
CAMTP

CENTER FOR APPLIED MATHEMATICS AND THEORETICAL PHYSICS
UNIVERZA V MARIBORU

17. Simpozij fizikov Univerze v Mariboru

Zbornik povzetkov

Hotel Piramida
Maribor, 13., 14. in 15. december 2018

Naslov: 17. Simpozij fizikov Univerze v Mariboru -
Zbornik povzetkov

Urednika: prof. dr. Marko Robnik
doc. dr. Anita Prapotnik Brdnik

Založnik/
Prireditelj simpozija: CAMTP - Center za uporabno
matematiko in teoretično fiziko,
Univerza v Mariboru

Kraj založbe: Maribor

Datum izida: December, 2018

Naklada: 50

Tisk: CopyCenter Oberčkal Bojan s.p.

CIP - Kataložni zapis o publikaciji
Univerzitetna knjižnica Maribor

SIMPOZIJ fizikov Univerze v Mariboru (17 ; 2018 ; Maribor)

Zbornik povzetkov / 17. simpozij fizikov Univerze v Mariboru, hotel Piramida, Maribor, 13., 14. in 15. december 2018 ; [urednika Marko Robnik, Anita Prapotnik Brd-
nik ; [organizacija simpozija] CAMPT, Center for Applied, Mathematics and Theoretical
Physics, Univerza v Mariboru. - Maribor : CAMTP - Center for Applied Mathematics
and Theoretical Physics, 2018

ISBN 978-961-94576-0-3

1. Robnik, Marko, 1954- 2. CAMTP (Maribor)

COBISS.SI-ID 95664129

CAMTP

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

Organizacijski odbor:

Prof.Dr. Marko Robnik, CAMTP

Doc.Dr. Anita Prapotnik Brdnik, Katedra za aplikativno fiziko, Fakulteta za gradbeništvo,
prometno inženirstvo in arhitekturo

Urednika:

Prof.Dr. Marko Robnik, CAMTP

Doc.Dr. Anita Prapotnik Brdnik, Katedra za aplikativno fiziko, Fakulteta za gradbeništvo,
prometno inženirstvo in arhitekturo

Generalni sponzor simpozija:



ALMA MATER EUROPAEA

— Evropski center, Maribor —



E N E R G I J A

Generalni pokrovitelj simpozija:

EASA - European Academy of Sciences and Arts (Salzburg)



PREDGOVOR

Naši Simpoziji fizikov Univerze v Mariboru, ali na kratko kar Božični simpoziji fizikov, imajo že tradicijo, saj imamo letos že jubilejnega sedemnajstega po vrsti. Namen je strokovno druženje slovenskih fizikov, ob prisotnosti ter aktivni udeležbi nekaterih uglednih kolegov iz tujine kot častnih vabljenih gostov. Letos imamo pet uglednih vabljenih predavateljev iz tujine, iz odličnih raziskovalnih skupin, tako da s tem ostajajo naša srečanja nacionalna z mednarodno udeležbo. Srečanje je le ena od številnih dejavnosti CAMTP - Centra za uporabno matematiko in teoretično fiziko Univerze v Mariboru, ki sicer organizira kar sedem serij mednarodnih znanstvenih srečanj.

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 študentom 1. in 2. stopnje 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 pomemben prispevek pri nadaljnjih uspešnih aktivnostih Fakultete za naravoslovje in matematiko Univerze v Mariboru, ter Fakultete za matematiko in fiziko Univerze v Ljubljani, in seveda inštitutov z oddelki za fiziko, kot sta Inštitut Jožef Stefan v Ljubljani ter CAMTP v Mariboru.

V čast nam je, da je generalni pokrovitelj Simpozija Evropska akademija znanosti in umetnosti (European Academy of Sciences and Arts, Salzburg).

Prof.Dr. Marko Robnik, član EASA, Direktor CAMTP
in Doc.Dr. Anita Prapotnik Brdnik, FGPA UM

FOREWORD

Our Symposia of Physicists at the University of Maribor, or shortly Christmas Symposia, have a tradition, as this year it is already the 17th one. The purpose is the scientific socializing of Slovenian physicists along with the participation of some distinguished colleagues from abroad as our honorary guests. This year we have five invited speakers from abroad, from some best research groups, so that our meetings remain national with international participation. The meeting is only one of the many activities of CAMTP - Center for Applied Mathematics and Theoretical Physics, which organizes seven series of international scientific meetings.

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 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 in 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 can attend all the lectures of the conference free of charge. In this way we contribute to the popularization of physics and the education in this field.

At the end we would like to stress that our gatherings are an important contribution to the activities of the Faculty of Natural Sciences and Mathematics (Maribor) and the Faculty of Mathematics and Physics (Ljubljana), and of course also for the institutes IJS in Ljubljana and CAMTP in Maribor.

It is our privilege that the general patron of the Symposium is the European Academy of Sciences and Arts (Salzburg).

Prof.Dr. Marko Robnik, Member of EASA, Director of CAMTP
and Prof.Dr. Anita Prapotnik Brdnik, FGPA UM

Seznam vseh udeležencev 17. Simpozija fizikov Univerze v Mariboru

List of all participants at the 17th Christmas Symposium of Physicists of the University of Maribor

Ms. Barbara Arcet
CAMTP, University of Maribor
barbara.arcet@gmail.com

Prof.Dr. Denis Arčon
IJS and FMF, University of Ljubljana
denis.arcon@fmf.uni-lj.si

Prof.Dr. Jurij Avsec
FE, University of Maribor
jurij.avsec@um.si

Dr. Benjamin Batistić
CAMTP, University of Maribor
benjamin.batistic@gmail.com

Dr. Bruno Bertini
FMF, University of Ljubljana
bruno.bertini@fmf.uni-lj.si

Prof.Dr. Tamas Biro
H.A.S. Wigner Research Centre for Physics,
Institute for Particle and Nuclear Physics, Budapest, Hungary
Biro.Tamas@wigner.mta.hu

Prof.Dr. Janez Bonča
FMF, University of Ljubljana and IJS, Ljubljana
janez.bonca@fmf.uni-lj.si

Prof.Dr. Simon Čopar
FMF, University of Ljubljana
simon.copar@fmf.uni-lj.si

Dr. Elnaz Darsheshdar
CAMTP, University of Maribor
darsheshdare@gmail.com

Prof.Dr. Rudolf Dvorak
University of Vienna, Austria
dvorak@astro.univie.ac.at

Dr. Jeffrey Everts
FMF, University of Ljubljana
jeffrey.everts@gmail.com

Prof.Dr. Svjetlana Fajfer
IJS and FMF, University of Ljubljana
svjetlana.fajfer@ijs.si

Prof.Dr. Brigita Ferčec
FE and CAMTP, University of Maribor
brigita.fercec@gmail.com

Prof.Dr. Marko Gosak
FNM, University of Maribor
marko.gosak@uni-mb.si

Ms. Katja Klobas
FMF, University of Ljubljana
katja.klobas@fmf.uni-lj.si

Mr. Pavel Kos
FMF, University of Ljubljana
pavel.kos@fmf.uni-lj.si

Prof.Dr. Peter Kržan
IJS and FMF, University of Ljubljana
peter.krizan@fmf.uni-lj.si

Mr. Ivan Kukuljan
FMF, University of Ljubljana
ivan.kukuljan@fmf.uni-lj.si

Mr. Marko Ljubotina
FMF, University of Ljubljana
marko.ljubotina@fmf.uni-lj.si

Mr. Črt Lozej
CAMTP, University of Maribor
clozej@gmail.com

Prof.Dr. Rene Markovič
FNM, University of Maribor
renemarkovic@gmail.com

Prof.Dr. Matjaž Perc
FNM and CAMTP, University of Maribor
matjaz.perc@um.si

Prof.Dr. Tatjana Petek
FERI and CAMTP, University of Maribor
tatjana.petek@um.si

Prof.Dr. Willibald Plessas
University of Graz, Austria
willibald.plessas@uni-graz.at

Prof.Dr. Anita Prapotnik Brdnik
FGPA, University of Maribor
anita.prapotnik@um.si

Prof.Dr. Tomaž Prosen
Faculty of Mathematics and Physics, University of Ljubljana
tomaz.prosen@fmf.uni-lj.si

Prof.Dr. Anton Ramšak
IJS and FMF, University of Ljubljana
anton.ramsak@fmf.uni-lj.si

Prof.Dr. Marko Robnik
CAMTP, University of Maribor
robnik@uni-mb.si

Prof.Dr. Valery Romanovski
CAMTP, University of Maribor
valerij.romanovskij@um.si

Prof.Dr. Peter Schmelcher
ZOQ - Center for Optical Quantum Technologies,
University of Hamburg, Germany
peter.schmelcher@physnet.uni-hamburg.de

Dr. Spyridon Sotiriadis
FMF, University of Ljubljana
spyridon.sotiriadis@fmf.uni-lj.si

Prof..Dr. Andraž Stožer
Institute for Physiology, Faculty of Medicine, University of Maribor
stožera@googlemail.com

Prof.Dr. Daniel Svenešek
FMF, University of Ljubljana
daniel.svensek@fmf.uni-lj.si

Prof.Dr. Hans-Jürgen Stöckmann
University of Marburg, Germany
Stoeckmann@physik.uni-marburg.de

Dr. Matthieu Vanicat
FMF, University of Ljubljana
matthieu.vanicat@gmail.com

Prof.Dr. Nataša Vaupotič
FNM, University of Maribor
natasa.vaupotic@um.si

Mr. Lenart Zadnik
FMF, University of Ljubljana
lenart.zadnik1@student.fmf.uni-lj.si

Prof.Dr. Slobodan Žumer
Jozef Stefan Institute, Ljubljana
slobodan.zumer@fmf.uni-lj.si

Dr. Bojan Žunkovič
FMF, University of Ljubljana
znajob@gmail.com

Prof.Dr. Tomaž Zwitter
FMF, University of Ljubljana
tomaz.zwitter@fmf.uni-lj.si

**Urnik 17. Simpozija fizikov
Univerze v Mariboru**

Četrtek, 13. december 2017	
Chair	Robnik
09:00-09:15	otvoritev/opening
09:15-10:00	Perc
10:00-10:20	Gosak
10:20-10:50	Vanicat
10:50-11:20	Svenšek
11:20-11:45	Coffee & Tea
11:45-12:30	Dvorak
12:30-13:15	Zwitter
13:15-13:30	Lozej
13:30-15:00	Lunch
Chair	Ramšak
15:00-15:45	Stöckmann
15:45-16:15	Everts
16:15-16:30	Kos
16:30-17:00	Coffee & Tea
17:00-17:30	Bonča
17:30-17:50	Stožer
19:00-20:00	1. Concert
20:00-23:00	Dinner

Petek, 14. december 2017	
Chair	Stöckmann
09:00-09:45	Biro
09:45-10:15	Ramšak
10:15-10:45	Čopar
10:45-11:15	Fajfer
11:15-11:45	Coffee & Tea
11:45-12:30	Schmelcher
12:30-13:15	Križan
13:15-13:30	Klobas
13:30-15:00	Lunch
Chair	Žumer
15:00-15:30	Robnik
15:30-16:00	Bertini
16:00-16:30	Sotiriadis
16:30-16:45	Kukuljan
16:45-17:15	Coffee & Tea
17:15-18:00	Arčon
19:00-20:00	2. Concert
20:00-23:00	Dinner

Sobota, 15. december 2017	
Chair	Biro
09:00-09:45	Prosen
09:45-10:30	Plessas
10:30-11:15	Žumer
11:15-11:45	Coffee & Tea
11:45-12:15	Avsec
12:15-12:45	Vaupotič
12:45-13:15	Prapotnik Brdnik
13:15-13:30	Ljubotina
13:30-15:00	Lunch
Chair	Plessas
15:00-15:30	Markovič
15:30-15:45	Darsheshdar
15:45-16:00	Zadnik
16:00-16:30	Romanovski
16:30-17:00	Coffee & Tea
17:00-17:30	Petek
17:30-18:00	Ferčec
19:00-	Dinner

Frustracija v spin-1/2 verigah

DENIS ARČON

Institute Jožef Stefan
Jamova 39, 1000 Ljubljana, Slovenia
Faculty of mathematics and physics, University of Ljubljana, Jadranska 19,
SI-1000 Ljubljana, Slovenia
denis.arcon@ijs.si

Raziskave kvantnega magnetizma so se izkazale kot izredno bogato področje za iskanje novih stanj snovi. Nizko-dimenzionalni sistemi še naprej ostajajo najpomembnejši modelni sistemi, kjer kvantne fluktuacije dominirajo pri nizkih temperaturah. Prehod iz paramagnetnega v feromagnetno ali pa antiferomagnetno stanje je eden najbolj standardnih primerov zloma simetrije v kondenzirani snovi. Pod značilno temperaturo, Curijevo v primeru feromagnetov in Néelovo v primeru antiferomagnetov, se magnetni momenti uredijo vzdolž določene kristalne smeri. V nekaterih primerih antiferomagnetov pa magnetni sistem paroma ne more minimalizirati vseh interakcij takrat govorimo o geometrijski frustraciji. Posledice geometrijske frustracije se odražajo v močnem znižanju Neelove temperature magnetnega urejanja in stanju z zapleteno magnetno ureditvijo ali pa celo s stanjem, kjer se magnetni momenti ne uredijo vse do temperature 0. V prispevku bom predstavil ključno vlogo magnetnih frustracij v spinskih verigah. V modelnem sistemu β -TeVO₄ smo tako odkrili pri različnih temperaturah in magnetnih poljih spinsko kiralno fazo, kolinearno fazo z valom spina, "spin-stripe" fazo ter nematično fazo [1-3].

Reference

- [1] M. Pregelj et al., *Nat. Commun.* **6** (2015) 7255.
- [2] M. Pregelj et al., *Phys. Rev. B* **94** (2016) 081114(R).
- [3] M. Pregelj et al., *poslano v objavo v Nature Quant. Mater.* (2018).

Frustration in spin-1/2 chains

DENIS ARČON

*Institute Jožef Stefan
Jamova 39, 1000 Ljubljana, Slovenia
Faculty of mathematics and physics, University of Ljubljana, Jadranska 19,
SI-1000 Ljubljana, Slovenia
denis.arcon@ijs.si*

The field of quantum magnetism has proven to be a very rich playground to uncover novel states of matter. Low dimensional antiferromagnets remain model systems to stabilize ground states where quantum fluctuations dominate the low-temperature physics. In conventional antiferromagnets, magnetic moments align antiparallel with respect to the nearest neighbour moments below a characteristic Néel temperature. However, in certain low dimensional magnetic systems with geometrically frustrated lattice not all interactions can be pairwise optimised. In such cases, the role of geometrical frustration is typically manifested in a drastic suppression of Néel temperature, in a state with a very complicated non-collinear magnetic order or even in a complete suppression of long range magnetic order and establishment of elusive quantum spin liquid. In this talk I will demonstrate the crucial role of frustration on spin chains, which show remarkably rich phase diagrams as a function of temperature and magnetic field. On an archetypal example of β -TeVO₄, I will discuss vector chiral, collinear amplitude modulated, spin-stripe and nematic orders [1-3].

References

- [1] M. Pregelj et al., *Nat. Commun.* **6** (2015) 7255.
- [2] M. Pregelj et al., *Phys. Rev. B* **94** (2016) 081114(R).
- [3] M. Pregelj et al., *submitted to Nature Quant. Mater.* (2018).

