
CAMTP

CENTER FOR APPLIED MATHEMATICS AND THEORETICAL PHYSICS
UNIVERZA V MARIBORU

9. Simpozij fizikov Univerze v Mariboru

*Posvečen Profesorju Siegfriedu Grossmannu
ob njegovem 80. življenjskem jubileju*

Zbornik povzetkov

Hotel Piramida
Maribor, 9., 10. in 11. december 2010

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

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PREDGOVOR

Naši Simpoziji fizikov Univerze v Mariboru, ali na kratko kar Božični simpoziji, imajo že tradicijo, saj imamo letos že devetega po vrsti. Namen je strokovno druženje slovenskih fizikov, ob prisotnosti ter aktivni udeležbi nekaterih uglednih kolegov iz tujine kot častnih vabljenih gostov, pri čemer je srečanje že 2006 preraslo regionalne okvire in je postalo nacionalno srečanje. Letos imamo okoli tretjino vabljenih predavateljev iz tujine, iz odličnih raziskovalnih skupin, tako da postajajo naša srečanja mednarodna. Srečanje je le ena od številnih dejavnosti CAMTP - Centra za uporabno matematiko in teoretično fiziko Univerze v Mariboru, ki sicer organizira kar pet serij mednarodnih znanstvenih srečanj. Glej www.camtp.uni-mb.si

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

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

Vsem dodiplomskim študentom dovoljujemo brezplačno udeležbo na vseh predavanjih, in s tem prispevamo k popularizaciji fizike ter k dodatnemu izobraževanju na tem področju.

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

Profesor Siegfried Grossmann - 80. življenjski jubilej



Letošnje srečanje je posvečeno Profesorju Siegfriedu Grossmannu z Univerze v Marburgu, Nemčija, ob njegovem 80. življenjskem jubileju. Rodil se je 28. februarja 1930 v Königsbergu, v Vzhodni Prusiji. Mesti Marburg, kjer dela od leta 1964, in Maribor sta partnerski mesti, univerzi pa sta partnerski univerzi, kar daje naši povezavi še poseben pečat. Profesor Grossmann je eden največjih teoretičnih fizikov 20. in 21. stoletja v svetovnem okviru. Njegovo znanstveno delo obsega naslednja področja: jedrska fizika, splošna statistična fizika, transportna teorija, nelinearna dinamika, mehanika tekočin in teorija turbulence, fazni prehodi, laserska fizika, Bose-Einsteinova kondenzacija. Njegovo delo obsega več kot 241 originalnih člankov. Izjemno je dejaven tudi na področju poučevanja fizike na univerzitetnem in gimnazijskem nivoju. Napisal je več učbenikov, ki so že desetletja nepogrešljiv vir znanja v matematični fiziki. Imel je in še vedno ima številne svetovalne funkcije v Nemčiji. Veliko je naredil ne le za fiziko v Nemčiji, temveč tudi v svetovnem obsegu, in še posebej za fiziko v Sloveniji, saj je kot zvesti prijatelj CAMTP prijazno podpiral dejavnosti in povezave z Univerzo v Marburgu in drugimi v Nemčiji. Že od leta 1994 je redni vsakokratni predavatelj na naših mednarodnih poletnih šolah in konferencah "Let's Face Chaos through Nonlinear Dynamics", ki jih organizira CAMTP, od leta 1999 pa tudi častni direktor. Je

prejemnik Max-Planckove Medalje Nemškega fizikalnega društva v letu 1995 ter številnih drugih priznanj, med drugim tudi najvišjega nemškega državnega priznanja (Großes Verdienstkreuz des Verdienstordens der Bundesrepublik Deutschland, 1996), je član treh akademij znanosti, prejemnik častnega doktorata na Univerzi Duisburg-Essen. Leta 2005 je prejel tudi Pečat Mesta Maribor, ki mu ga je podelil tedanji župan Maribora gospod Boris Sovič.

V veselje nam je, da ga lahko ob 80. življenjskem jubileju počastimo tudi v Mariboru. Še vedno je izjemno dejaven na področju znanstveno raziskovalnega dela in objavlja članke v elitnih fizikalnih revijah, tudi skupaj z mlajšimi sodelavci. V posebno čast in veselje nam je, da nam bo v otvoritvenem plenarnem enournem predavanju predstavil svoje najnovejše znanstveno delo.

Njegovo znanstveno življenje in delo je podrobno dokumentirano na spletni strani:

<http://www.physik.uni-marburg.de/de/personal/grossmann-siegfried/startseite.html>

Na koncu tega zbornika pripenjava njegov bolj podroben znanstveni življenjepis, ki sta ga napisala njegova nekdanja učenca Profesorja Peter Richter (Univerza Bremen, Nemčija) ter Detlef Lohse (Univerza Twente, Enschede, Nizozemska)

Marko Robnik in Dean Korošak

FOREWORD

Our Symposia of Physicists at the University of Maribor, or shortly Christmas Symposia, already have a tradition, as this year it is already the 9th one. The purpose is the scientific socializing of Slovenian physicists along with the participation of some distinguished colleagues from abroad as our honorary guests. The Symposium in 2006 has already grown large by exceeding the regional boundaries and became a national meeting. This year almost one third of invited speakers come from abroad, from some best research groups, so that our meetings are becoming international indeed. The meeting is only one of the many activities of CAMTP, Center for Applied Mathematics and Theoretical Physics of the University of Maribor, which organizes five series of international scientific meetings. See www.camtp.uni-mb.si

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

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

All undergraduate students are welcome and can attend all the lectures of the conference free of charge. In this way we contribute to the popularization of physics and to the additional education in this field.

Our gathering can be an important contribution to the activities of the young and successful Faculty of natural sciences and mathematics of the University of Maribor under the leadership of the Dean Mrs. Prof.Dr. Nataša Vaupotič.

Professor Siegfried Grossmann - 80th Birthday



This year our meeting is dedicated to Professor Siegfried Grossmann from the University of Marburg, Germany, on the occasion of his 80th birthday. He was born on 28 February 1930 in Königsberg, East Prussia. The City of Marburg, where he is working since 1964, and Maribor are partner cities, and the two universities are partner universities, which gives an additional imprint to our relationship. Professor Siegfried Grossmann is one of the greatest theoretical physicists of the 20th and 21st century in the worldwide context. His scientific research work includes the following fields: nuclear physics, general statistical physics, transport theory, nonlinear dynamics, fluid dynamics and turbulence theory, phase transitions, laser physics, Bose-Einstein condensation. His work comprises more than 241 original papers. He is also extremely active in the domain of physics education at the university level and physics teaching at the high school level. He has written several text books, which are still indispensable source of knowledge in mathematical physics. He had and still has numerous advisory functions in Germany. He has done a great deal for the physics not only in Germany, but also worldwide, and in particular in Slovenia, since as a good friend of CAMTP he has faithfully supported activities and collaborations with the University of Marburg, and with other universities in Germany. Since 1994 he is a regular invited lecturer at our

international summer schools and conferences "Let's Face Chaos through Nonlinear Dynamics", organized by CAMTP, since 1999 he is also a honorary director. He is recipient of the Max-Planck Medal of the German Physical Society in the year 1995 and of many other awards and honours, among them the highest decoration of Germany (Großes Verdienstkreuz des Verdienstordens der Bundesrepublik Deutschland, 1996). He is a member of three academies of sciences and earned the Honorary Doctorate at the University of Essen-Duisburg. In the year 2005 he was awarded the Seal of the City of Maribor by the mayor of the city of Maribor, Mr. Boris Sovič.

It is our pleasure, that we have the opportunity to honour him in Maribor on occasion of his 80th birthday. He is still extremely active in the scientific research and publishes papers in elite physics journals, also jointly with younger colleagues. It is our special privilege and pleasure that he will present to us his most recent scientific work in his plenary and opening one-hour lecture.

His scientific life and work is described in detail at the web page:

<http://www.physik.uni-marburg.de/de/personal/grossmann-siegfried/startseite.html>

At the end of this Programme Book we attach his more detailed scientific biography, written by his former students Professors Peter Richter (University of Bremen, Germany) and Detlef Lohse (University of Twente, Enschede, The Netherlands)

Marko Robnik and Dean Korošak

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**Urnik 9. Simpozija fizikov
Univerze v Mariboru**

Četrtek, 9. december 2010	
Chair	Robnik
09:00-09:15	Welcome and Opening
09:15-10:15	Grossmann
10:15-10:45	Burgdörfer
10:45-11:15	Prosen
11:15-11:30	tea, coffee
11:30-12:00	Horvat
12:00-12:30	Ramšak
12:30-13:00	Biro
13:00-13:30	Kamenik
13:30-15:00	lunch
Chair	Korošak
15:00-15:30	Repovš
15:30-16:00	Daido
16:00-16:30	tea, coffee
16:30-17:00	Fajfer
17:00-17:30	Stöckmann
17:30-18:00	Ziherl
18:00-18:30	Batistić
20:00-	Concert and Welcome dinner

Petek, 10. december 2010	
Chair	Stöckmann
09:00-09:30	Eckhardt
09:30-10:00	Prelovšek
10:00-10:30	Dvorak
10:30-11:00	Veble
11:00-11:30	tea, coffee
11:30-12:00	Haake
12:00-12:30	Korošak
12:30-12:45	Ferčec
12:45-13:00	Vidmar
13:00-13:30	Zwitter
13:30-15:00	lunch
Chair	Biro
15:00-15:30	Muševič
15:30-16:00	Vaupotič
16:00-16:30	tea, coffee
16:30-17:00	Bonča
17:00-17:30	Richter
17:30-18:00	Zidanšek
18:00-18:15	Puc
18:15-18:30	Abina
20:00-	Concert and Conference dinner

Sobota, 11. december 2010	
Chair	Prosen
09:00-09:30	Plessas
09:30-10:00	Bountis
10:00-10:30	Ravnik
10:30-11:00	Đonlagić
11:00-11:30	tea, coffee
11:30-12:00	Flach
12:00-12:30	Kerševan
12:30-13:00	Fregolente
13:00-13:30	Bachelard
13:30-15:00	lunch
Chair	Plessas
15:00-15:30	Wunner
15:30-16:00	Papamikos
16:00-16:30	tea, coffee
16:30-17:00	Ruffing
17:00-17:15	Leonhardt
17:15-17:30	Manos
17:30-17:45	Žunkovič
17:45-18:00	Babič
18:00-18:15	Rožič
18:30	Farewell drink
20:00	Last dinner

Izboljšave migracije za raziskave z georadarjem

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Georadar [1] je geofizikalna metoda, ki z radarskimi pulzi preiskuje prostor in predmete pod površino. Omogoča iskanje skritih predmetov [2] ter izdelavo približnih slik z metodo, ki se imenuje migracija. Migracija se uporablja kot ključna metoda procesiranja radarskih podatkov z namenom izboljšanja resolucije in razvijanja prostorsko realističnih slik podpovršinskih objektov. Naloga migracije je pretvorba izmerjenih časovnih signalov v prostorsko informacijo, s čimer se popravi pozicija in amplituda posnetih signalov na osnovi iskanja idealne difrakcijske hiperbole [3]. V tem prispevku bomo predstavili nekaj izboljšav Kirchhoffove in Stoltove migracijske metode, ki prispevajo h kakovosti slike detektiranih objektov.

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- [2] Ambrožič M, Martinšek M, Najdovski D, Zidanšek A. Detection of the underground object by a triangular radar system. V: GUZOVIC, Zvonimir (ur.), DUIC, Neven (ur.), BAN, Marko (ur.). 5th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, September 29 - October 3, 2009, Dubrovnik, Croatia. CD proceedings. (2009)
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Improvements of migration for georadar investigations

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Georadar (GPR) [1] is a geophysical method, which uses radar pulses to investigate places and objects underground. It can find location of hidden objects [2] and create an approximated image. The final method in GPR for data processing, called migration, improves resolution and develops spatially realistic images of the subsurface objects. The purpose of this method is to convert measured time domain radar signal into spatial information. Furthermore, migration tries to correct the position and amplitude of the recorded GPR signals with the aim to find an ideal diffraction hyperbola [3]. Finally, in this contribution we present several improvements of Kirchhoff and Stolt migration methods, which affect the quality of calculated image.

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Fraktalna dimenzija robotsko lasersko kaljenega orodnega jekla

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Predstavil bom fraktalno strukturo pri robotsko lasersko kaljenem orodnem jeklu. Prav tako bom pokazal eksperimentalne rezultate in analize fraktalnih vzorcev, ki se pojavljajo pri robotsko laserskem kaljenju. Na koncu bom še pokazal fraktalno dimenzijo pri robotsko lasersko kaljenem orodnem jeklu. Robotsko lasersko kaljenje se uporablja v letalski, avtomobilski in vesoljski industriji.

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Fractal dimension of the robotically laser hardening tool steel

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I will present a fractal structure with a robotic laser hardening tool steel. I also will show the experimental data and the analysis of fractal patterns that occur in robotic laser quenching. In the end I will show a fractal dimension of the robotically laser hardening tool steel. Robotic laser hardening is used in the aerospace, automotive and aerospace industries.

