CAMTP

Center for Applied Mathematics and Theoretical Physics
Univerza v Mariboru

4. Simpozij fizikov Univerze v Mariboru

Zbornik povzetkov

Hotel Piramida
Maribor, 15. in 16. december 2005

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

Urednika:
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doc. dr. Dean Korošak, Katedra za aplikativno fiziko, Fakulteta za gradbeništvo

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Urnik 4. Simpozija fizikov Univerze v Mariboru Hotel Piramida, Maribor, 15. in 16. december 2005

Četrtek, 15. december 2005	
09:00-10:00	Flach
10:00-10:15	Šoster
10:15-11:00	Marhl
11:00-11:30	čaj, kava
11:30-12:00	Ruffing
12:00-12:30	Meiler
12:30-13:30	Žumer
13:30-13:45	Korošak
13:45-15:00	kosilo
15:00-16:00	Robnik
16:00-16:30	čaj, kava
16:30-17:00	Zidanšek
17:00-18:00	Podgornik
20:00-23:00	večerja

Petek, 16. december 2005	
09:00-10:00	Fajfer
10:00-10:30	Prapotnik Brdnik
10:30-11:00	Dobnikar
11:00-11:30	čaj, kava
11:30-11:45	Cvikl
11:45-12:00	Marčič
12:00-12:30	Romanovskij
12:30-13:30	Podgornik
13:30-13:45	Dobovišek
13:45-15:00	kosilo
15:00-16:00	Zavrtanik
16:00-16:30	čaj, kava
16:30-17:00	Perc
17:00-17:30	Mencinger
17:30-18:00	Tkalec
18:00-18:30	Spindler
18:30-19:15	Stefanovska
19:15-	zaključek

Ali lahko vodi pot do Bose-Einsteinove dipolarne kondenzacije ekscitonov preko organskih polprevodnikov?

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Šele sedaj je moč razumeti [1], po več kot desetletju od prvih objavljenih eksperimentov, najpomembnejše ključne procese, s katerimi se lahko zadovoljivo popiše obliko krivulj, kot se jih na vzorcih kovina1/enoplastni organski polprevodnik/kovina2, (LED diode), izmeri z metodo kapacitivne spektroskopije [2]. Le-ti so: a) od zunanje napetosti odvisna gostota induciranih presenih nabojev na mejni plasti kovina/polprevodnik [3], b) omejitev električnega toka skozi organski polprevodnik zaradi prisotnosti prostorskega naboja v njem in c) tokovno odvisnega notranjega električnega polja, ki nastane zaradi t.im. zaporednega (notranjega) upora plasti polprevodnika [1]. Meritve kapacitete v odvisnosti od zunanje napetosti za primer strukture, ki sestoji iz dvoplastnih organskih polprevodnikov, pri čemer ena plast podpira predvsem transport elektronov, druga plast pa vrzeli [4], pa je mogoče popisati z dodatno vpeljavo gostote električnega dipolnega momenta na stiku ob vmesni plasti obeh organskih polprevodnikov Alq3-NPB [5].

V prispevku bodo predstavljeni argumenti, ki kažejo na dejstvo, da je gostota električnega dipolnega momenta na mejni plasti obeh organskih polprevodnikov posledica obstoja ekscitonov, ki se nahajajo v (nesevalnem) to je tripletnem stanju. Celoten sistem porazdelitve električnih nabojev v neposredni okolici vmesne plasti zapisanih dvoplastnih organskih polprevodnikov je takšen, da se v Alq3 plasti nahajajo presežni elektroni, v NPB plasti pa presežne vrzeli, kar močno spominja na model dveh vzporednih ravnih površin raznoimenskih nabojev v limiti majhne medsebojne oddaljenosti [6,7]. V odsotnosti tuneliranja med ravninama predstavlja model dvojne plasti elektron-vrzel izhodišče za raziskave Bose-Einsteinove kondenzacije ekscitonov dipolnega kondenzata kjer vsak eksciton, ki je navzven električno nevtralen, poseduje električni dipolni moment s stalno usmerjenostjo v prostoru enako za vse kvazi-delce [7]. Na tem izhodišču bodo podani nekateri "ad hoc" ar-

gumenti, ki kažejo na potencialno možnost dipolne kondenzacije ekscitonov, ki bi se posledično utegnila odraziti v meritvah optične absorpcije in luminiscence dvoplastne strukture organskih polprevodnikov.

Prvi korak k zapisanemu cilju je potrditev domneve, da je gostota dipolnega momenta dejansko povezana z ekscitoni. Ena od očitnih neposrednih možnosti verifikacije je v dejstvu, da se kakšno od elektrod (danega dvoplastnega vzorca) nadomesti, tako da se v vzorec injektirajo zgolj in samo naboji enakega predznaka. V ta namen bodo podani rezultati preliminarne raziskave C-U karakteristik za dvoplastni sistem Al/PTCDA/CuPC/ITO izmerjenih pri 10 kHz [8]. Ta dvoplastni sistem sestoji iz snovi istoimenskega preferenčnega transporta vrzeli z manjšo gostoto ekscitonov, ki je funkcija injektiranja elektronov v sistem iz Al katode. Naknadna zamenjava Al z Ag ali ITO električnim stikom se utegne, po pričakovanju, odraziti v določeni spremembi C-U karakteristike, kar pa bo predmet nadaljnjih raziskav.

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Does the road to Bose-Einstein exciton condensate lead through organic semiconductors?

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After more than a decade since the first experimental results were published, it is now possible to understand the key processes [1] that determine the shape of the capacitance spectroscopy curves obtained on metal1/organic semiconductor/metal2 systems [2]. These are: a) bias dependent interface charge at metal/semiconductor interface [3], b) space charge limited current in organic semiconductor, and c) current dependent internal electric field caused by the internal resistivity of the semiconductor layer [1]. Capacitance vs. voltage measurements on two-layered organic semiconductor with electrons as charge carriers in one layer and holed in the other [4] could be described by introducing the electric dipole density at the interface between the organic semiconductor layers Alq3-NPB [5].