Klasična in statistična termodinamika v energetiki od začetkov in pogled razvoja v prihodnost - od makro preko mikro do nano

JURIJ AVSEC

*FE - Fakulteta za energetiko, Univerza v Mariboru
Hočevarjev trg 1, 8270 Krško, Slovenija*

*FERI - Fakulteta za elektrotehniko, računalništvo in informatiko Univerza v
Mariboru, Koroška cesta 46, 2000 Maribor, Slovenija jurij.avsec@um.si*

Termodinamika v energetiki se danes razvija na več znanstvenih področjih. Ena izmed pomembnejših področij je izračun termodinamičnih veličin stanja. Izračun termodinamičnih veličin stanja je možen s pomočjo klasične in statistične termodinamike. Klasična termodinamika izračunava termodinamične veličine brez vpogleda v mikrostrukturo materialov, v pomoč pa ji je eksperimentalna tehnika. Statistična termodinamika izračunava termodinamične veličine na osnovi molekularne strukture snovi. Predstavil bom uporabo termodinamike v energetiki in energetske tehnologijah. Rezultati, pridobljeni z matematičnimi modeli, so podkrepjeni tudi z eksperimentalnimi rezultati in kažejo na zelo dobro uje-manje. Predstavil bom matematične modele v makro, mikro in nano področjih za primere, ki so zanimivi za energetiko.

Reference

- [1] J. Avsec and U. Novosel, *Journal of energy technology* **11** (2018) 23–32.
- [2] H. J. Löffler, *Thermodynamik I, II*, Springer-Verlag, Berlin, 1969.
- [3] K. Stephan and F. Mayinger, *Thermodynamik, I, II*, Springer-Verlag, Berlin, Heidelberg, 1986

Classical and statistical thermodynamics from beginning and future development - from macro through micro to nano

JURIJ AVSEC

*FE - Faculty of Energy Technology, University of Maribor
Hočevarjev trg 1, 8270 Krško, Slovenia*

*FERI - Faculty of Electrical Engineering and Computer Science, University of
Maribor, Koroška cesta 46, 2000 Maribor, Slovenia jurij.avsec@um.si*

Nowadays, thermodynamics in energy engineering in many areas is present. One vital part is the calculation of thermodynamic properties. The calculation of the thermodynamic quantities of the state for real materials enables us both classical and statistical thermodynamics. Classical thermodynamics has no insight into the microstructure, but it allows the calculation of thermodynamical function of state with the help of macroscopic observation of phenomena. Unlike the classical thermodynamics the statistical thermodynamics does enable the computation of the thermodynamical functions of the state by studying molecular structure of the matter. All analytical data are compared with experimental results and they show good agreement. I will discuss the application of thermodynamics in energy engineering problems. I will show the mathematical models for macro, micro and nano regimes in some special applications related to energy technology.

References

- [1] J. Avsec and U. Novosel, *Journal of energy technology* **11** (2018) 23–32.
- [2] H. J. Löffler, *Thermodynamik I, II*, Springer-Verlag, Berlin, 1969.
- [3] K. Stephan and F. Mayinger, *Thermodynamik, I, II*, Springer-Verlag, Berlin, Heidelberg, 1986

Exact Spectral Form Factor and Entanglement Spreading in a Minimal Model of Many-Body Quantum Chaos

BRUNO BERTINI

*Department of Physics, Faculty of Mathematics and Physics
University of Ljubljana, Jadraska 19, SI-1000 Ljubljana, Slovenia
bruno.bertini@fmf.uni-lj.si*

I show that the periodically driven Ising chain in transverse field, for some particular values of the couplings, can be regarded as a minimal model for many body quantum chaos. Specifically, I present an exact proof of the fact that the spectral correlations are described by random matrix theory. This result implies ergodicity for any finite amount of disorder in the longitudinal field, excluding the possibility of many-body localisation. The method used provides a novel route for obtaining exact non-perturbative results in non-integrable systems. As an example of this, I provide exact results on the entanglement spreading from a class of initial states.

Reference

- [1] B. Bertini, P. Kos, and T. Prosen, <https://arxiv.org/abs/1805.00931> [PRL in print].

Maverick Temperatures

TAMÁS S. BIRÓ

*H.A.S. Wigner Research Centre for Physics
Institute for Particle and Nuclear Physics, Budapest, Hungary
Biro.Tamas@wigner.mta.hu • www.rmki.kfki.hu/ tsbiro*

A review of Stephen William Hawking’s most physical ideas, in particular the Hawking radiation, the Hawking temperature and the Bekenstein–Hawking formula for the black hole horizon entropy is given. Recent thermodynamical reasoning about a stable equation of state, $S \sim E^a V^b$ including an invariant volume due to Christodoulou and Rovelli, is also presented, solving the thermal stability problem (delivering positive heat capacity at fixed volume), and restoring Euler homogeneity ($a + b = 1$) at the same time. The value of the entropy associated to the horizon, however, deviates by a factor of $8/3$ from the original Bekenstein–Hawking formula in this framework.

References

- [1] T. S. Biró, V. G. Czinner, H. Iguchi, P. Ván: *Black hole horizons can hide positive heat capacity*, Phys. Lett. B **782**, 228, 2018.

Večdelčna lokalizacija v sistemih koreliranih elektronov sklopljenih z različnimi bozonskimi prostostnimi stopnjami

JANEZ BONČA

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

Sklopitev med elektroni ter spinskimi valovi vodi do delokalizacije v sistemu z neredom, ki ga elektroni čutijo preko naključno porazdeljenih potencialnih energij. Analiza temelji na analizi dinamike ene vrzeli v eno dimenzionalnem t - J modelu [1]. V primeru delokalizacije vrzeli je njena dinamika subdifuzivna.

Izračun dinamike ene vrzeli v primeru naključno porazdeljenih magnetnih polj pokaže da močan nered, ki se sklaplja na spinski podprostor, vodi do lokalizacije naboja ter tudi spinskih prostostnih stopenj. Z večanjem nereda se najprej lokalizirajo spinske prostostne stopnje. Do lokalizacije naboja pride šele pri večjih vrednostih nereda, ko spinska lokalizacijska dolžina pade pod velikost ene mrežne razdalje. Na koncu bom obravnaval tudi primer končnega dopiranja.

Obravnaval bo tudi primer, ko je kvantni delec v eni dimezniji ter naključnem potencialu sklopljen z disperzivnimi bozonskimi prostostnimi stopnjami. Bozonska disperzija je ključnega pomena za delokalizacijo delca [3,4].

References

- [1] J. Bonča and M. Mierzejewski, Phys.Rev.B **95**,214201(2017).
- [2] G. Lemut, M. Mierzejewski and J.Bonča, , Phys.Rev.Lett. **199**,246601(2017).
- [3] J. Bonča, S.A. Trugman and M. Mierzejewski, Phys.Rev.B **97**,174202(2018).
- [4] P. Prelovšek, J.Bonča and M. Mierzejewski, Phys.Rev.B **98**,125119(2018).

Many Body Localization in Correlated Electron Systems Coupled to Different Bosonic Degrees of Freedom

JANEZ BONČA

*Faculty of Mathematics and Physics, University of Ljubljana, SI-1000 Ljubljana,
Slovenia*

*J. Stefan Institute, SI-1000 Ljubljana, Slovenia
janez.bonca@ijs.si • www-f1.ijs.si*

I will show that electron-magnon interaction delocalizes the particle in a system with strong charge disorder. The analysis is based on results obtained for a single hole in the one-dimensional t - J model. Unless there exists a mechanism that localizes spin excitations, the charge carrier remains delocalized even for a very strong charge disorder and shows subdiffusive motion up to the longest accessible times [1].

When a single hole in a spin background is subject to a random magnetic field, strong disorder that couples only to the spin sector localizes both spin and charge degrees of freedom. Weaker disorder first causes localization in the spin sector. Carriers become localized for somewhat stronger disorder when the spin localization length is of the order of a single lattice spacing. I will also discuss finite doping [2].

Finally I will discuss the problem of a quantum particle in a random potential, coupled to different bosonic degrees of freedom [3,4]. Bosonic dispersion is responsible for the delocalization of the particle.

References

- [1] J. Bonča and M. Mierzejewski, Phys.Rev.B**95**,214201(2017).
- [2] G. Lemut, M. Mierzejewski and J.Bonča, Phys.Rev.Lett.**199**,246601(2017).
- [3] J. Bonča, S.A. Trugman and M. Mierzejewski, Phys.Rev.B**97**,174202(2018).
- [4] P. Prelovšek, J.Bonča and M. Mierzejewski, Phys.Rev.B **98**,125119(2018).

Katastrofe v holesteričnih kapljicah

SIMON ČOPAR^a, GREGOR POSNJAK^b, IGOR MUŠEVIČ^b, JOSEPH POLLARD^c, GARETH ALEXANDER^c

^a*Fakulteta za matematiko in fiziko, Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenija*

^b*Institut Jožef Stefan, Jamova 39, SI-1000 Ljubljana, Slovenija*

^c*University of Warwick, Coventry, CV4 7AL, Velika Britanija*

Nedavno smo z razvojem naprednih eksperimentalnih metod za 3D konfokalno rekonstrukcijo direktorskega polja [1] prvič pokazali obstoj točkastih defektov višjega topološkega naboja -2 in -3 v holesteričnih kapljicah s pravokotnim površinskim sidranjem [2]. Površinsko sidranje v povezavi z nujnim pogojem sferične topologije ograditve povzroči frustracijo holesteričnega reda v kapljici in stabilizira netrivialna metastabilna stanja, sestavljena iz množice točkastih defektov, povezanih s kiralnimi mehurčki.

Tradicionalni model holesterikov s pomočjo Volterrove konstrukcije obravnava holesterik kot smektiku podobno strukturo s plastmi ničelne gaussove ukrivljenosti, ki ne dovoljuje obstoja točkastih defektov [3]. Za teoretično razlago opaženih struktur smo sestavili splošnejši model, v katerem holesterik predstavimo kot normirano Beltramijevo vektorsko polje, ki ga razvijemo v gradientno polje s kiralno perturbacijo [4]. Kiralni defekti različnih topoloških nabojev so manifestacije ničel harmoničnih funkcij, ki jih klasificiramo s pomočjo teorije katastrof [5]. Napovemo tudi potek razpada defektov, kar omogoči opis topoloških molekul in obnašanja holesteričnih defektnih linij, ki imajo vlogo topoloških vezi.

Reference

- [1] G. Posnjak, S. Čopar & I. Muševič, *Sci. Rep.* **6** (2016) 26361.
- [2] G. Posnjak, S. Čopar & I. Muševič, *Nat. Commun.* **8** (2017) 14594.
- [3] M. Kleman & J. Friedel, *Rev. Mod. Phys.* **80** (2008) 61.
- [4] J. Pollard, G. Posnjak, G. P. Alexander, S. Čopar, I. Muševič, *Point defects, topological chirality and singularity theory in cholesteric liquid crystal droplets*, (v pripravi).
- [5] V. I. Arnol'd, *Russ. Math. Surv.* **30** (1975) 1.

Catastrophes in cholesteric droplets

SIMON ČOPAR^a, GREGOR POSNJAK^b, IGOR MUŠEVIČ^b, JOSEPH POLLARD^c, GARETH ALEXANDER^c

^a*Faculty of mathematics and physics, University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia*

^b*Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia*

^c*University of Warwick, Coventry, CV4 7AL, UK*

With the help of newly developed 3D confocal reconstruction method for director fields [1], we recently demonstrated the existence of defects with higher topological charges -2 and -3 in cholesteric droplets with perpendicular surface anchoring [2]. The anchoring, together with confinement with mandatory spherical symmetry, creates frustration of the cholesteric order in the droplet and stabilizes nontrivial metastable states composed of many point defects, bound by chiral bubbles.

Traditional cholesteric model, based on Volterra construction, treats cholesteris as smectic-like structure consisting of layers with zero Gaussian curvature, which does accomodate point defects [3]. On a quest to explain the experimental findings, we constructed a more general model of a cholesteric as a normalized Beltrami vector field, which can be expanded into a gradient field with a chiral perturbation [4]. Chiral defects of different topological charges are manifestations of zeros of harmonic functions, which can be classified with help of catastrophe theory [5]. We also predict unfoldings of defects, which allows us to describe topological molecules and behaviour of cholesteric defect lines, which act as topological bonds.

References

- [1] G. Posnjak, S. Čopar & I. Muševič, *Sci. Rep.* **6** (2016) 26361.
- [2] G. Posnjak, S. Čopar & I. Muševič, *Nat. Commun.* **8** (2017) 14594.
- [3] M. Kleman & J. Friedel, *Rev. Mod. Phys.* **80** (2008) 61.
- [4] J. Pollard, G. Posnjak, G. P. Alexander, S. Čopar, I. Muševič, *Point defects, topological chirality and singularity theory in cholesteric liquid crystal droplets*, (in preparation).
- [5] V. I. Arnol'd, *Russ. Math. Surv.* **30** (1975) 1.

Martingale Strategy for Modeling Quantum Adiabatic Evolution

ELNAZ DARSHESH DAR

*CAMTP - Center for Applied Mathematics and Theoretical Physics
University of Maribor, Mladinska 3, SI-2000 Maribor, Slovenia
Darsheshdare@gmail.com*

The general goal of a quantum computers is to solve a discrete optimization problem which is a search for the ground state of a spin-glass like classical Ising model where the spin-spin couplings are not identical. This optimization is very common in mathematics, economics and engineering. When N denotes the total number of sites, the number of choices, 2^N , leads to an exponentially long solution time and nonlinear optimization problem. Quantum annealing is a procedure that reaches the ground state of a classical Ising model by turning off adiabatically the transverse magnetic field. This alternative quantum computation method solves the optimization problem for the classical Ising model faster if implemented on a quantum device.

We propose a strategy for modeling the behavior of an adiabatic quantum computer described by an Ising Hamiltonian with N sites and the coordination number Z , based on large coordination number expansion. In each order, the ground state energy is found neglecting the higher-order correlations between the sites, as long as the set of equations remains non-singular. The conditions of the appearance of a singularity, equivalent to the disappearance of energy gap in the given approximation, can be directly obtained from the equations. Then the next order in the expansion must be used, at the price of an N -fold increase in computational resources. This "martingale" strategy allows reducing the computational costs to a power of N rather than 2^N , with a finite probability of success.

The method which we used, is large coordination number expansion characterizing the general lattice Hamiltonian. It assumes that the coordination number Z (number of couplings of a given site with other sites) is large, so that next order corrective terms $1/Z^l$ give decreasingly smaller contributions to the lattice system dynamics. This expansion provides a general framework of hierarchical equations for n -sites reduced density matrices allowing us to determine systematically equilibrium properties such as the ground state as well as nonequilibrium dynamics.

Comparing the predictions to the experimental results obtained by using an adiabatic quantum computer would help quantify the importance of multi-site correlations, and the influence of decoherence, on its operation.