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Vlasov Dynamics and Regularity in Long-Range Systems

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Long-range interactions are encountered in a wide range of systems, from wave-particle interactions (plasma physics, Free Electron Lasers, Collective Atomic Recoil Laser) to astrophysics and hydrodynamics. They are characterized by a strong coupling of all the bodies (potential in $1/r^a$, with $a < d$ the dimension of the system), and their dynamics exhibits a special feature: These systems get trapped in out-of-equilibrium regimes over very long times, diverging with the number of bodies in interaction. These dynamics are called “Quasi-Stationary States” (QSS).

We first characterize the QSS in the framework of the Hamiltonian Mean-Field model (HMF), composed of N rotators globally coupled through the total magnetization of the system. It can then be shown that when the number of degrees of freedom of the system increases (via the number of particles), the trajectories tend toward periodic and quasi-periodic orbits (presence of invariant tori). Eventually, in $N \rightarrow \infty$ limit, the system is described by a Vlasov equation, which is infinite-dimensional, and yet the particles have regular trajectories.

Finally, we show that these results can be generalized to more complex systems such as lattices (existence of a continuum of Vlasov equations) and wave-particle dynamics (emergence of low-dimensional bifurcations).

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

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Klasična struktura Hamiltonskih sistemov se odraža v statistiki energijskega spektra ustreznega Hamiltonskega operatorja. V tem kontekstu je najpomembnejša statistična mera porazdelitev razmikov med sosednjimi energijskimi nivoji, $P(S)$. Če je klasični sistem integrabilen, je $P(S)$ Poissonova porazdelitev, če je klasični sistem v celoti kaotičen, je $P(S)$ GOE porazdelitev. Za klasične sisteme mešanega tipa, kjer fazni prostor sestavlja tako regularna kot kaotična komponenta, vemo, da je v semiklasični limiti $P(S)$ Berry-Robnikova (BR) porazdelitev. Preden dosežemo semiklasično limito, in s tem zadostimo pogojem BR teorije, moramo upoštevati efekte lokalizacije lastnih stanj na kaotični komponenti in efekte tuneliranja med kaotično in regularno komponento. Efekt lokalizacije na kaotični komponenti fenomenološko dobro opišemo, če v BR teoriji nadomestimo GOE porazdelitev za kaotične nivoje z Brodyevo porazdelitvijo. Efekt tuneliranja obravnavamo s pomočjo ustreznega modela naključnih matrik. Sklopitve med kaotičnimi in regularnimi nivoji poskušamo modelirati na dva načina: kot blok matriko (T-model), kjer sklapljamo samo regularne in kaotične nivoje ali kot razpršeno matriko (S-model), kjer sklapljamo naključne pare nivojev. Na osnovi primerjave obeh modelov s konkretnimi fizikalnimi podatki ugotovimo, da zgolj S-model dobro opiše efekte tuneliranja.

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

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Classical structure of the Hamiltonian system reflects in the statistical properties of the energy spectrum of the corresponding quantum Hamiltonian operator. In this context the nearest energy level spacing distribution, $P(S)$, is the most important statistical measure. If the classical system is integrable, the corresponding $P(S)$ is the Poisson distribution, while if the classical system is fully chaotic, the corresponding $P(S)$ is the GOE distribution. For the classical systems of the mixed type, where the phase space is the composition of the regular and the chaotic component, we know, that in the semiclassical limit $P(S)$ is the Berry-Robnik (BR) distribution. Before we reach the semiclassical limit and thus satisfy the condition of the BR theory, we have to consider the effects of the localization on the chaotic component and the effects of the tunneling between the chaotic and regular component. The effects of the localization on the chaotic component are well described by replacing the GOE distribution with the Brody distribution in the BR theory. The tunneling effects can be described by the proper random matrix model. We propose two random matrix models: block matrix (T-model) where we couple regular and chaotic levels and sparsed matrix (S-model) where we couple random pairs of levels. By comparison of models with the numerical data of the physical system we conclude that only the S-model successfully describes the tunneling effects.

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Thermodynamics with abstract composition rules

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I review how the validity of the basic laws of thermodynamics can be extended to non-additive composition formulas of classically extensive quantities, like energy, volume, particle number and entropy. Based on a general definition of the thermodynamical limit as a large number of repetitions of the micro-composition prescription, I show that effective composition rules for such repeatedly composed systems are associative, can be uniquely mapped to the addition and are zeroth-law compatible. Based on this construction the canonical distribution, the entropy formula and classical mesoscopic approaches, like e.g. the Boltzmann equation, all generalize in a natural manner. A few examples for composition laws used in physics will be shown and in particular recent experimental high energy particle spectra are reviewed in the framework of this generalized canonical statistics.

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Elektronsko fononska sklopitev vodi do znižanja kinetične energije bipolarona v $t - J$ -Holsteinovem modelu

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S pomočjo metode točne diagonalizacije v omejenem funkcijskem prostoru [1-3] smo izračunali kinetično energijo ter efektivno maso polarona in bipolarona v $t - J$ -Holsteinovem modelu. Z večanjem elektronsko fononske sklopitve se zmanjšuje kinetična energija bipolarona v primerjavi s kinetično energijo polarona. Ob tem se zmanjša tudi povprečno število fononov v sistemu bipolarona. Posledično se zmanjša tudi efektivna bipolaronska masa [4]. Naši rezultati kažejo na nov mehanizem v sistemih koreliranih elektronov, sklopljenih z mrežnimi prostostnimi stopnjami, vsled katerega pride ob vezavi parov vrzeli do povečane mobilnosti vsled znižanja kinetične energije ter zmanjšanja efektivne mase. Privlačna sklopitev je posledica medsebojnega sodelovanja mrežnih ter magnetnih prostostnih stopenj.

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Gain of the kinetic energy of bipolarons in the t-J-Holstein model based on electron-phonon coupling

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Using exact diagonalization within a limited functional space [1-3] we explore the kinetic energy and the effective mass of polaron and bipolaron in the t - J -Holstein model. With increasing electron-phonon coupling bipolaron kinetic energy is lowered in comparison with that of the polaron. This effect is accompanied with "undressing" of bipolaron from lattice degrees of freedom. Consequently, the effective bipolaron mass becomes smaller than the polaron mass [4]. Our results lead to a novel paradigm where in a correlated system, coupled to quantum lattice degrees of freedom, upon pair formation the bipolaron mobility increases due to a lower effective mass as well as due to a detectable gain in bipolaron kinetic energy. The attractive potential for binding of bipolaron appears as a cooperative interplay between magnetic and lattice degrees of freedom.

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Quasi–Stationary Chaotic States in Multidimensional Hamiltonian Systems

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We study numerically probability density functions (pdfs) of chaotic orbit coordinates, viewed as independent random variables in weakly chaotic regimes of three multi–dimensional Hamiltonian systems: Two Fermi–Pasta–Ulam (FPU– β) oscillator chains with different boundary conditions and number of particles and a microplasma of identical ions confined in a Penning trap and repelled by mutual Coulomb interactions. For the FPU systems, we show that, when chaos is limited within “small size” phase space regions, these pdfs are well approximated, for surprisingly long times (typically up to $t \approx 10^6$), by a q –Gaussian ($1 < q < 3$) distribution and tend to a true Gaussian ($q = 1$) for longer times, as the orbits eventually enter into “large size” chaotic domains of phase space. In the many-particle case, q –Gaussians are seen to be related to the existence of a single chaotic breather, which breaks down at higher energies as equipartition occurs and the pdfs become Gaussian. In the case of the microplasma Hamiltonian, we make use of these q –Gaussian distributions to identify: (a) a low–energy range of “weak chaos”, over which the system “melts” and the q –index of the distributions attains a maximum $q \approx 1.8$ returning quickly to the $q = 1$ (Gaussian) value and (b) a wide energy range, over which a “liquid to gas” transition occurs, where q rises again, reaching $q \approx 1.4$ at $E \approx 50$, before returning slowly back to $q = 1$, at higher energies $E > 200$.

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Quantum dynamics on the attosecond scale[1]

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With the advent of sub - femtosecond ultrashort XUV pulses and of phase-stabilized IR pulses with sub-cycle time resolution, novel pathways have been opened up for studying time-resolved electronic quantum dynamics on the attosecond scale. These experiments pose challenges for theory: How do short pulses interact with matter? Which novel information can be extracted from time-resolved spectroscopies that cannot be gained from precision experiments in the spectral domain ? In this talk, these issues will be addressed with the help of a few examples. Attosecond streaking allows a direct look at electronic correlations and rearrangement processes. Photoemission from solid surfaces reveal an attosecond time delay between conduction electrons and core electrons and provide time-resolved information on electron transport, plasmon excitation and dissipation. Attosecond pulses allow not only to probe but also to control and manipulate electronic dynamics which we will illustrate for two-electron emission and molecular break-up.

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Aging transition and spatiotemporal dynamics in coupled qualitatively different oscillators

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Large populations of coupled dissipative oscillators have been one of the most popular targets of research in nonlinear dynamics. It is now well known that such dynamical systems exhibit a variety of curious behaviors which may lead to novel applications, e.g. synchronization and clustering. Such a system is typically supposed to be an ensemble of all *active* oscillators, where "active" means being capable of showing self-sustained activity such as oscillation and chaos. The theme of this talk is to discuss how the dynamics of such a large scale dynamical system may change when it is subjected to an *aging* process in a generalized sense, in which active oscillators are replaced by *inactive* ones. Taking a class of diffusively coupled limit-cycle oscillators as an example, I will show that under some conditions, the aging causes a remarkable transition to quiescence (a steady state) and that such a transition, termed an *aging transition*, possesses several different kinds of features, depending on the coupling strength, the coupling architecture and so forth. Spatiotemporal dynamics of a locally coupled system will also be discussed.

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The three Trojan Problem

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We treat the problem of three massive bodies in the Trojan configuration. It is well known that in the so-called restricted three-body problem, where two massive bodies (m_1 and m_2) have Keplerian orbits and a third massless body m_3 moves in the gravitational field of the two primaries, there exist the two stable Lagrangian points L_4 and L_5 . The equilibrium points form an equilateral triangle with the primary bodies and motion in the vicinity is stable for mass ratios of the primaries above a certain limit. In the Solar system there move thousands of Trojan asteroids close to the Lagrangian points of the Sun-Jupiter system, but also Neptune 'hosts' such asteroids. When the system consists of 4 massive bodies, namely a central much more massive body (we may call it host star) and three less massive bodies (we may call them planets), then there exist a stable configuration up to certain masses for slightly shifted equilibrium points namely 47° instead of 60° in the classical Lagrange configuration. We investigate the stability regions around this equilibrium point for different masses, libration with respect to the primary and slightly smaller and larger semimajor axis.

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Vlakenski mikro-optični senzorji in druge naprave

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Podan je pregled tehnologije za mikro-obdelavo optičnega vlakna, ki ne vključuje litografskega maskiranja. Tehnologija temelji na vnosu germanijevega dioksida v silicijevo steklo, kar spremeni hitrost jedkanja stekla v primeru, da takšno steklo izpostavimo sredstvu za jedkanje kot npr. HF ali pufrani HF. Vnos germanijevega dioksida v silicijevo steklo tako omogoča nadzorovano izdelavo mikro-votlin in podobnih struktur na vrhu optičnega vlakna. Kadar takšna mikro-obdelana vlakna nadalje zvarimo, lahko izdelamo vrsto različnih mikro-optične naprave znotraj ali na vrhu optičnega vlakna. Predstavljena tehnologija mikro-obdelave je bila uporabljena za načrtovanje in praktično izdelavo mikro-kolimatorjev, vlakenskih zrcal, tlačnih in temperaturnih senzorjev ter senzorjev raztezkov.

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All-fiber micro-optic sensors and devices

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An overview of a maskless optical fiber micromachining technology is presented. When germania is doped into silica glass, the etching rate of silica changes when exposed to the etching medium such as HF or buffered HF. Introduction of germania in silica glass thus allows for controlled formation of micro cavities and similar structures at the tip of optical fiber. When such micro-machined fibers are further combined or spliced, various micro-optic devices can be created inside or at the tip of an optical fiber. The presented micromachining technology was applied to design and practical formation of micro-collimators, in-fiber mirrors, pressure, strain, and temperature sensors.

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Turbulence transition in shear flows: what can we learn from pipe flow?

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According to textbook wisdom, flow down a pipe becomes turbulent near a Reynolds number of about 2000. This simple statement misses many subtleties of the transition: the absence of a linear stability of the laminar flow, the sensitive dependence on perturbations that sometimes succeed and sometimes fail to induce turbulence and the unexpected observation that the turbulent state, once achieved, is not persistent but can decay. All these observations are compatible with the formation of a strange saddle in the state space of the system. I will focus on three aspects: on the appearance of 3-d coherent states, on the information contained in lifetime statistics and on results on the boundary between laminar and turbulent regions. The properties observed in pipe flow suggest a generic structuring of state space in flows where turbulent and laminar flow coexist.

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Top kvark in fizika hadronskih trkalnikov

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Med fundamentalnimi fermioni ima top kvark največjo maso. Kljub dejstvu, da je bil top kvark odkrit v devetdesetih letih prejšnjega stoletja pri poskusih na visokih energijah v hadronskem trkalniku, je njegova vloga zelo pomembna tudi pri nizkih energijah. V fiziki Standardnega modela so njegove lastnosti zelo dobro raziskane. Predstavila bom rezultate naših raziskav o vplivu korekcij močne interakcije na procese razpada top kvarka. Velike energije hadronskega trkalnika LHC omogočajo zelo natančen študij njegovih lastnosti v produkciji in razpadih na katere lahko vpliva tudi fizika izven Standardnega modela. Navedla bom lastnosti razširitve Standardnega modela, v kateri nastopajo skalarni mezon in posledice njihovega obstoja na fiziko top kvarka.