It is argued that the electric dipole density at the interface between the organic semiconductors is caused by the excitons in (non-radiative) triplet state. In the vicinity of the two-layer organic semiconductor interface the Alq3 layer contains the excess electrons while the NPB layer contains the excess of holes. This charge distribution is very similar to a model of two parallel planes with opposite charges in the limit of small separation [6,7]. Neglecting the interplane tunneling, the electron-hole double layer model serves as a starting point for investigation of Bose-Einstein exciton condensate in which each, otherwise neutral, exciton has a permanent electrical dipole moment pointing in the same direction for all quasiparticles [7]. On this basis some ad-hoc arguments will be presented supporting the possibility of exciton condensate and its effect in measurements of optical absorption and luminiscence in two-layer organic semiconductor structure.

The first step in confirmation of the presented conjecture is establishing the excitonic origin of the dipole moment density. This could be achieved by replacing one of the electrodes of the two-layer sample to achieve the injection of charge carriers with the same sign. To support this the results of preliminary investigation of C-U

characteristics of two-layer Al/PTCDA/CuPC/ITO system at 10 kHz [8] will be presented. In this system the predominant charge carriers are holes with the lower exciton density depending on the electron injection from the Al electrode. Further study is directed to the influence of replacement of Al contact with Ag or ITO on C-U characteristics in two-layer organic semiconductor structure.

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Kemotaktično Gibanje Bakterij

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Podal bom pregled znanih dejstev in odprtih vprašanj na področju gibanja bakterij / iskanja hrane.

Reference

[1] M. Kollman *et al.*, *Nature* **438** (24.11.2005) 504-507; and the references therein

Chemotactic Motion of Bacteria

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The signalling network bacteria use to find food (chemotactic apparatus) has many interesting characteristics. It is sensitive over four orders of magnitude, capable of perfect adaption and very robust to external influences. In one of the most investigated bacteria, E. coli, the chemotactic apparatus is decoupled from other metabolic processes and therefore appealing to theoretical investigations. I will present an overview of our knowledge on different aspects of chemotaxis and some ideas from our very recent work.

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Modeliranje sklopitve stimulacije in skrčitve gladkih mišic

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Predstavil bom trenutne raziskave skupine za biofiziko, ki deluje znotraj Laboratorija za biofiziko na Oddelku za fiziko Pedagoške fakultete v Mariboru. Naše osrednje raziskovalno delo predstavlja matematično modeliranje procesov, ki potekajo med krčenjem gladkih mišic, vse od nastanka kalcijevega signala do razvoja sile v mišici. Rezultate modelov aktivacije encima MLCK (kinaza lahkih verig miozina), ki je eden izmed najpomembnejših členov pri procesu krčenja mišic, in fosforilacije molekul miozina bom predstavil in jih primerjal z eksperimentalno dobljenimi vrednostmi in rezultati matematičnih modelov drugih avtorjev. V nadaljevanju bom govoril o izpopolnjenem modelu razvoja sile v mišici, ki prvi napove eksperimentalno potrjen časovni zaostanek razvoja sile za dvofaznim kalcijevim signalom.

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Modeling of stimulation-contraction coupling in smooth muscle cells

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I will present the recent research work of the biophysics group, which operates within the framework of the Laboratory of Biophysics of the Department of physics at the Faculty of Education in Maribor. Our main interest of research is mathematical modeling of stimulation-contraction coupling in smooth muscle cells, from calcium signaling to force development. The recent results of our modeling of MLCK (myosin light chain kinase) enzyme activation, which is one of the most important steps in muscle contraction, and the results of our modeling of myosin phosphorylation will be presented and compared to experimental data and to the results of other models. Furthermore, I am going to discuss the improved model of force development in smooth muscles, which is the first to predict the time gap between the force development and the biphasic calcium signal.

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Fizika onkraj Standardnega modela v redkih mezonskih razpadih

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Standardni model opisuje močne, šibke in elektromagnetne interakcije osnovih delcev. Kljub temu, da se rezultati eksperimentalnih meritev dobro ujemajo s teoretičnimi napovedmi, obstajajo številni teoretični razlogi za obstoj fizike onkraj Standardnega modela. Novi eksperimentalni centri (kot npr. Veliki hadronski trkalnik v CERN-u) bi morda neposredno opazili nove delce. Vendar se učinki nove fizike lahko opazijo tudi v nizkoenergijskih procesih. Redki razpadi mezonov B in K omogočajo preverjanje veljavnosti Standardnega modela za kvarke tipa d. Obstoj nove fizike v sektorju kvarkov tipa u se lahko preveri v razpadih čarobnih mezonov. Ogledali si bomo mogoče učinke razširjenega minimalnega supersimetričnega Standardnega modela in modela z najmanjšim Higgsom v razpadih čarobnih mezonov in njihov preplet z fiziko, ki izhaja iz Standardnega modela.

Reference

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Search for physics beyond Standard Model in rare meson decays

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Standard model describes strong, weak and electromagnetic interactions of elemetary particles. Although the existing experimental results agree well with the theoretical predictions, there are numerous theoretical reasons why we expect existence of physics beyond Standard model. New experimental facilities like Large Hadron Collider in CERN will eventually directly observe new particles. However, the effects of new physics might appear also in the low energy regime. The rare decays of B and K mesons offer unique opportunity to test the Standard model for the down-like quarks, while the appearence of new physics in the up-like quark sector can be tested in the charm meson decays. I discuss possible effects of the minimal supersymmetric extension of the Standard model and Littlest Higgs model in the charm meson decays and their interplay with the physics coming from the Standard model.

