CAMTP

Center for Applied Mathematics and Theoretical Physics
Univerza v Mariboru

10. Simpozij fizikov Univerze v Mariboru

Zbornik povzetkov

Hotel Piramida
Maribor, 8., 9. in 10. december 2011

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

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

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Generalni sponzor simpozija: **www.gen-energija.si**

PREDGOVOR

Naši Simpoziji fizikov Univerze v Mariboru, ali na kratko kar Božični simpoziji, imajo že tradicijo, saj imamo letos že desetega po vrsti. Namen je strokovno druženje slovenskih fizikov, ob prisotnosti ter aktivni udeležbi nekaterih uglednih kolegov iz tujine kot častnih vabljenih gostov, pri čemer je srečanje že 2005 preraslo regionalne okvire in je postalo nacionalno srečanje. Letos imamo šest uglednih vabljenih predavateljev iz tujine, iz odličnih raziskovalnih skupin, tako da s tem ostajajo naša srečanja mednarodna. (Lanskoletno srečanje, 9. po vrsti, je bilo izjemoma pretežno mednarodnega značaja, saj je bilo posvečeno Prof. Siegfriedu Grossmannu ob njegovem 80. življenjskem jubileju.) Srečanje je le ena od številnih dejavnosti CAMTP - Centra za uporabno matematiko in teoretično fiziko Univerze v Mariboru, ki sicer organizira kar 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, dosedanji udeleženci, potrjujejo to stališče in cenijo naš znanstveni program. Simpozij daje priložnost mladim raziskovalcem, da predstavijo svoje delo ter se o svojih rezultatih pogovorijo z izkušenimi znanstveniki. S to dejavnostjo prispevamo tudi k popularizaciji fizike v naši družbi, na trajen način. Menimo, da je nujno poskrbeti za večjo popularizacijo naravoslovnih ved v naši družbi, in fizika igra pri tem ključno vlogo. Vsem dodiplomskim študentom dovoljujemo brezplačno udeležbo na vseh predavanjih, in s tem prispevamo k popularizaciji fizike ter k dodatnemu izobraževanju na tem področju.

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

ORGANIZATORJA:
Prof.Dr. Marko Robnik, Direktor CAMTP in Prof.Dr. Dean Korošak

Profesor Siegfried Grossmann - Častni doktor UM

Profesor Siegfried Grossmann z Univerze v Marburgu, Nemčija, prejme častni doktorat Univerze v Mariboru.

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 največnjih 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 270 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 tej priložnosti ponovno 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).

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FOREWORD

Our Symposia of Physicists at the University of Maribor, or shortly Christmas Symposia, already have a tradition, as this year it is already the 10th one. The purpose is the scientific socializing of Slovenian physicists along with the participation of some distinguished colleagues from abroad as our honorary guests. The Symposium in 2005 has already grown large by exceeding the regional boundaries and became a national meeting. This year we have six invited speakers from abroad, from some best research groups, so that our meetings remain international. (The 9th Symposium last year was predominantly international, as it was dedicated to Professor Siegfried Grossmann on occasion of his 80th birthday.) The meeting is only one of the many activities of CAMTP, Center for Applied Mathematics and Theoretical Physics of the University of Maribor, which organizes 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 students, the undergraduate and graduate students. Such general meetings in the field of physics practically no longer exist in the world, although to our opinion they are important for the widening of the intellectual horizon of all physicists. Our colleagues from abroad, the participants so far, confirm our view and appreciate our scientific programme. The meeting is also an opportunity for the young researchers to present their work and discuss it with the experienced scientists. With this activity we also contribute to the promotion and the popularization of physics in our society. We are convinced that it is quite urgent to care about the more intense popularization of natural sciences in our society, and physics plays a key role in this context. All undergraduate students are welcome and can attend all the lectures of the conference free of charge. In this way we contribute to the popularization of physics and to the additional education in this field.

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

ORGANIZERS:
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Professor Siegfried Grossmann receives Honorary Doctorate of UM

Professor Siegfried Grossmann from the University of Marburg, Germany, is awarded the Honorary Doctorate of the University of Maribor.

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 270 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 indispensible 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 wolrdwide, 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 recepient 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 awared 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 again in Maribor on this occasion. 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).

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Urnik 10. Simpozija fizikov Univerze v Mariboru

Četrtek, 8. december 2011	
Chair	Robnik
09:00-10:00	Grossmann
10:00-11:00	Križan
11:00-11:30	tea, coffee
11:30-12:30	McClintock
12:30-13:00	Bonča
13:00-13:30	Šmit
13:30-15:00	lunch
Chair	Prosen
15:00-16:00	Schmelcher
16:00-16:30	tea, coffee
16:30-17:00	Robnik
17:00-17:30	Dvorak
17:30-17:45	Grozdanov
17:45-18:15	Vaupotič
19:00-19:45	Č. Dr. Grossmann
19:45-	Concert and Dinner

Petek, 9. december 2011	
Chair	McClintock
09:00-10:00	Žumer
10:00-11:00	Mihailović
11:00-11:30	tea, coffee
11:30-12:30	Aizawa
12:30-13:00	De Ninno
13:00-13:30	Ramšak
13:30-15:00	lunch
Chair	Šmit
15:00-16:00	Prosen
16:00-16:30	tea, coffee
16:30-17:30	Plessas
17:30-18:00	Manos
18:00-18:30	Tkalec
18:30-18:45	Batistić
18:45-19:00	Žumer
19:45-	Concert and Dinner

Sobota, 10. december 2011	
Chair	Aizawa
09:00-10:00	Šarler
10:00-10:30	Stepišnik
10:30-11:00	Arčon
11:00-11:30	tea, coffee
11:30-12:30	Rosina
12:30-13:00	Veble
13:00-13:30	Čopič
13:30-15:00	lunch
Chair	Plessas
15:00-15:30	Horvat
15:30-16:00	Žagar
16:00-16:30	tea, coffee
16:30-16:45	Fregolente
16:45-17:00	Huljev Čadež
17:00-17:30	Žitko
17:30-17:45	Abina
17:45-18:00	Puc
19:45	Farewell drink and dinner

Metode pri teraherčnem pulznem slikanju

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Teraherčno (THz) pulzno slikanje je neinvazivna optična tehnika, ki temelji na elektromagnetnem valovanju v frekvenčnem področju med 0,1 THz in 10 THz oz. v območju odgovarjajoče valovne dolžine med 3 mm in 30 μm [1-2]. Teraherčno slikanje in spektroskopija sta hitro razvijajoči se področji s širokim razponom možnosti uporabe v medicini, varnosti, farmaciji, umetnosti, diagnostiki polprevodniških naprav ter mnogih drugih aplikacijah [3-4]. Na vseh omenjenih področjih je za uporabo v realnih razmerah nujno potreben nadaljnji razvoj tako THz sistemov kot tudi slikovnih tehnik. Večina sedanjih raziskav je usmerjenih v izboljšave strojne opreme, medtem ko slikovne tehnike za THz sisteme niso dovolj raziskane. Iz tega razloga smo se odločili razviti algoritme za potrebe THz slikanja, ki so lahko uporabni v transmisijski kot tudi refleksijski geometriji sistema. Predstavili bomo tri različne tehnike slikanja, prilagojene različnim aplikativnim zahtevam. Slikanje v časovnem prostoru je najhitrejša metoda, ki omogoča samo detekcijo objektov brez spektralne informacije. Multispektralna metoda na osnovi Fourierjeve transformacije omogoča slikanje pri različnih frekvencah in podaja specifične odzive posameznih snovi. Mapiranje prostorske porazdelitve ponuja možnost sočasne vizualizacije posameznih substanc znotraj vzorca. Predlagane metode slikanja so osnova za klasifikacijo in identifikacijo preiskovanih materialov pri posameznih aplikacijah.

Reference

[1] Zhang, X.-C. and Jingzhou Xu, Introduction to THz Wave Photonics, ISBN: 978-1-4419-0977-0, Springer, (2010).

[2] Walther, M., et al., Chemical sensing and imaging with pulsed terahertz radiation, Analytical and Bioanalytical Chemistry, vol. 397, pp. 1009-1017, (2010).

[3] Yao-Chun, S. and Taday, P. F., Development and Application of Terahertz Pulsed Imaging for Nondestructive Inspection of Pharmaceutical Tablet, Selected Topics in Quantum Electronics, IEEE Journal of, vol. 14, pp. 407-415, (2008).

[4] Wallace, V. P., et al., Three-dimensional imaging of optically opaque materials using nonionizing terahertz radiation, J. Opt. Soc. Am. A, vol. 25, pp. 3120-3133, (2008).

Methods for terahertz pulse imaging

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Terahertz (THz) pulse imaging is a non-invasive optical technique using electromagnetic radiation, typically defined in the frequency range of 0.1 THz to 10 THz, corresponding to a wavelength range of 3 mm to 30 μm [1-2]. Terahertz imaging and spectroscopy is the rapidly developing field that could be applicable to wide range of applications in medicine, security, pharmaceutical science, inspection of artworks, semiconductor device diagnostics and many others [3-4]. Further development of THz systems and imaging techniques is necessary for applications in real world conditions. Much of the present research is focused on improving the system hardware, whereas the imaging techniques have not been explored much. Therefore, we developed several algorithms for THz imaging that could be used in transmission as well as reflection geometry. In this contribution we present three different imaging techniques each suitable for different applications. Time-domain imaging is used for fast imaging without the need for spectroscopic information; multispectral imaging with Fourier transform allows imaging at different frequencies whereas spatial distribution map is able to differentiate between various compounds within the sample. The proposed methods are the foundation for classification or identification of investigated materials for specific applications.

References

[1] Zhang, X.-C. and Jingzhou Xu, Introduction to THz Wave Photonics, ISBN: 978-1-4419-0977-0, Springer, (2010).

[2] Walther, M., et al., Chemical sensing and imaging with pulsed terahertz radiation, Analytical and Bioanalytical Chemistry, vol. 397, pp. 1009-1017, (2010).

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Seismicity statistics in view of chaos theory

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A variety of seismic phenomena observed in the world often reveal some common aspects and characteristic behaviors in statistical sense, and the empirical laws of those statistical behaviors have been pursued in the framework of statistical seismology though the complex physical mechanisms of earthquakes have not yet been elucidated in details.
In my talk, several universal aspects in the empirical laws are studied from the viewpoint of deterministic chaos theory, where it is especially emphasized that the statistical behaviors of earthquakes have strong similarity with the stationary-nonstationary chaos transition in a critical regime. Next, by use of the Data-Catalog(Japan,California,Taiwan) we point out that a universal constant exists in the seismic statistics. The physical meaning of the universal constant is not clear so far, but we discuss the temporal shift of the seismicity statistics before and after the big earthquake at 3.11(2011) near Fukushima . Contents of my talk will be the followings, and please refer the details in the attached Reference.

References

Please see the attached paper by Aizawa entitled, "Foundations of earthquake statistics in view of non-stationary chaos", Bussei kenkyu (Kyoto University) Dec.(2011),in press.

Superprevodnost v tekmi z antiferomagnetno urejanim Mottovim izolatorskim stanjem v dopiranih fulerenskih soleh

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Superprevodnost v fulerenskih soleh dopiranih z alkalnimi kovinami (A_3C_{60} kjer je A = alkalna kovina) so dolgo razlagali znotraj BCS teorije, kjer so za tvorbo Cooperjevih parov odločilna visokofrekvenčna intramolekularna nihanja. Z našimi zadnjimi rezultati [1-3] pa smo to preprosto sliko ovrgli in dokazali pomembnost elektronskih korelacij v teh sistemih. Za kubične Cs_3C_{60} faze, ki obdržijo trojno degeneracijo elektronsko aktivnih t_{1u} orbital, smo pokazali, da so pod normalnimi pogoji pravzaprav izolatorji. Vzrok za to so močne elektronske korelacije, ki prevladajo nad kinetično energijo delokaliziranih elektronov in so tudi odgovorne za antiferomagnetno urejanje pri temperaturi $T_N = 46$ K v A15 [1,2] ter $T_N = 2$ K v fcc fazi [3]. Ob uporabi visokih pritiskov, A15 preide v kovinsko fazo in postane superprevoden pri presenetljivo visoki kritični temperaturi $T_C = 38$ K (pri tlaku 0.79 GPa) [1]. Najvišja kritična temperatura za fcc fazo je 35 K [3]. V tem prispevku bomo poročali o naših NMR meritvah pri nizkih temperaturah in visokih tlakih s katerimi lahko natančno raziskujemo tako Mottovo izolatorsko kot tudi kovinsko/superevodno fazo ter prehajanje med njima.

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Superconductivity competing with the antiferromagnetic Mott insulating state in alkali-doped fullerides

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Superconductivity in alkali fullerides (A_3C_{60} where A = alkali metal) was for many years discussed within the BCS theory where high-energy intramolecular phonons are responsible for the Cooper pairing with $s-$wave symmetry. This view has been challenged recently by us with the discovery that cubic Cs_3C_{60} [1-3], which retain the threefold degeneracy of the electronically active t_{1u} orbitals, is under ambient pressure conditions insulator. In these compounds, the electronic correlations win over the kinetic energy due to the electronic delocalisation and are responsible for the antiferromagnetic insulating (AFI) ground state with $T_N = 46$ K in the A15 [1,2] and $T_N = 2$ K in the fcc polymorph [3]. With the application of pressure, A15 Cs_3C_{60} undergoes a metal-insulator transition (MIT) and the superconductivity is restored at the surprisingly high temperature of $T_C = 38$ K at 0.79 GPa [1]. The highest superconducting transition temperature in fcc phase is 35 K [3]. In this contribution we report on our temperature and pressure dependent local probe NMR investigations of both cubic Cs_3C_{60} phases for the study of Mott insulating and high-temperature superconducting states

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Dinamika hitrosti v časovno odvisnih biljardih

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Časovno odvisni biljardi so pomemben model za razumevanje raznih fizikalnih pojavov, kot na primer izvor visokih energij kozmičnih delcev [1]. Dobro je zano, da hitrost delca v časovno odvisnih biljardih narašča po potenčnem zakonu $v = n^{\beta}$, s številom trkov n, kjer β imenujemo eksponent pospeševanjai [2,3,4,5,6,7,8]. Temu pojavu pravimo Fermijevo pospeševanje. Različne vrednosti parametra β in sploh mehanizem, ki privede do Fermijevega pospeševanja, sta zaenkrat slabo razumljena. Osnovna tehnična težava je nezveznost hitrosti pri trku delca s premikajočo steno biljarda. V tem prispevku bom predstavil način kako lahko dinamiko hitrosti obravnavamo s pomočjo splošne transformacije hitrosti in koordinat, ki je zvezna funkcija časa in jo imenujem črtkana hitrost v'. Že iz same strukture diferencialne enačbe za v' lahko razberemo veliko splošnih lastnosti časovno odvisnih biljardov, ki do sedaj niso bili poznani (na primer β). Teorijo bom apliciral na primer popolnoma kaotičnih biljardov.