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Top quark and hadronic colliders physics

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The top quark is the heaviest among fundamental fermions. Although top quark has been discovered at high energies in the experiments on hadronic collider in nineties, its role in the low - energy physics has been very important. Within Standard model top quark properties have been carefully investigated. I will present our results on the strong interaction effects in the top quark decay. Very high energies at large hadron collider enable very precise study of its properties in the single and double production as well as in decays, which might be modified by the physics beyond standard model. I plan to discuss basic properties of the physics beyond Standard model containing colored scalar mesons, which existence might affect top quark physics.

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Pogoji za integrabilnost s homogenimi nelinearnostmi pete stopnje

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Problem integrabilnosti sistemov diferencialnih enačb je eden izmed osrednjih problemov v teoriji navadnih diferencialnih enačb. Čeprav je integrabilnost redek pojav in splošen sistem ni integrabilen, so integrabilni sistemi pomembni v študiji različnih matematičnih modelov, ker motnje integrabilnih sistemov pogosto kažejo bogato sliko bifurkacij.

Obravnavamo problem integrabilnosti za sistem

$$\begin{aligned}\dot{x} &= x - a_{40}x^5 - a_{31}x^4y - a_{22}x^3y^2 - a_{13}x^2y^3 - a_{04}xy^4 - a_{-15}y^5, \\ \dot{y} &= -y + b_{5,-1}x^5 + b_{40}x^4y + b_{31}x^3y^2 + b_{22}x^2y^3 + b_{13}xy^4 + b_{04}y^5,\end{aligned}\tag{1}$$

kjer so x, y, a_{ij}, b_{ji} kompleksne spremenljivke. Izkaže se, da so računi, ki so vključeni k določitvi nujnih pogojev za integrabilnost za polno družino (1), tako težki, da ne morejo biti izvedeni niti z uporabo močnih računalnikov in sistemov moderne algebre. Tako je smiselno obravnavati nekatere poddružine sistema (1). Nedavno so bili dobljeni pogoji za integrabilnost za poddružino (1) z $a_{-15} = b_{5,-1} = 0$, ki se imenuje Lotka-Volterra sistem in jih najdemo v [1]. Mi smo obravnavali integrabilnost sistema (1) z $a_{-15}b_{5,-1} \neq 0$ in našli nujne pogoje za obstoj lokalnega prvega integrala oblike $\Psi(x, y) = xy + h.o.t.$ za sledeče štiri poddružine tega sistema

$$(C_1) a_{40} = b_{04} = 0, \quad (C_2) a_{31} = b_{13} = 0, \quad (C_3) a_{13} = b_{31} = 0, \quad (C_4) a_{04} = b_{40} = 0.$$

Za večino primerov smo pokazali, da so dobljeni pogoji tudi zadostni za obstoj lokalnega prvega integrala.

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Integrability of some systems with homogeneous quintic nonlinearities

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The problem of integrability of systems of differential equations is one of central problems in the theory of ODE's. Although integrability is a rare phenomenon and a generic system is not integrable, integrable systems are important in studying various mathematical models, since often perturbations of integrable systems exhibit rich picture of bifurcations.

We consider the problem of integrability for the system

$$\begin{aligned}\dot{x} &= x - a_{40}x^5 - a_{31}x^4y - a_{22}x^3y^2 - a_{13}x^2y^3 - a_{04}xy^4 - a_{-15}y^5, \\ \dot{y} &= -y + b_{5,-1}x^5 + b_{40}x^4y + b_{31}x^3y^2 + b_{22}x^2y^3 + b_{13}xy^4 + b_{04}y^5,\end{aligned}\tag{2}$$

where x, y, a_{ij}, b_{ji} are complex variables. It turns out that the computations involved in the determination of the necessary conditions of integrability for the full family (2) are so heavy that they cannot be completed even using powerful computers and modern algebra systems. Thus, it is reasonable to study some subfamilies of system (2). Recently, the integrability conditions for the subfamily of (2), with $a_{-15} = b_{5,-1} = 0$, called Lotka-Volterra system, have been obtained in [1]. We study the integrability of system (2) with $a_{-15}b_{5,-1} \neq 0$ and we found necessary conditions for existence of the local first integral of the form $\Psi(x, y) = xy + h.o.t.$ for the following four subfamilies of this system

$$(C_1) a_{40} = b_{04} = 0, \quad (C_2) a_{31} = b_{13} = 0, \quad (C_3) a_{13} = b_{31} = 0, \quad (C_4) a_{04} = b_{40} = 0.$$

For the most cases we show that the obtained conditions are also sufficient conditions for the existence of the local first integral.

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Nonlinear Waves: the Fermi-Pasta-Ulam Problem of Equipartition, and The Fate of Anderson Localization

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I will discuss and review two interrelated problems of statistical mechanics of nonlinear waves. The first case is the Fermi-Pasta-Ulam problem, where no equipartition was observed originally, despite the assumed nonintegrability of the underlying model. We will go through the history of this old problem, see some recent results, and discuss the Kolmogorov-Arnold-Moser results in the light of localization in action space. Then we turn to the second case - the dynamics of nonlinear waves in disordered media. Skipping nonlinearity (i.e. wave-wave interactions) the problem is reduced to the celebrated case of P. W. Anderson, for which he showed that, under certain mild conditions, one-dimensional systems will show Anderson localization. I will show recent results on the propagation of nonlinear waves through such disordered media, and discuss the fate of Anderson localization in the presence of wave-wave interactions.

In-flight dissipation as a mechanism to suppress Fermi acceleration.

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Dissipative systems have attracted much attention during the development of non-linear dynamics since they can be used to explain different physical phenomena in different fields of science. The billiard models are often considered since they can be easily described mathematically and can be realized experimentally in many different ways. From the mathematical point of view, a billiard is defined by a connected region $Q \subset R^D$, with boundary $\partial Q \subset R^{D-1}$ which separates Q from its complement. If the system has a time-dependent boundary, $\partial Q = \partial Q(t)$, it can exchange energy with the particle upon collisions. In such a case it is possible to investigate the phenomenon called Fermi acceleration, i.e., the unlimited energy growth. According to Loskutov-Ryabov-Akinshin (LRA) conjecture [1], the existence of a chaotic component in the phase space with static boundary is a sufficient condition to observe Fermi acceleration when a time dependent perturbation is introduced. Results that corroborate the validity of this conjecture include the time dependent oval billiard, stadium billiard and Lorentz gas. However, it is still not clear what happens in integrable systems when we introduce time dependent perturbation on the boundary. Recently, it was shown even that a specific time dependent perturbation in the boundary of an elliptical billiard (integrable) leads to the unlimited energy growth [2]. The separatrix gives place to a chaotic layer and the particles can experience unlimited energy growth while diffusing in the chaotic layer. Since the phenomenon of Fermi acceleration is present in this model our next step is to introduce dissipation into the system. For one and two dimensional billiard problems that show unlimited energy growth, it has been shown that the introduction of dissipation via inelastic collisions is a sufficient condition to break down the phenomenon of Fermi acceleration. We assume that the particles are immersed in a fluid, and the dissipative drag force is considered to be proportional to the square of the particle's velocity. In our approach, we consider a two-dimensional time dependent elliptical billiard close to the transition conservative-to-dissipative case. Our results allow us to confirm that when in-flight dissipation (due to a drag force) is introduced into

the model the unlimited energy growth is suppressed. In both, conservative as well as dissipative cases, we describe the behaviour of the average velocity using scaling formalism [3].

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The ultimate range of thermal convection: Multiple scaling? Multiple states?

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Based on joint work with Detlef Lohse

In the last decade turbulent thermal convection has been studied very intensively. Precise measurements of the heat flow through Rayleigh-Bénard cells together with theory have confirmed our physical picture that the effective heat transport, measured by the Nusselt number Nu , is determined by the properties of (a) the still quasi-laminar, Prandtl type boundary layers, from which thermal plumes detach, and (b) from the turbulent fluctuations in the bulk; see [1,2,3,4,5]. The different scaling of the thermal and kinetic boundary layer thicknesses with the Rayleigh number Ra lead to the breaking of a pure geometric scaling, i. e., there is no simple power law $Nu \propto Ra^\beta$. Instead, the exponent $\beta(Ra, Pr)$ depends on Ra and the Prandtl number Pr , which both may vary over a wide range.

A long standing mystery is the heat transport for extremely strong thermal driving Ra beyond about 10^{14} , known as the ultimate range of thermal convection. Conflicting experiments [6,7] stimulated many ideas to better understand Rayleigh-Bénard convection and its various aspects. Quite recently new measurements in the ultimate range with a new apparatus, the so called Goettingen U-Boot, have been performed and still are under way in order to resolve the puzzles of this range. Preliminary results [8,9,10] shed new and quite surprising light on the ultimate regime. They add to the richness of phenomena rather than resolving the existing puzzles.

These new data prompted us to reanalyze the ultimate range theoretically, cf. [11]. Our main ideas and results are presented in this talk. Apparently the ultimate range shows structures, depending again on the various properties of the boundary layers. While the velocity boundary layer has become turbulent beyond some 10^{14} , extending thus with its log-law profile over the whole RB-cell, the thermal boundary layer may still be laminar, the heat transport either being plume or bulk fluctuation dominated, until it also becomes turbulent with its own log-law profile. These distinct

states enjoy different scaling behaviors $Nu \propto Ra^\beta$ with typically $\beta = 0.14, 0.22,$ and 0.38 . If the system even switches between these states, also other exponents between these values may occur. – Such features have been found in model systems like the Lorenz equations, cf. [12] and are known as multiple states of highly nonlinear systems.

After a short *status quo* overview the talk aims at contributing to the present discussion of the recently detected surprising properties of the ultimate range of thermal convection and to offer a possible physical understanding.

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Randomness in classical deterministic motion

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Certain billiards on surfaces of constant negative curvature, known as (pseudo-) arithmetic, are fully chaotic but have periodic orbits highly degenerate in length. Depending on the boundary conditions for the quantum wave functions, the energy spectra either have uncorrelated levels usually associated with classical integrability (arithmetic case) or conform to the “universal” Wigner-Dyson type (pseudo-arithmetic case) although the classical dynamics in both cases is the same. The Maslov indices of orbits within multiplets of degenerate length either yield equal phases for the respective Feynman amplitudes (and thus Poissonian level statistics) or give rise to amplitudes with uncorrelated phases (leading to Wigner-Dyson level correlations). The recent semiclassical explanation of spectral universality in quantum chaos is thus extended to the latter case of pseudo-arithmetical billiards.

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Določeni novi napredki v klasični teoriji termoelektričnosti

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Z uporabo termoelektričnih efektov lahko izgradnimo majhne in tihe toplotne stroje in hladilnike, vendar je njihov izkoristek majhen v primerjavi z ostalimi stroji s te vrste. S ciljem izboljšati njihov izkoristek, smo študirali učinkovitost klasično-mehanskih sistemov. Ugotovljeno je bilo, da se tipična mera izkoristka ZT lahko v določenih primerih bistveno izboljša. Prav tako je bil predstavljen preprost klasični model toplotnega stroja/hladilnika, ki obljublja, da bo podal nekaj splošnih smernic za načrtovanje teh strojev v prihodnje. Model je sestavljen iz toplega in hladnega termokemičnega rezervoarja povezanih z vodniki, ki jih modeliramo kot klasične deterministične sipalce. V posebnih primerih kanalov lahko pridobimo analitične rezultate in pokažemo, da je izkoristek blizu Carnotovega izkoristka za ceno nizke proizvodnje moči v primeru toplotnega stroja oz. pretoka toplote v primeru hladilnika.

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Some recent developments in classical theory of thermoelectricity

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Using the thermoelectric effect we can build very small and noiseless heat engines and refrigerators, but their efficiency is small compared to other machines of these kind. With the goal to improve their efficiency we have studied the performance of classical-mechanical systems. It was found that the common merit of efficiency ZT can be improved in certain cases. Additionally, a simple classical model of a heat engine/refrigerator is introduced, which promises to give some general guidelines for future designs. It is composed of a hotter and colder thermochemical bath connected via conductors modelled as classical deterministic scatterers (e.g. Poincaré maps). In specific cases of channels analytical results can be obtained showing that a near to Carnot efficiency is reachable at the price of a low-power output in the case of the heat engine or low heat transport in the case of refrigerator.