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Nonlinearity + Discreteness = Localized Excitations

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I will introduce the fascinating field of localizing energy by discreteness and nonlinearity. I will start with intuitive arguments and enter the beauty of a recently established mathematical theory of Discrete Breathers, which are time-periodic and spatially localized solutions of the equations of motion of a nonlinear Hamiltonian lattice. I will discuss properties of these excitations, and then continue to present experimental studies of the lattice dynamics of crystals, of interacting Josephson junction networks, of coupled optical waveguide systems, of micromechanical cantilever arrays, of antiferromagnets and of Bose-Einstein condensates trapped in optical lattices. Despite their apparent differences in the underlying physics, all these cases share the possibility to excite discrete breathers and to study their properties experimentally.

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Uporaba frakcijskega diferencialnega računa pri opisu transporta v porozni snovi

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V prispevku predstavljamo uporabo frakcijskega diferencialnega računa pri analizi izmerjenega dielektričnega odziva vlažnih zemljin, ki kažejo anomalne lastnosti v nizkofrekvenčnem delu. Vzrok za opaženo disperzijo prevodnosti pripišemo anomalni difuziji ionov v mešanici gline (kaolinit) in vode, čeprav je določitev ustreznega difuzijske procesa netrivialna saj različni dinamični procesi napovejo podobno časovno odvisnost povprečnega premika. Stohastična dinamika ionov je opisana z frakcijsko Langevinovo enačbo, kjer je eksponent potenčne frekvenčne odvisnosti prevodnosti povezan z potenco frakcijskega odvoda v enačbi gibanja.

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Fractional calculus applied to transport in porous matter

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We present the application of fractional calculus in the analysis of the measured dielectric response of the clay-water system which exhibits anomalous features in its low frequency part. It is suggested that the observed conductivity dispersion is a consequence of the anomalously diffusing ions in the clay-water system. It is however a non-trivial task to determine the correct underlying diffusion process since different dynamic processes yield the same mean square time dependence. The fractional Langevin equation is used to describe the stochastic dynamics of the single ion connecting the power-law exponent of the observed conductivity dispersion to the order of the fractional derivative in the fractional Langevin equation.

References

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Sipanje elektron-graviton v okviru teorije superstrun

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Prispevek predstavlja izračun amplitude sipanje elektron-graviton v okviru teorije superstrun. Izračunali smo amplitudo sipanja za dve zaprti struni, ki predstavljata elektron in dve brezmasni struni, ki predstavljata graviton. Izračun amplitude sipanja smo izvedli v Neveu-Schwarz (NS) sektorju v okviru teorije IIA zaprtih superstrun v limiti šibkega gravitacijskega polja (1, 2) in v desetdimenzionalnem prostoru. Izračunali smo amplitudo sipanja najnižjega reda štirih zaprtih superstrun na ploskvi s pozitivnim Eulerjevim številom. Uporabili smo perturbacijsko teorijo superstrun ter vpeljali superpolje in super-Riemanovim ploskvam vpeljali superkonformalno simetrijo ter hkrati prikazali njihovo geometrično predstavo.

Za graviton, ki vstopa v reakcijo sipanja predpostavimo, da je njegova transverzalna hitrost enaka nič in da se pojavlja v prostoru Aichelburg-Sexl metričnega tenzorja (3, 4). Za izračun amplitude sipanja smo uporabili po dva vertex operatorja za elektron in graviton. Elektronovi vertex operatorji vsebujejo Diracove matrike in spinorje. Vsak vertex operator zaprtih strun za elektron in graviton vsebuje sklopitveno konstanto, ki je povezana z normaliziranim vertex operatorjem gravitacijske sklopitve, $K = \pi\alpha' q_c' = 2\pi q_c$. Najpomembnejši del izračuna amplitude sipanja elektron-graviton je izračun pričakovane vrednosti produkta vseh štirih vertex operatorjev. Amplitudo sipanja smo izraunali na krogli. Pri izračunu sipalne amplitude smo upoštevali ohranitev gibalne količine , mase, identiteto Diracovih matrik, produkt spinorjev in pogoj za fizikalna stanja $k_i e_i = 0$.

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A electron-graviton scattering amplitude within the framework of superstring theory

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A paper deals with the electron-graviton scattering within the framework of superstring theory. We calculated the scattering amplitude for two closed superstrings which represent the electron and two massless closed superstrings which represent graviton. The scattering amplitude was carried out in the Neveu-Schwarz sector with type IIA closed superstring in the limit of weak gravitational field (1, 2) in the ten dimensional space. We considered the lowest order scattering amplitude of four closed superstrings, coming from surfaces with positive Euler number. We used superstring perturbation theory and introduced superfields and super-Riemann surfaces to give superconformal symmetry a geometric interpretation, and calculate tree-level amplitude.

The source graviton is taken to have vanishing transverse velocity and it produces the Aichelburg-Sexl metric (3, 4).For scattering amplitude calculation two electron and two graviton vertex operators were used. Electron's vertex operators contain Dirac's matrices and spinors. Each vertex operator has his own closed string coupling constant which relates the normalization of the vertex operator to the gravitational coupling, $K = \pi\alpha' q_c' = 2\pi q_c$. The expectation value of the four vertex operators is the main task of scattering amplitude calculation. The scattering amplitude was calculated on the sphere, using momentum conservation, mass-shell condition, identity of Dirac matrices, product of spinors and physical state condition $k_i e_i = 0$.