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The velocity dynamics in time dependent billiards

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Time dependent billiards are important models for understanding various physical systems, as for example the large energies of the cosmic rays [1]. It is well known that the velocity of the particle in time dependent billiards grows as a power law $v = n^{\beta}$, with the number of collisions n, where β is the acceleration exponent [2,3,4,5,6,7,8]. Various values for β and the mechanism of the Fermi acceleration are not well understood. The basic technical obstacle is that the velocity of the particle is discontinuous at the collision with a moving wall of a billiard. In this talk I shall present the way how we can investigate the velocity dynamics through the transformation of the velocity and the position, which is the smooth function of time and which I call the primed velocity v'. Solely from the structure of the differential equation for v', many interesting, previously unknown properties, of general time dependent billiards may be deduced (e.g. values of β). I shall apply the theory to the case of fully chaotic billiards.

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Neravnovesna dinamika večdelčnih sistemov pod vplivom konstantnega električnega polja

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Predstavil bom fundamentalno študijo Holsteinovega polarona v eni dimenziji ter ene vrzeli v t-J-Holsteinovem modelu pod vplivom zunanjega električnega polja. Ob upoštevanju kvantno mehanske narave problema sledimo časovnemu razvoju sistema začenši z osnovnim stanjem ko vključimo električno polje ob času nič ter vse do stacionarnega stanja. V sistemu Holsteinovega polarona opazimo adiabatski režim s Blochovimi oscilacijami kjer v povprečju ni električnega toka ter disipativni režim s končnim tokom [1]. V primeru t-J modela prav tako opazimo adiabatski režim, kateremu sledi režim linearne $I-V$ karakteristike pri vmesnih električnih poljih [2,3]. Pri visokih poljih se sistem nahaja v režimu negativne diferencialne upornosti. Na koncu bom prikazal soodvisnost med močnimi korelacijami ter sklopitvijo z mrežo v t-J-Holsteinovem modelu daleč od ravnovesja [4].

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Nonequilibrium dynamics of many-body systems, driven by a constant electric field

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I will present a fundamental study of a Holstein polaron in one dimension and a single hole in the two dimensional t-J-Holstein model driven by a constant electric field. Taking fully into account quantum effects we follow the time-evolution of systems from their ground state as the electric field is switched on at $t = 0$, until they reach a steady state. In the Holstein polaron we observe: adiabatic regime with Bloch oscillations and zero net current and a dissipative regime with a finite current that is further divided on a linear $I - V$ region and a region with a negative differential resistance[1]. In the t-J model adiabatic regime is observed followed by the positive differential resistivity at moderate fields where carrier mobility is determined [2,3]. At large field the system enters negative differential resistivity regime where current remains finite, proportional to $1/F$. Finally we discuss the interplay between strong correlations and lattice effects in a driven t-J-Holstein model [4].

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Raziskave tekočekristalnih elastomerov s svetlobo

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V tekočekristalnih elastomerih (LCE) je nematični director sklopljen z deformacijo polimerne mreže. Zaradi tega imajo LCE zanimive lastnosti, kot na primer izjemno veliko spremebo dolžine s temperature, kar bo morda uporabno za mehanske aktuatorje. Termično vzbujene fluktuacije nematičnega direktorja, ki jih lahko opazujemo s sipanjem svetlobe, in termomehanične meritve nam omogov cajo določiti vse bistvene parameter teorije LCE.

Posebno zanimivi so fotobčutljivi LCE, v katerih lahko nematični red in s tem mehansko stanje spreminjamo preko fotoizomerizacije derivatov azobenzena, ki pri obsevnju z UV svetlobo prehajajo iz trans v cis konformacijo. Določili smo porazdelitev cis izomera v odvisnosti od obsevanja. Pri tem smo analizirali procese nelinearne absorpcije in merili uklonske lastnosti mrežice, zapisane v vzorec z dvema UV laserskima žarkoma.

Probing liquid crystal elastomers with light

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In liquid crystal elastomers (LCE) the nematic director is coupled to the strain of the polymer network. This leads to some interesting properites of the LC elastomers like very large length change with temperature, potentially useful as artificial muscles. Thermally excited fluctuations of the nematic director, observed by dynamic light scattering, combined with thermo-mechanical measurements allow us to determine the important parameters of the theoretical model of LCE. Of particular interest are photosensitive LCE, where the nematic order and with it the mechanical state can be changed by photo-isomerization of an azobenzene derivative undergoing trans-cis isomerization. We determined the distribution of the cis isomer as a function of illumination dose by analyzing nonlinear absorption process and by measuring the diffraction properties of a grating written in the sample with two UV laser beams.

CITIUS: An ultra-fast VUV/X-ray light source for user experiments at Nova Gorica University

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We will present the principle and the expected performance of CITIUS, a new state-of-the-art VUV/X-ray, ultra-fast and tunable light source, which will be soon operational at Nova Gorica University. The strategic project for CITIUS realization has been funded within the program for cross-border Italy-Slovenia Cooperation 2007-2013. The source is based on the generation of high-order harmonics of a powerful femtosecond laser interacting with a gas of noble atoms. The CITIUS source will allow to carry out cutting-edge experiments on gas-phase and solid-state matter samples. Both the source development and the envisaged experimental program are intimately connected to those of FERMI@Elettra, the new single-pass free-electron laser, which is presently under commissioning at Sincrotrone Trieste.

On the stability of Earth's Trojans

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The gas giants Jupiter and Neptune are known to host Trojan asteroids, and also Mars has several co-orbiting Asteroids. In an extensive numerical investigation we checked the possibility of captures of asteroids by the terrestrial planets into the 1:1 mean motion resonance. Recently the first Earth Trojan has been observed (Connors et al, Nature 475) and found to be in an interesting orbit close to the Lagrange point L4. We did a study of the phase space structure of the Earth's Lagrange points with respect to eccentricities and inclinations of a large number of fictitious Trojans. The extension of stable zones could be established with the aid of dynamical mappings; the known Trojan 2010 TK7 finds himself only on the edge of this zone.

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Parameter-space for a dissipative Fermi-Ulam model

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The parameter-space for a dissipative bouncing ball model under the effect of inelastic collisions is studied. The system is described by using a two-dimensional nonlinear area-contracting map. The introduction of dissipation destroys the mixed structure of phase space of the non-dissipative case leading to the existence of a chaotic attractor and attracting fixed points which may coexist for certain ranges of control parameters. We have computed the average velocity for the parameter space and we have made a connection with the parameter space based on the maximum Lyapunov exponent. For both cases we have found an infinite family of self-similar structures of shrimp-shape which correspond to the periodic attractors embedded in a large region which corresponds to the chaotic motion. The procedure is of broad interest and can be extended to many other different two dimensional area contracting models [1].

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Ultimate state of strong turbulent convective heat and momentum transport

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Two recently built large facilities open the possibility to study turbulent transport in closed systems with solid boundaries for extremely large thermal or shear-based driving, the so called Goettingen UBoot, a Rayleigh-Bénard system, cf. [1] and the so called T^3C or Twente Turbulent Taylor Couette device, cf. [2]. The data from these facilities gave and ongoingly give surprising new insight into the *ultimate state* of turbulence under realistic conditions with physical boundaries. The talk is devoted to the physical interpretation, the understanding of the mechanisms, and the spatial flow structures of Rayleigh-Bénard and Taylor-Couette flows. Recent results are available in References [3] and [4], respectively, whose authors contributed to this talk and made it possible.

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Holographic duality: Condensed Matter Physics from String Theory

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The AdS/CFT correspondence, or holographic duality, is a duality between strongly coupled field theories and string theory (gravity). Originally, the four dimensional $\mathcal{N} = 4$ Superconformal Yang-Mills theory with the $SU(N)$ gauge group was shown to be dual, in the large N limit, to type IIB string theory compactified on $AdS_5 \times S^5$. Since field theory can be thought of as living on the four dimensional boundary of the five dimensional Anti-de Sitter bulk, it provides a holographic description of the gravity theory. The duality has since been extended to numerous other conformal and non-conformal large N cases. I will present the dictionary which relates quantities describing the dual theories. I will focus on discussing how properties of strongly coupled field theories, such as symmetries, temperature, density, etc., can be understood from the geometric picture of weakly coupled gravitational duals. Perhaps most striking is the relation between the energy scale of the field theory and the extra bulk dimension. I will also present applications of the duality to low energy physics, such as hydrodynamics and condensed matter physics. In particular, I will highlight the calculation of hydrodynamic transport coefficients which leads to the universal shear viscosity to entropy density bound for field theories. Finally, possible applications to superconductivity at high temperature will be discussed.

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Avtonomni relativistični satelitski navigacijski sistem

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Globalni satelitski navigacijski sistemi (GNSS), kot so Galileo in GPS, upoštevajo motnje, ki jih povzroča Zemlja na prostor in čas v njeni bližini (ukrivljenost prostora-časa) in učinke relativnega gibanja vesoljskih plovilih in uporabnikov (relativistični vztrajnostni učinki). Trenutno je v uporabi Newtonski koncept absolutnega prostora in časa, ki je vezan na povprečni geodetski model s številnimi relativističnimi popravki zavisoč od želene natančnosti. Nov in izviren pristop je modeliranje navigacijska sistema neposredno v okviru splošne teorije relativnosti, kjer prostor in čas nista več absolutna. Ta pristop poenostavlja navigacijske sisteme, povečuje njihovo zanesljivost in natančnost in, z ustrezno implementacijo, naredi avtonomne, kar bo podrobneje predstavljeno na predavanju.

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Autonomous relativistic global navigation satellite system

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Global Navigation Satellite Systems (GNSS), such as Galileo and GPS, have to consider distortions caused by the Earth on space and time in its vicinity (space-time curvature) and the effects of relative motions between the spacecrafts and the user (relativistic inertial effects). It uses the Newtonian conception of absolute space and time tied to an average geodetic model and add relativistic corrections depending on the desired accuracy. A new and original approach is to model the navigation system itself directly in the general relativity, where the space and time are not considered as absolute. This approach simplifies the navigation systems and makes it autonomous, which will be in more detail presented in the lecture.

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Prepletanje in razpletanje močno interagirajočih elektronov

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Obravnavamo časovni razvoj kvantne prepletenosti za primer več zaporednih sipanj dveh elektronov, predstavljenih z valovnima paketoma na enodimenzionalni verigi atomov s periodičnimi robnimi pogoji. Upoštevamo različne oblike interakcije: odboj s končnim dosegom, Hubbardov model, izmenjalna in Dzyaloshinskii - Moriya interakcija med najbližjimi sosedi. Kot mero prepletenosti uporabimo uglašenost (konkurenco) za delokalizirane elektrone [1]. Za izračun uglašenosti po večih sipanjih uporabimo formalizem sipalne matrike, problem prevedemo na dvonivojski sistem in podamo uglašenost kot projekcijo zavrtenega vektorja spina na Blochovi sferi. Z zaporednimi sipanji se elektrona prepletata in razpletata. Pokažemo, kako končna širina paketov zmanjša uglašenost. Za potrditev dušenja uglašenosti analiziramo sipanje dveh elektronov v zunanjem statičnem harmonskem potencialu in potrdimo ujemanje med analitičnimi rezultati in numerično simulacijo [2].

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Entangling and disentangling of strongly interacting electrons

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We consider the time evolution of entanglement for successive scatterings of two electrons, described as wavepackets, on an one-dimensional, homogeneous, tight binding array, with periodic boundary conditions. We consider various types of interaction: finite range repulsion, the Hubbard model, nearest neighbours exchange and Dzyaloshinskii - Moriya interaction. As a measure of the entanglement we use the concurrence for delocalized electrons [1]. We use scattering matrix formalism to calculate concurrence after multiple scatterings, map the problem to a two level system and give the concurrence as a projection of a vector on the Bloch sphere. With successive scatterings the electrons entangle and disentangle. The effect of finite wavepacket width is reduction of the concurrence. To observe damping of the concurrence we analize the scattering of the electrons in external static harmonic potential. We find perfect agreement between the analytical formulas and numerical simulations [2].

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Novi rezultati na področju fizike okusov

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V prispevku bom najprej obdelal nekaj novejših rezultatov raziskav, ki smo jih pri eksperimentih Belle in BaBar opravili v zadnjem letu. Obravnavali bomo komplementarnost meritev redkih procesov pri razpadih mezonov B in D z meritvami na Velikem hadronskem trkalniku (LHC). Na kratko bo govora tudi o naslednji generaciji poskusov v fiziki mezonov B in D, ter o novem projektu, ki ga v ta namen pripravljamo na pospeševalniku KEKB.

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Flavour Physics at the Intensity Frontier

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The paper discusses selected recent results from B factories, precision measurements of the unitarity triangle, a new method to determine ϕ_3, exclusive and inclusive measurements of $|V_{ub}|$), reviews the studies of rare B decays, direct CP violation and searches for CPT violation, investigation of CP violation in D decays, studies of $\Upsilon(5S)$ decays, new resonances h_b and Z_b, and properties of the $X(3872)$ state. Finally, the paper reviews plans for the future related to super B factories, and gives a summary and an outlook.

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Dynamical and observational chaos in barred galaxies

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The distinction between chaotic and regular behavior of orbits in galactic models is an important issue and can help our understanding of galactic dynamical evolution. In this talk, we deal with this issue by applying the techniques of the Smaller (and Generalized) ALingment Indices, SALI (and GALI), to extensive samples of orbits in a barred galaxy potential. We estimate the fraction of chaotic and regular orbits for different sets of initial conditions and we vary the model parameters, like the mass, size and pattern speed of the bar. We also combine the GALI method with new ways of interpreting Fourier spectra to distinguish strong chaotic motion from weak chaotic and regular and then classify chaotic trajectories with different rates of orbital diffusion in configuration space. Finally, we present some preliminary results showing velocity distribution diagrams, which can be useful in identifying regular and chaotic motion in real observational data.

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Rogue waves on the ocean and in superfluid helium

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Rogue waves on the ocean [1] are much higher (and steeper) than all the other waves around them. They are a menace to shipping, e.g. 22 super-carriers (vessels over 200m long) were lost at sea during 1968-1994, with 525 deaths. So it is obviously very important to understand how and why they are created. Unfortunately, they are difficult to study in the ocean because of their rarity, and because experiments are almost impossible. One likely generating mechanism involves nonlinear interactions within the "noisy background" of smaller wind-blown waves [2]. These nonlinear interactions are being studied through laboratory experiments on superfluid ^{4}He, where rogue waves can be studied under controlled conditions. We will review briefly the necessary background in turbulence and superfluidity, discuss why superfluid ^{4}He is an ideal medium for modelling nonlinear wave interactions and wave turbulence in the laboratory [3,4,5], present our observations of rogue waves [6], and consider their implications.