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Zlomitev elektrošibke simetrije brez Higgsovega bozona na LHC

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Ena ali več težkih resonanc s spinom 1 lahko nadomesti Higgsov bozon in ohrani perturbativno unitarnost standardnega modela do energij dosegljivih na velikem hadronskem trkalniku (LHC). Vendar morajo hkrati zadostiti tudi elektrošibkim preciznim testom. Predstavil bom napovedi generičnih modelov elektrošibke zlomitve brez lahkega Higgsovega bozona za LHC, če zahtevamo njihovo unitarnost do energij nekaj TeV ter ujemanje z elektrošibkimi preciznimi meritvami. V nedavni analizi smo pokazali, da lahko vsem zahtevam zadosti že scenarij z eno samo vektorsko resonanco mase $m_V \lesssim 0.5$ TeV. V prisotnosti dodatne aksialne resonance se meja na m_V povzpe do 1 TeV, aksialna masa pa tipično leži v območju $1.2m_V \lesssim m_A \lesssim 1.4m_V$. Potem bom obravnaval produkcijo tipa Drell-Yan vektorskih in aksialno vektorskih stanj na hadronskih trkalnikih. Osredotočil se bom na končna stanja $\ell^+\ell^-$, WZ ter stanja s tremi umeritvenimi bozoni. V primeru $\ell^+\ell^-$ obstoječe meritve na pospeševalniku Tevatron že omejujejo parametrični prostor takšnih modelov. Natančneje, izključujejo scenarij z osamljeno vektorsko resonanco. Po drugi strani so končna stanja z dvema ali tremi umeritvenimi bozoni (še posebno WZ , WWZ in WZZ) zelo zanimiva za LHC. V primeru relativno lahke aksialne resonance bi namreč njihove meritve lahko pomembno osvetlile vlogo resonanc s spinom 1 v elektrošibkih preciznih testih.

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ElectroWeak symmetry breaking without a Higgs boson at the LHC

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One or more heavy spin-1 fields may in principle replace the Higgs boson in keeping perturbative unitarity up to a few TeV while at the same time account for the electroweak precision tests. I shall discuss the viability of generic Higgsless models at low energies when compliance with electroweak precision observables and unitarity constraints at the LHC energy scale are imposed. Our recent analysis shows that a consistent description can be achieved even with a single light vector state $m_V \lesssim 0.5$ TeV. Introducing an additional axial-vector state, m_V is still predicted to be light (below 1 TeV) while typical values of m_A span over the window $1.2m_V \lesssim m_A \lesssim 1.4m_V$. Then I shall consider the Drell-Yan production of heavy vector and axial-vector states in generic Higgsless models at hadron colliders. I will focus in particular on the $\ell^+\ell^-$, WZ , and three SM gauge boson final states. In the $\ell^+\ell^-$ case, present Tevatron data already restricts the allowed parameter space of these models. In particular, it disfavors the single vector resonance scenario. The two and three gauge boson final states (especially WZ , WWZ , and WZZ) are particularly interesting in view of the LHC, especially for light axial-vector masses, and could shed more light on the role of spin-1 resonances in the electroweak precision tests.

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Prvi rezultati eksperimenta ATLAS na LHC

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Od pomladi leta 2010 je eksperiment ATLAS na Velikem hadronskem trkalniku zabeležil velik nabor podatkov ob trkih protonov pri težiščni energiji 7 TeV. V letu 2011 se bo ta nabor podatkov povečal še za nekaj redov velikosti. Predstavil bom prve rezultate meritev napovedi Standardnega modela v tem novem energijskem območju in pokazal odlično delovanje detektorja ATLAS. Predstavljeni bodo prvi primeri analiz onkraj Standardnega modela in priprave na nadaljnje raziskave.

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First results of the ATLAS Experiment at LHC

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Since Spring 2010 the ATLAS experiment at the Large Hadron Collider has recorded a substantial statistics of proton-proton collision data at a centre-of-mass energy of 7 TeV and a further increase by orders of magnitude is expected by the end of the year 2011. In this talk first results on Standard Model physics obtained in this new energy domain will be presented, demonstrating the outstanding performance of the ATLAS detector. First examples of BSM search results will be given and the preparation for a wider range of searches will be discussed.

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Kompleksne mreže v fraktalnem prostoru

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Neenakomerna razporeditev vozlov v prostoru ima velikokrat pomemben vpliv na strukturo skalno neodvisnih mrež vpetih v prostor. V tem prispevku bomo predstavili model geografskih mrež, kjer so vozli vpeti v fraktalni prostor in kjer lahko spreminjamo jakost prostorske vpetosti. Kadar so uteži vozlov takšnih mrež poténčno porazdeljene, so mreže skalno neodvisno urejene. Eksponent porazdelitve povezav v primeru močne prostorske vpetosti pada z naraščajočo fraktalno dimenzijo prostora in je v primeru šibke prostorske vpetosti enak $\gamma = 2$. Pokazali bomo, da je takšna odvisnost posledica prehoda iz nekompaktne v kompaktno ureditev mreže ter da ta prehod spremlja sprememba v učinkovitosti mreže.

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Complex networks on a fractal space

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The impact of inhomogeneous arrangement of nodes in space on network organization cannot be neglected in most of real-world scale-free networks. Here, we propose a model for a geographical network with nodes embedded in a fractal space in which we can tune the network heterogeneity by varying the strength of the spatial embedding. When the nodes in such networks have power-law distributed intrinsic weights, the networks are scale-free with the degree distribution exponent decreasing with increasing fractal dimension if the spatial embedding is strong enough, while the weakly embedded networks are still scale-free but the degree exponent is equal to $\gamma = 2$ regardless of the fractal dimension. We show that this phenomenon is related to the transition from a non-compact to compact phase of the network and that this transition accompanies a drastic change of the network efficiency.

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Long-term behaviour of logical circuits under the influence of randomness

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Logical gates are the very basis for our today's digital computing as they realise basic Boolean operations. Such gates are designed in a way that they do (hopefully) not depend on random influences. From a theoretical point of view it is, however, interesting to study the case where randomness is applied to such a gate. Now, clocked gates can be used to build arbitrary circuits. Under certain model assumptions these circuits will – once initialised – evolve by their own. This evolution can be described by a discrete, stochastic dynamical system. I shall give a brief introduction to the modelling I used. For circuits satisfying certain conditions I shall also give an easy description of their behaviour if evolution time tends to infinity.

Scaling with system size of the Lyapunov exponents for the Hamiltonian Mean Field model

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The Hamiltonian Mean Field (HMF) model is a prototype for systems with long-range interactions. It describes the motion of N particles moving on a ring, coupled through an infinite-range potential. The model has a second order phase transition at the energy density $U_c = 3/4$ and its dynamics is exactly described by the Vlasov equation in the $N \rightarrow \infty$ limit. Its chaotic properties have been investigated in the past, but the determination of the scaling with N of the Lyapunov Spectrum (LS) of the model remains a challenging open problem. We here show that the $N^{-1/3}$ scaling of the Maximal Lyapunov Exponent (MLE), found in previous numerical and analytical studies, extends to the full LS; not only, scaling is “precocious” for the LS, meaning that it becomes manifest for a much smaller number of particles than the one needed to check the scaling for the MLE. Besides that, the $N^{-1/3}$ scaling appears to be valid not only for $U > U_c$, as suggested by theoretical approaches based on a random matrix approximation, but also below a threshold energy $U_t \approx 0.2$. Using a recently proposed method (GALI) devised to rapidly check the chaotic or regular nature of an orbit, we find that U_t is also the energy at which a sharp transition from *weak* to *strong* chaos is present in the phase-space of the model. Around this energy the phase of the vector order parameter of the model becomes strongly time dependent, inducing a significant untrapping of particles from a nonlinear resonance.

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Fotonika na osnovi mehke snovi

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Nematski koloidi so disperzije trdnih ali tekočih delcev v nematskem tekočem kristalu. Kažejo nenavadne lastnosti samourejanja v robustne kristalne strukture in superstrukture, kjer so vezavne energije nekaj $1.000 kT$ na delec mikrometerske velikosti [1]. Zaradi izjemne mehanske stabilnosti na zunanje motnje, so ti materiali izjemno zanimivi za uporabo v fotoniki. Nedavno smo pokazali, da obstaja soroden razred materialov, ki jih tvorijo disperzije tekočokristalnih kapljic mikrometerskih dimenzij v izotropni tekočini [2]. Tekočokristalna kapljica v izotropni tekočini predstavlja optični mikroresonator, če je lomni količnik kapljice večji od tistega zunaj nje. Svetloba, ki nastane v kapljici, ostane v njej ujeta zaradi totalnega odboja na meji z zunanjo tekočino. Lastne frekvence elektromagnetnega polja v nematskih mikroresonatorjih je mogoče učinkovito spreminjati z zunanjim električnim poljem, obseg uglaševanja pa je stokrat večji kot v trdni snovi. Razpravljaj bom o idejah in strategijah uporabe samoorganizacijskih in optičnih lastnosti mehke snovi, ki lahko vodijo do novih principov uravnavanja in generiranja toka svetlobe po mehki snovi.

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Soft Matter Photonics

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Nematic colloids are fascinating materials showing unusual ability to assemble into robust colloidal crystalline structures and superstructures with binding energies exceeding several $1.000 kT$ per micrometer size particles [1]. This makes them very robust against external perturbation and therefore potentially interesting for technological applications in photonics. Another class of photonic micro-objects has recently been demonstrated, based on dispersions of micrometer-diameter nematic droplets in an immiscible carrier fluid [2]. Having the index of refraction higher than the carrier liquid, the nematic droplet is an optical microresonator, where the light could be trapped and is circulating inside the droplet due to the total internal reflection at the surface. Nematic optical microresonators are superior to the solid-state microresonators, because the tuning range of their resonant frequencies is nearly two orders of magnitude larger. This promises applications in optical microdevices, where the flow of light could be controlled by soft-matter microoptical devices. Ideas and strategies are discussed, how liquid crystalline-based microoptical devices could be assembled or even self-assembled using mechanisms of nematic colloidal assembly. We discuss advantages and disadvantages of this soft-matter approach compared to today's main-stream hard-matter approach.

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A class of time-dependent anharmonic oscillators and their symmetries

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Some group theoretic methods for integrating differential equations due to S. Lie and E. Noether are introduced and then applied to a class of time-dependent nonlinear second order differential equations.

In particular, in the first part of this talk some basic concepts will be briefly introduced; namely: continuous groups of transformations and their infinitesimal generators, the concept of a symmetry of a differential equation, simple methods of finding those symmetries (using Lie's algorithm) and how to use them (how to reduce the order of the equation by one, or two in the case of Noether symmetries for equations derived from a variational principle) [1,2,3].

In the second part, Lie's method will be applied to a class of time-dependent, nonlinear oscillators with cubic nonlinearity [4]. A classification of different cases with respect to their Lie point symmetries will be presented and the corresponding reductions of the order of each equation will be given. In some of these cases a second reduction, i.e. integration, is possible due to the special character of the symmetry, namely to preserve also the action integral (that is to be of Noether type). In such cases explicit exact analytic solutions of the underlying systems are given.

This analysis was motivated by the studies of the adiabatic invariants and of the statistical properties of time dependent Hamiltonian systems, the linear and nonlinear oscillators, and finds application in this context, see [5] and references therein.

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Symmetries in low-energy hadron physics

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Hadrons (mesons and baryons) constitute most of the visible matter in the universe and interact by strong forces. The latter are described within field theory by quantum chromodynamics (QCD). The corresponding Lagrangian connects the fermionic matter fields (i.e. quarks) with the bosonic force fields (i.e. gluons) and exhibits, in the three-flavor case, a-priori a chiral symmetry $SU(3)_{\text{left}} \times SU(3)_{\text{right}}$. For low-energy hadrons this symmetry gets spontaneously broken and a residual $SU(3)$ symmetry remains. The transition from the chiral to the chirally broken phase is essentially not understood till now, but is manifested as an experimental fact. In the talk I will emphasize that approaches to QCD for hadrons at low energies should essentially observe the symmetries left from spontaneous breaking of chiral symmetry as well as the Lorentz symmetry of special relativity. The former is $SU(3)$, notably implying the existence of Goldstone bosons, and the latter is encoded in the Poincaré invariance of the theory. In particular, I will demonstrate that a relativistic quark model respecting these symmetries succeeds in a comprehensive description of baryon properties known from spectroscopy, the electromagnetic as well as weak structures, and elastic low-energy reaction processes.

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Neobičajne transportne lastnosti železovih pniktidov

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Spojine na osnovi železa in pniktidov so v zadnjih dveh letih v središču raziskav znotraj fizike trdnih snovi. Predvsem je razlog v visokih temperaturah prehoda v superprevodno stanje, ki so poleg kupratov najvišje doslej. Poleg tega imajo te snovi vrsto nenavadnih lastnosti, npr. bližino magnetnim nestabilnostim in nekonvencionalno naravo superprevodnega stanja, kar je zelo podobno fiziki kupratov, kljub očitnim razlikam v elektronski strukturi obeh familij supertprevodnikov. V predavanju sem bom posvetil zlasti transportnim lastnostim v normalnem kovinskem stanju, ki odstopajo od običajnih Fermijevih tekočin. Predstavil bom fenomenološko teorijo, osnovano na modelu dveh pasov, ki ju povezuje spinsko posredovana interakcija. Pokazal bom, da so anomalne temperaturne odvisnosti in velike vrednosti upornosti, termonapetosti in Hallove konstante posledica močne sklopitve s spinskimi fluktuacijami in majhnih Fermijevih energij relevantnih elektronskih pasov.