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Metuljčna struktura celične signalizacije

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V bioloških celicah poteka zanesljiv in učinkovit prenos celičnih signalov preko kalcija kot posrednika med izvenceličnimi signali in reguliranimi celičnimi procesi. Pojavlja se vprašanje, kako lahko en sam posrednik zagotavlja simultan prenos večih signalov, kar poznamo kot t.i. metuljčno strukturo celične signalizacije [1]. Predstavljamo tri različne možnosti za takšen simultan prenos celičnih signalov. S prvim modelom pokažemo, da lahko kompleksne bursting oscilacije hkrati prenašajo dva signala in pri fizioloških koncentracijah kalcija zagotavljajo selektivno regulacijo dveh celičnih procesov preko selektivne aktivacije proteinov [2]. V drugem modelu pokažemo, da lahko dvostopenjska proteinska kaskada deluje kot pasovni frekvenčni filter za časovno omejene oscilacije. Takšne pasovne filtre lahko učinkovito povežemo v mrežo tristopenjskih signalnih kaskad, ki preko frekvenčne filtracije časovno omejenih oscilacij selektivno regulirajo celične procese [3]. Z zadnjim modelom predstavimo minimalni mehanizem za učinkovit simultan prenos celičnih signalov [4].

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The Bow-Tie Structure of Cellular Signalling

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In biological cells reliable and effective cellular signalling is performed by connecting several external signals with several target processes via calcium as a second messenger. The question arises how only one second messenger can transmit more than one signal simultaneously, which is known as the bow-tie structure of cellular signalling [1]. We present three different possibilities for this simultaneous signal transduction. The first mathematical model shows that complex bursting patterns of calcium oscillations can perform this function of simultaneous transmission of two signals at physiological calcium concentrations by selective activation of two calcium-binding proteins, and hence selective regulation of two cellular processes [2]. In the second model, we show that a two-level protein cascade can act as a band-pass filter for time-limited oscillations. The band-pass filters are combined into a network of three-level signalling cascades that by filtering the frequency of time-limited oscillations selectively switches cellular processes on and off [3]. In the last model we present a minimal mechanism providing effective simultaneous transmission of intracellular signals [4].

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O linearizaciji na primerih

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Govoril bom o različnih aspektih linearizacije. Najprej bom prikazal pridobitev Jacobijeve (linearizacijske) matrike vektorske funkcije več spremenljivk. Začel bom z linearnim Taylorjevim približkom funkcije ene spremenljivke (t.j. s tangento na krivuljo). Potem bom omenil pomen parcialnih odvodov v primeru, ko je funkcija, ki jo želimo linearizirati, funkcija dveh ali več spremenljivk.

Nato se bom osredotočil na avtonomne sisteme NDE. Ker nelinearnega sistema v splošnem ne moremo rešiti, je seveda linearizacija zelo pomembna. Toda vprašanje je kako dobro lineariziran sistem odraža dejansko stanje nelinearnega sistema?

Najpomebnejše točke (tudi s stališča linearizacije) so tako imenovane kritične oz. stacionarne točke (ekvilibriji), kjer je hitrost toka $\vec{x}'$ ničelna. Zato bom predstavil in komentiral nekatere splošno znane izreke o linearizaciji: Poincarejev linearizacijski izrek, Hartmanov izrek, Izrek o stabilni mnogoterosti in Izrek o centralni mnogoterosti (glej tudi [2,3]). Uporabil bom primere, na katerih bom prikazal prednosti in slabosti, ki lahko pri različnih prijemih nastopijo. Poudaril bom pomen hiperbolčnih kritičnih točk. Primeri bodo izbrani tako, da bom pokazal, da je včasih (vendar redko) tudi trivialna linearzacija smiselna.

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On Linearization by Examples

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I shall talk about different aspects of linearization. First of all I will show the concept of the Jacobian matrix (for a vector function of many variables), beginning with linear Taylor's approximations of $f: RI \to RI$ (i.e. with the tangential line of the curve). Next, I will mention the meaning of partial derivatives for the function $f: RI^2 \to RI$ or $f: RI^n \to RI$

Next, We will focus ourself on autonomous systems of ODEs. Since nonlinear systems can not be solved in general, the linearization is of high importance. But the question of fidelity raises up, in other words: how well does the linearized system reflect the situation of the nonlinear flow?

The most interesting points of a homogeneous system of ODEs (also from the linearization point of view) are the so called critical or stationary points (equilibria), where the velocity $\vec{x}'$ of the flow is zero. Therefore, I shall present and comment some well-known results on linearization at a stationary point: the Poincare's linearization theorem, the Hartman's theorem, the Theorem of the stable manifold and the Theorem of the centre manifold (see also [2,3]). I will use few examples to illustrate the (dis)advantages and/or problems arising at different cases. I will emphasize the concept of hyperbolicity. I will choose the examples in such a manner that also the so called trivial (i.e. formal) linearization will be useful. But, on the other hand I will emphasize that this is rather rare.

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Ekcitabilnost - Paradigma za robustno prostorsko dinamiko

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Ekcitabilnost je prisotna na številnih področjih znanosti, od kemije, nevrofiziologije in kardiologije, do laserske optike. Posebej značilno za ekcitabilne sisteme je, da nadkritične zunanje motnje inducirajo ne-trivialne veliko-amplitudne odmike od stabilnega stacionarnega stanja. Pomembno je, da so med temi odmiki ekcitabilni sistemi zelo šibko dovzetni za zunanje perturbacije. V navezi z nedavno odkritim dejstvom, da je čas, ki ga sistem preživi proč od stabilnega stacionarnega stanja, pomembna količina, ki določa prostorsko dinamiko sistema, bomo ekcitabilnost proglasili za ključno lastnost, ki omogoča robusten prenos informacij med sklopljenimi elementi prostorsko razširjenega ekcitabilnega sistema. Pokazali bomo, da lastne prostorske frekvence z šumom induciranih valov ni moč spremeniti z determinističnimi vali različnih oblik in/ali širin. Iz bio-medicinskega stališča so predstavljeni rezultati pomembni, ker sugerirajo, da bi lahko ekcitabilnost nevronske dinamike predstavljala lastni obrambni mehanizem možganov, še posebej pred deterministčnim zunanjimi vplivi, kot je na primer elektromagnetno sevanje, ki ga emitirajo naprave za brezžično komunikacijo, katerim je zaradi specifične ekcitabilne dinamike nevronov onemogočen škodljiv vpliv.