Reference

- [1] M. W. Johnson, M. H. S. Amin, S. Gildert, T. Lanting, F. Hamze, N. Dickson, R. Harris, A. J. Berkley, J. Johansson, P. Bunyk, E. M. Chapple, C. Enderud, J. P. Hilton, K. Karimi, E. Ladizinsky, N. Ladizinsky, T. Oh, I. Perminov, C. Rich, M. C. Thom, E. Tolkacheva, C. J. S. Truncik, S. Uchaikin, J. Wang, B. Wilson and G. Rose, *Nature* **473** (2011) 164.
- [2] D. Bertsimas and J. Tsitsiklis, *Stat. Science* **8** (1933) 10.
- [3] P. Navez, G. Tsironis, and A. Zagoskin, *Phys. Rev. B* **95** (2017) 064304.
- [4] P. Navez, F. Queisser, and R. Schtzhold, *Phys. Rev. A* **94** (2016) 023629.
- [5] P. Navez and R. Schtzhold, *Phys. Rev. A* **82** (2010) 063603.
- [6] K. Konstantin, P. Navez, F. Queisser, and R. Schtzhold *EPJ Quantum Technology* **1** (2014) 12.
- [7] E. Darsheshdar, S. M. Moniri, P. Navez and A. Zagoskin *arXiv:1804.02670* (2018).

GAIA - The 1 billion star surveyor

RUDOLF DVORAK

*University of Vienna, AstroDynamicsGroup
rudolf.dvorak@univie.ac.at*

In December 2013 the astrometric satellite GAIA was launched from the Kosmodrom Baikonur into an orbit around the Sun Earth Lagrange point L2 by the European Space Agency ESA. Equipped with two big mirrors of of 145cm x 50cm Gaia is an ambitious mission to chart a three-dimensional map of our Galaxy revealing the formation, composition and also evolution of our Galaxy. Gaia will provide positional and radial velocity measurements with very high accuracies which are needed to have a stereoscopic and kinematic census of about one billion stars which amounts to about 1 per cent of the Galactic stellar population. Besides the precise determination of the positions in the sky and the proper motions of stars its equipment allows photometric and spectroscopic measurements which will lead to new and precise results for different fields in astronomy e.g. like precise radii of planet-hosting Keplerstars and consequently better determinations of the radii of the planets in these extrasolar systems.

References

- [1] www.sci.esa.int/gaia
- [2] The Gaia Collaboration Team: Gaia Data Release 2, Astronomy and Astrophysics 616, 2018

Topological shapes of electric double layers

JEFFREY EVERTS

*Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, 1000 Ljubljana, Slovenia
jeffrey.everts@gmail.com*

Charged surfaces in contact with liquids containing ions are accompanied in equilibrium by an electric double layer consisting of a layer of electric charge on the surface that is screened by a diffuse ion cloud in the bulk fluid. This screening cloud determines not only the interactions between charged colloidal particles or polyelectrolytes and their self-assembly into ordered structures [1], but it is also pivotal in understanding, for example, how the interaction of a charged colloidal particle with an oil-water interface can be tuned from attractive to repulsive by varying the salt concentration [2]. However, little is known to what spatial complexity the electric double layers can be designed. Here, we show that electric double layers of non-trivial topology -including tori, multi-tori and knots- can be realised in charged colloids with complex-shaped particles, using numerical modelling. We show that the topology of double layers can be defined via a cut-off in the ion concentration without any loss of generality, and demonstrate that the double layer topology can be tuned by changing the Debye screening length of the medium, or by changing the shape and topology of the (colloidal) particle [3]. More generally, this work is an attempt to introduce concepts of topology in the field of charged colloids, which could lead to novel exciting material design paradigms. If time permits, we will finally discuss the coupling of electric double layers to a nematic texture, as dictated by a liquid crystalline medium.

References

- [1] J.C. Everts, M.N. van der Linden, A. van Blaaderen and R. van Roij, *Soft Matter* **12** (2016) 6610-6620.
- [2] J.C. Everts, S. Samin and R. van Roij, *Phys. Rev. Lett.* **117** (2016) 098002.
- [3] J.C. Everts and M. Ravnik, *Sci. Rep.* **8** (2018) 14119.

Kršitev univerzalnosti leptonskega števila

SVJETLANA FAJFER

Oddelek za fiziko FMF, Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenija
Institut J. Stefan, Jamova 39, SI-1000 Ljubljana, Slovenija
svjetlana.fajfer@ijs.si

Mnoge študije fizike izven Standardnega modela so spodbudile uganki opaženi v razpadih mezonov B. Obstajata uganki $R_{D^{(*)}}$ and $R_{K^{(*)}}$. Prva je opažena pri razpadih, katere povzroči nabiti tok v razmerju razpadnih širin za $B \rightarrow D^{(*)}\tau\nu$ in $B \rightarrow D^{(*)}\mu\nu$ in drugo uganko določi razmerje med razpadnimi širinama za $B \rightarrow K^{(*)}\mu^+\mu^-$ and $B \rightarrow K^{(*)}e^+e^-$. Izmerjena vrednost in vrednost izračunana s pomočjo pripspevkov Standardnega modela za anomalni magnetni moment muona se neujemata. Vse te anomalije kažejo na morebitno kršitev univerzalnosti leptonskega števila. Praviloma se za opise $R_{D^{(*)}}$ and $R_{K^{(*)}}$ uporabljajo metode efektivnih Lagrangianov. Modeli Nove fizike, ki vsebujejo lahke leptokvarke lahko razložijo B mezonske anomalije. V primeru, da je Nova fizika prisotna v razpadih mezonov B, obstajajo procesi na nizkih in visokih energijah kateri lahko dodatno testirajo prisotnost Nove fizike.

Reference

- [1] I. Doršner, S. Fajfer, A. Greljo, J. F. Kamenik and N. Košnik, *Phys. Rept.* **641** (2016) 1.
- [2] D. Bečirević, S. Fajfer and N. Košnik, *Phys. Rev. D* **92** (2015) 1, 014016.
- [3] S. Fajfer, I. Doršner, N. Košnik and I. Nišandžić, *JHEP* **1311** (2013) 084.
- [4] S. Fajfer and N. Košnik, *Phys. Lett. B* **755** (2016) 270L.
- [5] S. Fajfer and N. Košnik, *Eur. Phys. J. C* **75** (2015) 567.
- [6] D. Bečirević, I. Doršner, S. Fajfer, N. Košnik, D. A. Faroughy and O. Sumensari, *Phys. Rev. D* **98** (2018) 55003.
- [7] S. Fajfer, N. Konik and L. Vale Silva, *Eur. Phys. J. C* **78** (2018) no.4, 275.
- [8] I. Doršner, S. Fajfer, D. A. Faroughy and N. Košnik, em *JHEP* **1710** (2017) 188.
- [9] I. Doršner, S. Fajfer and N. Košnik, *Eur. Phys. J. C* **77** (2017) no.6, 417.

Lepton flavour universality violation

SVJETLANA FAJFER

Oddelek za fiziko FMF, Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenija
Institut J. Stefan, Jamova 39, SI-1000 Ljubljana, Slovenija
svjetlana.fajfer@ijs.si

Currently B meson puzzles motivate many studies of New Physics due to the observed deviations from the Standard Model predictions. There are two B meson puzzles $R_{D^{(*)}}$ and $R_{K^{(*)}}$. The first one denotes the deviations in the decays driven by the charge current in the ratio of the decay widths for $B \rightarrow D^{(*)}\tau\nu$ and $B \rightarrow D^{(*)}\mu\nu$, while the second one is related to the ratio of the decay widths for $B \rightarrow K^{(*)}\mu^+\mu^-$ and $B \rightarrow K^{(*)}e^+e^-$. Also, the measured muon anomalous magnetic moment differs from the SM predictions. All these anomalies points towards Lepton number universality violation. Usually, the effective Lagrangian approach containing New Physics are used to approach $R_{D^{(*)}}$ and $R_{K^{(*)}}$. Among many models of new Physics, varieties of leptoquark models are suggested to resolve both B meson anomalies. If New Physics is confirmed in B decays a number of processes at low and high energies should confirm its presence.

References

- [1] I. Doršner, S. Fajfer, A. Greljo, J. F. Kamenik and N. Košnik, *Phys. Rept.* **641** (2016) 1.
- [2] D. Bečirević, S. Fajfer and N. Košnik, *Phys. Rev. D* **92** (2015) 1, 014016.
- [3] S. Fajfer, I. Doršner, N. Košnik and I. Nišandžić, *JHEP* **1311** (2013) 084.
- [4] S. Fajfer and N. Košnik, *Phys. Lett. B* **755** (2016) 270L.
- [5] S. Fajfer and N. Košnik, *Eur. Phys. J. C* **75** (2015) 567.
- [6] D. Bečirević, I. Doršner, S. Fajfer, N. Košnik, D. A. Faroughy and O. Sumensari, *Phys. Rev. D* **98** (2018) 55003.
- [7] S. Fajfer, N. Konik and L. Vale Silva, *Eur. Phys. J. C* **78** (2018) no.4, 275.
- [8] I. Doršner, S. Fajfer, D. A. Faroughy and N. Košnik, *em JHEP* **1710** (2017) 188.
- [9] I. Doršner, S. Fajfer and N. Košnik, *Eur. Phys. J. C* **77** (2017) no.6, 417.

Dinamika nekaterih analitičnih (iterativnih) preslikav

BRIGITA FERČEC

*FE - Fakulteta za energetiko, Univerza v Mariboru
Hočevarjev trg 1, 8270 Krško, Slovenia
CAMTP - Center za uporabno matematiko in teoretično fiziko
Univerza v Mariboru, Mladinska 3, SI-2000 Maribor, Slovenia
brigita.fercec@um.si*

Predstavila bom problem centra in pristop za določitev cikličnosti centrov v preslikavah, podanih z

$$f(x) = -x - \sum_{k=1}^{\infty} a_k x^{k+1}. \quad (1)$$

Glavna motivacija za zgoraj omenjena problema izhaja iz študije problema centra in problema cikličnosti ravninskih sistemov NDE. Prav tako bom obravnavala bifurkacije limitnih ciklov vsake komponente raznoterosti centra nekaterih posebnih primerov preslikav (1), ki izhajajo iz algebraičnih enačb oblike $x + y + h.o.t. = 0$.

Reference

- [1] M. Mencinger, B. Ferčec, R. Oliveira, D. Pagon, *Applied mathematics and computation* **295** (2017) 114–125.
- [2] M. Mencinger, B. Ferčec, *Applied mathematics and computation* **306** (2017) 73–85.
- [3] V. Romanovski, A. Rauh, *Dynamic Systems and Applications* **7** (1998) 529–552.
- [4] V. Romanovski, *Math. Comput. Sci* **1** (2007) 253–265.

The dynamics of some analytic (iterated) maps

BRIGITA FERČEC

*FE - Faculty of Energy Technology, University of Maribor
Hočevarjev trg 1, 8270 Krško, Slovenia
CAMTP - Center for Applied Mathematics and Theoretical Physics
University of Maribor, Mladinska 3, SI-2000 Maribor, Slovenia
brigita.fercec@um.si*

I shall discuss the center problem and the approach to estimate the cyclicity of centers in maps given by

$$f(x) = -x - \sum_{k=1}^{\infty} a_k x^{k+1}. \quad (1)$$

The main motivation for these problems originates from the study of center and cyclicity problems of planar systems of ODEs. I will also consider the bifurcation of limit cycles from each component of the center variety of some particular cases of maps (1) arising from algebraic equations of the form $x + y + h.o.t. = 0$.

References

- [1] M. Mencinger, B. Ferčec, R. Oliveira, D. Pagon, *Applied mathematics and computation* **295** (2017) 114–125.
- [2] M. Mencinger, B. Ferčec, *Applied mathematics and computation* **306** (2017) 73–85.
- [3] V. Romanovski, A. Rauh, *Dynamic Systems and Applications* **7** (1998) 529–552.
- [4] V. Romanovski, *Math. Comput. Sci* **1** (2007) 253–265.

Fizika slovenskih leposlovnih del: s teorijo kompleksnih mrež do novih spoznanj

RENE MARKOVIČ^{1,2,3}, MATJAŽ PERC^{1,4,5}, VLADIMIR GRUBELNIK^{1,6},
MARKO MARHL^{1,2,7}, MARKO GOSAK^{1,7,*}

¹*Fakulteta za naravoslovje in matematiko, Univerza v Mariboru, Koroška cesta 160, 2000 Maribor, Slovenija*

²*Pedagoška fakulteta, Univerza v Mariboru, Koroška cesta 160, 2000 Maribor, Slovenija*

³*Fakulteta za energetiko, Univerza v Mariboru, Hočevarjev trg 1, 8270 Krško, Slovenija*

⁴*CAMTP Center za uporabno matematiko in teoretično fiziko, Univerza v Mariboru, Mladinska 3, 2000 Maribor, Slovenija*

⁵*Center za kompleksne znanosti, Josefstädterstraße 39, 1090 Dunaj, Avstrija*

⁶*Fakulteta za elektrotehniko, raunalnitvo in informatiko, Univerza v Mariboru, Koroška cesta 46, 2000 Maribor, Slovenija*

⁷*Medicinska fakulteta, Univerza v Mariboru, Taborska ulica 8, 2000 Maribor, Slovenija*

**marko.gosak@um.si*

V prispevku bomo pokazali, kako lahko orodja s področja znanosti o kompleksnih sistemih uporabimo za vrednotenje nekaterih statističnih lastnosti pisnih besedil. Naša študija sestoji iz dveh delov. V prvem delu se osredotočimo na osnovne statistične lastnosti besedil in na porazdelitev pogostosti besed. Izkaže se, da pojavnost besed glede na njihov rank približno sledi potenčni funkciji, kar je v skladu z Zipfovimi zakonom [1]. Naši rezultati kažejo na to, da se z naraščajočo priporočeno starostjo bralcev tako dolžina besedil kakor tudi povprečna dolžina besed monotono povečujeta. Po drugi strani pa se delež unikatnih besed in vrednost Zipfovega eksponenta zmanjšujeta [2]. V drugem delu naše študije uporabimo orodja s področja teorije kompleksnih mrež za opis strukture besedila in za vrednotenje interakcij med literarnimi liki [3]. Naši rezultati pokažejo, da sintaktična povezanost besed tvori kompleksno in heterogeno mrežo, ki izkazuje lastnosti mrež malega sveta. Prav tako se izkaže, da so mreže besed manj modularne in bolj učinkovite pri besedilih namenjenim starejšim bralcem. Nekoliko pričakovano pa narava socialnih interakcij med literarnimi liki z naraščajočo starostjo bralcev postaja vse bolj kompleksna [2]. V študiji izpostavimo, da tovrstni empirični pristopi, ki temeljijo na znanosti kompleksnih sistemov, predstavljajo pomembno vlogo na področju sodobne kvantitativne lingvistike in imajo velik potencial v kontekstu razvoja avtomatizirane klasifikacije literarnih del.

Reference

- [1] C.T. Kello, *et al.*, *Trends Cogn. Sci.* **14** (2010) 223.
- [2] R. Markovič, M. Gosak, M. Perc, M. Marhl, V. Grubelnik, *J. Complex Networks* **cny018** (2018).
- [3] J. Cong, H. Liul, *Phys. Life Rev.* **11** (2014) 598.