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Anomalous Transport Properties of Iron Pnictides

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Iron pnictide compounds are in last two years one of the most investigated materials within the solid state community, predominantly since they show besides cuprates the superconductivity at highest temperatures. Moreover, they reveal several properties, in particular the vicinity to the magnetic instability and an unconventional pairing symmetry, similar to cuprates although the electronic structures are rather different. In the talk I will concentrate on normal state transport properties which are also quite far from the usual Fermi-liquid framework. I will present a phenomenological theory of quasiparticle scattering and transport relaxation in iron pnictides based on a simplified two-band model with the spin-fluctuation-induced interband coupling. It is shown that the anomalous temperature dependence and large values of normal-state resistivity, thermopower and Hall constant can be interpreted as the consequence of strong coupling to spin fluctuations and low Fermi energies of relevant electron bands.

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Nekaj točno rešljivih modelov transporta v kvantnih mnogo-delčnih verigah daleč od ravnovesja

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Predstavil bom pristop k reševanju odprtih mnogo-delčnih kvantnih sistemov, ki temelji na Fockovih prostorih gostotnih operatorjev. Takšna obravnava je še posebej primerna za študij Lindbladovih ali Redfieldovih master enačb za kvadratne fermionske ali bozonske verige in omogoči izračun nekaterih eksplicitnih rezultatov o kvantnem transportu in neravnovesnih kvantnih faznih prehodih. Kot primer bomo obravnavali Heisenbergovo XY verigo spinov $1/2$ [1, 2, 3]. Pokazal bom tudi kako v nekaterih primerih interagirajočih odprtih kvantnih verig lahko zapišemo ekspliciten izraz za neravnovesno stacionarno stanje, npr. za XX verigo s t.i. “dephasing” šumom [4], fermionsko Hubbardovo verigo, ali za Heisenbergovo XXZ verigo spinov $1/2$ [5] za katero znamo analitično reproducirati nedavno numerično opaženo negativno diferencialno prevodnost [6].

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On some exactly solvable cases of far from equilibrium transport in many-body quantum chains

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An approach towards exact solution of many-body open quantum systems based on Fock spaces of density operators shall be reviewed. Such treatment is particularly well suited for studying Lindblad or Redfield master equations of quadratic fermionic or bosonic chains where certain explicit results on heat transport and non-equilibrium phase transitions can be obtained. As an example we outline Heisenberg XY spin 1/2 chain [1, 2, 3]. Furthermore, one is able to write down explicit non-equilibrium steady states for some interacting quantum spin chains, such as XX chain with dephasing noise [4], fermionic Hubbard chain, or Heisenberg XXZ spin 1/2 chain [5] for which we analytically reproduce recently numerically observed negative-differential-conductance [6].

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Enodimenzionalni niz anten za georadar

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Georadar [1] je geofizikalna metoda, ki z radarskimi pulzi preiskuje prostor in predmete pod površino. Omogoča iskanje skritih predmetov [2] ter oceno njihovih materialnih lastnosti, kot je dielektrična konstanta. Najbolj razširjeni so sistemi z monostatsko konfiguracijo oddajne in sprejemne antene [3]. Razvili smo linearno antensko polje, sestavljeno iz niza širokopasovnih georadarskih anten (UWB). Predstavili bomo lastno razvit sistem, s katerim je možno narediti sliko skritih predmetov pod površino in izboljšati resolucijo sistema v prečni smeri. Predstavili bomo nekaj primerov uporabe in nekaj testnih meritev, iz katerih smo ocenili prostorsko ločljivost sistema.

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One-dimensional linear array of antennas for georadar

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Georadar [1] is a geophysical method, which uses radar pulses to investigate places and objects underground. It can find hidden objects [2] and estimate their material properties like a dielectric constant. Nowadays, the most commonly used systems are based on monostatic antenna configuration [3]. However, we developed a linear antenna array consisting of ultra-wideband antennas (UWB). Here we will describe an in-house developed system of linear antenna array for georadar. It allows us to investigate the underground and create images of hidden objects below the surface with increased horizontal resolution. Furthermore, we will present some applications and preliminary measurements for the determination of the spatial resolution of the system.

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Kvantna prepletenost v sistemih sklopljenih elektronov

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Einstein, Podolsky in Rosen so v svojem članku iz leta 1935 zaključili, da je opis realnosti v okviru kvantne mehanike in valovnih funkcij nepopoln. Danes je omenjeni članek sicer najbolj citirano Einsteinovo delo, a kvantne prepletenosti – ki je bila razlog za takratne dvome – ne obravnavamo več kot paradoks, ampak kot enega od gradnikov kvantne obdelave informacije.

V predavanju bomo najprej vpeljali kvantitativno mero prepletenosti delcev, uglešenost (concurrence) in formacijsko prepletenost (entanglement of formation), za sistem sklopljenih elektronov [1,2]. Kot primer bomo prikazali prepletenost elektronov na sistemih kvantnih pik, sklopljenih z okolico (rezervoarjem), kjer se elektroni sklopijo ali v lokalno prepleteno stanje ali pa v stanje, ko so prepleteni z elektroni v rezervoarju (več-delčno Kondovo stanje) [3,4].

Kvantne prepletenosti ne moremo predstaviti in obravnavati v okviru klasične fizike. Lahko pa vizualiziramo kvantno prepletenost v prostoru Bohmovih skritih spremenljivk. Prikazali bomo, kako se da v okviru de Broglie - Bohmove interpretacije kvantne mehanike nazorno predstaviti prepletenost dveh kvantnih bitov.

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Quantum entanglement in interacting electron systems

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Einstein, Podolsky and Rosen have in their paper from 1935 concluded that quantum mechanical description of reality as given by wave functions is not complete. Although this article represents Einsteins's most cited publication, is today quantum entanglement – the origin of the debate in 1935 – not considered a paradox, but is an essential resource in emerging field of quantum information processing.

We will present how quantitative measures of entanglement, concurrence and entanglement of formation, can be introduced in fermionic systems [1,2]. As an example the entanglement of interacting electrons in quantum dots coupled to external leads will be considered and the interplay between local entangled state and extended many-body Kondo state will be revealed [3,4].

Quantum entanglement can not be expressed or discussed in the framework of classical physics. However, entangled qubits can be visualized in the space of Bohm hidden variables. It will be shown how in the de Broglie - Bohm interpretation of quantum mechanics entanglement of two interacting qubits can be identified.

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Modeliranje toka nematskega tekočega kristala z metodo Lattice Boltzmann

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Pomemben element razvoja mikro-fluidnih in laboratorij-na-čipu naprav je nadzor materialnih tokov v mikro-ograjnih geometrijah [1]. V tekočih kristalih je tok sklopljen z deformacijo v orientacijskem redu tekoče kristalnih molekul [2], kar ponuja zanimiv kontrolni mehanizem za tok in nove možne aplikacije, kot na primer samostavljene črpalke v aktivnih tekoče kristalnih koloidih. Zapletenost osnovnih enačb v mikro-fluidnih pojavih tekočih kristalov - posplošena Navier-Stokesova enačba, sklopljena z enačbami nematodinamike - zahteva uporabo učinkovitih in robustnih numeričnih shem.

Tukaj predstavimo profile povratnega toka nematskega tekočega kristala v ogradjenih kanalih in votlinah. Delo temelji na fenomenološkem Beris-Edwards modelu, ki ga rešimo s hibridno Lattice Boltzmann metodo. Ta metoda uporablja hkratni eksplicitni diferenčni časovni razvoj orientacijskega reda tekočega kristala in Lattice Boltzmann metodo za materialni tok. Kot vir povratnega toka raziščemo: (i) neravnovesne konfiguracije defektov, ki ustvarijo tok ob relaksaciji v ravnovesno stanje, in (ii) gradientne tlaka, ki ustvarijo stacionarne tokove podobne Poiseuillevemu. Posebej izpostavimo pomen tipov orientacijskega sidranja na površinah kanalov in votlin.

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Modelling Material Flow in Nematic Liquid Crystals Using Lattice Boltzmann Method

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Controlling material flow in micro-confined geometries is an important element in developing microfluidic and lab-on-the-chip devices [1]. Flow in liquid crystals is coupled to deformation in the orientational order of liquid crystalline molecules [2], which offers a novel steering mechanism for the flow and possibly novel applications, such as self assembled pumps in active liquid crystal colloids. The complexity of governing equations in microfluidic phenomena of liquid crystals -generalized Navier-Stokes equation coupled to equations for nematodynamics- require efficient and robust numerical schemes and solvers.

Here, we present back-flow profiles of nematic liquid crystal in confined channels and cavities. Our study is based on phenomenological Beris-Edwards model, which is solved via hybrid lattice Boltzmann method. The method combines explicit finite difference time evolution for orientational order dynamics and Lattice Boltzmann method for the material flow. As driving sources for back-flow, we explore (i) nonequilibrium configurations of defects that generate flow when relaxing to equilibrium and (ii) local pressure gradients that generate stationary Poiseuille-like flow. The role of surface anchoring types at the walls of channels and cavities is demonstrated.

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Teorija dimenzij in fizika

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Predstavil bom matematično teorijo dimenzij in jo pojasnil na nekaterih fizikalnih primerih. Nato si bomo ogledali krajša filma o dimenzijah 3 in 4, s posebnim poudarkom na tem, kako si lahko predstavljamo višjedimenzionalne prostore.

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Dimension theory and physics

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We shall present mathematical theory of dimensions and illustrate it on some examples from physics. Then we shall present two short movies on dimensions 3 and 4, with special emphasis on how one can view higher-dimensional spaces.

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Stability of relative equilibria in spinning tops

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Relative equilibria in rigid body dynamics are stationary solutions of the Euler-Poisson equations and come in four kinds: two of them are steady rotations about the vertical axis, the other two are carousel type motion where a body-fixed axis revolves around the vertical along a cone. They exist whether or not the system's overall behavior is integrable, and are called Staude solutions because they were first described in [1]. However, it was not before Katok [3] and Tatarinov [4] presented the first bifurcation diagrams that their full complexity became apparent. The set of classical rigid body systems possesses four essential parameters: two moments of inertia and two coordinates for the center of mass. The bewildering variety of different bifurcation diagrams in this four-dimensional parameter set has captured much attention, see [5] for an example. But what about the stability of these relative equilibria? This question has remained largely in the dark, probably because on first sight it looks deceptively complicated. But as a matter of fact it is surprisingly simple! Grammel's demonstration how the problem reduces to the solution of a quadratic equation [2] seems to have been forgotten. Using this hint it has now become straightforward to add to the bifurcation diagrams the full information about the eigenvalues of linear perturbations of the relative equilibria [6].

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Feroelektrične koloidne mešanice z magnetnimi nanodelci: novi mehki magnetoelektriki

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Magnetoelektriki so zelo zanimivi za raziskovalce predvsem zaradi njihovih lastnosti, kot npr. nadzor magnetnih lastnosti preko električnih in obratno, ter zaradi njihove uporabe, npr. pri shranjevanju podatkov [1]. Predstavila bom naše eksperimentalno delo, kjer smo preučevali mešanico magnetnih nanodelcev (ND) in feroelektričnega tekočega kristala (TK) SCE9 v okolici feroelektrične SmC* faze. Dielektrične in toplotne lastnosti omenjenih mešanic smo študirali s pomočjo dielektrične spektroskopije in kalorimetrije visoke ločljivosti. Opazimo podobne efekte kot v primeru aerosilnih delcev [2]. Vpliv električnega polja na magnetno susceptibilnost, ki smo ga izmerili s SQUID susceptometrom, potrjuje obstoj indirektne sklopitve magnetizacije nanodelcev in polarizacije v tekočem kristalu. To potrjuje obstoj magnetoelektričnosti v mehkih kompozitnih materialih kot je mešanica magnetnih ND in feroelektričnega TK.

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Ferroelectric colloidal mixtures with magnetic nanoparticles: new soft magnetoelectrics

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Magnetoelectrics are recently attracting considerable attention of researchers due to their properties, i.e., in such materials it would be possible to control the magnetic properties via electrical ones, and vice versa and also due to their potential for applications, for example in information storage industry [1]. I will present our experiments and data analysis obtained on mixture of magnetic nanoparticles (NPs) and the ferroelectric liquid crystal (LC) SCE9 in the vicinity of the ferroelectric smectic C* phase. The impact of the magnetic NPs on the Goldstone and soft mode dielectric response has been determined by the dielectric spectroscopy measurements and the disordering effects on the ferroelectric phase transition have been studied by the high resolution calorimetry. Similar disordering effects were found as in case of the aerosils [2]. Measurements of the impact of the electrical field on the magnetic susceptibility via SQUID susceptometer verified the indirect coupling between the NP's magnetic moments and LC's electrical polarization. This demonstrates that magnetoelectricity can be found in soft composite materials such as mixtures of magnetic NPs and ferroelectric LCs.

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Quantum Difference-Differential Equations

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Differential equations which contain the parameter of a scaling process are usually referred to by the name Quantum Difference-Differential Equations. Some of their applications to discrete models of the Schrödinger equation are presented and some of their rich, filigrane und sometimes unexpected analytic structures are revealed.