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Excitability - A paradigm for robust spatial dynamics

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Excitability is ubiquitous in various areas of science, ranging from chemistry, neurophysiology and cardiology, to laser optics. Characteristically, when a sup-threshold external stimulus is applied, excitable systems exhibit nontrivial large-amplitude excursions away from the stable steady state. During the excursion time, however, these systems are very robust against various external perturbations. Recently, we found that the excursion time is the defining quantity determining the spatial dynamics of space-extended excitable media. Thus, by jointly considering these two facts, we will argue that the excitability is crucial for assuring robust information transmission among coupled units in space. In particular, we will show that the inherent noise-induced spatial frequency of excitatory events cannot be altered by deterministic forcing waves of various shapes and/or widths. From the biomedical point of view, our results suggest that the robust excitable nature of neuronal dynamics might provide an internal defence mechanism for the brain, preventing deterministic environmental influences, like for example the omnipresent electromagnetic radiation emitted by wireless communication devices, to impair its proper functioning.

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Difraktogram 51 in odkritje strukture DNK

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Predstavil bom znameniti difraktogram 51 rentgenskega sipanja na DNK, ki ga je posnela Rosalind Franklin in je bil osnova za model dvojne vijačnice Watsona in Cricka. Ogledali si bomo njegove lastnosti in skušali razumeti, kaj nam pove, podobno kot je skušal Thomas Young razumeti pomen hieroglifov. Na koncu predavanja naj bi vsakdo znal razložiti, zakaj je DNK dvojna vijacnica, s periodo 10 baznih parov in fazno zamaknjenima verigama.

Fizika DNK

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DNA, molekula življenja, ima vrsto različnih lastnosti, ki so zanimive iz čisto fizikalne perspektive. Obravnaval bom nekatere od teh lastnosti in povezanih fizikalnih problemov, ki jih predstavljajo za fiziko. Med drugim enačbo stanja DNK, fazni diagram, interakcije med odseki DNK, naravo kondenziranih mezofaz, elastične lastnosti, in narovo stanja DNK v kromatinu in virusih.

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The Physics of DNA

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DNA, the molecule of life, has a wide variety of properties that are of interest also from a purely physics perspective. We will discuss a number of these properties and the associated problems they pose for physicists. These include its equation of state, its phase diagram, the interactions between different DNA molecules, the nature of its condensed mesophases, its elastic properties, the nature of the state of DNA in chromatin and viruses.

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Kršitev simetrije CP na delu faznega prostora pri razpadnih kanalih $B^{\pm} \to K^{\pm}\pi^{+}\pi^{-}$ in $B^{\pm} \to K^{\pm}K^{+}K^{-}$

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Predstavila bom pomen in možnost opaziti kršitev simetrije CP na delu faznega prostora v razpadnih kanalih $B^{\pm} - > pi^{+}pi^{-}K^{\pm}$ in $B^{\pm} - > K^{+}K^{-}K^{\pm}$. Krsitev simetrije CP je posledica interference med neresonančno in resonančnimi razpadnimi ampiltudami. Vmesna rezonančna stanja, ki razpadejo v $pi^{+}pi^{-}$ in $K^{+}K^{-}$ ali $K^{-}pi^{+}$ so lahko mezoni $\bar{c}c$ s kvantnimi števili $J^{P} = 0^{+}, 1^{-}, 1^{+}$ ali pa mezon $\phi(1020)$. Največjo kršitev simetrije CP na delu faznega prostora pričakujemo v bližini rezonančnega mezona χ_{c0}, v bližini $K_0^*(1430)$ in $\psi(2S)$ rezonanc pa pričakujemo 10% kržitev simetrije CP.

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CP violation in the partial width asymmetries for $B^{\pm} \to K^{\pm}\pi^{+}\pi^{-}$ and $B^{\pm} \to K^{\pm}K^{+}K^{-}$decays

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We investigate a possibility of observing CP asymmetries in the partial widths for the decays $B^- -> pi^+ pi^- K^-$ and $B^- -> K^+ K^- K^-$ produced by the interference of the non-resonant decay amplitude with the resonant amplitudes. The resonant states which subsequently decay into $pi^+ pi^-$ and $K^+ K^-$ or $K^- pi^+$ are charmonium $\bar{c}c$ states with $J^P = 0^+, 1^-, 1^+$ or the $\phi(1020)$ meson. We find that the largest partial width asymmetry comes from the χ_{c0} resonance, while the resonances $K_0^*(1430)$ and $\psi(2S)$ give a partial width asymmetry of the order 10

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Eksaktna analiza adiabatskih invariant za časovno odvisni harmonski oscilator

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Teorija adiabatskih invariant ima dolgo zgodovino in je zelo pomembna in uporabna v številnih vejah fizike, klasično in kvantno, vendar je redko osnovana na rigoroznih rezultatih. Obravnaval bom časovno odvisni eno-dimenzionalni harmonski oscilator, katerega Newtonova enačba $\ddot{q} + \omega^2(t)q = 0$ v splošnem ni rešljiva. Ogledali si bomo časovni razvoj začetnega ansambla faznih točk z ostro določeno energijo E_0 v času $t = 0$ in izračunali rigorozno porazdelitev energije E_1 v času $t = T$, ki je v celoti (vsi momenti, vključno z varianco μ^2) določena s prvim momentom $\bar{E}_1$. Na primer, $\mu^2 = E_0^2[(\bar{E}_1/E_0)^2 - (\omega(T)/\omega(0))^2]/2$, in vsi višji sodi momenti so potence μ^2, medtem ko so lihi momenti ekzaktno enaki nič. Pri idealni adiabatičnosti imamo $\bar{E}_1 = \omega(T)E_0/\omega(0)$, in varianca μ^2 je enaka nič, medtem ko za končne T izračunamo $\bar{E}_1$ in μ^2 za povsem splošen primer z uporabo WKB teorije do vseh redov. Dokažemo: če je $\omega(t)$ iz razreda $\mathcal{C}^m$ (vsi odvodi do in vključno reda m so zvezni), potem imamo $\mu \propto T^{-(m+1)}$, medtem ko je za analitične $\omega(t)$ (iz razreda $\mathcal{C}^\infty$), znano, da imamo eksponentni zakon $\mu \propto \exp(-\alpha T)$. Porazdelitev končnih energij je univerzalna, saj ni odvisna od podrobnosti $\omega(t)$.