Physics of Slovene belles-lettres: insights from complex network approaches

RENE MARKOVIČ^{1,2,3}, MATJAŽ PERC^{1,4,5}, VLADIMIR GRUBELNIK^{1,6},
MARKO MARHL^{1,2,7}, MARKO GOSAK^{1,7,*}

¹*Faculty of Natural Sciences and Mathematics, University of Maribor, Koroška
cesta 160, SI-2000 Maribor, Slovenia*

²*Faculty of Education, University of Maribor, Koroška cesta 160, SI-2000 Maribor,
Slovenia*

³*Faculty of Energy Technology, University of Maribor, Hočevarjev trg 1, SI-8270
Krško, Slovenia*

⁴*CAMTP Center for Applied Mathematics and Theoretical Physics, University of
Maribor, Mladinska 3, 2000 Maribor, Slovenija*

⁵*Complexity Science Hub, Josefstädterstraße 39, A-1090 Vienna, Austria*

⁶*Faculty of Electrical Engineering and Computer Science, Koroška cesta 46,
SI-2000 Maribor, Slovenia*

⁷*Faculty of Medicine, University of Maribor, Taborska ulica 8, SI-2000 Maribor,
Slovenia*

**marko.gosak@um.si*

In the present contribution we demonstrate how the tools from the realms of complexity science can be used to quantify some statistical properties of written language. Our study consists of two parts. In the first part we focus on basic statistical properties of texts and on the frequency-rank distribution of words. We show that the frequency of word occurrence is roughly an inverse power-law function of its rank, which is in accordance with the Zipf's law [1]. Our results indicate that with the increasing recommended age of readers, the length of texts and the average length of words increase, whereas the fraction of unique words and the Zipf's exponent decrease [2]. In the second part we utilize the complex network theory to describe the structure of language as well as the interactions between characters [3]. Our findings reveal that the syntactic connectivity of words forms a complex and heterogeneous network that is characterized by small-world properties. Moreover, it turns out that the extracted networks of words from texts for older age groups are less modular and more efficient, whereas the social interactions between literary characters become progressively more complex with increasing recommended age for readers [2]. Taken together, we demonstrate that such empirical complexity science-based approaches can be a valuable repertoire in the field of modern contemporary linguistics and have a huge potential in the development of automated classifications of literary works.

References

- [1] C.T. Kello, *et al.*, *Trends Cogn. Sci.* **14** (2010) 223.
- [2] R. Markovič, M. Gosak, M. Perc, M. Marhl, V. Grubelnik, *J. Complex Networks* **cny018** (2018).
- [3] J. Cong, H. Liul, *Phys. Life Rev.* **11** (2014) 598.

Časovno odvisen matrično produktni nastavek za interagirajočo reverzibilno dinamiko

KATJA KLOBAS

*Fakulteta za matematiko in fiziko, Univerza v Ljubljani
Jadranska 19, SI-1000 Ljubljana, Slovenija
katja.klobas@fmf.uni-lj.si*

Predstavila bom eksplicitni časovno odvisni matrično produktni nastavek, ki opiše časovno evolucijo poljubne lokalne opazljivke v interagirajočem in determinističnem diskretnem modelu, ki so ga vpeljali Bobenko in sodelavci [1]. Konstrukcija nastavka vsebuje eksplicitno rešitev problema inverznega sipanja v realnem prostoru in času. Uporabnost nastavka bom prikazala na dveh primerih; eksaktnem izračunu dinamičnega strukturnega faktorja in profilu magnetizacije po časovni evoluciji ekstremnega primera nehomogenega začetnega stanja. Oba rezultata rigorozno demonstrirata balističen transport z difuzijskimi popravki.

Reference

- [1] A. Bobenko, M. Bordemann, C. Gunn and U. Pinkall, *Commun. Math. Phys.* **158** 127 (1993).
- [2] K. Klobas, M. Medenjak, T. Prosen and M. Vanicat, arXiv:1807.05000 (2018).

Time-dependent matrix product ansatz for interacting reversible dynamics

KATJA KLOBAS

*Faculty of Mathematics and Physics, University of Ljubljana
Jadranska 19, SI-1000 Ljubljana, Slovenia
katja.klobas@fmf.uni-lj.si*

I will present an explicit time-dependent matrix product ansatz (tMPA) which describes the time-evolution of any local observable in an interacting and deterministic lattice gas, specifically for the rule 54 reversible cellular automaton of Bobenko *et al* [1]. The construction is based on an explicit solution of real-space real-time inverse scattering problem. I will discuss two applications of this tMPA; the exact and explicit computation of the dynamic structure factor, and the solution of the extremal case of the inhomogeneous quench problem. Both of these exact results rigorously demonstrate a coexistence of ballistic and diffusive transport behaviour in the model, as expected for normal fluids.

References

- [1] A. Bobenko, M. Bordemann, C. Gunn and U. Pinkall, *Commun. Math. Phys.* **158** 127 (1993).
- [2] K. Klobas, M. Medenjak, T. Prosen and M. Vanicat, arXiv:1807.05000 (2018).

Reševanje kaotičnega kvantnega mnogodelčnega modela

PAVEL KOS

*Oddelek za Fiziko, Fakulteta za Matematiko in Fiziko
Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenia
pavel.kos@fmf.uni-lj.si • chaos.fmf.uni-lj.si*

Ko govorimo o rešljivih modelih, imamo običajno v mislih proste ali integrabilne modele. Ti modeli imajo mnoge posebne lastnosti, ki se razlikujejo od lastnosti generičnih sistemov, ki se obnašajo kaotično.

Pokazal bom, kako nam je s pomočjo posebne lastnosti dualne točke brčnega Isingovega modela uspelo izračunati spektralni form faktor in časovni potek entropije prepletenosti za kaotični kvantni mnogodelčni sistem. Spektralni form faktor nam pokaže, da je model kaotičen ne glede na velikost nereda v magnetnem polju v z smeri. Časovni potek entropije prepletenosti nam pove, da se informacija v modelu širi z maksimalno hitrostjo in doseže maksimalno vrednost.

Reference

- [1] P. Kos, M. Ljubotina and T. Prosen, *Phys. Rev. X* **8** (2018) 021062.
- [2] B. Bertini, P. Kos and T. Prosen, arXiv:1805.00931.

Solving Chaotic Quantum Many-body System

PAVEL KOS

*Department of Physics, Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
pavel.kos@fmf.uni-lj.si • chaos.fmf.uni-lj.si*

When talking about solvable models, we usually have in mind free and integrable models. These models have many special properties, which are different from those of the generic models that are chaotic.

I will demonstrate how using a special property of the duality point of the kicked Ising spin chain, we managed to compute the spectral form factor and the time evolution of the entanglement entropy for a chaotic quantum many-body system. The spectral form factor shows that the model behaves chaotically for any disorder in the magnetic field in the z direction. The dynamics of the entanglement entropy indicates that the information spreads with a maximal speed and saturates to the maximum value.

References

- [1] P. Kos, M. Ljubotina and T. Prosen, *Phys. Rev. X* **8** (2018) 021062.
- [2] B. Bertini, P. Kos and T. Prosen, arXiv:1805.00931.

Belle II - prve izkušnje

PETER KRIŽAN

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

V predavanju bom najprej predstavil motivacijo za naslednjo generacijo poskusov v fiziki tekih kvarkov in leptonov, iskanju signalov fizikalnih procesov, ki jih ne moremo zadovoljivo popisati v okviru Standardnega modela, teorije osnovnih delcev in njihovih interakcij. Sledil bo pregled najbolj zanimivih trenutkov pri nastajanju novega detektorja ter rezultati prvih meritev. Na koncu bom predstavil še načrte za bodočnost.

Belle II - first experience with a new detector

PETER KRIŽAN

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

In the talk we will first discuss the motivation for the next generation of experiments in heavy flavour physics, searches for phenomena that cannot be accommodated in the Standard model, the theory of elementary particles and their interactions. We will then present some interesting steps in the construction of the Belle II spectrometer, and discuss the first experience with the next generation detector. We will finish by our plans for the future.

KPZ fizika v kvantni Heisenbergovi spinski verigi

MARKO LJUBOTINA

*Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, SI-1000, Ljubljana, Slovenia
marko.ljubotina@fmf.uni-lj.si • chaos.fmf.uni-lj.si./ljubotina*

Predstavil bom pojav KPZ (Kardar-Parisi-Zhang) fizike v kvantni Heisenbergovi spinski verigi ter njeni Troterizirani verziji, ki omogoča enostavnejšo numerično obravnavo.

KPZ physics in the quantum Heisenberg spin chain

MARKO LJUBOTINA

*Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, SI-1000, Ljubljana, Slovenia
marko.ljubotina@fmf.uni-lj.si • chaos.fmf.uni-lj.si./ljubotina*

I will present the emergence of KPZ (Kardar-Parisi-Zhang) physics in the quantum Heisenberg spin chain and its integrable Trotterization, which allows for simpler numerical treatment.

Struktura, velikost in statistične lastnosti kaotičnih komponent v Hamiltonskem sistemu z mešanim faznim prostorom

ČRT LOZEJ

*CAMTP - Center za uporabno matematiko in teoretično fiziko
Univerza v Mariboru, Mladinska 3, SI-2000 Maribor, Slovenia
clozej@gmail.com • www.camtp.uni-mb.si*

Generični Hamiltonski dinamični sistemi niso ne integrabilni ne popolnoma kaotični. Ali bo gibanje kaotično ali ne zavisi od začetnega pogoja. Fazni prostor je razdeljen na več invariantnih komponent. V tipičnem primeru kaotična komponenta, imenovana tudi kaotično morje, obdaja neskončno število regularnih komponent, imenovanih Kolmogorov-Arnold-Moserjevi (KAM) otoki [1]. Struktura kaotične komponente je zato tipično zelo zapletena. V tovrstnih dinamičnih sistemih je pogost tudi pojav lepljivosti [2]. Zapletena struktura kaotične komponente in lepljivost predstavljata precejšnjo oviro pri natančnem določanju njene velikosti. Motivacija za določitev velikosti kaotične komponente izvira tudi iz področja kvantnega kaosa, ker je pomemben parameter pri preučevanju spektrov ekvivalentnega kvantnega sistema v semiklasični limiti [3, 4, 5].

Na predavanju bomo predstavili statistične lastnosti največje kaotične komponente v enoparametrični družini biljardov [6, 7]. S spreminjanjem parametra lahko dobimo vse od popolnoma regularnega (integrabilnega) do popolnoma kaotičnega (ergodičnega) Hamiltonskega sistema. Fazni prostor razdelimo na mrežo celic in z iteracijami kaotične orbite določimo katere celice pripadajo kaotični komponenti. Dinamiko polnjenja celic primerjamo s tako imenovanim naključnim modelom [8], ki predpostavlja popolnoma nekorelirane obiske celic in dobro opiše polnjenje celic ergodičnih sistemov. Pokazali bomo, da naključni model zaradi pojava lepljivosti ne more opisati dinamike polnjenja celic v sistemih z mešanim faznim prostorom. Določene asimptotske lastnosti sistema, kot je porazdelitev zasedenosti celic in povprečni časi vračanja so še vedno dobro opisani s tem modelom, kar omogoča določitev velikosti kaotične komponente.

Reference

- [1] E. Ott, *Chaos in Dynamical Systems* (Cambridge Univ. Press, 1993).
- [2] L. A. Bunimovich in L. V. Vela-Arevalo, *Chaos: An Interdisciplinary Journal of Nonlinear Science* **22** (2013) 026103
- [3] B. Batistić in M. Robnik, *Phys.Rev. E* **88** (2013) 052913
- [4] B. Batistić in M. Robnik, *J. Phys. A: Math.& Theor.* **43** (2010) 215101
- [5] B. Batistić in M. Robnik, *J. Phys. A: Math.& Theor.* **45** (2013) 315102
- [6] M. Robnik, *J. Phys. A: Math. Gen.* 16 (1983) 3971
- [7] Č. Lozej in M. Robnik, *Phys.Rev. E* **97** (2018) 012206
- [8] M. Robnik, J. Dobnikar, A. Rapisarda, T. Prosen, in M. Petkovšek, *J. Phys. A: Math. Gen.* 30 (1997) L803

Structure, size and statistical properties of chaotic components in a mixed-type Hamiltonian system

ČRT LOZEJ

*CAMTP - Center for Applied Mathematics and Theoretical Physics
University of Maribor, Mladinska 3, SI-2000 Maribor, Slovenia
clozej@gmail.com • www.camtp.uni-mb.si*

Generic Hamiltonian dynamical systems are neither integrable nor fully chaotic. Whether the motion is chaotic or not depends on the initial condition. The phase space is divided into various invariant components. Typically, the chaotic component, known as the chaotic sea, surrounds an infinite number of Kolmogorov-Arnold-Moser (KAM) islands [1]. The chaotic component thus exhibits a very complex structure. In dynamical systems of this type the phenomenon of stickiness [2] is usually also present. Both the complex structure of the phase space and stickiness pose a serious obstacle in determining the size of the chaotic component. Additional motivation for determining the size of the chaotic component is provided by quantum chaos, as it is an important parameter in the study of the spectra of the equivalent quantum system in the semiclassical limit [3, 4, 5].

In the talk we will present the statistical properties of the largest chaotic component in a single parameter family of billiards [6, 7]. By changing the value of the parameter, we may acquire anything from a fully regular (integrable) to a fully chaotic (ergodic) Hamiltonian system. We divide the phase space into a grid of cells and determine which of them belong to the chaotic component by the iteration of a chaotic orbit. We compare the dynamics of the cell filling with the so-called random model [8], that assumes completely uncorrelated cell visits and accurately describes the filling of cells for ergodic systems. We will show that due to stickiness the random model fails to describe the cell filling in systems with mixed phase spaces. Certain asymptotic properties like the distribution of cell occupancies and average cell return times are still well described with the random model, which enables us to determine the size of the chaotic component.

References

- [1] E. Ott, *Chaos in Dynamical Systems* (Cambridge Univ. Press, 1993).
- [2] L. A. Bunimovich and L. V. Vela-Arevalo, *Chaos: An Interdisciplinary Journal of Nonlinear Science* **22** (2013) 026103
- [3] B. Batistić and M. Robnik, *Phys.Rev. E* **88** (2013) 052913
- [4] B. Batistić and M. Robnik, *J. Phys. A: Math.& Theor.* **43** (2010) 215101
- [5] B. Batistić and M. Robnik, *J. Phys. A: Math.& Theor.* **45** (2013) 315102
- [6] M. Robnik, *J. Phys. A: Math. Gen.* 16 (1983) 3971
- [7] Č. Lozej and M. Robnik, *Phys.Rev. E* **97** (2018) 012206
- [8] M. Robnik, J. Dobnikar, A. Rapisarda, T. Prosen, in M. Petkovšek, *J. Phys. A: Math. Gen.* 30 (1997) L803

Modeliranje sovisnega vpliva planarne celine polarizacije in mehanskih medcelinih interakcij v planarnih tkivih

RENE MARKOVIČ^{1,2,3}, MARKO GOSAK^{1,4} and MARKO MARHL^{1,2,4}

¹*Fakulteta za naravoslovje in matematiko, Univerza v Mariboru, Koroška cesta 160, SI-2000 Maribor, Slovenija*

²*Pedagoška fakulteta, Univerza v Mariboru, Koroška cesta 160, SI-2000 Maribor, Slovenija*

³*Fakulteta za energetiko, Univerza v Mariboru, Hočevarjev trg 1, SI-8270 Krško, Slovenija*

⁴*Inštitut za fiziologijo, Medicinska fakulteta, Univerza v Mariboru, Taborska ulica 8, Maribor, Slovenija*

Natančna strukturna organizacija epitelijskih celic je pomembna za pravilno delovanje in nadaljnji razvoj različnih tkiv [1]. Mehanizem pakiranja epitelijskih celic je povezan z mehanskimi interakcijami med celicami, ki tkivo vodijo v stanje najnižje mehanske energije [2]. Ob mehanskih interakcijah je pomemben način organiziranja planarna celična polarnost (PCP), ki zagotavlja orientacijsko usmerjanje celic. Signalizacijski mehanizem PCP je posledica asimetrične porazdelitve nekaterih transmembranskih proteinov, ki jih razporejajo specifične znotrajcelične signalne poti [3,4]. Pokazano je bilo, da mutacije in druge motnje v PCP signalizaciji povzročajo popačeno citoarhitekturo epitelnega sloja. Mutantne celice z motnjami aktivnosti signalnih proteinov predstavljajo topološke napake, kar lahko privede do disfunkcij v delovanju tkiv [5]. Eksperimentalno je bilo pokazano, da so v bližini mutiranih celic [6] prisotne razlike napetosti vezi med celicami. Slednje nas je motiviralo razviti matematični model, ki združuje procese razvijanja tkiv po konceptu minimiziranja mehanske energije in tudi medcelične polarizacije. Naši rezultati kažejo, da zmanjšanje mehanskih interakcij med normalnimi in mutiranimi celicami epitela predstavlja možen regulatorni mehanizem, ki zmanjšuje vpliv topoloških napak, ki jih povzročajo mutirane celice.