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Freak waves in the linear regime: A microwave study

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Microwave transport experiments have been performed in a quasi-two-dimensional resonator with randomly distributed scatterers, each mimicking an r^{-2} repulsive potential. Analysis of both stationary wave fields and transient transport shows large deviations from Rayleigh's law for the wave height distribution, which can only partially be described by existing multiple-scattering theories. At high frequencies, the flow shows branching structures similar to those observed previously in stationary imaging of electron flow. Semiclassical simulations confirm that caustics in the ray dynamics are likely to be responsible for the observed structures. Particular conspicuous features observed in the stationary patterns are "hot spots" with intensities far beyond those expected in a random wave field. Reinterpreting the flow patterns as ocean waves in the presence of spatially varying currents or depth variations in the sea floor, the branches and hot spots lead to enhanced frequency of freak or rogue wave formation in these regions.

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Tekoči kristali iz ukrivljenih molekul

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Odkritje tekočih kristalov, ki jih sestavljajo ukrivljene molekule, je popolnoma spremenilo pogled na urejanje v tekočinskih fazah [1]. Ti tekoči kristali tvorijo faze, ki so večinoma polarne. Poleg tega je ureditev molekularnih dipolov neodvisna od naklona molekul glede na normalo na plast, ki jo tvorijo molekule [2]. Do odkritja tekočih kristalov iz ukrivljenih molekul so imele tekočokristalne faze iz paličastih molekul feroelektrične lastnosti le v primeru, da so osnovni gradniki molekule brez zrcalne simetrije (kiralne molekule). Njihova polarna ureditev je sekundarni ureditveni parameter in je možna le, če je simetrija sistema dovolj nizka (molekule morajo biti nagnjene glede na plast). Ukrivljene molekule pa so v splošnem zrcalno simetrične (nekiralne), pa vendar tvorijo kiralne strukture [3]. Zaradi tega spontanega zloma kiralne simetrije so tekoči kristali iz ukrivljenih molekul še posebej zanimiv modelski sistem. Ker je optična anizotropija v tekočih kristalih iz ukrivljenih molekul zelo velika, pa so ti materiali zelo zanimivi tudi za aplikacije.

Zlom zrcalne simetrije vodi do direktne sklopitve med divergenco polarizacije in povprečnim naklonom molekul. Čeprav je sistem lokalno polaren, divergenca polarizacije omogoča tvorbo makroskopsko nepolarnih sistemov [5,6] in je zato energijsko ugodna. Zaradi sklopitve med divergenco polarizacije in naklonom postanejo homogene, laminarne, plasti molekul nestabilne in se nagubajo (polarizacijsko modulirana in plastno nagubana faza). Če je gubanje premočno, se plasti "zlomijo", deli plasti pa tvorijo stolpce (stolpičaste faze).

Na predavanju bom predstavila lastnosti tekočih kristalov iz ukrivljenih molekul in teoretični model za opis in napoved njihovih lastnosti [7, 8, 9]. Posvetila se bom predvsem dvodimenzionalnim strukturam in njihovemu odzivu na zunanja polja [10].

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Bent-core liquid crystals

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The discovery of bent-core liquid crystals opened a new view on order in liquid-like phases [1]. Bent-core liquid crystals form phases which are in general polar. In addition the ordering of the molecular dipoles (polar order) is independent of the tilt order (molecular tilt with respect to the layer normal) [2]. Before the discovery of bent-core liquid crystals ferroelectricity was observed only in systems formed by chiral rodlike molecules. In these liquid crystals the polar order was a secondary order parameter. Ferroelectricity was possible only if the symmetry of the system was low enough, which required that the molecules tilt with respect to the layer normal. On the other hand, bent-core molecules are in general achiral but they form chiral superstructures [3]. This spontaneous breaking of chiral symmetry makes the bent-core liquid crystals an especially interesting model system. Since bent-core liquid crystals have large optical anisotropy their intensive study is motivated by the application point of view as well.

A direct consequence of the chiral symmetry breaking is coupling between the polarization splay and tilt [4]. Splay of polarization is an escape from the macroscopic polarity of the structure [5, 6]. Coupling between the polarization splay and tilt makes the homogeneously layered structure unstable with respect to polarization modulation and layer undulation (polarization modulated and layer undulated phases). If undulation is too strong, layers break and form stacks (columns) of layer fragments (columnar phases).

I will present the properties of bent-core liquid crystal phases and theoretical modeling of their structure properties [7, 8, 9]. I will focus on the two-dimensional structures and their response to the external fields [10].

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Hibridna metoda za izračun Ruelle-Pollicottovih resonanc

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Predstavili bomo numerično metodo za izračun Ruelle-Pollicottovih resonanc v dinamičnih sistemih. Z upoštevanjem korelacij večih opazljivk čez več časovnih korakov sestavimo efektivni grobo zrnati propagator. Metodo primerjamo z običajnimi pristopi za izračun resonanc na primeru perturbirane mačje preslikave in pokažemo, da je numerično učinkovita in robustna.

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A hybrid method for calculation of Ruelle-Pollicott resonances

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We present a numerical method for calculation of Ruelle-Pollicott resonances of dynamical systems. It constructs an effective coarse-grained propagator by considering the correlations of multiple observables over multiple timesteps. The method is compared to the usual approaches on the example of the perturbed cat map and is shown to be numerically efficient and robust.

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Neravnovesne lastnosti Holsteinovega polarona v konstantnem zunanjem električnem polju

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Opis sistemov daleč stran od ravnovesja predstavlja enega od temeljnih problemov v fiziki. V svojem govoru bom predstavil študijo Holsteinovega polarona [1,2] v eni dimenziji, ki se pod vplivom konstantnega zunanjega električnega polja zapelje stran iz ravnovesja. Z uporabo časovno odvisne Lanczoseve metode [3,4] in z upoštevanjem vseh kvantnih efektov lahko sledimo časovnemu razvoju sistema iz njegovega osnovnega stanja ob $t = 0$, ko vključimo polje, do stacionarnega stanja oziroma stanja s konstantnim tokom.

Pri majhni vrednosti elektronsko-fononske (EF) sklopitve kaže sistem dušene Blochove oscilacije, značilne za energijski pas s prostimi elektroni. Numerični izračun za stacionarno vrednost toka je v tej limiti primerjan s predlaganim analitičnim izrazom za tok, ki je odvisen od EF sklopitve in jakosti polja. Odvisnost stacionarnega toka od polja bo prikazana za različne režime EF sklopitve. V območju močne sklopitve velika energijska reža med osnovnim in prvim vzbujenim stanjem vodi do pojava skoraj idealnih Blochovih oscilacij, ki so posledica gibanja polarona vzdolž polaronskega pasu.

Reference

- [1] J. Bonča, S. A. Trugman in I. Batistić, *Phys. Rev. B* **60** 1633 (1999).
- [2] A. S. Alexandrov, *Polarons in Advanced Materials, Springer Series in Material Sciences Vol. 103* (Springer, Dordrecht, 2007).
- [3] P. T. Jun in J. C. Light, *J. Chem. Phys.* **85** 5870 (1986).
- [4] M. Mierzejewski in P. Prelovšek, *arXiv:1007.3383* (2010).

Non-equilibrium properties of Holstein polaron driven by constant electric field

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Description of systems far from equilibrium represents one of the fundamental open problems in physics. I will present a study of a Holstein polaron [1,2] in one dimension driven away from equilibrium by a constant electric field along the chain. Using a time-dependent Lanczos method [3,4] and taking fully into account quantum effects, we follow the time-evolution of the system from its ground state as the constant electric field is switched on at $t = 0$, until it reaches a steady state.

At small electron-phonon (EP) coupling the system experiences damped Bloch oscillations characteristic for free electron band. An analytic expression of the steady state current in this limit is proposed in terms of EP coupling and electric field. We investigate the steady state current vs. field dependence for different regimes of EP coupling. In the strong coupling regime a large gap in the spectrum is responsible for observation of nearly perfect Bloch oscillations arising from the polaron motion along the polaron band.

References

- [1] J. Bonča, S. A. Trugman and I. Batistić, *Phys. Rev. B* **60** 1633 (1999).
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Recent developments in cosmology – theory and observation

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What sort of universe do we live in? Observations of supernovae in distant galaxies made by the Hubble space telescope and highly resolved measurements of the cosmic microwave background radiation by the WMAP satellite have brought tremendous progress over the last decade in answering this question. Comparisons of the observations with the predictions of general relativity suggest that we live in a flat, expanding Friedmann universe, with accelerating expansion rate, in which baryonic matter only contributes 4 per cent to the total energy budget. The rest appears to be comprised of "dark matter" (23 per cent), which can be tracked down indirectly by X-ray observations, and yet unknown "dark energy" (73 per cent), which drives the accelerated expansion of the universe. I shall review these developments, discuss present and future satellite missions for cosmology, and address the question whether or not globally the universe might possess a nontrivial topology.

Sončna energija iz orbite: inovativni koncepti

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Glaser je že leta 1968 predlagal izgradnjo sončnih elektrarn v vesolju z namenom proizvodnje elektrike za Zemljo (1). Ideja je sčasoma dozorela in podpisana je že bila prva pogodba v Kaliforniji, ki ima predvideno dobavo električne energije v letu 2016 (2). Opisali bomo nekaj scenarijev ter inovativnih konceptov za znižanje stroškov takšne proizvodnje in dobave elektrike. Najbolj ugodna lega sončnih elektrarn v geostacionarni orbiti, saj lahko od tam dobavljajo elektriko do zelene fiksne točke na Zemlji praktično 24 ur na dan. Prva elektrarna bi bila zgrajena na Zemlji in izstreljena v nizko orbito. Nato bi se s proizvedeno energijo dvignila v geostacionarno orbito. Izgradnja nadaljnjih elektrarn bi bila smiselna v robotskih tovarnah na Luni, saj bi to dodatno znižalo stroške, predvsem zaradi lažje izstrelitve elektrarne v geostacionarno orbito. Tako bi lahko že pred polovico tega stoletja njena proizvodna cena padla pod trenutno tržno ceno elektrike (3).

Reference

- [1] Glaser PE, *Science Magazine* **162** (1968) 857-861.
- [2] Evans P, *Gizmag* (19. april 2009) 11495.
- [3] Zidanšek A, Ambrožič, Milfelner M, Blinc R, Lior N, *Energy* (2010) sprejeto v objavo.

Solar orbital power: innovative concepts

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Solar power plants positioned in space for terrestrial electricity use have been proposed by Glaser in 1968 (1). The idea has matured and is close to commercial exploitation with the first contract for orbital electricity signed in California with delivery in 2016 (2). Here we describe several different scenarios and innovative concepts to reduce costs. The best option is to put the power plant into a geostationary orbit where it can provide power to a fixed location on the Earth surface almost 24 hours a day. The first power plant would have to be built on Earth and launched into the low Earth orbit. From there it can be lifted to the geostationary orbit using the power it produces. Further reduction in costs is achieved if the power plants are built in robotic self-replicating factories on the Moon. In this way the cost of orbital electricity could fall below the current market prices of electricity well before the middle of this century (3).

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- [1] Glaser PE, *Science Magazine* **162** (1968) 857-861.
- [2] Evans P, *Gizmag* (April 19, 2009) 11495.
- [3] Zidanšek A, Ambrožič, Milfelner M, Blinc R, Lior N, *Energy* (2010) accepted.

Morfometrija in struktura naravnih poligonalnih pokritij

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Prerez mnogih prizmatičnih naravnih celičnih struktur, npr. tesnih živalskih in rastlinskih tkiv ter bazaltnih stolpov, je poligonalno pokritje ravnine. Da bi razumeli opaženo visoko stopnjo univerzalnosti teh struktur, analiziramo morfometrične lastnosti nabora eksperimentalnih vzorcev. Raziščemo porazdelitev reducirane ploščine poligonov; to je izoperimetrični kvocient, ki meri podolgovitost poligonov. Dobljene porazdelitve so zelo ostre in zdi se, da pripadajo isti družini. S primerjavo frekvenc razredov poligonov priredimo vsakemu eksperimentalnemu vzorcu modelsko pokritje s poligoni z enakimi ploščinami in enakimi obsegi. Dobro ujemanje nakazuje, da lastnosti naravnih naključnih poligonalnih pokritij v veliki meri določa že mediana reducirane ploščine. Ta sklep pomaga razumeti, odkod univerzalnost opaženih struktur kljub zelo raznorodnemu fizikalnemu izvoru.

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- [1] A. Hočevar in P. Ziherl, *Phys. Rev. E* **80** (2009) 011904.
- [2] A. Hočevar, S. El Shawish in P. Ziherl, poslano v objavo.

Morphometry and structure of natural polygonal tilings

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The cross-section of many prismatic natural cellular partitions such as compact animal and plant tissues and basalt columns is a polygonal tiling of a plane. To understand the observed universality of their structure, we analyze the morphometry of a set of living and inanimate planar cellular partitions. We characterize them by the distributions of polygon reduced area, which measures of the elongation of polygons. These distributions are fairly sharp and seem to belong to the same family. By comparing the frequencies of the polygon classes, we map the samples onto model tilings of equal-area, equal-perimeter polygons. We argue that the random two-dimensional patterns can be parametrized by their median reduced area alone. These findings provide a new insight into the origin of the universality of these natural structures, whose mechanics are patently dissimilar.

References

- [1] A. Hočevar and P. Ziherl, *Phys. Rev. E* **80** (2009) 011904.
- [2] A. Hočevar, S. El Shawish, and P. Ziherl, submitted.