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Femtosekundne trajektorije skozi zlom simetrije

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Študij trajektorij različnih sistemov skozi prehod z zlomom simetrije - bodisi v fiziki kondenzirane materije, v kozmologiji, elementarnih delcih ali financah - je postal zelo popularen v zadnjih letih. Kondenzirana materija ponuja raznolikost simetrij parametrov reda in mikroskopskih interakcij, ki jih lahko raziskujemo zelo podrobno s pomočjo različnih metod. S pomočjo nove posebej razvite metode femtosekundne spektroskopije lahko opazujemo tako enodelčne fermionske kot kolektivne bozonske vzbuditve s femtosekundno ločljivostjo v realnem času skozi fazni prehod v sistemih z elektronskimi prehodi v urejeno elektronsko stanje, bodisi z valovi gostote naboja, ali v superprevodno stanje. Zanimivosti, ki jih lahko opazujemo na ta način, so koherentne oscilacije parametra reda med trajektorijo v urejeno stanje, pojav topoloških defektov in njihova izničenja, ki povzročijo emisijo valov amplitudnih oscilacij s končno frekvenco, analognim Higgsovim bozonom. Modeliranje opazovanj je presenetljivo uspešno zgolj na osnovi Ginzburg-Landau teorije brez prostih parametrov v sistemih z valovi gostote naboja. V superprevodnikih pa se meritve odlično ujemajo z napovedmi Kabanova in Lu-Daca, ki v modelu upoštevajo tudi termalno dinamiko ter posebej obravnavajo fermionsko in bozonsko temperaturo.

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Femtosecond trajectories through symmetry-breaking transitions in correlated electron systems.

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The study of system trajectories through symmetry breaking phase transitions (SBTs) - whether in condensed matter physics, cosmology or finance - has become a topic of significant interest in recent years. Condensed matter systems as model systems offer a variety of different order parameter symmetries and microscopic interactions, yet can be probed in great detail using new spectroscopy methods. Using new specially devised femtosecond spectroscopy techniques we are able to study the femtosecond evolution of bosonic and fermionic excitations through an electronic charge-ordering transition in charge-density-wave systems[1,2] and in the La1.9Sr0.1CuO4 superconductor[3] revealing coherent aperiodic undulations of the order parameter, critical slowing down, and creation of the particle-hole gap as the system evolves through the SBT. Of particular interest is the observation of spectro-temporal distortions arising from spontaneous annihilation of topological defects and concurrent emission of Higgs waves, analogous to topological excitations discussed by the Kibble-Zurek cosmological model. Modeling based on Ginzburg-Landau theory developed by Brazovskii is used to reproduce the aftermath of the transition in CDWs without free parameters1,2. The two types of system studied highlight the difference between constrained evolution and rapid quench behaviour. Comparison of data with predictions of Lu-Dac and Kabanov in the close vicinity of the transition indicates behavior beyond TDGL predictions.

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Universal quark model for baryons

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A new constituent-quark model is presented that is capable of describing all known baryons with flavors *up*, *down*, *strange*, *charm*, and *bottom*. It is formulated in a relativistic framework, relying on a Poincaré-invariant mass operator for three confined constituent quarks, interacting through the exchange of Goldstone bosons in an $SU(5)_F$ flavor symmetry. The model is an extension of the so-called Goldstone-boson-exchange relativistic constituent-quark model published by the Graz group more than a decade ago [1]. This model has been very successful in describing a series of baryon properties within $SU(3)_F$, i.e. of the nucleons and hyperons. Notable achievements beyond the baryon spectroscopy are among others the description of the baryon electromagnetic and axial form factors [2], the microscopic explanation of meson-baryon interaction vertices [3], and the baryon classification into flavor multiplets [4]. The extended quark model preserves all features of the previous one in the $SU(3)_F$ sector and covers in addition the baryons with flavors *charm* and *bottom*. Thereby it also offers a solution to the intricate problem of quark-quark interactions between light-heavy and heavy-heavy flavors.

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Točno neravnovesno stacionarno stanje odprte anizotropne Heisenbergove verige

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Predstavil bom pristop k problemu neravnovesnega kvantnega transporta v eni dimenziji [1], ki temelji na teoriji odprtih kvantnih sistemov in Lindbladovi enačbi [2].

Demonstriral bom netrivialno točno rešitev mnogo-delčne Lindbladove enačbe za močno koreliran Hamiltonov operator (anizotropne Heisenbergove verige spinov 1/2) in preproste de-koherenčne (Lindbladove) operatorje, ki delujejo le na obeh robovih verige. Zapisal bom ekzakten nastavek v obliki tenzorske mreže s topologijo lestve [3], ki opiše neravnovesno stacionarno stanje odprte Heisenbergove verige v ekstremnem neravnovesnem režimu, za poljubno močno sklopitev z rezervoarji/okolico. Mnogodelčni gostotni operator neravnovesnega stacionarnega stanja končnega sistema n spinov je tedaj - do normalizacijske konstante - polinom reda $2n-2$ v sklopitveni konstanti. Zanimive fizikalne opazljivke lahko učinkovito računamo s pomočjo prehodnega (transfer) operatorja, ki spominja na klasični Markovski proces. V izotropnem primeru najdemo univerzalni kosinusni spinski profil, skaliranje spinskega toka kot $\propto 1/n^2$ in korelacije dolgega dosega v ravnovesnem stanju.

Še več, perturbacijsko verzijo našega nastavka [4[lahko uporabimo za zapis novega psevdo-lokalnega ohranitvenega zakona v anizotropnem Heisenbergovem modelu, ki nam omogoči rigorozno oceno spinske Drudejeve uteži (balističnega transportnega koeficienta).

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Exact nonequilibrium steady state of a strongly driven open anisotropic Heisenberg chain

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We address the non-equilibrium quantum transport problem in one dimension [1] using the approach of open quantum system and Lindblad equation [2]. In fact, we demonstrate a non-trivial exactly solvable case of the many-body Lindblad equation with strongly correlated bulk Hamiltonian (namely, the anisotropic Heisenberg spin 1/2 chain) and simple dissipation/decoherence (i.e. Lindblad) operators acting on the boundary two spins of the chain only. An exact ladder-tensor-network ansatz is presented [3] for nonequilibrium steady state of the open Heisenberg model in the far from equilibrium regime. We show that the steady-state density operator of a finite system of size n is – apart from a normalization constant – a polynomial of degree $2n-2$ in the coupling constant. Efficient computation of physical observables is facilitated in terms of a transfer-operator reminiscent of a classical Markov process. In the isotropic case we find cosine spin profiles, $1/n^2$ scaling of the spin current, and long-range correlations in the steady state. Furthermore, the perturbative (weak coupling) version of our ansatz [4] is used to derive a novel pseudo-local conservation law of the anisotropic Heisenberg model, by means of which we rigorously estimate the spin Drude weight (the ballistic transport coefficient) in the easy-plane regime. This closes a long standing question in strongly correlated condensed matter physics.

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Viri in detektorji za spektroskopsko teraherčno slikanje na daljavo

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V okolju smo nenehno izpostavljeni različnim virom teraherčnega (THz) sevanja, od sevanja kozmičnega ozadja do sevanja okolja pri različnih temperaturah. Večina naravnih virov sevanja je nekoherentnih in tako manj primernih za uporabo. Tekom zadnjih dveh desetletij je tehnološki napredek na področju optike in elektronike pripomogel k razvoju različnih tipov THz izvorov in detektorjev, ki jih delimo na optične in elektronske [1-2]. O njihovi uporabi se odločamo na osnovi namena in zahtevnosti želene aplikacije. Veliko pozornosti je namenjeno razvoju sistemov, ki omogočajo realno-časovno slikanje na daljših razdaljah v refleksijskem načinu in normalnih atmosferskih razmerah [3-4]. V tem prispevku smo se osredotočili na optimizacijo potencialnih THz virov in detektorjev za spektroskopsko THz slikanje v refleksijskem načinu. S predlaganimi THz viri in detektorji je mogoče izgraditi sistem, ki omogoča slikanje na daljavo v normalnih atmosferskih okoliščinah, kjer največjo omejitev predstavlja vpliv vlage na absorpcijo THz valovanja. Dosedanje raziskave na področju THz detekcije in slikanja na daljavo so bile po večini usmerjene v frekvenčno območje nekaj sto GHz. Predstavljeni viri in detektorji omogočajo slikanje na frekvencah večjih od 600 GHz, kjer se opazijo nekatere pomembne značilnosti kemijske strukture snovi.

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Sources and detectors for stand-off spectroscopic terahertz imaging

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Terahertz (THz) radiation is surrounding us in every day's life, including the radiation from cosmic background and environmental radiation caused by different temperatures. Most of the natural THz sources are incoherent and therefore inappropriate for practical use. In the last decades, technological advances in the fields of optics and electronics have contributed to the development of different types of THz sources and detectors. Generally, we can divide them in to two separate groups: optical and electronic [1-2]. However, the use of them depends on application needs. Currently, many research works are concerned with the development of the systems, which are able to provide real-time imaging at larger distances in reflection geometry at normal atmospheric conditions [3-4]. In this contribution we consider to optimize potential THz sources and detectors for spectroscopic THz imaging in reflection geometry. Proposed THz sources and detectors enable construction of a system for stand-off imaging at normal atmospheric conditions, where the water vapour absorption is a major obstacle. Previous research regarding THz detection and imaging basically focused on low frequencies region in the range of few hundred GHz, whereas the presented sources and detectors are capable of imaging at frequencies higher than 600 GHz, where some major characteristics of chemical structure for substance are observable.

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Geometrijska obravnava kvantne prepletenosti

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Kljub temu, da je za podroben mikroskopski opis fizikalnih problemov potrebna polna kvantno mehanska obravnava, v splošnem o različnih fizikalnih količinah razpravljamo kot o klasičnih spremenljivkah. Ena od izjem je kvantna prepletenost, ki na videz nima nikakršne klasične analogije. Pokazali bomo, da se dva spinsko prepletena elektrona vseeno da analizirati s spremenljivkami v navadnem tridimenzionalnem prostoru, in sicer s koti med vrtilno količino prvega in drugega delca. Takšna formulacija nam omogoči, da kvantno prepletenost izrazimo kot pričakovano vrednost ustreznih trigonometrijskih operatorjev [1].

Podobno lahko predstavimo kvantno prepletenost v okviru de Broglie-Bohmove interpretacije kvantne mehanike, ki omogoča direkno vizualizacijo dinamike spinskega gibanja dveh prepletenih elektronov. Prepletenost je tukaj izražena s povprečno vrednostjo ansambla v Bohmovem prostoru skritih spremenljivk. Dodatno se izkaže, da se kvantno prepleteni pari gibljejo na specifičen način, česar v standardni formulaciji kvantne mehanike ne moremo analizirati [2].

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Geometrical view of quantum entanglement

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Although a precise description of microscopic physical problems requires a full quantum mechanical treatment, physical quantities are generally discussed in terms of classical variables. One exception is quantum entanglement which apparently has no classical counterpart. However, two entangled electron spins, or qubits, can be analyzed in terms of ordinary three-dimensional space geometric properties, as are the angles between their angular momenta. This formulation allows concurrence, a measure of quantum entanglement, to be expressed as expectation values of trigonometric functions of the azimuthal angle between the two angular momenta [1].

We demonstrate also how quantum entanglement may be within the de Broglie-Bohm interpretation of quantum mechanics visualized, giving new insight into this mysterious phenomenon and a language to describe it. On the basis of our analysis of the dynamics of a pair of qubits, quantum entanglement is linked to concurrent motion of angular momenta in the Bohmian space of hidden variables and to the average angle between these momenta [2].

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Adiabatske invariante in statistične lastnosti časovno odvisnih linearnih in nelinearnih hamiltonskih oscilatorjev

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Predstavil bom nekaj najnovejših študij 1D časovno odvisnih linearnih [1] in nelinearnih hamiltonskih oscilatorjev [12]. Naš glavni interes je oceniti točnost ohranitve adiabatskih invariant in s tem povezano vprašanje statističnih lastnosti, kot je časovni razvoj energije in porazdelitve energije za mikrokanonične ansamble začetnih pogojev. V primeru linearnega oscilatorja lahko ta problem rešimo rigorozno in rešitve lahko zelo dobro aproksimiramo s pomočjo WKB metode, ki smo jo razvili eksaktno do vseh redov [10,1]. Izkaže se, v vsej splošnosti in rigorozno, da se vrednost adiabatske invariante pri povprečni energiji v linearnem oscilatorju nikoli ne zmanjša, in se ohranja samo v idealno adiabatskih spremembah sistema (neskončno počasne spremembe Hamiltonove funkcije). Ta lastnost pa ne velja več za nelinearne oscilatorje, v splošnem, vendar se povrne pri dovolj hitrih (neadiabatskih) spremembah hamiltoniana.

Glavna težava pri nelinearnih oscilatorjih je, da ne poznamo faznega toka, v nasprotju z linearnim oscilatorjem, kjer je tok linearen v faznem prostoru. Zato je težko dobiti analitične rezultate, saj moramo povprečiti dane količine (energijo) kot funkcijo končnih koordinat v faznem prostoru po začetnih pogojih, predpostavljajoč mikrokanonično porazdelitev začetnih pogojev. Tako uporabimo kot modelski sistem časovno odvisni kvartični oscilator, za katerega je možnih nekaj analitičnih rezultatov, medtem ko je veliko rezultatov dobljenih s pomočjo numerične integracije.

Medtem ko se linearni oscilator vede kot zgoraj obrazloženo, vidimo, da se lahko vrednost adiabatske invariante (akcije) pri povprečni končni energiji v kvartičnem oscilatorju zmanjša za dovolj počasne (adiabatske) spremembe hamiltoniana, a vendarle narašča pri dovolj hitrih spremembah, še posebej v primeru parametričnih brc (instantani nezvezni skoki sistemskega parametra). Slednji rezultat lahko rigorozno dokažemo, tudi za druge potenčne potenciale, in izpeljemo univerzalno skalirno

funkcijo. Študiramo tudi parametrično brcanje kvartičnega oscilatorja, namreč za primer brce in anti-brce, in periodično brcanje. V teh primerih je hamiltonian odsekoma konstanten, zato imamo eksakten analitičen fazni tok (propagator) izražen z Jacobijevimi eliptičnimi funkcijami. Študiramo parametrične rezonance v linearnem ter nelinearnem oscilatorju in njihovo statistiko. V nelinearnem primeru najdemo generično nelinearno sliko (regularni otoki obdani s kaotičnim morjem), in za začetne pogoje izbrane v kaotičnem morju opazimo neomejeno naraščanje energije, kar je analogija Fermijevega pospeševanja v 2D časovno odvisnih biljardnih sistemih.