Reference

- [1] W.J. Nelson, *Cold Spring Harb Perspect Biol* **1** 2009 a000513.
- [2] T. Lecuit and P.F. Lenne, *Nat Rev Mol Cell Bio* **8** 2007 633644
- [3] J.A. Zallen, *Cell* **129** 2007 10511063.
- [4] R. Markovič, M. Gosak, R. Repnik, S. Kralj and M. Marhl, *Adv Planar Lipid Bilayer Liposomes* **20** 2014 197217.
- [5] L.V. Goodrich and D. Strutt, *Dev* **138** 2011 187792.
- [6] K. Classen, K.I. Anderson, E. Marois and S. Eaton, *Dev Cell* **9** 2005 805817.

Modelling the interplay between planar cell polarity signaling and mechanical cell-cell interactions in planar tissues

RENE MARKOVIČ^{1,2,3}, MARKO GOSAK^{1,4} and MARKO MARHL^{1,2,4}

¹*Fakulteta za naravoslovje in matematiko, Univerza v Mariboru, Koroška cesta 160, SI-2000 Maribor, Slovenija*

²*Pedagoška fakulteta, Univerza v Mariboru, Koroška cesta 160, SI-2000 Maribor, Slovenija*

³*Fakulteta za energetiko, Univerza v Mariboru, Hočevarjev trg 1, SI-8270 Krško, Slovenija*

⁴*Inštitut za fiziologijo, Medicinska fakulteta, Univerza v Mariboru, Taborska ulica 8, Maribor, Slovenija*

A precise structural organization of epithelial cells is needed for a proper functioning and development of different tissues [1]. The epithelial cell packing mechanism is associated with mechanical interactions between cells which place the tissue in a state of the lowest mechanical energy [2]. In addition, the planar cell polarity (PCP) signaling pathway has been recognized as another important mechanism for epithelial organization that ensures orientational ordering of the cells. PCP is a consequence of an asymmetric distribution of certain transmembrane proteins which is driven by specific intracellular signaling pathways [3,4]. Mutations and other disruptions of these pathways were found to cause an impaired cytoarchitecture of the epithelium layer. Mutant cells with disrupted activities of signaling proteins basically represent topological defects, which can lead to dysfunctions in tissue operation [5]. Motivated by the fact that regional variations of bond tensions were found in the vicinity of mutant cells [6], we implement a computational model that combines the tissue development processes following the concept of mechanical energy minimization and the intracellular polarization. Our results reveal that a decrease in mechanical interactions between normal and mutant epithelium cells represents a conceivable regulatory mechanism that diminishes the impact of topological defects caused by mutant cells.

References

- [1] W.J. Nelson, *Cold Spring Harb Perspect Biol* **1** 2009 a000513.
- [2] T. Lecuit and P.F. Lenne, *Nat Rev Mol Cell Bio* **8** 2007 633644
- [3] J.A. Zallen, *Cell* **129** 2007 10511063.
- [4] R. Markovič, M. Gosak, R. Repnik, S. Kralj and M. Marhl, *Adv Planar Lipid Bilayer Liposomes* **20** 2014 197217.
- [5] L.V. Goodrich and D. Strutt, *Dev* **138** 2011 187792.
- [6] K. Classen, K.I. Anderson, E. Marois and S. Eaton, *Dev Cell* **9** 2005 805817.

Tisočletje likovne umetnosti skozi oči fizike

MATJAŽ PERC

*Oddelek za fiziko, Fakulteta za naravoslovje in matematiko,
Univerza v Mariboru, Koroška cesta 160, SI-2000 Maribor, Slovenija*

*CAMTP - Center za uporabno matematiko in teoretično fiziko, Univerza v
Mariboru, Krekova 2, SI-2000 Maribor, Slovenija
matjaz.perc@gmail.com • www.matjazperc.com*

Dvajseto stoletje se pogosto opisuje kot stoletje fizike. Dejansko bi brez fundamentalnih raziskovalnih prebojev v fizikalnih laboratorijih širom po svetu človeška družba danes zagotovo bila zelo drugačna kot je sedaj [1,2]. Kar je preteklih 100 let bilo za fiziko, je preteklo tisočletje bilo za likovno umetnost. Od bizantinske umetnosti, renesanse in realizma, do popa, zadnjih 1000 let je gostilo nekatera umetniško najbolj produktivna obdobja našega obstoja. Masovna digitalizacija likovnih del nam danes omogoča natančno kvantitativno analizo zgodovine likovne umetnosti, in to na zelo obsežni časovni in prostorski skali. V študiji, ki jo bom predstavil [3], smo analizirali več kot 140000 likovnih del od več kot 2300 umetnikov, ki so bile ustvarjene med leti 1031 in 2016. Na podlagi kompleksnosti in entropije prostorskih vzorcev v likovnih delih smo uspeli slednje hierarhično kategorizirati v dvo-dimenzionalnem prostoru reda-nereda in enostavnosti-kompleksnosti, kar nam razkrije časovni razvoj likovne umetnosti, ki se ujema za najpomembnejšimi umetniškimi obdobji preteklega tisočletja. Študija tako nakazuje naslednji korak v analizi masovnih podatkovnih baz, kjer se oddaljujemo od tekstovne semantike [4] in približujemo kvantifikaciji subjektivnih lastnosti del kot so estetika in privlačnost.

Reference

- [1] M. Perc, Self-organization of progress across the century of physics, *Sci. Rep.* **3**, 1720 (2013)
- [2] T. Kuhn, M. Perc, D. Helbing, Inheritance patterns in citation networks reveal scientific memes, *Phys. Rev. X* **4**, 041036 (2014)
- [3] H. Y. D. Sigaki, M. Perc, H. V. Ribeiro, History of art paintings through the lens of entropy and complexity, *Proc. Natl. Acad. Sci. U.S.A.* **115**, E8585-E8594 (2018)
- [4] R. Markovic, M. Gosak, M. Perc, M. Marhl, V. Grubelnik, Applying network theory to fables: Complexity in Slovene belles-lettres for different age groups, *J. Complex Netw.* (2018) doi: 10.1093/comnet/cny018

A millennium of visual arts through the eyes of physics

MATJAZŽ PERC

*Department of Physics, Faculty of Natural Sciences and Mathematics,
University of Maribor, Koroška cesta 160, SI-2000 Maribor, Slovenia*

*CAMTP - Center for Applied Mathematics and Theoretical Physics,
University of Maribor, Krekova 2, SI-2000 Maribor, Slovenia
matjaz.perc@gmail.com • www.matjazperc.com*

The 20th century is often referred to as the century of physics. From x-rays to the semiconductor industry, the human society today would indeed be very different were it not for the progress made in physics laboratories around the world [1,2]. What the past 100 years have been for science, the past millennium has been for the arts. From the late Byzantine and Islamic art to Renaissance, Realism and Pop art, the past 1000 years are packed with the most productive periods of our creative existence. The availability of digitized visual artworks allows us to perform large-scale quantitative analysis of the history of art. We have analyzed almost 140,000 visual artworks [3], the majority of which were paintings, by more than 2,300 artists created between the years 1031 and 2016. Based on the complexity and entropy of spatial patterns in the artworks, we were able to hierarchically categorize the artworks on a scale of order-disorder and simplicity-complexity, ultimately revealing a clear temporal evolution of the artworks that coincides with the main historical periods of art. Our research indicates a shift in data science, away from semantics [4] towards the quantification of more subjective properties of artworks like aesthetics and beauty.

References

- [1] M. Perc, Self-organization of progress across the century of physics, *Sci. Rep.* **3**, 1720 (2013)
- [2] T. Kuhn, M. Perc, D. Helbing, Inheritance patterns in citation networks reveal scientific memes, *Phys. Rev. X* **4**, 041036 (2014)
- [3] H. Y. D. Sigaki, M. Perc, H. V. Ribeiro, History of art paintings through the lens of entropy and complexity, *Proc. Natl. Acad. Sci. U.S.A.* **115**, E8585-E8594 (2018)
- [4] R. Markovic, M. Gosak, M. Perc, M. Marhl, V. Grubelnik, Applying network theory to fables: Complexity in Slovene belles-lettres for different age groups, *J. Complex Netw.* (2018) doi: 10.1093/comnet/cny018

Ohranjevalci posplošene entropije konveksnih kombinacij stanj

TATJANA PETEK

FERI – Fakulteta za elektrotehniko, računalništvo in informatiko, Univerza v Mariboru, Koroška c. 46, SI-2000 Maribor
CAMTP – Center za uporabno matematiko in teoretično fiziko
Univerza v Mariboru, Mladinska 3, SI-2000 Maribor, Slovenia
tatjana.petek@um.si

Tako imenovani ohranjevalci so preslikave med strukturiranimi množicami (npr. algebrami, vektorskimi prostori, konveksnimi množicami), ki ohranjajo izbrane lastnosti elementov domene; ohranjajo npr. kako množico, funkcijo ali relacijo v naslednjem smislu: če ima element domene ali skupina elementov izbrano lastnost, imajo to lastnost tudi njihove slike. Študij takih preslikav nam pogosto omogoči karakterizacijo algebrajsko pomembnih preslikav ali pa preslikav, ki so takim blizu, npr. izomorfizmov, jordanskih izomorfizmov, jordanskih *-izomorfizmov, ipd., in to le z njihovimi ohranjevalskimi (običajno nealgebrajskimi) lastnostmi. Pozitiven sebi adjungiran linearen operator s sledjo ena, delujoč na realnem, kompleksnem ali kvaternionskem Hilbertovem prostoru H , imenujemo *stanje*. Množico vseh stanj na H bomo označili z $S(H)$. Obravnavali bomo preslikave $\phi : S(H) \rightarrow S(H)$, kjer je H končnorazsežen Hilbertov prostor, ki na vseh konveksnih kombinacijah stanj ohranjajo vrednosti določene entropijske funkcije, recimo Shannonovo ali pa katero drugo entropijsko funkcijo. Izkaže se, da morajo take preslikave ohranjati konveksne kombinacije, natančneje, biti morajo oblike $X \mapsto UXU^*$, kjer je U neka realno linearna izometrija na H . Predstavili bomo tudi najnovejše izsledke raziskav.

Reference

- [1] X. Fang, Y. Lao, *Advances in Mathematical Physics* (2018).
- [2] M. Gaál, G. Nagy, *Bull. of the Austral. Math. Soc.*, **98**(1) (2018) 102–108.
- [3] K. He, J. Hou, M. Li, *Applied Mathematics Letters* 25 (2012) 1153–1156.
- [4] K. He, Q. Yuan, J. Hou, *Linear Algebra Appl.* 467 (2015) 243–253.
- [5] M. Karder, T. Petek, *Linear Algebra Appl.* 532 (2017) 86–98.

Preservers of generalized entropy of convex combinations of states

TATJANA PETEK

FERI – Faculty of Electrical Engineering and Computer Science, University of Maribor, Koroška c. 46, SI-2000 Maribor

*CAMTP – Center for Applied Mathematics nad Theoretical Physics
University of Maribor, Mladinska 3, SI-2000 Maribor, Slovenia
tatjana.petek@um.si*

The so-called preservers are maps between structured sets (e.g. algebras, vector spaces, convex sets) which preserve certain properties of elements in the domain of the map. Typically, such a map can preserve a set, a function or a relation in the following sense: If the elements of the domain have a chosen property, then also their images have the same property. Studying such maps often leads to characterization of algebraically important maps or maps being close to such maps, for example, isomorphisms, Jordan isomorphisms, Jordan $*$ -isomorphisms, etc, only by their (non-algebraic) preserving properties. Positive linear trace-one operator acting on a real, complex or quaternion Hilbert space H , is called *state* or *density operator*. The set of all density operators on H will be denoted by $S(H)$. With H being a finite-dimensional Hilbert space, we consider maps $\phi : S(H) \rightarrow S(H)$, which preserve the values of an entropy function, say Shannon or some other, on every convex combination of density operators. It turns out that such a map must preserve all convex combinations of density operators, more precisely, it must be of the form $X \mapsto UXU^*$, where U is a fixed real isometry of H . We present also the recent development of the topic.

References

- [1] X. Fang, Y. Lao, *Advances in Mathematical Physics* (2018).
- [2] M. Gaál, G. Nagy, *Bull. of the Austral. Math. Soc.*, **98**(1) (2018) 102–108.
- [3] K. He, J. Hou, M. Li, *Applied Mathematics Letters* 25 (2012) 1153–1156.
- [4] K. He, Q. Yuan, J. Hou, *Linear Algebra Appl.* 467 (2015) 243–253.
- [5] M. Karder, T. Petek, *Linear Algebra Appl.* 532 (2017) 86–98.

Quantum chromodynamics in the domain of spontaneously broken chiral symmetry

WILLIBALD PLESSAS

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

The fundamental quantum field theory of strong interactions, quantum chromodynamics (QCD), has not yet been amenable to a universally valid solution, despite tremendous efforts invested now over more than four decades. Depending on energy/momentum, temperature, and pressure QCD is obviously governed by distinct degrees of freedom. For instance, it has been learned relatively fast that in the high-energy regime perturbative methods work reliably, due to the property of asymptotic freedom at zero or low temperature. However, in other areas of the QCD phase diagram different scenarios are obviously met. Especially at high temperatures quarks appear to remain confined beyond the chiral-restoration line and a particular chiral-spin symmetry prevails [1,2].

At low energies QCD is characterized by the spontaneous breaking of chiral symmetry. The corresponding dynamics can be viewed as resting on altered degrees of freedom, namely constituent quarks with dynamical masses and Goldstone bosons, instead of current quarks and gluons. I will discuss the construction of a universal framework for the description of low-energy baryons along a Poincarè-invariant formalism taking into account this kind of dynamics. In particular I will present a relativistic constituent-quark model based on Goldstone-boson exchange, show to which extent it works for all known baryons, and hint to its extension for a realistic description of baryon resonances with proper decay characteristics.

References

- [1] C. Rohrhofer, Y. Aoki, G. Cossu, H. Fukaya, L. Y. Glozman, S. Hashimoto, C. B. Lang and S. Prelovšek, *Phys. Rev. D* **96**, (2017) 094501.
- [2] L. Y. Glozman, *Eur. Phys. J. A* **54** (2018) 117.