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Exact analysis of adiabatic invariants in time-dependent harmonic oscillator

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The theory of adiabatic invariants has a long history, and very important implications and applications in many different branches of physics, classically and quantally, but is rarely founded on rigorous results. Here we treat the general time-dependent one-dimensional harmonic oscillator, whose Newton equation $\ddot{q}+\omega^2(t)q = 0$ cannot be solved in general. We follow the time-evolution of an initial ensemble of phase points with sharply defined energy E_0 at time $t = 0$ and calculate rigorously the distribution of energy E_1 after time $t = T$, which is fully (all moments, including the variance μ^2) determined by the first moment $\bar{E}_1$. For example, $\mu^2 = E_0^2[(\bar{E}_1/E_0)^2 - (\omega(T)/\omega(0))^2]/2$, and all higher even moments are powers of μ^2, whilst the odd ones vanish identically. In ideal adiabaticity $\bar{E}_1 = \omega(T)E_0/\omega(0)$, and the variance μ^2 is zero, whilst for finite T we calculate $\bar{E}_1$, and μ^2 for the general case using exact WKB-theory to all orders. We prove that if $\omega(t)$ is of class $\mathcal{C}^m$ (all derivatives up to and including the order m are continuous) $\mu \propto T^{-(m+1)}$, whilst for class $\mathcal{C}^\infty$ it is known to be exponential $\mu \propto \exp(-\alpha T)$. The distribution of final energies $P(E_1)$ is universal as it does not depend on the details of $\omega(t)$.

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Časovna reverzibilnost dvodimenzionalnih sistemov NDE

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Proučujem dvodimenzionalni sistem

$$\dot{x} = X(x, y), \qquad \dot{y} = Y(x, y), \tag{1}$$

kjer so funkcije na desni strani polinomi. Naj bo Q grupa rotacij fazne ravnine sistema (1). Predstavil bom algoritem za izračunavanje končne baze invariant grupe Q ter pokazal, da te invariante določajo množico vseh časovno reverzibilnih sistemov v družini (1).

Opisal bom tudi množico vseh časovno-reverzibilnih sistemov v posebni družini kompleksnih polinomskih differencialnih enačb in predlagal visoko zmogljiv računski algoritem za izračun te množice. Obravnaval bom tudi medsebojno povezavo problema časovne reverzibilnosti in problema centra.

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Time-reversibility in two-dimensional systems of ODE

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Consider two-dimensional system

$$\dot{x} = X(x, y), \qquad \dot{y} = Y(x, y), \tag{1}$$

where the right-hand sides are polynomials. Let Q be the group of rotation of the phase space of system (1). We give an algorithm to compute a finite basis of invariants of the group Q and show that these invariants determine the set of all time-reversible systems in the family (1). They also determine the number of axes of symmetry of the phase space picture of trajectories of system (1).

We also characterize the set of all time–reversible systems within a particular family of complex polynomial differential equations in two complex dimensions and give an efficient computational algorithm for finding this set. An interconnection of time-reversibility and the center problem is discussed as well.

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A Similarity Solution of a Discrete Diffusion Equation

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We discuss the similarity solution to a discrete diffusion equation which is constructed on a basic linear grid. The similarity solution is analytically derived.

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Meritve zeta potenciala površin teflonskih in poliamidnih folij

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Meritve zeta potenciala smo izvajali z merilnim sistemom EKA, katere proizvajalec je firma Anton Paar iz Gradca, na vzorcih poliamida in teflona v obliki folij. V ploščati merilni celici imenovanega merilnega sistema se teflonske folije standardno uporabljajo za zatesnitev celice in določitev kanala med folijami vzorca, po katerem med meritvijo teče raztopina elektrolita. Z meritvami smo želeli preveriti vpliv priprave teflonskih folij na zeta potencial njih samih, pa tudi na meritve zeta potenciala hidrofilnih vzorcev kot je poliamid. Ob koncu predlagamo standarden postopek priprave ploščate merilne celice, ki bi minimiziral vpliv okolice na rezultate meritev in bi tako omogočal čim boljšo primerljivost rezultatov meritev zeta potenciala hidrofilnih vzorcev.

The zeta potential measurements of polytethrafluoroethylene and polyamide foil surfaces

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The zeta potential measurements were carried out on PTFE and PA foils using EKA measuring device which was developed in the firm of Anton Paar in Graz, Austria. In the flat measuring cell of this system the PTFE foils are standardly used to close the cell and to form the channel between the foils of the sample. The purpose of these measurements was to investigate the influence of PTFE foils pretreatment to their zeta potential measurements as well as to investigate the influence of their pretreatment to results of zeta potential measurements on other hydrophilic samples such as polyamide. As final result the standard procedure of flat measuring cell pretreatment is suggested in order to minimize the influence of enviroment to zeta potential measurement results and to enable good comparativity between zeta potential measurement results of hydrophilic samples.