Naš študij prispeva k razumevanju statističnih lastnosti linearnih ter nelinearnih oscilatorjev in njihovih adiabatskih invariant. Adiabatska limita je zelo pomembna, a tudi drugi vmesni primeri, in tudi drugi ekstrem, nasproten adiabatskemu primeru, namreč parametrično brcanje, je pomemben. Napovedujemo, da se pri parametričnih brcah adiabatska invarianta pri srednji končni energiji zmerom poveča, kar je povezano z ireverzibilnostjo v srednjem, saj je entropija logaritem adiabatske invariante. To lahko strogo dokažemo za potenčne potenciale. Razumevanje večkratnih brc in njihova pojavnost v statističnem vedenju takšnih sistemov je velikega pomena v kontekstu statistične mehanike nizko-dimenzionalnih hamiltonskih sistemov.

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Adiabatic invariants and some statistical properties of the time-dependent linear and nonlinear Hamiltonian oscillators

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I shall present some recent studies of 1D time-dependent linear [1] and some nonlinear oscillators [12]. Our main concern is the accuracy of preservation of the adiabatic invariants and the related question of the statistical properties, such as the time evolution of the energy distribution for the microcanonical ensemble of initial conditions. In case of the linear oscillator this problem can be largely solved rigorously and the solutions can be well approximated using the WKB method, which we develop exactly to all orders [10,1]. It turns out in full generality and rigorously that the adiabatic invariant at the average final energy in a linear oscillator never decreases, and remains constant only for ideal adiabatic changes (infinitely slow variation of the parameter of the Hamiltonian). This property is lost in nonlinear oscillators, in general, but reappears for sufficiently fast (nonadiabatic) variation of the Hamiltonian.

In nonlinear oscillators the main problem is that we do not know the phase flow, unlike the linear oscillator case where the flow is linear in phase space. Therefore it is hard to obtain the analytic results, as we must average the relevant quantities (the energy) as a function of final phase space coordinates with respect to the initial conditions, assuming a microcanonical distribution of the initail conditions. Therefore we use as a model system the time dependent quartic oscillator, for which some analytic results are posssible, whilst many results are obtained by numerical integrations.

While the linear oscillator behaves like explained above, for the quartic oscillator we see that the adiabatic invariant (action) at the average energy can decrease for sufficiently slow (adiabatic) variation of the Hamiltonian, but increases for sufficiently fast changes, in particular in parametric kicks (instantaneous discontinuous jump of the system parameter). The latter result can be rigorously proven, also for other

power law potentials, and a universal scaling function for the action is derived. We also study parametrically kicked quartic oscillator, like kick and anti-kick, and periodic kicking. As in this case the Hamiltonian is piecewise constant, we have the rigorous exact analytic phase flow (propagator) in terms of the Jacobi elliptic functions. We study the parametric resonances in the linear and nonlinear oscillator, and their statistical behaviour. In the nonlinear case we find the generic nonlinear picture (regular islands surrounded by chaotic sea), and for the initial conditions in the chaotic sea we observe unbounded energy growth, which is an analogy of Fermi acceleration in 2D time dependent billiard systems.

Our study contributes to the understanding of the statistical behaviour of linear and nonlinear oscillators and of their adiabatic invariants. The adiabatic limit is very important, but also other intermediate cases, and also another extreme, opposite to the adiabatic case, namely the parametric kicking. We predict that in parametric kicks the adiabatic invariant at the average final energy always increases, which is linked to irreversibility in the mean, since the entropy is the logarithm of the adiabatic invariant. We can prove this rigorously for the power law potentials. The understanding of the multiple kicks and their impact on the statistical behaviour of such systems is of great importance in the context of statistical mechanics of low-dimensional Hamiltonian dynamical systems.

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Gruče supertežkih kvarkov kot kandidati za temno snov

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Poenotena teorija spinov-nabojev-družin, ki jo je predlagala Norma Mankoč Borštnik, napoveduje osem družin kvarkov in leptonov. Pri tem peta družina ni sklopljena z nižjimi in je zato zelo stabilna. Pridružil sem se analizi, ali so supertežki nevtroni (gruče udd) iz pete družine možni kandidati za temno snov.

Skušal bom odgovoriti na nekatere predsodke proti kandidatom, ki sodelujejo z močno interakcijo. (i) Pričakujejo, da so supertežki kvarki preveč kratkoživi. Vendar jih predlagana simetrija odklopi od nižjih družin in so zato praktično stabilni. (ii) Pričakujejo, da je najlažji bodisi nabiti barion uuu bodisi nabiti barion ddd, odvisno od tega, kateri kvark je lažji, u ali d; nabite gruče pa ne morejo tvoriti temne snovi. [Notacija u i d se tukaj nanaša na peto družino kvarkov]. Vendar elektro-šibka interakcija med kvarki najbolj "olajša" nevtralni barion n=udd, če je le masna razlika med petima kvarkoma u in d dovolj majhna. (iii) Bojijo se, da imajo delci z močno interakcijo dosti prevelik presek, da bi bili lahko "temni". Vendar vodi "jedrska sila" med barioni pete družine do silno majhnih presekov, če so le mase dovolj velike (in so potem premeri dovolj majhni). Za m=100 TeV, na primer, je velikost gruč kvečjemu 10^{-5} fm in geometrijski presek kvečjemu 10^{-10} fm^2. (iv) Končno ostaja vprašanje, ali so kvarki pete družine oziroma njihove gruče nastali in preživeli po velikem poku in tekom razvoja galaksij. Verjetno so!

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Superheavy quark clusters as candidates for the dark matter

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In the unified Spin-Charge-Family theory of Norma Mankoč Borštnik, eight families of quarks and leptons are predicted, with the fifth family decoupled from the lower ones and therefore rather stable. I have joined the analysis whether the superheavy neutrons (udd clusters) of the fifth family might be viable candidates for dark matter.

I shall try to answer a few prejudices against strongly interacting candidates. (i) Superheavy quarks are expected to be too short-lived. However, the symmetry of the proposed theory decouples them from the lower families, so they are practically stable. (ii) Either the charged baryon uuu or the charged baryon ddd might be the lightest, depending on whether u or d is lighter, so charged clusters cannot constitute dark matter. [The notation u and d refers here to the quarks of the fifth family]. However, if one takes into account also the electro-weak interaction between quarks, then the neutral baryon n=udd can very probably be the lightest, provided the u-d mass difference is not too large. (iii) Strongly interacting particles are feared to have far too large cross section to be "dark". However, the fifth family baryons, interacting with the fifth family "nuclear force", have very small cross section if the masses are large enough (the sizes are then small enough). For m= 100 TeV, for example, the size of the cluster is of the order 10^{-5} fm or less and the geometrical cross section as small as 10^{-10} fm^2. (iv) Finally, did the fifth family quarks and/or their clusters form and survive after the big bang and during galaxy formation? Probably yes.

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Nonequilibrium dynamics of spatiotemporally driven billiards and lattices

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An overview of selected recent developments for time-driven billiards and lattices is provided. Our first focus is the dynamical evolution of ensembles of particles propagating in an elliptical billiard with harmonically driven boundaries. In contrast to the static integrable ellipse the corresponding periodically driven billiard shows Fermi acceleration. For short and intermediate time scales the underlying mechanism relies on intermittent phases of laminar and stochastic behavior of the strongly correlated angular momentum and velocity motion. With increasing velocity of the ensemble we observe an evolution from a large chaotic sea with stickiness due to regular islands to thin chaotic channels with diffusive motion. As a consequence, we encounter a crossover from amplitude dependent tunable subdiffusion to universal normal diffusion in momentum space with increasing time of acceleration. Based on the above-analysis of the dynamics of the driven elliptical billiard we develop and analyze a scheme to achieve both spatial and energetic focusing of an ensemble of neutral particles by including frictional forces. The interplay of two competing mechanisms, acceleration due to collisions with the oscillating billiard walls and decceleration caused by friction, leads to the emergence of attractors in phase space. Their specific properties, i.e. spatial localization and energy spread, can be controlled and tuned by varying e.g. the frequency of the time-dependent billiard.

As a first example of the nonequilibrium dynamics in spatiotemporally driven lattices we explore the directed transport in phase-modulated lattices. Tuning the parameters of the driven unit cell of the lattice selected parts of the classical phase space can be manipulated in a controllable manner which allows us to control the magnitude and direction of the current. Several mechanisms for transient localization and trapping of particles in different wells of the driven unit cell are presented

and analyzed. Even more, we present and analyze mechanisms for the patterned deposition of particles in a spatio-temporally driven lattice. The working principle is based on the breaking of the spatio-temporal translation symmetry, which is responsible for the equivalence of all lattice sites, by applying modulated phase shifts to the lattice sites. The patterned trapping of the particles occurs in confined chaotic seas, created via the ramping of the height of the lattice potential. Complex density profiles on the length scale of the complete lattice can be obtained by a quasi-continuous, spatial deformation of the chaotic sea in a frequency modulated lattice.

Finally we develop a mechanism for the controlled conversion of ballistic to diffusive motion and vice versa. This process takes place at the interfaces of domains with different time-dependent forces in lattices of laterally oscillating barriers. As a consequence long-time transient oscillations of the particle density are formed which can be converted to permanent density waves by an appropriate tuning of the driving forces. The proposed mechanism opens the perspective of an engineering of the nonequilibrium dynamics of particles in inhomogeneously driven lattices.

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Meritev omejene difuzije molekul v nanoporah z metodo odneva spinov v nehomogenem magnetnem polju

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Odmev jedrskih spinov v polju sunkov nehomogenega polja (gradienta) je eno najučinkovitejših orodij za študij molekularnega transporta v heterogenih sistemih kot so biološka tkiva, kromatografska sita, beton, kamni, glina i.t.d. Metoda zahteva, da so sunki gradienta krajši kot pa karakteristični časi molekularne difuzije. Metodo uporabljamo lahko le za meritve omejene difuzije v porah, ki so veje od nekaj μm, zaradi indukcijske omejitve gradientnih tuljav. Z uvedbo novega naina obdelave experimentalnih podatkov z Fourierjevo transformacijo, pa nam metoda posreduje informacije tudi, e zgornjemu pogoju ni zadoeno. To je omogoilo meritev omejene lastne difuzije vode v nanometerskem situ iz poliamidne membrane, Fig.2.

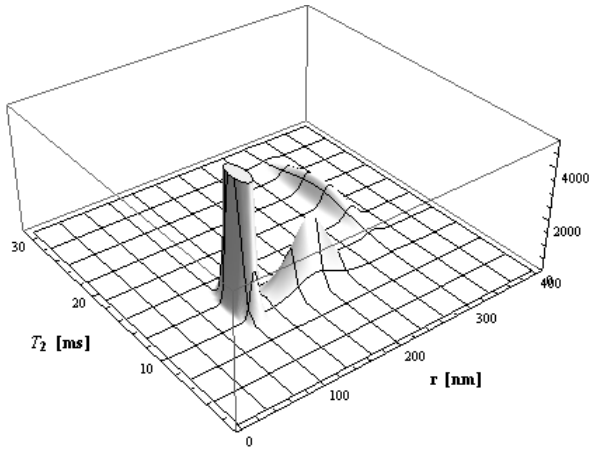

Figure 1: Porazdelitev por po premeru(r) in spinski relaksaciji(T_2) v situ iz poliamidne membrane

Measurements of restricted diffusion in nanopores by the method of spin echo in nonuniform magnetic field

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The magnetic field gradient spin echo appears as a most efficient tool for the non-invasive elucidation of the molecular transport in heterogeneous media such as biologic tissues, chromatographic sieves, heterogeneous catalysts, concrete, rocks or clays, etc. Method requires the pulses of magnetic field gradient to be shorter than than the characteristic times of molecular motion. Thus, the implementation of method for the measurements of restricted diffusion is posible only in pores larger than a few μm due to the induction limit of gradient coils. We have introduced a new concept, in which experimental data treated through q-space Fourier transformation, provide information about the restricted self-diffusion even if the above condition is not satisfied. It permits to measure the self-diffusion of water in the nanosieve made of polyamid membrane, Fig.2.

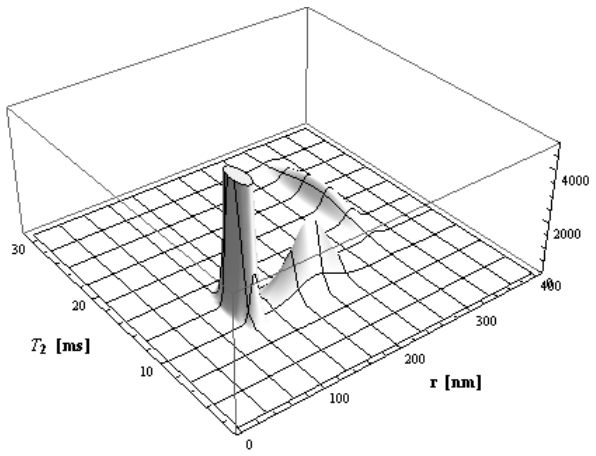

Figure 2: Distribution of pore size (r) and spin relaxation (T_2) in the sieve of polyamid membrane

O novem brezmrežnem načinu numeričnega reševanja sistemov s faznimi spremembami

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Predstavljena je struktura nove brezmrežne metode za izračun eno-območno formuliranega makroskopskega sklopljenega prenosa toplote, mase, gibalne količine in sestavin, kot tudi modelov faznega polja in celičnih avtomatov evolucije mikrostrukture. Rešitveni postopek je formuliran v vozliščih, ki so lahko neuniformno razporejena. Obravnavano območje in rob sta razdeljena na prekrivajoče se vplivne domene. Na vsaki izmed njih so polja predstavljena s kolokacijo z multikvadričnimi radialnimi baznimi funkcijami na ustrezni podmnožici vozlišč. V primeru modeliranja s celičnimi avtomati so na vsaki podmnožici točk definirana prehodna pravila. Uporabljena je eksplicitna časovna diskretizacija. Vse vodilne enačbe so rešene na podlagi močne formulacije; posledično ni integriranja. Poligonizacija ni prisotna. Rešitev lahko preprosto in efektivno prilagodimo v smislu preporazdelitve in/ali zgostitve vozlišč, kar je posebej pomembno pri problemih z velikimi gradienti polj. Prikazano je postopno testiranje metode, ki ji sledijo industrijski primeri kot npr. razvoj zrnate stukture pri kontinuirnem ulivanju jekla in modeliranje turbulentnega toka s strjevanjem. Rezultati, izračunani z novim pristopom, so primerjani z analitičnimi rešitvami, dobro dokumentiranimi testnimi primeri in komercialnimi paketi. Metoda se izkaže za zelo preprosto za programiranje, natančno, obravnava različnih fizik je pregledno vpeljana. Numerična implementacija v 2D ali 3D je zelo podobna.