Letala na električni pogon - izziv prihodnosti

ANITA PRAPOTNIK BRDNIK

*Fakulteta za gradbeništvo, prometno inženirstvo in arhitekturo
Univerza v Mariboru, Smetanova ulica 17
SI-2000 Maribor, Slovenija*

Potniški letalski promet doživlja hiter in konstanten porast in se vsakih 15 let podvoji. Glavna Evropska letališča bodo kmalu dosegla polno kapaciteto in bodo morala zavračati nove potencialne polete. Glavni razlog, ki preprečuje širjenje glavnih letališč je okoljevarstveni, saj okoliški prebivalci močno nasprotujejo povečanju hrupa in onesnaženosti zraka. Ena od možnih rešitev bi bila elektrifikacija letal. Opisala bom torej omejitve in možnosti uporabe alternativnih goriv v potniškem letalstvu za majhna, do 70 sedežna letala.

Reference

- [1] Airbus presentation, *Global market forecast*, 2018
- [2] TASK Force, *Learning from national, regional and local strategies on airport capacity, Final Report*, 2015
- [3] Prof. Dr. Manfred Fishedick et. al., *Shell hydrogen study*, Hamburg 2017
- [4] Isidor Buchmann, *Batteries in a Portable World*, ISBN 978-0968211847, 2016

Electrification of aeroplanes - future challenges

ANITA PRAPOTNIK BRDNIK

*Faculty of Civil Engineering, Transport Engineering and Architecture
University of Maribor, Smetanova ulica 17
SI-2000 Maribor, Slovenia*

Passenger aircraft industry is fast and steady growing and doubles every 15 years. Main European hubs will soon reach maximum capacity and would be forced to reject potential aeroplane lines. The main reason that prevents further extension of airports capacities is ecological. Most large hubs are mainly situated near the large cities and their residents are against further increase of air and noise pollution. One of the solutions to prevent or reduce noise and air pollution would be an electrification of aeroplanes. The possibilities and restrictions of usage of alternative fuels in small, up to 70-seater aeroplanes will be discussed.

References

- [1] Airbus presentation, *Global market forecast*, 2018
- [2] TASK Force, *Learning from national, regional and local strategies on airport capacity, Final Report*, 2015
- [3] Prof. Dr. Manfred Fishedick et. al., *Shell hydrogen study*, Hamburg 2017
- [4] Isidor Buchmann, *Batteries in a Portable World*, ISBN 978-0968211847, 2016

Reverzibilni celični avtomati in neravnovesna statistična mehanika

TOMAŽ PROSEN

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

Izpeljava ireverzibilnih makroskopskih statističnih zakonov, kot so npr. Fourierov ali Fickov zakon, iz reverzibilnih mikroskopskih enačb gibanja, je eden od osrednjih fundamentalnih problemov statistične fizike. V zadnjih letih smo bili priča izrazitemu napredku pri razumevanju dinamike in neravnovesne statistične fizike integrabilnih sistemov [1], zato si obetamo, da bi lahko omenjeno povezavo razumeli vsaj za določene razrede netrivialnih integrabilnih sistemov z močno interakcijo.

V predavanju bom predstavil družino reverzibilnih celičnih avtomatov, ki modelira sisteme interagirajočih delcev, za katero lahko dokažemo obstoj difuzije in točno rešimo več zanimivih paradig statistične fizike, npr. neravnovesna stacionarna stanja sistema med dvema stohastičnima rezervoarjema [2], problem relaksacije v neravnovesno stacionarno stanje [3], ali celo problem eksplicitnega časovnega razvoja makroskopskih stanj, oz. konkretno izračuna t.i. nehomogenega kvenča in dinamičnih korelacijskih funkcij v visokoentropijskih ravnovesnih stanjih [4,5].

Reference

- [1] P. Calabrese, F. H. L. Essler in G. Mussardo, uredniki ‘Special issue on quantum integrability in out of equilibrium systems’, *J. Stat. Mech.*, 064001 (2016).
- [2] T. Prosen in C. Mejia-Monasterio, *J. Phys. A: Math. Theor.* **49**, 185003 (2016).
- [3] T. Prosen in B. Buča, *J. Phys. A: Math. Theor.* **50**, 395002 (2017).
- [4] M. Medenjak, K. Klobas in T. Prosen, *Phys. Rev. Lett.* **119**, 110603 (2017).
- [5] K. Klobas, M. Medenjak, T. Prosen in M. Vanicat, *e-print arXiv:1807.05000*.

Reversible Cellular Automata and Statistical Mechanics

TOMAŽ PROSEN

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

Derivation of macroscopic statistical laws, such as Fourier's, Ohm's or Fick's laws, from reversible microscopic equations of motion is one of the central fundamental problems of statistical physics. In recent years we have witnessed a remarkable progress in understanding the dynamics and nonequilibrium statistical physics of integrable systems [1]. This encourages us to attempt to understand the aforementioned connection at least in specific classes of nontrivial integrable systems with strong interactions.

In my talk I will introduce a family of reversible cellular automata, which model systems of interacting particles, and for which we can prove the existence of diffusion and exactly solve several interesting paradigms of statistical physics, e.g.: [2] nonequilibrium steady states of the system between two stochastic reservoirs, [3] the problem of relaxation to the nonequilibrium steady state, or even [4,5] the problem of explicit time evolution of macroscopic states, for instance, the solution of inhomogeneous quench problems and the calculation of dynamical structure factor in highly entropic equilibrium states.

References

- [1] P. Calabrese, F. H. L. Essler and G. Mussardo, Editors, 'Special issue on quantum integrability in out of equilibrium systems', *J. Stat. Mech.*, 064001 (2016).
- [2] T. Prosen and C. Mejia-Monasterio, *J. Phys. A: Math. Theor.* **49**, 185003 (2016).
- [3] T. Prosen and B. Buča, *J. Phys. A: Math. Theor.* **50**, 395002 (2017).
- [4] M. Medenjak, K. Klobas and T. Prosen, *Phys. Rev. Lett.* **119**, 110603 (2017).
- [5] K. Klobas, M. Medenjak, T. Prosen and M. Vanicat, *e-print arXiv:1807.05000*.

Stabilnost neadiabatnih holonomnih transformacij kvantnih bitov

ANTON RAMŠAK

*Fakulteta za matematiko in fiziko, Univerza v Ljubljani
Institut Jožef Stefan, Ljubljana*

Ena od obetavnih metod manipulacije in transformacij kvantnih bitov, ki so osnovni gradniki naprav za kvantno obdelavo informacije, je uporaba Rashbovega pojava. Pri tej metodi odigra vlogo magnetnega polja, ki bi ga bilo nemogoče uporabiti na zelo majhnem področju, sklopitev spina s tirnim gibanjem elektronov. Elektroni v teh časovno odvisnih sistemih pridobijo kvantne faze, ki so posplošitev znane Berryjeve faze. S pomočjo točnih unitarnih transformacij [1] smo dokazali, da pri teh procesih lahko razmerje med neadiabatno Anandanovo in adiabatno fazo Wilczeka in Zeeja zavzame katerokoli realno število [2]. Pokazali smo tudi, da posplošitev na časovno odvisne Kramerjeve dublete na kvantnem obroču omogoča pokritost celotne Blochove sfere [3]. Točno je mogoče analizirati tudi stabilnost in zvestobo transformacij (angl. "fidelity") in kot primer bomo pokazali rezultate vpliva obarvanega šuma tipa Ornsteina in Uhlenbecka, kjer je beli šum znan posebni primer [4]. Prikazali bomo tudi, kako je mogoče obravnavane neadiabatne sisteme sklopiti s termalno kopeljo. Tudi tukaj unitarne transformacije omogočajo točno obravnavo, s preslikavo v Floquetovo bazo in z izpeljavo ustrezne Lindbladove enačbe. Na konkretnem primeru bomo prikazali tipične rešitve [5].

Reference

- [1] T. Čadež, J. H. Jefferson, and A. Ramšak, *Phys. Rev. Lett.* **112**, 150402 (2014).
- [2] A. Ramšak, T. Čadež, A. Kregar, and L. Ulčakar, *Eur. Phys. J. ST* **227**, 353 (2018).
- [3] A. Kregar, J. H. Jefferson, and A. Ramšak, *Phys. Rev. B* **93**, 075432 (2016); A. Kregar and A. Ramšak, *Int. J. Mod. Phys. B* **30**, 1642016 (2016).
- [4] L. Ulčakar and A. Ramšak, *New J. Phys.* **19**, 093015 (2017); L. Ulčakar and A. Ramšak, *Int. J. Mod. Phys. B* **32**, 1840028 (2018).
- [5] B. Donvil, L. Ulčakar, T. Rejec, and A. Ramšak, in preparation.

Stability of non-adiabatic holonomic qubit manipulations

ANTON RAMŠAK

*Faculty of mathematics and physics, University of Ljubljana
Jožef Stefan Institute, Ljubljana, Slovenia*

A promising method of qubit manipulation in quantum information processing applications is the manipulation where the Rashba effect in non-adiabatic systems induces quantum phases, including the spin rotation. By the virtue of exact unitary transformations [1] we prove that the ratio of the non-adiabatic Anandan phase and the adiabatic Wilczek-Zee counterpart can be tuned to any real number [2]. It is demonstrated also that the results can be generalised to time-dependent Kramers doublet states on a quantum ring with tuneable spin-orbit interaction which proves that any qubit transformation on the Bloch sphere is feasible in this system [3]. Stability properties of qubit transformations and the corresponding fidelity can also be studied exactly and as an example we present results for spin-orbit dynamics influenced by the Ornstein-Uhlenbeck coloured noise of driving fields [4]. Finally we demonstrate how these non-adiabatic systems can be coupled to thermal baths. In particular, by the known unitary transformation [1] the system can be expressed in the Floquet basis which enables an exact derivation of the Lindblad equation. Some typical solutions of the corresponding Lindblad equation will be presented [5].

References

- [1] T. Čadež, J. H. Jefferson, and A. Ramšak, *Phys. Rev. Lett.* **112**, 150402 (2014).
- [2] A. Ramšak, T. Čadež, A. Kregar, and L. Ulčakar, *Eur. Phys. J. ST* **227**, 353 (2018).
- [3] A. Kregar, J. H. Jefferson, and A. Ramšak, *Phys. Rev. B* **93**, 075432 (2016); A. Kregar and A. Ramšak, *Int. J. Mod. Phys. B* **30**, 1642016 (2016).
- [4] L. Ulčakar and A. Ramšak, *New J. Phys.* **19**, 093015 (2017); L. Ulčakar and A. Ramšak, *Int. J. Mod. Phys. B* **32**, 1840028 (2018).
- [5] B. Donvil, L. Ulčakar, T. Rejec, and A. Ramšak, in preparation.

Analiza parametrično periodično vzbujanega klasičnega in kvantnega linearnega oscilatorja

MARKO ROBNIK

*CAMTP - Center za uporabno matematiko in teoretično fiziko
Univerza v Mariboru, Mladinska 3, SI-2000 Maribor, Slovenia
Robnik@uni-mb.si • www.camtp.uni-mb.si*

Proučujemo, teoretično in numerično, vedenje klasičnega in kvantnega parametrično periodično vzbujanega linearnega oscilatorja. Kot osnovno paradigmo takšnega Floquetovega sistema obravnavamo primer harmonične oscilacije oscilatorjeve frekvence, ki je priročen za teoretično in numerično obravnavo, a ohranja vse splošne lastnosti. Izpeljemo eksplicitno analitično formulo za kvantni propagator s pomočjo klasičnega propagatorja. Uporablja joč to izpeljemo eksplicitno eksaktno formulo za razvoj pričakovane vrednosti energije, za poljubno normirano začetno stanje. V primeru, ko je začetno stanje stacionarno lastno stanje, je razvoj natančno enak kot za klasični mikrokanonični ansambel začetnih pogojev z isto začetno energijo. Izvedemo popolno numerično analizo vedenja sistema v območjih nestabilnosti (*lacunae*), kjer se energija oscilatorja eksponentno povečuje, kakor tudi v območjih stabilnosti, še posebej na meji med stabilnostnim ter nestabilnostnim območjem. Numerično potrdimo s popolno zanesljivostjo, da meji med stabilnim in nestabilnim območjem klasično in kvantno *eksaktno* sovpadata, v skladu s teorijo, in dobimo vrsto pomembnih empiričnih rezultatov, še prav posebej enačbo eliptičnega tipa, s katero izrazimo hitrost eksponentnega naraščanja energije v lacunah kot funkcijo drugih sistemskih parametrov. Verjamemo, da so naš pristop in rezultati generičnega tipa, t.j. uporabni v večini tovrstnih linearnih Floquetovih sistemov, in predstavimo motivacijo za splošno teorijo, klasično in kvantno.

Reference

- [1] V. Grubelnik, M. Logar, M. Robnik and Y. Xia, *Physical Review E* (2018) submitted.

Analysis of the parametrically periodically driven classical and quantum linear oscillator

MARKO ROBNIK

*CAMTP - Center for Applied Mathematics and Theoretical Physics
University of Maribor, Mladinska 3, SI-2000 Maribor, Slovenia
Robnik@uni-mb.si • www.camtp.uni-mb.si*

We study theoretically and computationally the behaviour of the classical and quantum parametrically periodically driven linear oscillator. As a basic paradigm of such a Floquet system we consider the case of the harmonic oscillation of the oscillator frequency, which is convenient to handle theoretically and computationally, while keeping the general features. We derive explicit analytic formula for the quantum propagator in terms of the classical propagator. Using this, we derive the explicit exact formula for the evolution of the expectation value of the energy starting from an arbitrary normalizable initial state. In the case of the starting pure stationary eigenstate the evolution is exactly the same as for the classical microcanonical ensemble of initial conditions of the same starting energy. We perform a rather complete computational analysis of the system's behaviour inside the instability regions (lacunae), where the energy of the oscillator increases exponentially, as well as in the stability regions, and in particular in the vicinity of the (in)stability borders. We confirm also numerically with absolute certainty that the borders of (in)stability regions classically and quantally coincide *exactly*, in accordance with the theory, and find a number of important empirical results, especially an equation of the elliptic type describing the rate of exponential energy growth inside the lacunae in terms of other system's quantities. We believe that our approach and findings are of generic linear type, i.e. applicable in most such linear Floquet systems, and present a strong motivation for a general theory, classically and quantally.

References

- [1] V. Grubelnik, M. Logar, M. Robnik and Y. Xia, *Physical Review E* (2018) submitted.

Periodične rešitve in limitni cikli v nekaterih biokemičnih modelih

VALERIJ ROMANOVSKIJ

*CAMTP - Center za uporabno matematiko in teoretično fiziko
Univerza v Mariboru, Mladinska 3, SI-2000 Maribor, Slovenia
Fakulteta za elektrotehniko, računalništvo in informatiko
Fakulteta za naravoslovje in matematiko
Univerza v Mariboru, SI-2000 Maribor Slovenia
valerij.romanovskij@um.si • www.camtp.uni-mb.si*

Obravnavamo problem obstoja prvih integralov in bifurkacij limitnih ciklov v tridimenzionalnih sistemih navadnih diferencialnih enačb, ki se pojavljajo pri študiji ekoloških in biokemičnih modelov. Najprej predstavimo pristop, ki omogoča najti invariantne ploskve in Darbouxove integrale v polinomskih sistemih, in ki se lahko uporabljamo tudi za določitev centralnih mnogoterosti sistema. Nato je predstavljena metoda za proučevanje bifurkacij limitnih ciklov na centralni raznoterosti.