Organizacija zvezdastih polimerov v tankih plasteh

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Zvezdasti polimeri so sestavljeni iz razlicnih polimernih krakov, ki so povezani v eni skupni točki, tako da tvorijo kompleksno zvezdasto molekulo. Urejanje taksnih molekul je odvisno od kemijske sestave posameznih krakov, njihove molekulske mase in medsebojnih interakcijskih energij. V tankih plasteh je organizacija zvezdastih polimerov dodatno omejena z debelino plasti in površinskimi interakcijami. Ti sistemi kažejo zelo veliko občutljivost na zunanje vplive kot so sprememba temperature in uporaba različnih topil. Z njimi lahko kontroliramo lokalno urejenost polimerne plasti. Področja uporabe takšnih "pametnih površin" segajo od shranjevanja podatkov do selektivnih senzorjev, filtrov in membran. Pri našem delu smo z mikroskopijo na atomsko silo (AFM) proučevali urejanje zvezdastega polimera sestavljenega iz treh krakov: polistirena, poliizoprena in poli(metil metakrilata) [1,2]. Pripravili smo 20 nm debele polimerne nanose na silicijevem substratu. Z naknadno termično in kemično obdelavo teh nanosov smo vplivali na organizacijo polimerov na molekularni in makroskopski ravni.

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Organisation of star-shaped polymers in thin films

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Star-polymers are built from different polymer blocks, which are covalently bound together at one junction point forming a star-shaped molecule. The ordering of such molecules depends on the chemical composition, molecular mass and the interaction energies between the different blocks. In thin films their ordering is additionally determined by interfacial interactions at boundary surfaces and film thickness. These systems show a high sensitivity to external stimuli like temperature changes and solvent treatment and in this way their structure can be well controlled. The use of such "smart surfaces" ranges from data storage to highly selective sensors, filters and membranes. Using atomic force microscopy (AFM) we studied the ordering of a star terpolymer consisting of polystyrene, polyisoprene and poly(methyl methacrylate) [1,2]. Thin films of about 20 nm thickness were prepared by spin-casting the polymer solution onto silicon wafers. With subsequent thermal and chemical treatment the organisation of the polymer was altered microscopically and macroscopically.

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Simulacija JMR spektrov ikozaedričnega kvazikristala Al-Pd-Mn

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Predstavil bom simulacijo spektrov ikozaedričnih kvazikristalov Al-Pd-Mn in njihovih aproksimantov iz družine kovinskih zlitin ξ'-Al-Pd-Mn, ki temelji na razlagi meritev z jedrsko magnetno resonanco (JMR). Izkaže se, da obliko JMR spektrov kvazikristalov v glavnem določa električna kvadrupolna interakcija. Z merjenjem kotne odvisnosti JMR spektra je mogoče določiti porazdelitev lokalnih mrežnih okolic v ikozaedričnem kvazikristalu, ki je v splošnem anizotropna. S pomočjo novega numeričnega modela, ki temelji na eksaktni strukturi kvazikristalnega aproksimanta ξ'-Al-Pd-Mn smo simulirali porazdelitev orientacij lastnih sistemov tenzorja gradienta električnega polja. Izhajali smo iz izotropnega Czjzekovega modela za amorfno snov in ga izpopolnili za opis anizotropne strukture kvazikristala. Izračunani JMR spektri uspešno reproducirajo glavne značilnosti doslej izmerjenih spektrov in obenem služijo kot napoved rezultatov meritev na vzorcu ξ'-Al-Pd-Mn.

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Theoretical simulation of NMR spectra of icosahedral Al-Pd-Mn quasicrystal

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I will present theoretical study of NMR spectra of icosahedral Al-Pd-Mn quasicrystals and their ξ'-Al-Pd-Mn approximants, based on explanation of measurements with nuclear magnetic resonance (NMR). It tourned out that the electric quadrupole interaction mainly determines the shape of the observed NMR spectra. The information about the distribution of the local atomic environments in icosahedral quasicrystals was accessed by measuring the orientation dependece of the NMR spectrum. On the basis of numerical simulation in exact structure of quasicrystalline approximant, the distribution of the electric field gradient principal axes system orientations was obtained. We started with the isotropic Czjzek model for amorphous solid and upgraded it for suitable description of anisotropic structure of quasicrystal. The calculated angular-dependend NMR spectra reproduces well the general features of the experiment and should serve as an example for the results obtained in the future experiments.

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Observatorij Pierre Auger: Opazovanje kozmičnih žarkov ekstremnih energij

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Obstoj kozmičnih žarkov z energijami okrog 10^{20} eV je eden najzanimivejših nerešenih problemov današnje astrofizike osnovnih delcev. Te kozmične žarke obdaja kar nekaj skrivnosti: posedujejo makroskopske energije, njihovi izvori in vrsta delcev so nam neznani, njihov spekter pa nakazuje možnost, da bi se njihovi izvori znali nahajati v bližnjem vesolju. Ker je njihova pogostost na Zemlji izredno majhna (na km^2 površine pade le en kozmični žarek z energijo nad 10^{20} eV na stoletje), so meritve izredno zahtevne in kličejo po gradnji ogromnih observatorijev. Mednarodna kolaboracija P. Auger želi dokončno odstrniti tančico skrivnosti in poiskati odgovore o naravi kozmičnih žarkov ekstremnih energij. Zato smo znanstveniki iz 57 raziskovalnih intitucij iz 17 držav v provinci Mendoza v Argentini že izgradili 2.000 km^2 observatorija, ki bo, ko bo dokončan, meril 3.000 km^2. Observatorij že leto dni zajema podatke, zato bom v predavanju predstavil tudi prve rezultate.

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Pierre Auger Observatory: Observing Extremely High Energy Cosmic Rays

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One of the most fascinating puzzles in particle astrophysics today is that of the origin and nature of the highest energy cosmic rays. These cosmic rays have macroscopic energies, they seem to come from no known astrophysical source, their chemical composition is mostly unknown and their spectrum indicates that their sources may exist in the nearby Universe. Their extremely low flux (for particles with $E > 10^{20}$ eV, 1 particle/km^2/century) makes the observations difficult and calls for huge observatories. The Pierre Auger Collaboration is a major international effort consisting of 57 institutions from 17 countries. The observatory is recently under construction in Province of Mendoza, Argentina. The surface of 2.000 km^2 out of 3.000 km^2 has been filled with surface and fluorescence detectors and is already taking data. In addition to the motivation and description of the observatory, I will present also first preliminary results.