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On a New Meshless Approach for Numerical Solution of Phase Change Systems

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Structure of a new meshless solution procedure for calculation of one-domain formulated coupled macroscopic heat, mass, momentum and species transfer problems as well as phase field concepted models and cellular automata models of microstructure evolution is represented. The solution procedure is defined on a set of nodes which can be non-uniformly distributed. The domain and boundary of interest are divided into overlapping influence areas. On each of them, the fields are represented by the multiquadrics radial basis functions collocation on a related sub-set of nodes. The transition rules are defined for a set of nodes on the influence area in case of cellular automata modelling. An explicit timestepping discretisation is performed. All governing equations are solved in their strong form, i.e no integrations are performed. The polygonisation is not present. The solution can be easily and efficiently adapted in node redistribution and/or refinement sense, which is of utmost importance when coping with fields exhibiting sharp gradients. Gradual benchmarking of the method is represented, followed by industrial examples such as the grain structure formation in continuous casting of steel and turbulent flow with solidification. The results of the new approach are compared with the analytical solutions, well documented bench-mark solutions and commercial packages. The method turns out to be extremly simple to code, accurate, inclusion of the complicated physics can easily be looked over. The coding in 2D or 3D is very similar.

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Meritve s pospešenimi ioni v arheometriji

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Z arheometričnimi meritvami skušamo izvedeti kaj več o predmetih kulturne dediščine: kako so bili narejeni, odkod so dobili surovine in kako so trgovali z njimi, s tem pa rekonstruiramo življenje v preteklosti. Za analize so še posebej primerne metode s pospešenimi ioni, saj predmete le malo poškodujejo, omogočajo pa analize zelo majhnih količin snovi. V predavanju bodo predstavljene metode protonsko vzbujenih rentgenskih žarkov in žarkov gama in metoda elastičnega sipanja, ki jih izvajamo na tandemskem pospeševalniku IJS s protonskim žarkom v zraku. Kot primeri uporabe si bomo ogledali rabo kovin na rimski vojaški opremi, sledili bomo načinom izdelave stekla od antike do renesanse, na oljnih slikah pa iskali individuialne poteze pri rabi pigmentov. Na področju eksperimentalne arheologije bodo predstavljeni balistični poskusi s pračnimi izstrelki.

Ion beam analysis in archaeometry

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Archaeometric measurements try to get more information about the objects of cultural heritage: how they were made, where their raw materials were obtained, and how they were traded; with this knowledge we can reconstruct life in the past. The methods of ion beam analysis are particularly appropriate for such work, as they inflict negligible damage to the objects, but are able to analyze minute amount of matter. The lecture will review the methods of proton-induced X-rays and gamma rays and the method of elastic scattering, which are practiced at the Tandetron accelerator of the Jožef Stefan Institute, using proton beam in the air. As application of these methods we will study the use of metals on Roman military equipment, we will follow production of glass from Antiquity till renaissance, and trace individual features in pigments of oil paintings. In the field of experimental archaeology we will report on ballistic experiments with sling projectiles.

Vozli in spleti v nematskih koloidih

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Izdelovanje vozlov in kontrolirano pletenje mikroskopskih zank iz polimerov, makromolekul in defektnih linij v kompleksnih tekočinah predstavlja izjemno velik izziv za raziskovalce na področju fizike materialov. Predstavil bom vozle in splete, ki smo jih sestavili v koloidni mešanici nematskega tekočega kristala in mikroskopsko majhnih steklenih kroglic z uporabo optične pincete. Identificirali in teoretično pojasnili smo vse vozle in splete z manj kot sedem križišči, med drugim Hopfov splet, Davidovo zvezdo in Boromejske kroge, ki stabilizirajo koloidne delce v kompleksno prepleten mehak kompozit. Vozle smo klasificirali s kvantiziranim spletnim številom - topološko invarianto, ki omogoča neposredno merjenje geometrijske faze. Tkanje poljubnih mikroskopskih vozlov in spletov v tekočekristalnih koloidih demonstrira pomen topologije pri izdelavi kompleksnih materialov in predstavlja nov način uporabe teorije vozlov v fizi ki.

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Reconfigurable knots in chiral nematic colloids

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Tying knots and linking microscopic loops of polymers, macromolecules, or defect lines in complex fluids is a challenging task for material scientists. We demonstrate the knotting of microscopic topological defect lines in chiral nematic liquid crystal colloids into knots and links of arbitrary complexity by using optical tweezers as a micromanipulation tool. All knots and links with up to six crossings, including the Hopf link, the Star of David, and the Borromean rings, are assembled, stabilizing colloidal particles into entangled soft matter composites. We classify the knots in chiral nematic colloids by the quantized self-linking number, a topological invariant that gives a direct measure of the geometric phase. Formation of arbitrary knots and links in nematic colloids demonstrates how relevant the topology can be for the material engineering of soft matter and reveals a novel manifestation of knot theory in physics.

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Feroelektrični smektični-A tekoči kristali: feroelektrični material z najvišjo do sedaj opaženo simetrijo

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Pred kratkim so odkrili tekočekristalne materiale, ki tvorijo feroelektrične plastne strukture, v katerih molekule v povprečju niso nagnjene na smektično plast. Tako imenovano ortogonalno feroelektrično smektično tekočekristalo fazo SmAPF so opazili v tekočih kristalih, ki jih tvorijo nesimetrične ukrivljene molekule, ki imajo v repu vgrajene silicijeve atome [1]. Ortogonalna feroelektrična smektična tekočekristalna faza je feroelektrični material z najvišjo do sedaj opaženo simetrijo.

Na predavanju bom predstavila kontinuumski fenomenološki model [2] za opis strukture v SmAPF fazi v odvisnosti od debeline celice, vrste sidranja na površini in jakosti zunanjega električnega polja. Napovedi teoretičnega modela bomo primerjali z meritvami dielektričnega odziva, rtg-sipanja, polarizacijske mikroskopije in meritvami SHG [3].

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Ferroelectric smectic-A liquid crystals: the highest-symmetry ferroelectric material found to date

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Recently the orthogonal ferroelectric smectic phase was observed in liquid crystalline material made of asymmetric bent-core molecules with carbosilane terminal group [1]. This phase represents the highest symmetry ferroelectric material found to date.

In our contribution we present a continuous phenomenological model [2] to describe how the inlayer structure in such a phase depends on the cell thickness, the strength of surface anchoring and the magnitude of the external bias electric field. Theoretical predictions will be compared with the experimental results of dielectric measurements together with X-ray analysis, polarizing microscopy and SHG activity [3].

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Pipistrel Taurus G4, zmagovalec tekmovanja 2011 Green Flight Challenge Sponsored by Google

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V predavanju bom predstavil letalo pipistrel taurus G4, prvo stirisedežno električno letalo na svetu. Letalo je bilo zasnovano izključno za udeležbo na tekmovanju 2011 Green Flight Challenge Sponsored by Google. Opisal bom pravila in zahteve tekmovanja. Prikazal bom zasnovo letala ter utemeljitve izbranih rešitev. Predstavil bom program testiranja in primerjavo med pričakovanimi ter dejanskimi lastnostmi letala. Na koncu bom opisal tudi samo tekmovanje.

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Pipistrel Taurus G4, winner of 2011 Green Flight Challenge Sponsored by Google

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I will introduce the Pipistrel Taurus G4, the first electric four seater aircraft in the world. The aircraft was designed solely for the purpose of participating in the 2011 Green Flight Challenge Sponsored by Google. I will describe the competition regulations and requirements. I will present the aircraft design and explain the choice of employed solutions. I will describe the test programme and the comparison of the expected and actual flight characteristics. In the end I will also present the actual competition.

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Nekatere lastnosti napak vremenskih napovedi

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Rezultati modelov za numerično napovedovanje vremena ne bodo nikoli perfektni. Ker resničnega stanja ozračja ne poznamo, lahko napake napovedi kvečjemu modeliramo; razumevanje lastnosti prognostičnih napak na različnih časovnih in prostorskih skalah bo vedno izziv. V postopku asimilacije podatkov za pripravo začetnih pogojev za numerično napovedovanje, kratkoročne napovedi so predstavljene s pomočjo spremenljivk, ki imajo dinamične in statistične lastnosti podobne tistim, ki jih imajo neznane prognostične napake. Diskutirala bom nekatere lastnosti prognostičnih napak z uporabo simulacij s perfektnim modelom. Časovno povprečene in časovno odvisne lastnosti napak bom opisala glede na najbolj pogosto uporabljene predpostavke pri numeričnem modeliranju.

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On the stubbornness of the weather-forecast errors

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Numerical weather-prediction (NWP) models are never going to be error-free. A reliable estimate of their forecast errors poses a real challenge, since the knowledge of the true state of the atmosphere is beyond our grasp. In data assimilation for NWP, short-range forecast errors are commonly referred to as background errors; they are frequently represented by surrogate quantities with statistical and dynamical properties assumed similar to those of the unknown forecast errors. Derived dependencies are built into the background-error covariance matrix for data assimilation. In this talk, I will describe the ongoing research of the large-scale forecast errors in the perfect-model framework. I would discuss some stationary and flow-dependent properties of the forecast errors with respect to the assumptions commonly used in the data assimilation modelling.

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Kvantne nečistoče v topoloških izolatorjih in superprevodnikih

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Sklopitev spin-tir v izolatorjih iz elementov z dna periodnega sistema lahko vodi h kompleksnim disperzijskim zvezam za valenčne elektrone, ki imajo netrivialne topološke lastnosti (ne da bi pri tem bila zlomljena invarianca na obrat časa). Na mejah tovrstnih materialov se nahajajo prevodniška stanja, ki pa imajo zelo nenavadne lastnosti, kot denimo togo zvezo med smerjo spina in smerjo gibanja elektrona. Če v takšnem sistemu vzpostavimo superprevodniške korelacije, se mejne vzbuditve obnašajo kot Majoranovi fermioni. Izjemno pomembno je razumeti vpliv magnetnih nečistoč na mejna stanja: ali lahko odpravijo topološko zaščito s tem, da zlomijo invarianco na obrat časa, ali pa so zasenčena (Kondov pojav)?

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Quantum impurities in topological insulators and superconductors

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Spin-orbit interaction in the insulators made of elements from the bottom of the periodic system can lead to complex dispersion relations for the valence-band electrons with non-trivial topological properties (without breaking the time-reversal invariance). On the boundaries of such materials, there are conducting states which turn out to have unusual properties, such as spin-momentum locking. Furthermore, if superconducting correlations are induced by the proximity effect, the boundary excitations behave as Majorana fermions. It is of fundamental interest to understand the effect of magnetic impurities on such boundary states: do they eliminate the topological protection by breaking the time-reversal invariance or are they screened by the Kondo mechanism?

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Geometrija in topologija kiralnih in koloidnih nematikov: od vozlov do skirmionov

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Nematski tekoči kristali, frustrirani z geometrijsko omejenostjo prostora in lastno kiralnostjo, predstavljajo privlačno topološko temo. Geometrija lahko vpliva preko ograditve tekočega kristala kot tudi preko disperzije delcev v njem [1]. S pregledom naših dosežkov, ki so plod sinergije teorijskih, simulacijskih in eksperimentalnih pristopov, bi rad pokazal, kako topologija in geometrija omogočata sestavljanje kompleksnih mehkih snovi. Z lasersko pinceto je pred kratkim uspelo tvoriti nematske pletenice, kjer disklinacje prepletajo koloidne delce v navadnih in kiralnih nematikih. Pletenice lahko vsebujejo vozle in splete poljubne kompleksnosti [2]. Namesto običajnega topološkega opisa, ki temelji na fundamentalni grupi nematskega parametra reda, vpeljemo novo topološko invarianto samo-ovojno število, ki omogoča kompletno klasifikacijo prepletenih defektnih struktur [3]. Enostavna shema za prevezavo disklinacij s polovično močjo pri pravokotnem križanju, ki temelji na tetraedrični rotaciji ustreznih segmentov disklinacij, nam omogoča napoved možnih pletenic in izračun samo-ovojnega števila. Pokažemo, kako to deluje za pletenice, ki imajo vozle in splete z do šestimi križanji. Modre faze I in II so močno kiralne nematske tekočine, kjer orientacijska modulacija nematske urejenosti tvori 3D kristalno mrežo. Cilindrična področja dvojnega zvoja nematskega direktorja so prepletena z mrežo nematskih disklinacij. Teoretično in z numeričnimi simulacijami pokažemo, kako taka struktura predstavlja regularno 3D mrežo pasti za submikronske koloidne delce, ki daje odlično osnovo za sestavljanje raznih 3D koloidnih kristalov [4]. Zamejitev teh faz v zelo tanke plasti vodi v celo vrsto eksotičnih, vendar regularnih kvazi 2D kristalov [5], ki vključujejo tudi skirmionske mreže [6]. Skirmioni kot topološke tvorbe imajo pomembno vlogo tudi pri nekaterih pojavih v kondenzirani snovi: kvanti Hallov pojav, kiralni magnetizem in Bose-Einsteinova kondenzacija. Tako lahko tanek močno kiralen nematski film služi kot modelni sistem za študije skirmionskih struktur z enostavnimi optičnimi metodami. V nadaljevanju predlagamo izrabo kvazi 2D defektnih struktur kot mreže pasti za samo-organizacijo koloid-

nih kristalov. Take strukture so močno odzivne na zunanje motnje, ki lahko vlivajo tako na tekoči kristal kot na delce in s tem odpirajo pot do fotonskih aplikacij.

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Geometry and Topology of Chiral and Colloidal Nematics: from Knots to Skyrmions

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Nematic liquid crystals frustrated by geometrical constrains and/or by intrinsic chirality offer an attractive topological playground. These constrains can be realized by dispersed particles and enclosing surfaces [1]. With an overview of our recent achievements resulting from the synergy of theoretical, simulation and experimental approaches I would like to show how topology and geometry enables the assembling of complex soft materials. Recently laser micromanipulation enabled formation of nematic braids of disclinations entangling colloidal particles in chiral and achiral nematic liquid crystals. Knots and links of arbitrary complexity were realized [2]. Instead of the conventional topological description given by the fundamental group of nematic order parameter we introduce a new topological invariant, the self-linking number, that enables a complete classification of entangled defect line structures [3]. A simple rewiring scheme for the orthogonal crossing of two half integer disclinations, based on a tetrahedral rotation of two relevant disclination segments allows us to predict nematic braids and their self-linking numbers. Colloids stabilized by nematic braids based on knots and links with up to six crossings are demonstrated. Further we show theoretically with the aid of numerical methods how chiral nematic blue phases I and II that are composed of regular arrays of so-called double-twist cylinders and -1/2 disclinations can be used as regular lattices of trapping sites for colloidal particles [4]. Possible assembling of 3D colloidal crystals is demonstrated. When these phases are confined to thin films between two parallel surfaces a number of exotic defect lattices [5] including quasi-two-dimensional Skyrmion lattice [6] appear. Skyrmions are particle-like topological entities that have an important role in various condensed matter systems, including 2D electron gases exhibiting the quantum Hall effect, chiral ferromagnets, and Boseinstein condensates. A chiral nematic liquid crystal film can thus serve as a model system, allowing direct investigation of Skyrmion structures by a variety of room temperature optical techniques. Further we propose the use of these quasi 2D lattices of trapping sites to self-assemble col-

loidal crystals [7]. Such systems that can be easily manipulated by external stimuli via effecting liquid crystal and/or colloidal particles are expected to be relevant for photonic applications.