Reference

- [1] V. Antonov, D. Dolićanin, V.G. Romanovski, J. Tóth, *MATCH Commun. Math. Comput. Chem.* **76** (2016) 455–474.
- [2] Y. Xia, M. Grašič, W. Huang and V. G. Romanovski, Limit Cycles in a Model of Olfactory Sensory Neurons, 2018, *International Journal of Bifurcation and Chaos* (accepted)

Periodic solution and limit cycles in some biochemical models

VALERY ROMANOVSKI

*CAMTP - Center for Applied Mathematics and Theoretical Physics
University of Maribor, Mladinska 3, SI-2000 Maribor, Slovenia
Faculty of Faculty of Electrical Engineering and Computer Science
Faculty of Natural Science and Mathematics
University of Maribor, SI-2000 Maribor Slovenia
valerij.romanovskij@um.si • www.camtp.uni-mb.si*

We investigate the existence of first integrals and limit cycle bifurcations in three-dimensional systems connected to ecological and biochemical studies. We first present an approach to find invariant surfaces and Darboux integrals in polynomial systems, which can be used also to determine center manifolds of the system. Then, a method to investigate limit cycle bifurcations on a center manifold is described.

References

- [1] V. Antonov, D. Dolićanin, V.G. Romanovski, J. Tóth, *MATCH Commun. Math. Comput. Chem.* **76** (2016) 455–474.
- [2] Y. Xia, M. Grašič, W. Huang and V. G. Romanovski, Limit Cycles in a Model of Olfactory Sensory Neurons, 2018, *International Journal of Bifurcation and Chaos* (accepted)

Ultralong-Range Molecules

PETER SCHMELCHER

Centre for Optical Quantum Technologies
University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany
pschmelc@physnet.uni-hamburg.de •
<http://photon.physnet.uni-hamburg.de/en/ilp/schmelcher/>

Ultralong-Range Molecules provide a new type of highly excited Rydberg molecules with a novel binding mechanisms different from the 'traditional' covalent or ionic binding. They combine Rydberg atoms with ground state atoms in a single molecule thereby leading to molecular properties inherited from the Rydberg component. Huge bond lengths and corresponding dipole moments belong to the peculiar features of this species. They have been observed spectroscopically approximately a decade ago and are now under intense investigation in several ultracold atom groups worldwide. Due to their small binding energies they are extremely sensitive even to weak external electric and magnetic fields, as we shall demonstrate in this presentation [1,2,3]. Bond lengths, local equilibria, orientation and alignment can be controlled using fields and vary largely with the degree of excitation of the Rydberg atom(s). We compare experimental results with theory [2] and demonstrate isotropic as well as anisotropic interaction effects with a rich structure of the resulting vibrational dynamics and states. More recently high resolution spectroscopy has even seen the spin structure of those states - and we demonstrate what is necessary in order to describe the latter and combine it with the external field effects [4]. Moving from diatomic to triatomic systems [5,6] the first evidence for three-body interactions has been demonstrated in theory and experiment opening-up the possibility of a full control of chemical reaction dynamics in these highly excited Rydberg molecules.

References

- [1] M. Kurz and P. Schmelcher, *Physical Review A* **88**, 022501 (2013).
- [2] A.T. Krupp, A. Gaj, J.B. Balewski, S. Hofferberth, R. Löw, T. Pfau, M. Kurz and P. Schmelcher, *Physical Review Letters* **112**, 143008 (2014).
- [3] M. Kurz and P. Schmelcher, *Journal of Physics B* **47**, 165101 (2014).
- [4] F. Hummel, C. Fey and P. Schmelcher, *Physical Review A* **97**, 043422 (2018).
- [5] C. Fey, M. Kurz and P. Schmelcher, *Physical Review A* **94**, 012516 (2016).
- [6] C. Fey, J. Yang, S.T. Rittenhouse, F. Munkes, M. Baluktsian, P. Schmelcher, H.R. Sadeghpour, J.P. Shaffer, arXiv:1803:09781.

Correlation Functions of the Quantum Sine-Gordon Model in and out of Equilibrium

SPYROS SOTIRIADIS & IVAN KUKULJAN

*University of Ljubljana, Faculty of Mathematics and Physics
Jadranska ulica 19, SI-1000 Ljubljana, Slovenia
spyridon.sotiriadis@fmf.uni-lj.si & ivan.kukuljan@fmf.uni-lj.si
• chaos.fmf.uni-lj.si*

Complete information on a quantum field theory (QFT) is provided by multipoint correlation functions. However, their theoretical calculation is a challenging problem. If the interaction is strong, perturbation theory fails and more complex approaches have to be developed. This has recently become an experimentally relevant problem, due to progress in cold-atom experiments. In a prominent recent experiment [1], researchers have succeeded in simulating QFT models and directly measuring higher order correlations. In order to provide a theoretical description, we have developed a non-perturbative method [2] to compute correlation functions of the quantum sine-Gordon model, a prototype model of a strongly interacting QFT which is of central interest from both theoretical and experimental point of view. Building upon the so-called Truncated Conformal Space Approach, we numerically construct higher order correlations in a system of finite size in various physical states of experimental relevance, both in and out of equilibrium. We measure deviations from Gaussianity due to the presence of interaction and analyse their dependence on temperature, explaining the experimentally observed crossover between Gaussian and non-Gaussian regimes. We find that correlations of excited states are markedly different from those of thermal states, which can be explained by the integrability of the system. We also study dynamics after a quantum quench, a sudden change in the system, observing the effects of the interaction on the time evolution of correlation functions, their spatial dependence and their non-Gaussianity.

References

- [1] T. Schweigler, V. Kasper, S. Erne, I. Mazets, B. Rauer, F. Cataldini, T. Langen, T. Gasenzer, J. Berges, and J. Schmiedmayer, *Nature* **545** 7654 323–326 (2017).
- [2] I. Kukuljan, S. Sotiriadis, G. Takacs *Phys. Rev. Lett.* **121** 110402 (2018).

Towards a Spin Resonance Analogue in Microwave Networks

HANS-JÜRGEN STÖCKMANN

Fachbereich Physik

Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany

stoeckmann@physik.uni-marburg.de

• *www.uni-marburg.de/fb13/forschungsgruppen/quantenchaos*

The universal properties of chaotic systems are well reproduced by the corresponding properties of random matrix ensembles. Depending on the symmetry with respect to time reversal and the presence or absence of a spin 1/2 there are three universality classes: the Gaussian orthogonal ensemble for systems with time-reversal invariance (TRI) and no spin 1/2, the Gaussian unitary ensemble for systems with broken TRI, and the Gaussian symplectic ensemble (GSE) for systems with spin 1/2 and TRI. We recently succeeded in an experimental realization of the GSE in microwave networks with a particular symmetry simulating a spin 1/2 system [1,2]. Thus now the whole spin 1/2 world is open to microwave analogue experiments [3]. In particular a microwave simulation of nuclear magnetic resonance should be possible. This means, however, to apply time-dependent variations in the 10 MHz regime to the networks, which is a real challenge. First results towards the realization of this objective will be presented.

References

- [1] A. Rehemanjiang, M. Allgaier, C. H. Joyner, S. Müller, M. Sieber, U. Kuhl, and H.-J. Stöckmann, *Phys. Rev. Lett.* **117** (2016) 064101.
- [2] A. Rehemanjiang, M. Richter, U. Kuhl, and H.-J. Stöckmann, *Phys. Rev.E* **97** (2018) 022204.
- [3] D. Dubbers and H.-J. Stöckmann. *Quantum Physics: The Bottom-Up Approach – From the Simple Two-Level System to Irreducible Representations*. Springer Berlin Heidelberg (2013).

Zmanjšana medcelična povezanost pri sladkorni bolezni tipa

2

ANDRAŽ STOŽER^{1,*}, MARKO GOSAK^{1,2}, JURIJ DOLENŠEK¹

¹*Inštitut za fiziologijo, Medicinska fakulteta, Univerza v Mariboru, Taborska ulica 8, 2000 Maribor, Slovenija*

²*Fakulteta za naravoslovje in matematiko, Univerza v Mariboru, Koroška cesta 160, 2000 Maribor, Slovenija*

**andraz.stozer@um.si*

V stanjih zmanjšane občutljivosti tarčnih tkiv na inzulin so opazili ojačane znotrajcelične signale na različnih stopnjah kaskade sklopitve med stimulacijo in sekrecijo v celicah beta in predvideva se, da je ta ojačitev mehanizem hiperinzulinemične kompenzacije med razvojem sladkorne bolezni tipa 2 (Gonzalez, et al. 2013). Ko se občutljivost tarčnih tkiv zmanjša še bolj, se znotrajcelična signalizacija še bolj ojača, zato motnje v znotrajcelični signalizaciji ne morejo v celoti razložiti dekompenzacije v smeri proti polno razviti sladkorni bolezni tipa 2. Pred kratkim so se pojavili dokazi, da v nasprotju z znotrajcelično signalizacijo pride do motenj v medcelični signalizaciji in da bi ta lahko bila primarna tarča diabetogenih faktorjev med razvojem sladkorne bolezni (Irles, et al. 2015; Johnston, et al. 2016). V naši raziskavi smo se odločili poiskati dokaze za moteno medcelično sklopitev med celicami beta pri miših in ljudeh s sladkorno boleznijo. Zapise kalcijevih odzivov na glukozo v celicah beta smo analizirali po kriteriju podobnosti med signali v vsakem izbranem paru celic oziroma med vsakima dvema področjema zanimanja. Na osnovi teh podobnosti smo konstruirali in kvantificirali grafe funkcionalne povezanosti (Stožer, et al. 2013; Gosak, et al. 2018). Tako pri miših kot ljudeh s sladkorno boleznijo so v primerjavi s kontrolnimi osebki vzorci funkcionalne povezanosti pokazali značilno zmanjšano število povezav. Na osnovi tega lahko rečemo, da je medcelična povezanost prizadeta zgodaj v razvoju sladkorne bolezni in bi v prihodnosti lahko postala zanimiva nova terapevtska tarča.

Reference

- [1] A.B. Gonzalez, et al., *Endocrinology* **154** (2010) 3515.
- [2] M. Gosak, R. Markovič, J. Dolenšek, M.S. Rupnik, M. Marhl, A. Stožer, M. Perc, *Phys. Life Rev.* **24** (2018) 118.
- [3] Irles, et al., *Mol. Cell. Endocrin.* **404** (2015) 46.
- [4] Johnston, et al., *Cell Metabolism* **24** (2016) 389.
- [5] A. Stožer, M. Gosak, J. Dolenšek, M. Perc, M. Marhl, M.S. Rupnik, D. Korošak, *PLoS Comput. Biol.* **9** (2013) e1002923.

Decreased Intercellular Connectivity in Type 2 Diabetes

ANDRAŽ STOŽER^{1,*}, MARKO GOSAK^{1,2}, JURIJ DOLENŠEK¹

¹*Institute of Physiology, Faculty of Medicine, University of Maribor, Taborska ulica 8, SI-2000 Maribor, Slovenia*

²*Faculty of Natural Sciences and Mathematics, University of Maribor, Koroška cesta 160, SI-2000 Maribor, Slovenia*

**andraz.stozer@um.si*

Augmented intracellular signals at different stages in the stimulus-secretion coupling cascade in insulin-secreting beta cells have been observed in states of decreased insulin sensitivity in target tissues and it is believed that this is the mechanism for the hyperinsulinemic compensation during development of type 2 diabetes mellitus (Gonzalez, et al. 2013). When insulin sensitivity decreases even more, even stronger intracellular signals are detected in beta cells, thus failure in the stimulus-secretion coupling cascade cannot account for decompensation towards frank diabetes. It has been suggested recently that intercellular connectivity, as opposed to intracellular signaling, could be the primary target of diabetogenic insults in pathogenesis of type 2 diabetes (Irls, et al. 2015; Johnston, et al. 2016). In our study, we set out to find evidence of disrupted intercellular connectivity in beta cells from mice and humans with type 2 diabetes. Traces of calcium responses to glucose were analyzed for similarity between every pair of beta cells or every two chosen regions of interest. Based on this similarity, functional connectivity graphs were constructed and quantified (Stožer, et al. 2013; Gosak, et al. 2018). In islets from both mice and humans with diabetes functional connectivity patterns showed a significantly reduced number of connections compared with normal islets. Thus, intercellular connectivity indeed seems to be affected early during development of type 2 diabetes mellitus and could become a new therapeutic target.

References

- [1] A.B. Gonzalez, *et al.*, *Endocrinology* **154** (2010) 3515.
- [2] M. Gosak, R. Markovič, J. Dolenšek, M.S. Rupnik, M. Marhl, A. Stožer, M. Perc, *Phys. Life Rev.* **24** (2018) 118.
- [3] Irls, *et al.*, *Mol. Cell. Endocrin.* **404** (2015) 46.
- [4] Johnston, *et al.*, *Cell Metabolism* **24** (2016) 389.
- [5] A. Stožer, M. Gosak, J. Dolenšek, M. Perc, M. Marhl, M.S. Rupnik, D. Korošak, *PLoS Comput. Biol.* **9** (2013) e1002923.

Sklopitev gostote in nematskega reda v izotropnih linearnih polimerih

DANIEL SVENŠEK

*Oddelek za fiziko, Fakulteta za matematiko in fiziko
Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenija
daniel.svensek@fmf.uni-lj.si • www.fmf.uni-lj.si*

Za polimere in druge povezane “linijske tekočine” je značilna makroskopska sklopitev gostote in ravnovesnega nematskega reda, ki jo opisuje *vektorski ohranitveni zakon* Meyer-de Gennesovega tipa [1-5]. Ta pa ne sklaplja fluktuacij teh dveh količin v izotropni fazi, podobno kot v primeru izotropnih tekočin nepovezanih nesferičnih delcev. Šele polni tenzorski opis nematskega reda polimernih talin/raztopin in *tenzorski ohranitveni zakon* [6,7], ki povezuje gostoto in orientacijski red, opišeta sklopljene fluktuacije gostote in nematskega reda tudi v izotropni fazi [7]. Prek te sklopitve krajevna variacija gostote oziroma koncentracije inducira nematski red in s tem akustično oziroma osmotsko dvolomnost v sicer izotropni polimerni talini/raztopini. Teoretične koncepte smo preverili z intenzivnimi simulacijami Monte Carlo izotropnih talin mehkih linearnih verig [5] različnih dolžin in fleksibilnosti, kjer smo primerjali numerično izračunane orientacijske korelacijske funkcije z napovedmi makroskopske teorije [7]. Z vpeljšano metodologijo lahko prek mikroskopskih simulacij določimo makroskopske parametre realističnih kontinuumskih modelov specifičnih polimernih materialov.

