 033901 (2008).

Uporaba georadarja za detekcijo skritih predmetov

ALEKSANDER ZIDANŠEK[1,2] in DIMITRIJ NAJDOVSKI[2,3]

[1]*IJS - Institut Jožef Stefan in* [2]*Mednarodna podiplomska sola Jožefa Stefana*
Jamova 39, SI-1000 Ljubljana, Slovenia
[3]*X3data*
Novi trg 6, SI-1000 Ljubljana, Slovenia
aleksander.zidansek@ijs.si • www.ijs.si

Predstavljeni bodo primeri uporabe georadarja za detekcijo skritih predmetov. Še posebej bodo izpostavljeni nekateri inovativni pristopi za prepoznavanje detektiranih predmetov, in sicer na podlagi Kirchhoffove migracije ter nevronskih mrež. Prikazanih bo nekaj primerov detekcije razli?nih predmetov z georadarjem.

Reference

[1] D. Najdovski, A. Zidanšek in R. Blinc, Detection of water leakages with ground penetrating radar. V: GUZOVIC, Zvonimir (ur.), DUIC, Neven (ur.), BAN, Marko (ur.). 4th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, Dubrovnik, Hrva?ka, junij 2007.

Application of Georadar for the detection of hidden objects

ALEKSANDER ZIDANŠEK[1,2] and DIMITRIJ NAJDOVSKI[2,3]

[1] *JSI - Institute J. Stefan Institute and* [2] *J. Stefan International Postgraduate School*
Jamova 39, SI-1000 Ljubljana, Slovenia
[3] *X3data*
Novi trg 6, SI-1000 Ljubljana, Slovenia
aleksander.zidansek@ijs.si • www.ijs.si

Some applications of Georadar for the detection of hidden objects shall be discussed. Innovative approaches for the recognition of the detected objects based on Kirchhoff migration and neural networks will be presented. Some examples of the detection of hidden objects with Georadar will be shown.

References

[1] D. Najdovski, A. Zidanšek and R. Blinc, Detection of water leakages with ground penetrating radar. In: GUZOVIC, Zvonimir (Ed.), DUIC, Neven (Ed.), BAN, Marko (Ed.). 4th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, Dubrovnik, Croatia, June 2007. CD proceedings.