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Foundations of earthquake statistics in view of non-stationary chaos theory

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This paper is dedicated to the memory of a dear friend of ours, Professor Shuichi Tasaki. He left us many excellent works in the field of nonequilibrium statistical mechanics with his broad interests, and he always encouraged us to challenge to new problems in complex nonlinear systems, which often reveal anomalous fluctuations, characteristic scalings, etc.

In this paper we discuss a simple dynamical model which reproduces a sequence of empirical laws in seismic statistics, and derive a universal relation that connects two important statistical laws; the Gutenberg - Richter distribution and the interoccurrence time distribution. These results imply that the seismic statistics can be well understood in terms of the stationary-nonstationary chaos transition near the critical regime. The results derived from the Data-Catalog in Japan, California, and Taiwan (JMA, SCEDC, TCWB), which support the universal relation, are briefly discussed.

§1. Introduction

Chaotic behaviors appeared in deterministic systems often reveal very clear statistical laws, and the origin of their probabilistic aspects is successfully understood in ergodic-theoretical framework. Earthquakes and their time evolution are also considered to be a kind of statistical phenomena which demonstrates some probabilistic natures, but their statistical laws still remain empirical ones at the present time though they are useful for future prediction and correspondence. We have to admit that it is not so easy to construct the dynamical model which precisely describes the details of the physical changes in earth crusts, however, it is an important subject for us to elucidate the universal aspects in seismological statistics and their dynamical origins from the viewpoint of deterministic chaos theory.

In this paper, we concentrate our discussions to the empirical laws in seismological statistics, that are clearly shown in a sort of scaling relations obtained by Wadati, Omori, Enya, Ishimoto-Iida, and Utsu. It will be shown that all these scaling relations are reproduced by a simple dynamical model based on the socalled Modified Bernoulli Map at least qualitatively, and that these statistical laws are universal in the critical regime which is induced by a big earthquake. The model proposed here is a toy-model, but it is emphasized that the model displays not only the ergodic-theoretical universal aspects observed in a wide class of dynamical systems, but also the common features in the earthquake statistics of the critical regime.[7)]

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§2. Chaotic dynamics which reveals the stationary - nonstationary chaos transition

One of the simplest random processes is coin-tossing, which generates a series of symbols, $\{\sigma_k\}$, where k stands for the discrete time at k-th trial, and $\sigma_k = \pm 1$ (for head or tail). The probability for the continuous occurrence of n-heads (or tails) is the exponential distribution, and the mean occurrence rate of head (or tail) approaches to $1/2$ when the number of trials goes to large enough. Statistical properties of the coin-tossing is reproduced by a chaotic dynamical system, socalled Bernoulli map, which is defined by

$$x_{k+1} = \begin{cases} 2x_k & (0 \le x < 1/2), \\ 2x_k - 1 & (1/2 \le x \le 1), \end{cases} \tag{2·1}$$

where x_k is the real number and k (integer) the discrete time. The Bernoulli map is ergodic and strong mixing under the invariant distribution $\rho(x) = 1$ $(0 \le x \le 1)$, and that when the symbolic dynamics is defined by $\sigma_k = \pm 1$ for $(0 \le x < 1/2)$, or for $(1/2 \le x \le 1)$ respectively, the sequence $\{\sigma_k\}$ has the same statistical properties as the above mentioned coin-tossing.

Let us generalize the Bernoulli map to include long-term memories in the coin-tossing process. The modified Bernoulli map (MBM) is given by,

$$x_{k+1} = \begin{cases} x_k + 2^{B-1} x_k^B & (0 \le x_k < 1/2), \\ x_k - 2^{B-1}(1 - x_k)^B & (1/2 \le x_k \le 1), \end{cases} \tag{2·2}$$

and the symbolic dynamics $\{\sigma_k\}$ by the same way as the Bernoulli map. When the parameter $B = 1$, the MBM is the original Bernoulli map, but in what follows, we consider the case for $B > 1$. The statistical properties of the MBM are well understood by ergodic-theoretical analysis. For instance, the invariant distribution $\rho(x)$ is well approximated by,

$$\rho(x) \propto x^{-(B-1)} + (1 - x)^{-(B-1)}, \ (0 \le x \le 1), \tag{2·3}$$

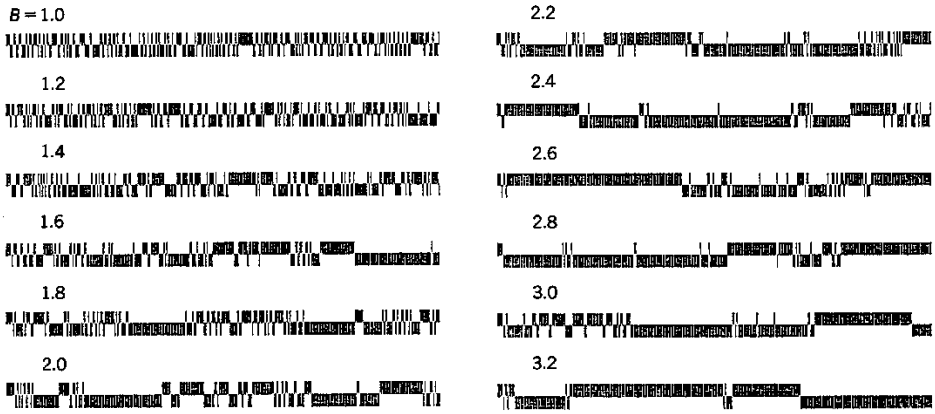

Fig. 1. Symbolic time series of the MBM for various B values.[7)]

and the waiting time probability $P(n)$, which describes the probability for the continuous n-occurrence of the state $\sigma = +1$ (or $\sigma = -1$), obeys,

$$P(n) \propto n^{-\beta}, \ \left(\beta = \frac{B}{B-1}\right) \tag{2·4}$$

This explains that the strong correlations or the long-term memories are generated in the MBM. Figure 1 shows typical time series for various cases. A striking point is that the sequence $\{\sigma_k\}$ is non-stationary and the mean waiting time $\langle n \rangle$ is divergent for $B \geq 2$, but is stationary with $\langle n \rangle =$ finite for $B < 2$. The critical regime appears near $B \cong 2$.[8)–12)]

§3. A metaphor model which simulates seismicity statistics

Here we propose a metaphorical model based on the chaotic behaviors in the MBM, which reproduces some scaling aspects appeared in many seismological studies. First, we assume that the symbolic variable $|\sigma_k|$ is proportional to the rate of energy accumulation in the earth crust, and the accumulated energy during the period of $\sigma > 0$ (or $\sigma < 0$) is release at once by an earthquake when the symbolic variable σ_i changes its sign, i.e., $\sigma_{i+1} = -\sigma_i$. This assumption means that the released energy by the earthquake E is related to the waiting time n defined in equation (2·4). Though the mechanism is still unclear, the following form is plausible from the consideration of nonlinear visco-elastic spring energy,

$$E \propto n^{1/\kappa'}, \tag{3·1}$$

where the exponent κ' is a parameter. Therefore, the energy distribution of the earthquake $P(E)$ becomes,

$$P(E) \propto E^{-\kappa}, \ \ (\kappa = \kappa'(\beta - 1) + 1). \tag{3·2}$$

The parameter B is considered to express the strength of earth-crusts or the tolerance to the strain in crust. Actually, it is shown in Figure 1 that the number of bigger earthquakes increases when the value B becomes large. The power law distribution in the earthquake energy was first pointed out by Wadati[1)] for several cases, and suggested to be $\kappa \cong 2.1$. Equation (3·2) is also consistent with the Gutenberg - Richter law.[6)]

The second assumption of our metaphor model is that the strength parameter B is sharply reduced by the occurrence of a big earthquake (mainshock), namely, the value just before the big earthquake, say B_{pre}, is larger than that after the big earthquake B_{post}, i.e., $B_{pre} > B_{post}$, and that the value B goes back slowly to the original value B_{pre}. If we assume the exponential recovery (relaxation time is τ) of the parameter B, the value B at time k, say $B(k) = B_k$, is given by

$$B_k = B_{pre} - (B_{pre} - B_{post})e^{-k/\tau}, \ \ (k = 0, 1, 2, \dots) \tag{3·3}$$

where k stands for the time measured from the moment of the main shock ($k = 0$). From these assumptions, the MBM dynamics after the occurrence of the big

earthquake is expressed by,

$$x_{k+1} = \begin{cases} x_k + 2^{B_k-1} x_k^{B_k} & (0 \le x < 1/2), \\ x_k - 2^{B_k-1}(1-x_k)^{B_k} & (1/2 \le x \le 1), \quad (k = 0, 1, 2, \dots). \end{cases} \tag{3·4}$$

Equations (3·3) and (3·4) are the metaphorical chaotic model which is used in what follows.

§4. Empirical statistical laws in seismicity statistics

Numerical results obtained by equations (3·3) and (3·4) are shown in Figures 2, 3, 4, and 5 under the following conditions; $B_{pre} = 5/2$, $B_{post} = 3/2$, and $\tau = 10^{3}$.[7] Figure 2 shows two sample paths of $\{\sigma_k\}$ for different initial data of x_0, where we can see that the interoccurrence time between two flip-flop jumps in $\{\sigma_k\}$ is very short when k is small enough. This corresponds to the fact that a series of small aftershocks are induced by a big earthquake. The accumulated number of the aftershocks in the interval $1 \le k \le t$, say $N(t)$, is a random variable depending on the initial data. The average number $\langle N(t) \rangle$ is shown in Figure 3, where the numerical data is very well adjusted by a logarithmic function,

$$\langle N(t) \rangle \propto \log(at + b), \tag{4·1}$$

where a and b are fitting parameters. It is important to point that this is quite consistent with the Omori formula,[2] and that the formula by Enya[3] is naively adopted in our metaphor model. By changing the values of B_{pre} and B_{post}, we can obtain the generalized Omori formula; $\langle N(t) \rangle \propto (at + b)^{\gamma}$, but we do not touch this problem here.

Figure 4 shows the energy distribution of aftershocks $P(E)$ at $\kappa' = 1$. The result is well fitted by,

$$P(E) \propto E^{-\kappa}, \quad (\kappa \cong 2.0 \; at \;\; \kappa' = 1) \tag{4·2}$$

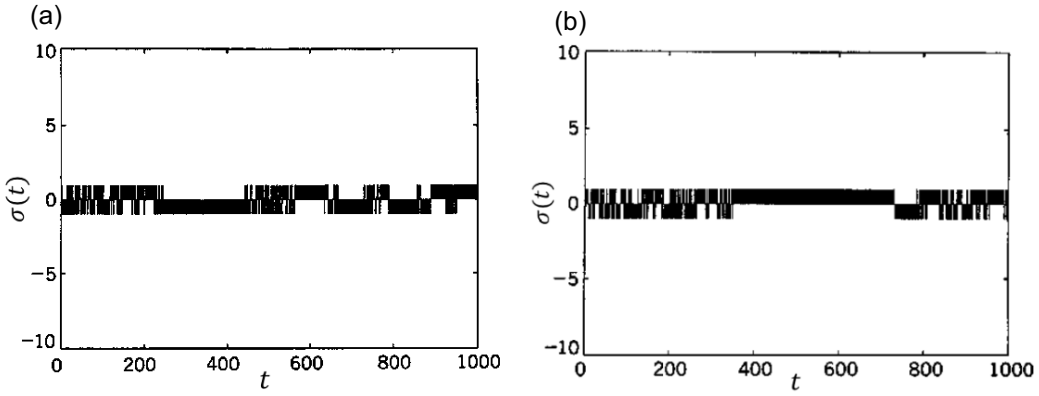

Fig. 2. Symbolic time series after the main shock at $k = 0$ for two different values of x_0.

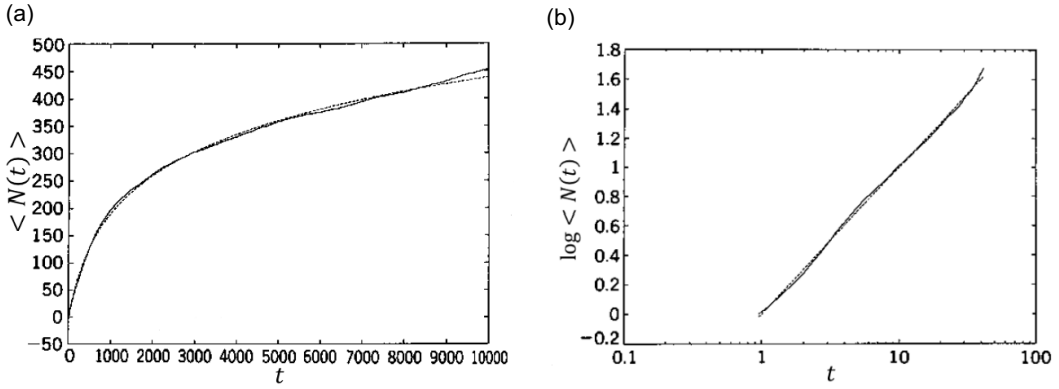

Fig. 3. Cumulative numbers of aftershocks for $1 \leq k \leq t$. (a) normal plot (long time) and (b) logarithmic plot (short time); Numerical plots are almost completely adjusted by a logarithmic curve (doted line) consistent with the Omori law in long time regime.

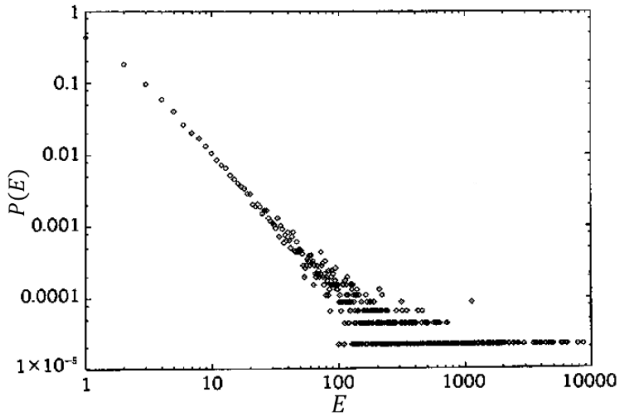

Fig. 4. Energy distribution of aftershocks. ($P(E) \simeq E^{-\kappa}, \kappa \cong 2.0$.)