Veliki spektroskopski pregledi neba

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Naša Galaksija je v vseh pogledih tipična, torej je študij njene strukture in nastanka relevanten tudi za razumevanje vesolja v celoti ("lokalna kozmologija", Freeman & Bland-Hawthorn 2002). To temo je evropska iniciativa Astronet (www.astronet-eu.org) postavila med glavne prioritete astrofizikalnih raziskav v naslednjih dveh desetletjih. Predstavil bom slovensko delo in vključevanje v najpomembnejše tekoče (RAVE, Esina misija Gaia) in bodoče projekte (Hermes, Galactic Chromo Dynamical Survey, Esina misija Plato). Rezultati nam prvič dajejo popolno dinamično in prostorsko informacijo o porazdelitvah zvezd, ki vključuje poznavanje temeljnih parametrov zvezdnih atmosfer, vključno s kemično sestavo. Tako lahko bolje opredelimo lastnosti posameznih galaktičnih komponent in študiramo njihov nastanek. V prihodnosti nam bo podroben študij zastopanosti posameznih kemičnih elementov omogočil vpogled v nastajanje zvezd v medtem že davno razpadlih zvezdnih kopicah, čemur bi lahko rekli galaktična arheologija.

Reference

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- [2] G.. Matijević, T. Zwitter, U. Munari, et al. *Astronomical Journal* **140** (2010) 184-195.
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- [7] M. Wilson, A. Helmi, H.L. Morrison, et al. *Mon. Not. R. Astr. Soc.* (2010), accepted, arXiv:1009.2052

Large Spectroscopic Stellar Surveys

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Our Galaxy appears typical in all respects, so the study of its structure and origins can be relevant also for the understanding of the Universe as a whole ("local cosmology", see Freeman & Bland-Hawthorn 2002). This topic has also been chosen as one of the top priorities in astrophysical research in the next two decades by the european initiative Astronet (www.astronet-eu.org). I will summarize the Slovenian work and contributions to the most important current and forthcoming collaborations (RAVE, Esa's missions Gaia and Plato, projects Hermes and Galactic Chromo Dynamical Survey). For the first time the results allow to obtain a complete dynamical and spatial information on stellar distributions, including the knowledge of the basic parameters of stellar atmospheres and their chemistry. This permits a detailed study of the structure and origin of individual galactic components. In the near future data on detailed chemical abundances will become available. So it will be possible to pinpoint the origin of each star to a particular stellar cluster, even if the cluster has dissapeared long ago. The situation can be described as Galactic archaeology.

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- [1] T. Zwitter, G. Matijević, M.A. Breddels, et al. *Astronomy and Astrophysics* (2010) accepted, arXiv:1007.4411
- [2] G.. Matijević, T. Zwitter, U. Munari, et al. *Astronomical Journal* **140** (2010) 184-195.
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Analitična rešitev skoraj izotropnega XY modela sklopljenega z okolico

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Obravnaval bom odprte kvantne sisteme [5,6]. Osredotočil se bom na njihov efektivni opis v Markovski aproksimaciji. Splošno teorijo bom uporabil na primeru XY modela, kjer je bil numerično opažen neravnovesni kvantni fazni prehod daleč od ravnovesja [1, 2,3]. V posebnih limitah je možna tudi analitična rešitev predstavljenega problema.

Kot primer bom analitično opisal skoraj izotropni XY model z Lindbladovo dinamiko, kjer lahko eksaktno izračunamo prehod med eksponentno padajočimi korelacijami in korelacijami dolgega dosega. V režimu dolgih korelacij opazimo nov fenomen korelacijskih resonanc, kjer dobimo pri določenih vrednostih parametrov sistema (npr. magnetnega polja) nenavadno velike korelacije.[4].

Reference

- [1] T. Prosen, *New J. Physics*, 10, 043026 (2008)
- [2] T. Prosen and B. Žunkovič, *New J. Physics*. 12, 025016 (2010)
- [3] T. Prosen and I. Pižorn, *Phys. Rev. Lett.* 101, 105701 (2008)
- [4] B. Žunkovič and T. Prosen *J. Stat. Mech.* (2010) P08016
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- [6] H.-P. Breuer and F. Petruccione, *The theory of open quantum systems*, Oxford University Press, 2002.

Analytic solution of nearly isotropic XY model coupled to the environment

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Quantum system coupled to the environment will be discussed [5, 6]. In particular the effective Markovian approach for quadratic Hamiltonians will be outlined. The general framework shall be applied to the XY spin 1/2 model, where a non-equilibrium phase transition has been observed numerically [1, 2, 3]. In certain limits even analytical calculations are possible.

As an example we will consider the steady state of a nearly isotropic boundary-driven open XY spin 1/2 chain in the Lindblad formulation, where a non-equilibrium quantum phase transition from exponentially decaying correlations to long-range order can be obtained analytically. In the regime of long-range order a new phenomenon of correlation resonances will be presented, where the correlation response of the system is unusually high for certain discrete values of the external bulk parameter (e.g. magnetic field).

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- [6] H.-P. Breuer and F. Petruccione, *The theory of open quantum systems*, Oxford University Press, 2002.

CONCERT PROGRAM, 9.12.2010

MARIJA DJURIĆ – Flavta (flute)

URŠKA OREŠIČ – Klavir, vokal (piano, vocal)

-
1. U. Orešič: KAPRICA ZA 2 (*Caprice for 2*)
 2. S. Prokofijev: Sonata in D-maj for flute and piano, op. 94
 - I. Moderato
 - II. Allegreto scherzando
 3. U. Orešič: KUKAWA for flute solo
Kukawin prepir (*Kukawa's arguing*), Kukawin tango (*Kukawa's Tango*)
 4. A. Piazzolla/ar. D. Varelas: LE MUERTE DEL ÁNGEL
 5. C. Bizet/ar. F. Borne: CARMEN HABANERA
 6. A. Piazzolla: TANGO ETUDE NO. 3 for flute solo
 7. G. Gershwin: SUMMERTIME (*from Porgy and Bess*)
 8. A. L.Weber/ar. U. Orešič: DON'T CRY FOR ME ARGENTINA
(*from Evita*)
 9. U. Orešič: LITTLE SWINGIN'
-



Marija Djurić je rojena 7. 7. 1976 v Nišu v Srbiji. Akademijo za glasbo v Banja Luki je končala leta 2002 v razredu profesorice Sanje Stijačić. Pred kratkim je uspešno končala prvi letnik podiplomskega študija v Banja Luki, v razredu profesorice Laure Levai- Aksin. Deluje v različnih orkestrih, nastopa kot solistka (s pianistko Urško Orešič), ter v komornih zasedbah (Tango Komorni trio s kitaristom S. Ismajlovičem in violinistko Doris Šegulo.) Poučuje flavto, kljunasto flavto in komorno igro na glasbeni šoli v Gornji Radgoni.

Urška Orešič (1981) je svojo glasbeno pot pričela na glasbeni šoli v Mariboru. Takrat je zapisala svoje prve skladbe in jih improvizirala na klavir. Študij glasbenega stavka in klavirja je nadaljevala na Glasbeni gimnaziji v Mariboru. Leta 2001 je vpisala študij kompozicije in glasbene teorije na Akademiji za glasbo v Ljubljani pri mentorju red. prof. Pavlu Mihelčiču in z odliko diplomirala leta 2005. Izpopolnjevala se je v poletnih šolah in seminarjih pri profesorjih F. Burtu, L. Voigtlaenderju in G. Fekete. Bila je Zoisova štipendistka, v času študija kompozicije je priredila dva celovečerna avtorska koncerta svojih komornih del, za katera je leta 2005 prejela Prešernovo nagrado Akademije za glasbo. Junija 2009 je diplomirala tudi iz klavirja pri mentorju izr. prof. Andreju Jarču, trenutno pa zaključuje še podiplomski študij z magistrsko disertacijo iz kompozicije. Njen skladateljski opus obsega solistična, zborovska, komorna in orkestralna dela. Je članica Društva slovenskih skladateljev in doslej je imela že preko 50 javnih izvedb svojih del, med njimi so najpomembnejša: opera *Večer z Rafaelom* (še neizvedena), več samospevov in skladb za glas v različnih zasedbah, *Vitis Vinifera* –

programska glasba o vinski trti, *Triton* za orkester, ki ga je za arhiv posnel Simfonični orkester RTV pod vodstvom En Shao, kot pomembne izvedbe pa si šteje skladbe *Skici za godala* s Komornim godalnim orkestrom Slovenske Filharmonije in Camerato Labacenzis, *Kaprice za 7* z ansamblom MD7 ter *Kremenov kamen s sonca* v izvedbi Slovenskega okteta.

Urška Orešič deluje kot vsestranska glasbenica: skladateljica, pianistka, korepetitorica in pevska različnih glasbenih zvrsti ter kot hotelska pianistka. Zaposlena je na Glasbeni šoli Gornja Radgona, kjer poučuje klavir, korepetira in je članica Big Banda.

Marija Djurić was born 7.7.1976 in town Nish of Serbia Republic. She studied with Professor Sanja Stijačić at Music Academy of Banja Luka, where she graduated in 2002. Permanently she continues her flute post - studying masters degree with Professor Laura Levai-Aksin in Banja Luka. Marija works as a solo and chamber musician with pianist Urška Orešič and plays in trio with Tango music with Samo Ismajlovič and Doris Šegula. She is employed as flute and chamber music teacher in The Music School of Gornja Radgona.

Urška Orešič (1981) began with very first musical education in her home town Maribor. While taking her first years of piano lessons at the primary Music School she began to compose her own musical ideas by improvising on the piano. She continued with studying the piano and theory at Musical High school in Maribor at Professor Milena Sever's piano class. In 2001 she accepted to Music Academy in Ljubljana where she was studying the composition and music theory with Professor Pavel Mihelčič. She successfully graduated in 2005 with writing the one act Opera "An Evening with Rafael". She took parts at different seminars and Summer schools in Europe and worked with professors F. Burt, L. Voigtlaender and G. Fekete. In June 2009 she graduated in piano studying with Professor Andrej Jarc. Now she is continuing her studying with writing her Masters degree of composition at Music Academy in Ljubljana.

Her musical opus includes solo, choir, chamber and orchestral works; she mostly likes vocal-instrumental music. She also had 2 solo evenings with only her works performed. The important works are: *The Sketches for strings*, performed by Chamber Slovene Filharmonic orchestra and Camerata Labacenzis, *Triton* which was recorded for Slovene promoting music with Radio Philharmonic orchestra and conductor En Shao and "*Kremenov kamen s sonca*" written for Slovenian Octet. Urška Orešič was a member of Zois scholarship and a student's Preseren Prize. As academic musician and the professor of the musical art she is working as a composer, chamber musician, occasional pianist and a singer. Permanently she is working as a piano teacher and accompanist at Gornja Radgona Music School. She is also a member of Big Band Music school Gornja Radgona.

CONCERT PROGRAM, 10.12.2010

E. Grieg: Sonata za klavir in violončelo v a-molu, op. 36 / Sonata for piano and cello in a minor, opus 36

Allegro agitato
Andante molto tranquillo
Allegro

B. Pucihar: Summer Sonata, op. 8

Nikolaj Sajko (1982) je študiral violončelo na ljubljanski Akademiji za glasbo v razredu profesorja Cirila Škerjanca in se izpopolnjeval na Univerzi Antona Brucknerja v Linzu. Lani je na ljubljanski Akademiji zaključil znanstveni magistrski študij na temo artikulacije in fraziranja v orkestrski igri. Deluje kot namestnik prvega čelista v Simfoničnem orkestru SNG Maribor. Udeležil se je več mednarodnih seminarjev pri profesorjih I. Gavrišu, E. Schoenfeld, A. Norasu, C. Onczayu in T. Kühneju. Je dobitnik Klasinčeve diplome in nagrade Antonia Tarsie. Bil je član mednarodnega mladinskega orkestra Gustav Mahler, ki deluje pod umetniškim vodstvom Claudia Abbada in član Svetovnega orkestra glasbene mladine. Kot solist je večkrat nastopil z Mariborsko filharmonijo, orkestrom Gaudeamus in mariborskim mladinskim komornim orkestrom, veliko se posveča tudi komornemu muziciranju.

Miha Haas (rojen 1983) je diplomiral na Akademiji za glasbo v Ljubljani, v razredu Dubravke Tomšič-Srebotnjak, podiplomski študij pa dokončal na Konzervatoriju v Bruslju, v razredu Aleksandra Madžarja.

Na državnih in mednarodnih tekmovanjih je doslej osvojil štiri prve, tri druge in eno tretjo nagrado. Prejel je Škerjančevo nagrado SGBŠ, Prešernovo nagrado Akademije za glasbo ter Prešernovo nagrado Univerze v Ljubljani. Nastopil je na 270 koncertih v Sloveniji, Avstriji, Italiji, Nemčiji, Belgiji, na Nizozemskem, Hrvaškem, Švedskem in Norveškem. Kot solist je igral z Orkestrom Slovenske filharmonije, z Orkestrom RTV Slovenija, s Simfoničnim orkestrom AG, z Orkestrom SGBŠ, s Celjskim godalnim orkestrom, z Orkestrom festivala Bled, s Pihalnim orkestrom Slovenske vojske. Veliko se posveča tudi komorni glasbi; redno nastopa z violinistom Matejem Haasom ter v klavirskem duu s pianistom Tadejem Horvatom. Od oktobra 2008 je zaposlen na Akademiji za glasbo v Ljubljani.