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MAGNETNORESONANČNE TEHNIKE ZA SLEDENJE KAKOVOSTI ŽIVIL

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Pri nadzoru kakovosti in avtentičnosti živil in hrane se poleg klasičnih kemijskih in bioloških metod v svetu vedno bolj uveljavljajo hitre in nedestruktivne fizikalno-kemijske metode, kot so metode jedrske magnetne resonance (NMR) in elektronske paramagnetne resonance (EPR).

Razvoj novih metod poteka v tekmovanju med željo nadzornih služb za čim bolj natančnim nadzorom in ponarejevalcev hrane, da lahko svojemu izdelku dodajo čimveč cenenih dodatkov brez strahu, da bi jih standardne metode za nadzor razkrile. Predstavljenih je nekaj primerov uporabe metod elektronske paramagnetne resonance (EPR), jedrske magnetne resonance (NMR) in slikanja z magnetno resonanco, ki omogoča nedestruktivno pridobivanje slike notranjosti danega živila, ne da bi ga morali razrezati ali obsevati z rentgenom.

Nedestruktivne magnetnoresonančne spektroskopske metode omogočajo meritve strukture in dinamike različnih vrst hrane. Prav tako nudijo možnost merjenja mikroskopskih lastnosti snovi, s katerimi lahko na primer določimo izvor in kvaliteto hrane, v nekaterih primerih pa lahko dokažejo tudi geografsko poreklo hrane.

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MAGNETIC RESONANCE TECHNIQUES FOR FOOD QUALITY TRACEABILITY

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Non-destructive physical-chemical methods, such as nuclear magnetic resonance (NMR) and electron paramagnetic resonance (EPR), are being used as complementary techniques to classical chemical and biological methods for food traceability and authenticity.

New methods are developed in competition between the food quality inspectors and counterfiters, who wish to add cheap additives without fear of being detected with standard inspection methods. Some examples of elektron paramagnetic resonance (EPR), nuclear magnetic resonance (NMR) in NMR imaging (MRI) are presented.

Non-destructive magnetic resonance methods allow for the determination of structure and dynamics of different types of food. They also provide opportunities for measuring the microscopic properties of food ingredients, which for example allow for the determination of food quality and authenticity, and in some cases also its geographical origin.

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Nematični tekoče kristalni elastomeri: urejenost in fazni prehod

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Nematični tekoče kristalni elastomeri so multifunkonalni materiali, ki jih sestavljajo kemijsko povezane polimerne verige s pripetimi nematogenimi segmenti. Ti so lahko vključeni v same verige, ali pa so nanje od strani pripeti [1]. Kombinacija entropične elastičnosti polimernih verig in orientacijska ureditev nematogenih segmentov daje tem materialom zanimive optične, toplotne in mehanske lastnosti, ki lahko v bodoče prinesejo tudi tehnološko uporabo. Med zanimivimi pojavi velja posebej izpostaviti: velike spremembe oblike materiala pri faznem prehodu, z nategom inducirano reorientacijo in ne nazadnje tudi mehko elastičnost [1, 2]. Čeprav so tekoče kristalni elastomeri vzbudili precej pozornosti, narava njihovega faznega prehoda še ni dokončno pojasnjena [3]. Prav tako se postavljajo vprašanja o konceptu mehke elastičnosti [4]. V tem predavanju bomo z uporabno enostavnega Landau-de Gennesoga opisa pokazali, kako razumemo urejujoče in razurejujoče vplive polimerne mreže na obnašanje nematičnega elastomera v okolice faznega prehoda v izotropno fazo. Devterijeva magnetna resonanca in kalorimetrija sta omogočila vpogled v molekularno ureditev in naravo faznega prehoda. Devterinane nematogene molekule 8CB so služile kot sonde za določitev urejenosti in kot razredčilo, ki zmanjšuje vpliv polimernih verig. Vzorci nematičnega elastomera so bili pripravljeni po freiburški

metodi. Z dodajanjem 8CB tekočega kristala je narava prehoda prešla iz superkritične v kritično. Podobno spremembo je prineslo zmanjšanje gostote zamreženja elastomera. Za konec bo na kratko opisan nematični elastomer s primešanimi ogljikovimi delci, kjer pride do posebej zanimivega elektro-mehanskega pojava.

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Nematic liquid crystal elastomers: Ordering and transitions

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Liquid crystal elastomers are multifunctional materials that are composed of cross linked polymer networks with either main-chain or side-chain mesogenic units [1]. The combination of the entropic elasticity of polymer networks with the orientational ordering of anisotropic, nematogenic molecular units yields complex materials with interesting optical, thermal, and mechanical properties that may in future lead to new technological applications. Among the interesting phenomena, the most unusual include large spontaneous shape change at phase transitions, strain-induced orientational transitions leading to new organized morphologies, and soft elasticity [1, 2]. Although liquid crystalline elastomers are attracting a lot of attention the nature of their phase transitions is still not completely understood [3]. Further there are questions about the applicability of the soft elastic description [4]. Here we use a simple phenomenological Landau-de Gennes type analysis to show how the balance between ordering and disordering effects of the polymer network is crucial for the behaviour of the system close the phase transition. Deuterium NMR and calorimetry yield information on local molecular ordering and in particular on the nature of the phase transitions in side-chain nematic liquid crystalline elastomers [5]. Deuterated 8CB molecules were used as probes and as nematic solvents to dilute the

effect of the polymer network. The side-chain elastomer samples were prepared according to the standard method developed in Freiburg laboratories. By adding low molecular weight liquid crystals to the elastomer the change from supercritical to critical regime is found. Similar change is found also with reducing the density of the polymer cross linking. Further we briefly discuss elastomeric composites including carbon particles where electro-mechanical effect is particularly interesting.

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