If we take the effect by κ' into account, the exponent obeys $\kappa = \kappa' + 1$. In these numerical analysis, we used the simulation data for $1 \leq k \leq T$ $(= 10 \times \tau)$, and the aftershocks occurred in $k > T$ are omitted because they are not the aftershocks induced by the main shock occurred at $k = 0$.

The reason why the exponent κ takes $\kappa \cong 2.0$ (at $\kappa' = 1$) can be analyzed by using the intrinsic properties of the MBM, where the bifurcation parameter B plays an essential roles in the statistical behaviors of the symbolic dynamics $\{\sigma_k\}$. As mentioned in Equation(2·4), there occurs a phase transition between stationary regime ($B < 2$) and nonstationary regime ($B \geq 2$), where the critical fluctuations dominate the statistical behaviors in the recovering process $B(k)$ in equation (3·3), namely, $B(k)$ passes always through the critical value $B = 2$ at a certain time under the condition of $B_{pre} > 2.0$, and $B_{post} < 2.0$. As the result, the waiting time distribution in equation (2·4) becomes $P(n) \propto n^{-2}$, and the energy distribution in a

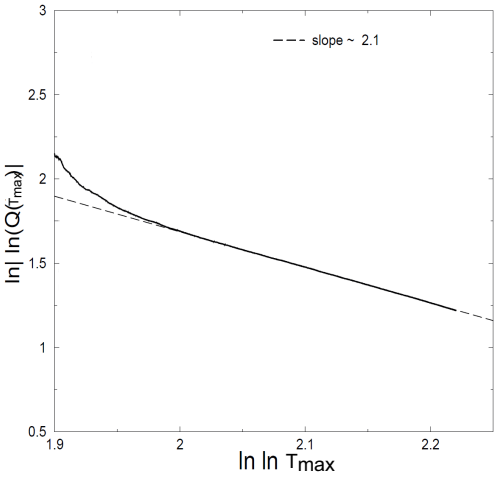

Fig. 5. Waiting time distribution of the maximum aftershock $P(T_{max})$ which obeys a log-Weibull distribution consistent with the Utsu formula.[13)14)]

wide critical regime becomes,

$$P(E) \propto E^{-(\kappa'+1)}. \tag{4·3}$$

Furthermore, by using equation (4·3), the energy distribution of the maximum aftershock E_{max} can be analyzed theoretically; $E_{max} = \mathrm{Max}[E_1, E_2, \cdots E_N]$ where E_j is the j-th aftershock energy and we take N large enough, the distribution $P(E_{max})$ becomes,

$$P(E_{max}) \propto E_{max}^{-(\kappa'+1)} L(E_{max}), \tag{4·4}$$

where $L(x)$ is a slowly varying function $L(x) \propto e^{Cx^{-\kappa'}}$ and C is a constant. Equation (4·3) is the same as the Ishimoto-Iida formula[4)] if we assume that the maximum amplitude a_{max} is related to E; $E \propto a_{max}^{\kappa''}$ where $\kappa'' = 2$ in the case of elastic matters, but in general case with nonlinear elasticity κ'' should be a parameter.

An important point in the above consideration is that the earth crust is in a critical state just after a big earthquake happened, and as the result there appear some characteristic scaling laws in statistical properties.

The last problem in our interests is to estimate the onset time of the maximum aftershock T_{max} by use of our metaphor model based on Equations (3·3) and (3·4). As we have not yet succeeded to derive any theoretical results regarding the onset time T_{max}, we only show the numerical results briefly. Figure 5 is the cumulative distribution function $Q(x) = \exp\left[\{\log(x/a) + b\}^{-(c-1)}\right]$ of the onset time $P(T_{max})$, which is adjusted by a log-Weibull distribution,

$$P(T_{max}) \propto \frac{1}{T_{max}} \frac{1}{(\log T_{max})^c} L(\log T_{max}), \tag{4·5}$$

where c is a constant parameter $c > 1$ and $L(x)$ is a slowly varying function and T_{max} is large enough. The dominant scaling term in the r.h.s. in Equation (4·5)

is T_{max}^{-1}, and this is consistent with the formula suggested by Utsu[5] in aftershock statistics. The onset time of the maximum aftershock is one of the most crucial problems in seismology, and must be carefully studied in relation to the Omori formula, especially the fluctuations from the mean behavior $N(t) - < N(t) >$ are strongly correlated to the onset of large aftershocks. Furthermore, the onset time T_{max} depend on the magnitude of the initial mainshock. There are so many difficult problems remained in determining the distribution $P(T_{max})$, but we can expect to obtain the enough information about statistical properties of aftershocks if we find out any useful dynamical models. The metaphor model proposed in the present paper is a challenge toward this goal from the recent development in chaotic dynamical system theory.[13)–15)]

§5. A universal relation and intrinsic meanings of the Gutenberg - Richter parameter

Recent studies show that the interoccurrence time distribution $P(\tau)$ is very well fitted by a Weibull distribution in various data catalog (in Japan, Taiwan, and California).[17)–21)] On the other hand, the magnitude distribution $P(m)$ obeys the Gutenberg - Richter law.[6)] Then two statistical laws can be unified into a universal relation in the following approach, and it is certified by the above mentioned data-catalog.[16)]

Here we consider the interrelation between the Gutenberg-Richter law, denoted in this subsection $P(m) \propto e^{-bm}$ and the Weibull distribution for the interoccurrence time ($P(\tau) \propto t^{-\alpha-1} \cdot e^{-(\tau/\beta)^{\alpha}}$). We assume that these two statistics are correct over wide ranges, and the parameters (α, β) are depending on the magnitude, i.e., $\alpha(m)$ and $\beta(m)$, then the following relation is easily obtained from the calculation of the mean interoccurrence time between two earthquakes whose magnitude is larger than m ,

$$\beta(m_1)e^{-bm_1}\Gamma\left(1+\frac{1}{\alpha_1}\right) = \beta(m_2)e^{-bm_2}\Gamma\left(1+\frac{1}{\alpha_2}\right), \tag{5·1}$$

where m_1 and m_2 are arbitrary values of magnitude. This implies that the quantity defined by $\beta(m_1)e^{-bm_1}\Gamma\left(1+\frac{1}{\alpha_1}\right)$ is a universal constant when we consider the local earthquakes in a relatively small area.

One of the most important results derived from equation (5·1) is that the GR parameter b is determined by two parameters, in other words, the parameters (α, β) depend on the magnitude m as well as on the GR parameter b,

$$\begin{aligned} \alpha &= f_\alpha(m, b) \\ \beta &= f_\beta(m, b), \end{aligned} \tag{5·2}$$

where the functional forms of f_α and f_β characterize the time series of earthquakes under consideration.

It is difficult to determine those forms completely from any seismological relations known so far, but it is possible for us to obtain the universal aspects of f_α and

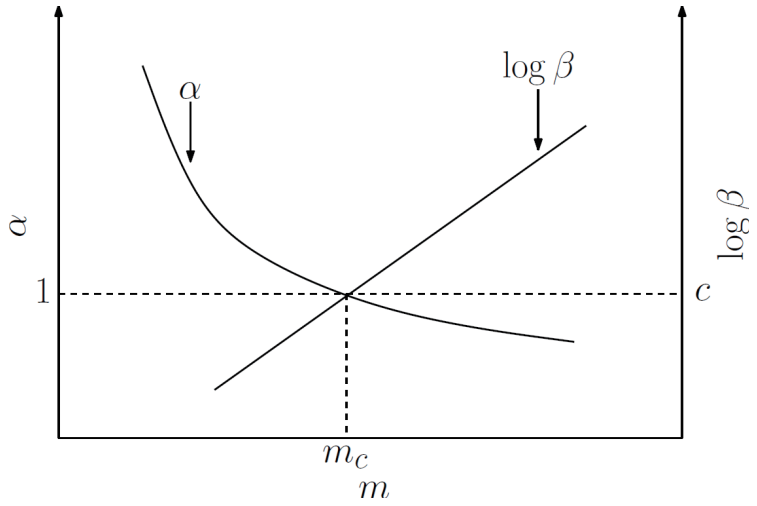

Fig. 6. Schematic picture of a universal behavior of $f_\alpha(m,b)$ and $f_\beta(m,b)$ near $m \simeq m_c$.

f_β by a perturbational approach. Here we consider a particular solution of equation (5·2) which satisfies the following conditions; $f_\beta(m,b) = \exp[b(m-m_c)+c]$ and $f_\alpha(m_c,b) = 1$, namely, the characteristic time β is a exponentilally increasing function of m, and the interoccurrence time distribution is an exponential one ($\alpha = 1$) at $m = m_c$, where b' and c are constant parameters. By use of this simplification, equation (5·1) is rewritten by putting $m_1 = m_c$ and $m_2 = m$,

$$(b'-b)(m-m_c) = -\log\Gamma\left(1+\frac{1}{\alpha(m)}\right) \cong \frac{1}{2}\Delta - \frac{3}{4}(\Delta)^2 + \cdots, \quad (\Delta = \alpha(m)-1). \tag{5·3}$$

Here we used the Taylor expansion near $m \cong m_c$ (i.e., $\alpha(m) \cong \alpha(m_c)$). Figure 6 shows the schematic result of equation (5·3). One can see that the universal relation is recognized in many cases,[17)–21)] though the exponential growth of β, $\log\beta(m) \simeq b'(m-m_c)+c$ is a little bit accelerated.

We have to remind that the solution mentioned above is not unique, but many other solutions for equation (5·2) are possible under the universal relation of equation (5·1). Further details will be studied in our forthcoming paper.[16)]

§6. Summary and Discussion

We demonstrated in the present paper that a series of significant empirical laws in seismology are systematically obtained from a simple chaotic dynamics based on the modified Bernoulli map. The essentially important nature of this model is that the stationary-nonstationary chaos transition process is embedded in the model, and that a universal phenomenon is induced in a wide critical regime near the transition point. Actually, the well-known empirical statistical laws in the earthquake statistics ; the formulas by Wadati(1932), Omori(1894), Enya(1901), Ishimoto-Iida(1939),

and Utsu(1961), are clearly explained in terms of the critical behaviors of our model. Furthermore, a universal relation between the Gutenberg-Richter law and the interoccurrence time distribution function is derived theoretically, and it is comfirmed in various earthquake data-Catalog(JMA, SCEDC, and TCWB) as well as in our theoretical model discussed in § 3. The details will be discussed in the following paper,[16] and the review article of our studies will appear elsewhere.[17),18)]

Acknowledgements

I deeply appreciate Prof. Shuichi Tasaki for his sincere encouragement, creative discussions and heartwarming friendship for long time more than twenty years. I pray, with my hands clasped, the soul of my dear friend may rest in peace.

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Siegfried Grossmann: the Great Man, our Teacher

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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 standard – 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 uncomparable 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.

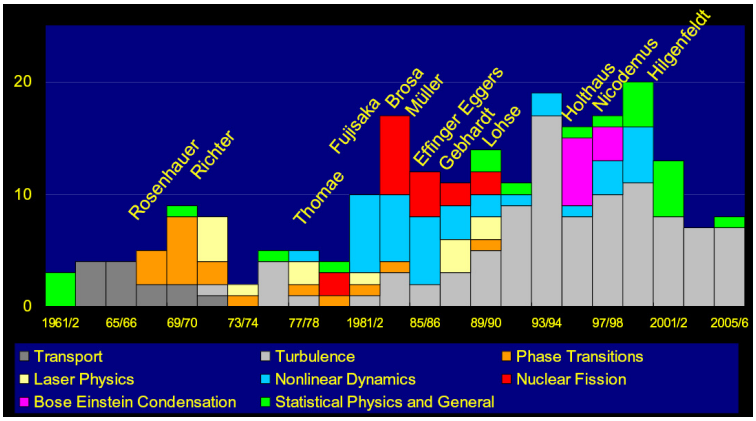

FIG. 1. Spectrum of S. Grossmann's scientific articles, at a resolution of 2 years, from 1961/62 through 2001/02. The number of papers is given by the height of a column. Colors code for fields of research: general statistical physics (green), transport theory (dark grey), phase transitions (orange), 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 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

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.

Concert

Thursday, 8. december 2011, 19:45
Caffe ART Hotel PIRAMIDA

Maribor Piano Trio

Joseph HAYDN
Piano trio C-dur, Hob. XV:27 (1797)
- Allegro
- Andante
- Presto

Johannes BRAHMS
Piano trio c-mol Op. 101 (1887)
- Allegro energico
- Presto non assai
- Andante grazioso
- Allegro molto

Astor PIAZZOLLA
Four seasons from Buenos Aires
- Summer (1964)
- Winter (1970)

Maribor Piano trio was first established in May 1990 by pianist Renata Neuvirt, violinist Viktor Petek, and cellist Petra Neuvirt. The group played extensively and placed highest in their category in the Rovere d'Oro competition in San Bartolomeo, Italy. The Slovenian composer Mitja Reichenberg dedicated them his Piano Trio "3 for 3". After a break in performance of more than a decade, they were joined by pianist Saša Gerželj Donaldson in 2011.

Mariborski klavirski trio

Mariborski klavirski trio sestavljajo trije odlični mariborski akademski glasbeniki: Viktor Petek- violina, Petra Neuvirt-violončelo in Saša Gerželj Donaldson-klavir.
Trio deluje od maja 1990, sprva v sestavi Renata Neuvirt- klavir, Viktor Petek- violina in Petra Neuvirt- violončelo ter je kmalu po začetku delovanja osvojil tretje mesto (drugo ni bilo podeljeno) na mednarodnem tekmovanju komornih skupin v Italiji v mestu San Bortolomeo. Temu uspehu je sledilo več koncertov. Slovenski skladatelj Mitja Reichenberg je triu posvetil skladbo "3 za 3".
Po nekaj letnem premoru od leta 2011 trio deluje v novi spremenjeni sestavi s pianistko Sašo Gerželj Donaldson.

VIKTOR PETEK, violina

Rojen leta 1970 v Mariboru, je glasbeno pot začel pri prof. Zvonki Pal na Glasbeni šoli v Mariboru in jo nadaljeval pri prof. Ivanu Palu na Srednji glasbeni in baletni šoli v Mariboru, ki jo je leta 1988 predčasno z odliko zaključil. Študij violine je nadaljeval pri prof. Christosu Polyzoidesu na Univerzi za glasbo v Gradcu - Avstrija. Leta 1994 je študij z odliko zaključil in isto leto pridobil naziv Magister artium ter nagrado avstrijskega Ministrstva za šolstvo in znanost za magistrsko nalogo.
Bil je večkratni dobitnik prvih nagrad na takratnih slovenskih, jugoslovanskih in mednarodnih tekmovanjih ter obiskoval mojstrske tečaje na področju violine in komorne glasbe pri priznanih mojstrih, kot so Igor Ozim, Valerij Klimov, Tomaž Lorenz in drugi.
Med leti 1990 - 1993 je bil koncertni mojster graškega visokošolskega orkestra ter sočasno član in nazadnje 2. koncertni mojster Graškega simfoničnega orkestra. Od leta 1993 je član Graškega filharmoničnega orkestra, od tega štiri leta kot koncertni mojster le-tega. Bil je tudi koncertni mojster komornega orkestra Amadeus v Mariboru v času njegovega delovanja 2000-2005.