Nikolaj Sajko (born in 1982) finished studies of cello performance at the Ljubljana Music Academy in the class of professor Ciril Škerjanec. Postgradually he attended the Anton Bruckner Private University and simultaneously completed his master thesis on theory of performance at the Ljubljana Music Academy.

He has attended numerous master classes with professors I. Gavriš, E. Schoenfeld, A. Noras, C. Onczay and T. Kühne.

For his musical achievements he was awarded "Dr. Roman Klasinc" diploma and the "Antonio Tarsia" prize. He was a member of Gustav Mahler Youth Orchestra (artistic director Claudio Abbado) and

Jeunesses Musicales World Orchestra. Appeared as soloist with Maribor philharmonic orchestra, Gaudeamus chamber orchestra and Maribor youth orchestra. He is also devoting a lot of his time to chamber music in several different chamber groups.

Since 2006 employed as co-principal cellist in the Symphony orchestra of Slovene national theater in Maribor and since 2008 teaches on the Conservatory of Music in Maribor.

Miha Haas (born in 1983) completed his studies of piano performance at the Academy of Music in Ljubljana in the class of Dubravka Tomšič-Srebotnjak and attended postgraduate studies at the Music Conservatory in Brussels in the class of Aleksandar Madžar.

He won four first prizes, three second prizes and one third prize in several state and international competitions. He was awarded with »Lucijan Marija Škerjanc« prize and »France Prešeren« prize for his musical achievements. He performed on about 270 concerts in Slovenia, Austria, Italy, Germany, Belgium, the Netherlands, Croatia, Sweden and Norway. He appeared as soloist with the Slovene Philharmonic Orchestra, the Radio Symphony Orchestra Ljubljana, Symphony Orchestra of the Academy of Music in Ljubljana, Symphony Orchestra of the Conservatory of Music in Ljubljana, String orchestra of Celje, Bled Festival Orchestra and Wind Band of Slovene Army. He is devoting a lot of his time to chamber music: regularly performs with the violin player Matej Haas and in piano duo with Tadej Horvat. Since October 2008 he is employed at the Academy of Music in Ljubljana.

Siegfried Grossmann: the Great Man, our Teacher

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The heavenly setting

When a man reaches the age of 75, it is allowed if not appropriate to call to mind the beautiful words of wisdom from the 90th Psalm – even if the man is Siegfried Grossmann and shows no sign of getting weak or less undertaking than ever. His life has been and continues to be rich and dense, blessed with challenging activity, with earned friendship and far-reaching influence (in space and time). We seize the opportunity to express our gratitude for every minute that we were privileged to enjoy his company.

It was an honor and great pleasure that Marko Robnik assigned us to share with the participants of his wonderful conference on Nonlinear Dynamics some memories of our times with Siegfried Grossmann, and our perspective as his former PhD students: one (P. H. R.) from the early times around 1970, the other (D. L.) from the period of maturity some twenty years later.

We would not have known much about the first half of his life had we not consulted with the Heavens and obtained relevant information from there. We followed the course of the planets through Siegfried's life and discovered an undisputable correlation between Saturn's pace and his. It takes Saturn 30 years to complete a cycle through the zodiac, and we shall show how this is reflected in Siegfried's epochs. Remember that Saturn's name in Greece was Kronos: he sets the cosmic time stan-

dard – a god not aiming for power like Jupiter but for wisdom and order.

Siegfried Grossmann was born on February 28, 1930, in a village near Königsberg. At that time Saturn was visiting Sagittarius, the archer, while Jupiter, on the opposite side of the sky, associated himself with Taurus, the bull. Everybody knows from his affair with Europa how much Jupiter loved to be a bull himself; nothing like that has been reported of Siegfried. On the other hand, combining wisdom with the skills of an archer in order to find the right arguments and place them precisely to the point: that is one of his characteristic strengths.

The family left Königsberg shortly after Siegfried was born, and moved to Berlin. So he did not see the destruction of his home town but instead witnessed the collapse of Germany's capital as a boy of age 15. Of course this also meant the end of terror in Germany, and only this liberation made all what followed possible. Saturn, at the low point of his cycle, has finally won his struggles with the ram and the bull and is just about to leave Taurus' house, looking ahead to better times.

The second epoch of 15 years are formative years. 1948 Siegfried finishes high School and begins to study at a Pedagogical High School, a teacher training for elementary school. He finishes this in 1951 and starts to study physics and mathematics at the Free University of Berlin, aiming at becoming a high school teacher. In 1955 he starts to teach,

two years as “Referendar”, then one year as “Assessor”, the starting ranks in the German hierarchy of a teacher’s career. At the end of this time he has developed his incomparable skills as a teacher, never to lose them again. Only then does he feel prepared to turn all his attention to science. Günther Ludwig invites him to be his assistant, and within a year, at age 30, he earns his doctoral degree.

At that point he is married to Marga. In 1959 his first son Christian was born. Marianne followed 1961, Peter 1966. Saturn has finished a full cycle and returned to Sagittarius where he meets Jupiter who has completed two and a half turns. Together they work out a plan for a brilliant future.

inspite of tempting offers from other institutions. One of us (P.H. R.) joined his group in that memorable year of 1968. He had been traveling through Germany, visiting a number of universities in search for a good place to do a PhD thesis. When lucky circumstances led him to meet and discuss with Professor Grossmann, there was no doubt he would stay in Marburg. The very same experience, some twenty years later, attracted the other one (D. L.) into Siegfried’s institute at Renthof 6. For both of us, this was one of the best decisions in our lives.

The graphic rendering of Siegfried’s scientific activities in Fig. 1 shows that near the end of the sixties, he widened his interest from transport theory to the theory of phase transitions. At that time, there was a widespread feeling among statistical physicists that a breakthrough in the understanding of critical phenomena was around the corner. Siegfried pursued the line of Yang and Lee and studied the distribution of complex zeros of the canonical partition function. As everybody knows, the solution came in 1971 when Kenneth Wilson applied renormalization theory to the scaling ideas of Leo Kadanoff and Michael Fisher – an achievement that Siegfried greatly admired. That problem being solved, he looked for new challenging fields of research. Non-equilibrium phase transitions were the obvious next topic, such as the laser threshold and: the transition to turbulence.

Turbulence! It took a lot of courage and self-confidence to enter a field which giants such as Heisenberg and Kolmogorov had considered to be one of the most difficult parts of physics. But Siegfried was determined, early on, to make it the main theme of his life as a scientist. By 2002 he had written 88 papers on the matter (by his own attribution of his papers to subjects), and has become the undisputed leader in the field – in Germany for sure, most certainly in Europe, and equal in rank with only a few others in the world. As the above graphic shows, it took him a while to take off. His first paper on turbulence from 1971, “Turbulent transport equations and Kubo formulae for eddy transport coefficients” (*Z. Naturforsch.* 26a, 1782-1791 (1971)), was still a link between his previously acquired expertise in transport theory and

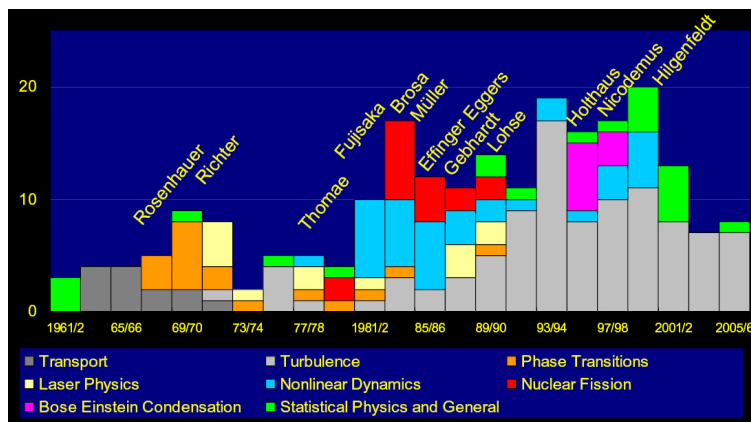


FIG. 1. Spectrum of S. Grossmann’s scientific articles, at a resolution of 2 years, from 1961/62 through 2001/02. The number of papers is given by the height of a column. Colors code for fields of research: general statistical physics (green), transport theory (dark grey), phase transitions (orange), laser physics (light yellow), turbulence (light grey), nonlinear dynamics (blue), nuclear physics (red), Bose-Einstein condensation (magenta). The names refer to coworkers in Marburg with whom S. G. had at least 4 joint publications.

Saturn’s second cycle

Siegfried’s career develops swiftly. Habilitation in 1962 (with work on quantum mechanical transport equations), an appointment at the Technical University of Munich (1963), Extraordinary Professor at the University of Marburg 1964, “Personal Ordinary Professor” 1966, finally Ordinary Professor 1968, all in Marburg where he has stayed ever since

his new love. A period of breeding followed where he developed the vision that ideas from renormalization theory ought to be a promising new idea to understand and quantitatively describe the scaling of eddies in energy dissipation. That's why his output in terms of number of papers came to a low point at the end of his third epoch. Saturn, midway in his second cycle, had to pass the bull's house again.

The outbreak started in 1975, with students like Erwin Schnedler, Stefan Thomae, Hirokazu Fujisaka – still not completely focused on turbulence: nonlinear dynamics came in as a new and exploding activity, starting with the seminal Grossmann-Thomae paper “Invariant distributions and stationary correlation functions of one-dimensional discrete processes” (*Z. Naturforsch.* 32a, 1353-1363 (1977)). This paper, though it got tremendous attention, would have deserved even more. It analyzed the period doubling scenario of the logistic map to unprecedented depth, including the first published value of the scaling exponent, the discovery that it applies on both sides of the accumulation point of the period doubling, and a correlation analysis for the chaotic attractors at Misiurewicz points. Another sidetrack in those years were contributions to nuclear fission: an application of ideas from hydrodynamics to the physics of heavy ion collisions (with Ulrich Brosa and Andreas Müller).

When turbulence took over as the prime activity in the middle of the eighties, it was supported by an excellent team of young people, notably Hans Effinger and Jens Eggers. The paper “Static structure function of turbulent flow from the Navier-Stokes equations” by Effinger and Grossmann (*Z. Phys. B* 66, 289-304 (1987)) was particularly influential: it is full of beautiful ideas and very nicely reveals the essentials of fully developed turbulence. Not only does it give a natural derivation of the different scaling regimes, but with this method they succeeded to directly calculate the Kolmogorov constant from the Navier-Stokes equation, of course in some approximation. As a newcomer around 1990, D. L. found this paper to be the most illuminating entrance to the fascinating world of turbulence.

The fifth epoch

By 1990, Saturn again with Sagittarius, Siegfried has reached the point of his career where the harvest can be collected: his scientific contributions earn him worldwide recognition; his matchless talent as teacher and his superior skills as moderator, councillor, referee, editor, evaluator earn him respect and admiration on all levels – from students to colleagues to professional organizations up to the federal minister of research and technology who appoints him to be chairman of a high ranking advisory committee for developing guidelines of the German federal policy in matters of science and technology (1990-92). This work had far-reaching implications for the direction of basic and applied research in our country.

Siegfried is invited into several academies: the European Academy of Sciences and Arts (1991), the Berlin-Brandenburgische Akademie der Wissenschaften and also the Deutsche Akademie der Naturforscher Leopoldina in Halle (both 1994). He is awarded highly prestigious prizes: the Max Planck-medal of the German Physical Society (1995), the Großes Verdienstkreuz des Verdienstordens of the Federal Republic (1996), the Karl Kupfmüller-Ring of the Technical University of Darmstadt (1997). He acts on many influential committees, including some that award prizes to students and scientists on all levels, most notably the Leibniz- and the Karl Heinz Beckurts-Prize. As a special honor, he is elected first Ombudsman of the German Science Foundation DFG, in recognition of his own impeccable integrity and his unsurpassed ability to handle conflicts.

Siegfried would not be himself if any of this could distract him from his prime concern with science. Fig. 1 proves that his activity continues to flourish – to this very day. We are proud to still be part of it. His attitude in doing science has not changed since we first met him: long and intense sessions at the blackboard that we both gratefully recall as the most effective part of our education as physicists. It was pure intellectual pleasure to see him come to the heart of a problem immediately, and to work it out in detail. He is not driven by any formalism

although he masters them all; his interest is finding a physical explanation of observed phenomena, simple or complex. An impressive recent example is his beautiful article “Hundert Jahre Grenzschichtphysik” (Physik Journal, October 2004) where he uses the opportunity of the 100th anniversary of Prandtl’s first paper on hydrodynamics to explain why an airplane can fly.

At the end of his fifth epoch, tireless as he is, he has started a new initiative: to improve the education of physics teachers in Germany. Using all the weight of his reputation he has put an enormous effort in convincing German authorities to give special attention to an appropriate teacher training *sui generis*. The heavens have more in stock, we are sure, for his sixth epoch, to the benefit of all of us.

Thinking of Siegfried, the planets and stars remind us of Immanuel Kant with whom he shares not only the birthplace but also many standards and virtues: as teacher, thinker, and as a man of wisdom and influence.