Svoj prvi mednarodni solistični nastop je imel z orkestrom dunajskega konservatorija na festivalu Wiener Festwochen leta 1992 z Beethovnovim violinskim koncertom ter od takrat kot solist in komorni glasbenik nastopa v Avstriji, Nemčiji, Angliji, Italiji, Turčiji, Španiji ter Sloveniji. Med leti 1995 in 2003 je bil član godalnega kvarteta Alea iz Avstrije, s katerim je posnel dve zgoščenki. Od leta 2011 se intenzivno posveča Mariborskemu klavirskemu triu, osnovanemu leta 1991.
Deluje tudi na pedagoškem področju. Tako je bil po zaključenem študiju od 1994 do 2004 asistent in kasneje samostojni učitelj violine na Univerzi za glasbo v Gradcu. Med leti 1999 in 2003 je bil tudi honorarni učitelj na Glasbeni šoli v Mariboru. Od leta 2009 sodeluje kot docent, koncertni mojster in solist na Mednarodnih dneh glasbe v avstrijskem Gmundnu.
Viktor Petek igra na italijansko violino, ki jo je izdelal Gioffredo Cappa iz Saluzza, c. 1690.

PETRA NEUVIRT, violončelo

Renata Neuvirt je rojena 1967 v Mariboru. Z odliko je končala Akademijo za glasbo v Ljubljani v razredu prof. Miloša Mlejnika. Svojo glasbeno kariero je začela kot prvi violončelist in vodja sekcije v SNG Maribor, kjer je bila zaposlena nadaljnjih 18 let. V tem času je sodelovala v Mariborski filharmoniji s številnimi svetovno priznanimi dirigenti in solisti.
Petra Neuvirt je bila članica številnih komornih zasedb, s katerimi je sodelovala na mnogih festivalih in koncertih.
Vrsto let se že ukvarja s pedagoškim delom, od leta 2003 pa je redno zaposlena na Konservatoriju za glasbo in balet Maribor kot profesor violončela in komorne igre na nižji in srednji glasbeni šoli. Z učenci in dijaki se redno udeležuje najrazličnejših tekmovanj po Sloveniji in tujini, kjer dosegajo vidnejše rezultate. Poučuje tudi na Zasebni glasbeni šoli Sv. Petra in Pavla na Ptuju.
Občasno še igra v orkestrih in je članica Mariborskega klavirskega tria.

SAŠA GERŽELJ DONALDSON, klavir

Saša Gerželj-Donaldson je svoj prvenec izvedla leta 1991 z orkestrom Konservatorija za glasbo Maribor. V času študija v Avstriji je nastopala kot solistka ter v klavirskem duu ter z Ansamblom za

sodobno glasbo. Redno je nastopala na številnih mednarodnih prizoriščih in festivalih, med drugim na Svetovnih glasbenih dnevih, Ciclo de Primavera Boadilla del Monte, Lange Nacht der Musik, EPTA in EPTA Pianissimo, Roy Thompson Hall, Rising Stars Toronto, Yamaha Showcase Canada in Festival Lent, Rottenturm festival, Miklavžev večer, Women Art Association Toronto, Mozart Gala RCM Toronto, Glasbeni september, Narodni dom Maribor, Orkestrski cikel ter Pro Solo. Leta 2004 je igrala Straussovo Burlesko op. 1 z Rotterdam Orchestra in Conradom von Alphenom. Snemala je za RTV Slovenija, ter RNE Španiji, ORF, CBC Canada. Prejela je več nagrad: Žiga Zois štipendijo(1994), nagrado Marta Debelli (1998), nagrado Ministrstva za kulturo republike Avstrije (2002), štipendijo Jun Fujimoto Yamaha (2004, 2005) in nagrado Margaret Phillips (2004, 2005) ter je dobitnica nagrade na mednarodnem klavirskem tekmovanju Silvio Bengalli.

Glasbeno šolanje je pričela na Konservatoriju za glasbo in balet Maribor, kjer je zaključila šolanje z odličnim uspehom. Študij je nadaljevala na Univerzi za glasbo in upodabljajočo umetnost Graz v razredu Walterja Kamper in Eike Strauba, kjer je 2003 uspešno zaključila magisterski študij. Med letoma 2004-2006 je z odliko opravila Artist Diplomo v razredu Johna Perryja in Leona Fleisherja na Kraljevem konservatoriju za glasbo v Torontu (Glenn Gould shool of music). Svojo pianistično znanje si je izpopolnjevala na mojstrskih tečajih pri Robertu McDonaldu, Rudolphu Kehrerju, Pascalu Rogeju, Marcu Durandu in drugih. Trenutno je pet let redna profesorica na Konservatoriju za glasbo in balet Maribor. Je članica žirij na državnih in mednarodnih tekmovanjih, prav tako redno izvaja glasbene delavnice za pianiste. Pred kratkim je bila povabljena kot aktivna udeleženka na Mednarodno EPTO 2011, ki bo v Lucernu-Švica in v EPTA Slovenije 2011, kjer se bo predstavila s solo recitalom in predavanjem.

Maribor Piano Trio

Maribor Piano Trio was first established in May 1990 by pianist Renata Neuvirt, violinist Viktor Petek, and cellist Petra Neuvirt. The group played extensively and placed highest in their category in the Rovere d'Oro competition in San Bartolomeo, Italy. The Slovenian composer Mitja Reichenberg dedicated them his Piano Trio "3 for 3". After a break in performance of more than a decade, they were joined by pianist Saša Gerželj Donaldson in 2011.

VIKTOR PETEK violin
was born in 1970 in Maribor. He began his studies with Zvonka Pal at Maribor's music school, and continued to work under Ivan Pal at Maribor Conservatory. He graduated early and with honours, and moved on to study with Christos Polyzoides at the University for Music and Performing Arts in Graz, Austria. In 1994 he completed his studies with honors and gained the title Magister artium and the special Prize of the Austrian Ministry of Education and Science for my Master's thesis.
He won first prize in multiple competitions throughout Slovenia, the former Yugoslavia and abroad and attended masterclasses for violin and chamber music with renowned musicians such as Igor Ozim, Valery Klimov and Tomaž Lorenz.
He was concert master of the University of Graz Orchestra from 1990 until 1993 and simultaneously a member and in 1993 second concert master of the Graz Symphony Orchestra. Since 1993 he is a member of the Graz Philharmonic Orchestra, and has spent four of those years as concert master. He has also had the role of concert master for the Amadeus Chamber Orchestra of Marbor for the time of its existence from 2000 until 2005.
He has made his international debut with the Vienna Conservatory Orchestra at the Wiener Festwochen Festival in 1992 playing the Beethoven's Violin Concerto and is performing since then as soloist and chamber musician in many countries, including Austria, Germany, Great Britain, Italy, Turkey and Slovenia.
He is also active in the field of education. For a decade after completing his studies, he taught as assistant and later as lecturer for violin at the University of Music in Graz. Between 1999 and 2003 he was also a part-time teacher at Maribor Conservatory. Since 2009, he has participated as a lecturer, concert master and soloist at the International Music Days in Gmunden, Austria.
Viktor Petek plays an Italian violin by Gioffredo Cappa, Saluzzo, c. 1690.

PETRA NEUVIRT was born in 1967 in Maribor. She graduated with honors from the Academy of Music in Ljubljana after studying with Milos Mlejnik. For the next 18 years she held the position of solo cellist in the SNG Maribor orchestra. During this time, she was also a member of the Maribor Philharmonic, playing with many world-renowned conductors and soloists. She has also been a member of numerous chamber ensembles, participating in festivals and concerts in Slovenia and abroad.

Ms. Neuvirt has taught for many years, and in 2003 became a full time employee of Maribor Conservatory. Her pupils regularly win awards in Slovenia and abroad in both solo and chamber group categories. She also teaches at Bishop's Private School of Music in Ptuj.

SAŠA GERŽELJ-DONALDSON, born in 1977, made her debut in 1991 with the Maribor Conservatory Orchestra. During her study in Austria, she performed as a soloist with the Ensemble for New Music Graz. Mrs. Gerželj-Donaldson has performed in numerous international venues and festivals, including World Music Days, Ciclo de Primavera Boadilla del Monte, Lange Nacht der Musik, EPTA, Roy Thompson Hall, Rising Stars Toronto, Yamaha Canada Showcase and Festival Lent, Mozart Gala RCM Toronto, Glasbeni September, Narodni dom Maribor-Orkesterski cikel. In 2004, she played Strauss' Burleske, Op. 1 with the Rotterdam Orchestra and Conrad von Alphen. She has made numerous recordings for RTV Slovenia, and RNE Spain, ORF. She has won many awards, including the Žiga Zois Scholarship (1994), the Marta Debelli Prize (1998), the Ministerium für Kultur Austria Prize

(2002), the Jun Fujimoto scholarship (2004, 2005) and the Margaret Phillips Award (2004, 2005). She was a prizewinner at the Pianello Val Tidone International Piano Competition.

Beginning her studies at Maribor Conservatory, Mrs. Gerželj-Donaldson completed her MA with Walter Kamper and Eike Straub at Kunstuniversität Graz. She completed her Artist Diploma under John Perry and Leon Fleisher at the Glenn Gould School at the Royal Conservatory of Music Toronto, performing in masterclasses by Robert McDonald, Rudolph Kehrer, Marc Durand and others. She is currently a full-time professor at the Conservatory of Music and Ballet Maribor. She has conducted piano masterclasses and sat on the jury for national and international piano competitions.

Her students have been successful on the international level, winning the special prize for the best performance of a classical piece at the Panmusica Austria competition in Vienna and Ars Nova Trieste, and first prizes in several competitions, including the Zlatko Grgošević competition in Zagreb, Temsig Slovenia and Concorso per Giovani Strumentisti/Povoletto. She will be conducting a lecture-recital at the European Piano Teachers Association meeting in Lucerne in November 2011 and at EPTA Slovenia 2011.

Concert

Friday, 9. december 2011, 19:45
Caffe ART Hotel PIRAMIDA

Feguš String Quartet

Franz Schubert
String Quartet in E- flat major D 87, op.post. 125,1
Allegro moderato
Scherzo.Prestissimo
Adagio
Allegro

Alban Berg
String Quartet Op. 3
I. Langsam
II. Mäßige Viertel

Sašo Grozdanov

Frédéric Chopin
Ballade No. 1 Op. 23 in G minor

Sergei Rachmaninov
Etudes-tableaux Op. 33 No. 2 in C major

Sergei Prokofiev
Sonata No. 3 Op. 28 in A minor

Feguš String Quartet has been performing since 1992, it's members are brothers: Filip and Simon Peter – violin, Andrej – viola and Jernej – cello. They started their educational path at Maribor Music Conservatory, after which their studies continued at State Conservatory of Carinthia in Klagenfurt (Austria). Since year 2008 they are enrolled in master studium of chamber music at »Universität für Musik undarstellende Kunst Graz« by Stephan Goerner (Carmina Quartet).

Sašo Grozdanov comes from Maribor. He is a PhD student of theoretical physics at Oxford University and is also one of the active participants at this symposium. He is an excellent pianist and he also attended some lectures on conducting at Academy of Music in Ljubljana.

Feguš String Quartet

"Brothers Feguš have obtained their place under the sun with high level of their art by which they insist. Their performance is distinguised by high level of focus, rounded sound, related experiencing of musical arts, important talent and knowledge worth of consideration. We cannot ignore the fact, that they perform before concerts halls full with audience, which nowdays rises so much greater attention."(J.Šetinc, 11.11.2009, Večer)

Feguš String Quartet has been performing since 1992, it's members are brothers: Filip and Simon Peter – violin, Andrej – viola and Jernej – cello.
They started their educational path at Maribor Music Conservatory, after which their studies continued at State Conservatory of Carinthia in Klagenfurt (Austria). In year 2001, Feguš String Quartet has been accepted for study of chamber music at prestigious private school »Scuola di Musica di Fiesole« (Florence, Italy) under mentorship of Milan Škampa (Smetana Quartet) and Piero Farulli (Quartetto Italiano), as well as Andreo Nannoni (Nuovo Quartetto) until year 2007. For their study they have also received stipendum of Italian President Carlo Azeglio Ciampi.
Since year 2008 they are enrolled in master studium of chamber music at »Universität für Musik und darstellende Kunst Graz« by Stephan Goerner (Carmina Quartet).

"Quartet Feguš is different from other already heard instrumental groups, that have the same composition, and as such is becoming comparable with topmost of string quartets" (M. Šijanec, 17.11.2005, Večer)

They have upgrated their knowledge on numerous international master classes, held by members of world – known quartets: Alban Berg Quartet, Amadeus Quartet, Borodin Quartet, Emerson Quartet, Juilliard Quartet, LaSalle Quartet, Guarneri Quartet as well as others.

In year 2001 Feguš String Quartet has qualified for »Isaac Stern Chamber Music Workshop« in Carnegie Hall (New York) under leadership of legendary violinist Isaac Stern and members of the best American Quartets.

They have participated on Orlando Festival, Kerkrade in Netherlands, Festival Pablo Casals in Prades, France, Festival »Strings Only!« in Zadar, International Festival of Young Musicians »DAM« in Priština and others.

They have concerted throughout Slovenia, Europe and USA (Pariz, Berlin, London, Washington, New York, Florence, Vienna itd.)

They recorded for Radio Slovenia, Radio Maribor, ARD, ORF, France Musique.
World premieres have been given of the Slovene and foreign composers: P. Ramovš, A. Lajovic, M. Feguš, J. Golob, D. Močnik, A. Weingerl, Č.S. Voglar, K. Aliçkaj, K. Gashi, D. Zeqiri, S. Spadini.

In year 2006 they released cd-disc with works of L. Janáček and M. Ravel and in 2011 cd with works of A. Webern and H. Wolf.

Also their hometown has given them special recognition for their work: they received City Seal of Maribor and Glazer's Charter for accomplishments in the area of culture. In Piran they also receieved an award for the best performance of Tartini work.

Sašo Grozdanov

Sašo Grozdanov was born in Maribor, where he attended the II. Gimnazija Maribor and studied piano at the Maribor Music Conservatory. He won several gold prizes at national and international piano competitions and took composition lessons at the Ljubljana Music Academy. After finishing secondary school, he studied physics at Harvard University, USA, where he graduated in 2009. In 2010 he received a Masters in mathematics from the University of Cambridge. He is currently enrolled in a PhD programme in theoretical physics at the University of Oxford, working on string theory.