Reference

- [1] P.G. de Gennes, *Mol. Cryst. Liq. Cryst. Lett.* **34** (1977) 177.
- [2] R.B. Meyer, *Physica A* **176** (1991) 63.
- [3] J.V. Selinger, R.F. Bruinsma, *Phys. Rev. A* **43** (1991) 2910.
- [4] D.R. Nelson, *Physica A* **177** (1991) 220.
- [5] A. Popadić, D. Svenšek, R. Podgornik, K. Ch. Daoulas, M. Praprotnik, *Soft Matter* **14** (2018) 5898.
- [6] D. Svenšek, R. Podgornik, *Phys. Rev. E* **93** (2016) 052703.
- [7] A. Popadić, D. Svenšek, R. Podgornik, M. Praprotnik, submitted, arXiv:1811.05252 [cond-mat.soft].

Density–nematic coupling in isotropic linear polymers

DANIEL SVENŠEK

*Dept. of Physics, Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
daniel.svenssek@fmf.uni-lj.si • www.fmf.uni-lj.si*

Polymers and other connected “line liquids” exhibit a coupling between density and equilibrium nematic order on the macroscopic level that gives rise to a Meyer-de Gennes *vectorial conservation law* [1-5]. Nevertheless, in the isotropic phase they exhibit fluctuations of the density and of the nematic order that are not coupled by this vectorial constraint, just like for isotropic liquids composed of disconnected non-spherical particles. It takes the proper tensorial description of the nematic order in polymer melts/solutions, leading to a *tensorial conservation law* [6,7] connecting density and orientational order, that finally implicates coupled density and nematic order fluctuations, already in the isotropic phase [7]. This coupling implies that a spatial variation of density or a local concentration gradient will induce nematic order and thereby an acoustic or osmotic optical birefringence even in an otherwise isotropic polymer melt/solution. We validate the theoretical conceptions by performing detailed Monte Carlo simulations of isotropic melts of soft worm-like chains [5] with variable length and flexibility, and comparing the numerically determined orientation correlation functions with predictions of the macroscopic theory [7]. The methodology drawn sets forth a means of determining the macroscopic parameters by microscopic simulations to yield realistic continuum models of specific polymeric materials.

References

- [1] P.G. de Gennes, *Mol. Cryst. Liq. Cryst. Lett.* **34** (1977) 177.
- [2] R.B. Meyer, *Physica A* **176** (1991) 63.
- [3] J.V. Selinger, R.F. Bruinsma, *Phys. Rev. A* **43** (1991) 2910.
- [4] D.R. Nelson, *Physica A* **177** (1991) 220.
- [5] A. Popadić, D. Svenšek, R. Podgornik, K. Ch. Daoulas, M. Praprotnik, *Soft Matter* **14** (2018) 5898.
- [6] D. Svenšek, R. Podgornik, *Phys. Rev. E* **93** (2016) 052703.
- [7] A. Popadić, D. Svenšek, R. Podgornik, M. Praprotnik, submitted, arXiv:1811.05252 [cond-mat.soft].

Matrix ansatz for non-equilibrium stationary states

MATTHIEU VANICAT

*Faculty of Mathematics and Physics, University of Ljubljana
Jadranska 19, SI-1000 Ljubljana, Slovenia
matthieu.vanicat@fmf.uni-lj.si*

Understanding systems that are out-of-equilibrium, *i.e.* carrying macroscopic currents of physical quantities (energy, charge, mass,...) is a major challenge of statistical physics. These systems lie beyond the scope of the usual Boltzmann distribution. I will present examples of non-equilibrium stationary states arising in exclusion processes. They are models of particles in interaction on a one dimensional lattice with L sites. The particles are evolving randomly on the lattice following simple stochastic rules. The lattice is connected at its extremities to particle reservoirs with different densities which drive the system out-of-equilibrium. I will explain how to compute exactly the stationary distribution (which does not obey a Boltzmann statistics) in a matrix product form. This will allow us to compute analytically physical quantities such as particle current and correlation functions.

References

- [1] N. Crampe, E. Ragoucy, V. Rittenberg and M. Vanicat, *Phys. Rev. E* **94** (2016) 032102.
- [2] M. Vanicat, *Journal of Statistical Physics* **166** (2017) 1129.
- [3] M. Vanicat, *Nuclear Physics B* **929** (2018) 298.

Kompleksne vijačne strukture v smektičnih fazah iz nekiralnih molekul

NATAŠA VAUPOTIČ

*Fakulteta za naravoslovje in matematiko
Univerza v Mariboru, Koroška 160, SI-2000 Maribor, Slovenija
Institut Jožef Stefan
Jamova 39, SI-1000 Ljubljana, Slovenia
natasa.vaupotic@um.si • www.fnm.um.si*

Nizkofrekvenčna resonančna rentgenska spektroskopija (RSoXS) je mogočno eksperimentalno orodje, ki omogoča hkratno preučevanje periodične modulacije elektronske gostote in lokalne orientacijske ureditve molekul. Metoda je tudi edina, ki omogoča preučevanje faz s homogeno elektronsko gostoto in orientacijsko ureditvijo molekul na nanonivoju (npr. nanovijačnice) [1,2]. Kombinacija meritev in modelskih napovedi omogoča zanesljivo napoved faznih struktur.

Predstavila bom raziskavo strukture v smektični fazi, ki jo tvorijo nekiralni upognjeni dimeri [3]. Višje temperaturna faza v tem materialu je zvojno-upogibna nematična faza. Zanja je značilna homogena elektronska gostota, dolge osi upognjenih dimerov pa se s periodo okoli 10 nm vijačijo po plašču stožca. Ko nižamo temperaturo, dobimo fazni prehod v bolj urejeno, plastno strukturo. S primerjavo RSoXS meritev in modeliranja smo ugotovili, da je struktura 4-plastna (zvojno-upogibna smektična-C faza), ki se dodatno vijači skozi prostor. Obe vrsti modulacije sta značilni za kiralne materiale in zato izjemno presenetljivi v akiralnih sistemih. Z modelom dobimo uvid v dogajanje pri nižjih temperaturah, ki so eksperimentalno nedosegljive. Tako ugotovimo, da z nižanjem temperature interakcije med molekulami želijo vzpostaviti preprosto dvoplastno antiklinsko strukturo.

Reference

- [1] C. Zhu, M. R. Tuchband, A. Young, M. Shuai, A. Scarbrough, D. M. Walba, J. E. Maclennan, C. Wang, A. Hexemer, N. A. Clark, *Phys. Rev. Lett.* **116**, 147803 (2016).
- [2] M. Salamończyk, N. Vaupotič, D. Pocięcha, C. Wang, C. Zhu, E. Górecka, *Soft Matter* **13**, 6694 (2017).
- [3] M. Salamończyk, N. Vaupotič*, D. Pocięcha, R. Walker, J. M. D. Storey, C. T. Imrie, C. Wang, C. Zhu, E. Górecka*, *članek v pripravi*.

Complex helicoidal structure of layered phases made of achiral molecules

NATAŠA VAUPOTIČ

*Faculty of Natural Sciences and Mathematics
University of Maribor, Koroška 160, SI-2000 Maribor, Slovenia
Jozef Stefan Institute
Jamova 39, SI-1000 Ljubljana, Slovenia
natasa.vaupotic@um.si • www.fnm.um.si*

Soft resonant x-ray scattering (RSoXS) is a powerful tool that enables a simultaneous study of the long-range electron density order in combination with the local orientational order of molecules and it is practically the only tool that enables orientational study of molecules in phases with no electron density modulation but nanoscale-ordered orientational (e.g. helical) structure [1,2]. Experimental studies have to be supported by theoretical modelling of the RSoXS response in order to give a reliable prediction of the phase structure.

We present a study of the smectic layer structure formed by achiral bent-core dimers [3]. The upper temperature phase of this material is a twist-bend nematic phase, a phase with a uniform electron density and nano-helical orientational structure of the long molecular axes. When temperature is lowered, a phase transition into a layered, smectic, structure is detected. A comparison of the experimental results with theoretical modelling shows that the structure is a deformed 4-layer twist-bend smectic C phase structure with a long helical pitch superimposed on the 4-layer structure. Both modulations are characteristic for chiral materials and are thus highly surprising in an achiral system. Modelling down to the experimentally unreachable temperatures shows, that the temperature dependence of the structure development in the smectic phase is due to system interactions that tend to unwind the helical structure into a simple anticlinic smectic phase.

References

- [1] C. Zhu, M. R. Tuchband, A. Young, M. Shuai, A. Scarbrough, D. M. Walba, J. E. Maclennan, C. Wang, A. Hexemer, N. A. Clark, *Phys. Rev. Lett.* **116**, 147803 (2016).
- [2] M. Salamończyk, N. Vaupotič, D. Pocięcha, C. Wang, C. Zhu, E. Górecka, *Soft Matter* **13**, 6694 (2017).
- [3] M. Salamończyk, N. Vaupotič*, D. Pocięcha, R. Walker, J. M. D. Storey, C. T. Imrie, C. Wang, C. Zhu, E. Górecka*, *to be published*.

Spinski transport in spodnja meja za Drudejevo utež v Troteriziranem XXZ modelu

LENART ZADNIK

Fakulteta za matematiko in fiziko
Univerza v Ljubljani, Jadranska 19, SI-1000 Ljubljana, Slovenija
lenart.zadnik@fmf.uni-lj.si • <https://www.fmf.uni-lj.si/si/>

Predstavil bom kvazilokalne ohranjene količine v Troteriziranem/gnanem XXZ modelu in njihov vpliv na spinski transport. Spinski transport v modelu je balističen tudi v območju anizotropij, ki v primeru zvezno-časovnega razvoja pripadajo režimu z vrzeljo.

Spin transport and Drude weight bound in the Trotterized XXZ model

LENART ZADNIK

Faculty of mathematics and physics
University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia
lenart.zadnik@fmf.uni-lj.si • <https://www.fmf.uni-lj.si/si/>

I will discuss quasilocal conservation laws in the Trotterized/driven XXZ model and their implications on the spin transport. Interestingly, the model exhibits ballistic transport for a range of anisotropies which, in the continuous-time case, belong to the gapped regime.

Topološki linijski defekti kot optični valovni vodniki v nematikih

SLOBODAN ŽUMER

Institut Jožef Stefan, Ljubljana, Slovenija
Fakulteta za matematiko in fiziko, Univerza v Ljubljani, Slovenija
slobodan.zumer@fmf.uni-lj.si • softmatter.fmf.uni-lj.si

Širjenje kompleksnih svetlobnih curkov vzdolž singularnih in ne-singularnih topoloških defektnih linij v nematikih je zanimivo zaradi možne uporabe v fotoniki. Za razliko od opisa širjenja svetlobe skozi regularne mreže kompleksnih defektov, ki temelji na razvoju po valovnih načinih [1], smo se odločili za prilagojeno metodo končnih razlik v časovni domeni, ki omogoča efektivno numerično reševanje Maxwellovih enačb. Posebej zanimivo je, kako se med takim širjenjem svetlobe združujejo topološke invariante nematskega polja in polarizacije [2]. Prav tako je pomembno fokusiranje in razprševanje svetlobnega curka vzdolž defektnih struktur za šibke in visoke svetlobne jakosti [2-4]. V slednjem primeru, smo modelirali tudi samo-preoblikovanje optičnih curkov. Ta pojav temelji na dielektrični sklopitvi v nematskega in električnega polja, kar zahteva simultano numerično reševanje Maxwellovih enačb in enačb za minimizacijo nematske proste energije. Za zaključek je dodan opis transformacije femto-sekundnih laserskih impulzov pri širjenju vzdolž defektnih linij.

Reference

- [1] J. Fukuda and S. Žumer, Reflection spectra and near-field images of a liquid crystalline half-Skyrmion lattice, *Optics Express* **26** (2018) 1174-1184.
- [2] M. Čančula, M. Ravnik and S. Žumer, Generation of vector beams with liquid crystal disclination lines, *Phys. Rev. E* **90** (2014) 022503.
- [3] M. Čančula, M. Ravnik, I. Muševič, and S. Žumer, Liquid microlenses and waveguides from bulk nematic birefringent profiles, *Optics Express* **24** (2016) 22177-22188.
- [4] J. Pišljari and M. Ravnik, Lensing and waveguiding in birefringent double-twist cylinders, *Optics Express* **26** (2018) 26327.

Topological line defects in nematics as optical waveguides

SLOBODAN ŽUMER

Jožef Stefan Institute, Ljubljana, Slovenia
Faculty of Mathematics and Physics, University of Ljubljana, Slovenia
slobodan.zumer@fmf.uni-lj.si • softmatter.fmf.uni-lj.si

Propagation of complex light beams along singular and nonsingular topological defects in nematic liquid crystals that is of interest for photonics will be discussed. In contrast to the light propagation through lattices of complex defect structures that are well addressed by wave expansion methods [1], we here used a customized Finite-Difference Time-Domain numerical procedure for solving electro-magnetic equations. We show how during such light propagation, topological invariants of the nematic and polarization fields combine [2]. Focusing and defocusing of the light propagating along such structures are analyzed for both weak and high intensity optical beams [2-4]. In the latter case, we also model the self-reshaping of high intensity optical beams by adding dielectric coupling to the nematic free energy and, in parallel to electromagnetic equations, numerically solve the minimization equations for the free energy of nematic fields. Finally, also transformations of femtosecond laser pulses will be briefly discussed.

References

- [1] J. Fukuda and S. Žumer, Reflection spectra and near-field images of a liquid crystalline half-Skyrmion lattice, *Optics Express* **26** (2018) 1174-1184.
- [2] M. Čančula, M. Ravnik and S. Žumer, Generation of vector beams with liquid crystal disclination lines, *Phys. Rev. E* **90** (2014) 022503.
- [3] M. Čančula, M. Ravnik, I. Muševič, and S. Žumer, Liquid microlenses and waveguides from bulk nematic birefringent profiles, *Optics Express* **24** (2016) 22177-22188.
- [4] J. Pišljari and M. Ravnik, Lensing and waveguiding in birefringent double-twist cylinders, *Optics Express* **26** (2018) 26327.

Struktura Galaksije na osnovi letošnjih objav rezultatov satelita Gaia in zemeljskih spektroskopskih pregledov neba

TOMAŽ ZWITTER

*Fakulteta za matematiko in fiziko
Univerze v Ljubljani, Jadranska 19, 1000 Ljubljana
tomaz.zwitter@fmf.uni-lj.si • fiz.fmf.uni-lj.si/zwitter*

Aprila je satelit Gaia objavil drugo javno objavo rezultatov, ki s svojo obsežnostjo in točnostjo predstavlja mejnik na skoraj vseh področjih astrofizikalnih raziskav. Po predstavitvi glavnih lastnosti tega podatkovnega seta bom naštel nekaj glavnih odkritij zadnjih mesecev in rezultate te satelitske misije povezal z opazovanji z Zemlje, zlasti s spektroskopskim pregledom neba Galah, ki je hkrati objavil največjo bazo kemičnih lastnosti in radialnih hitrosti zvezd doslej. Posebno pozornost bom namenil tudi rezultatom naše raziskovalne skupine.

Reference

- [1] Brown, A. G. A., et al., *Astronomy & Astrophysics*, **616** (2018) 1.
- [2] Buder, S., et al., *Mon. Not. Roy. Astr. Soc.*, **478** (2018) 4513.
- [3] Čotar, K., et al., *Mon. Not. Roy. Astr. Soc.*, (2018) astro-ph:1807.07977.
- [4] Kos, J., et al., *Mon. Not. Roy. Astr. Soc.*, **473** (2018) 4612.
- [5] Kos, J., et al., *Mon. Not. Roy. Astr. Soc.*, **480** (2018) 5242.
- [6] Kos, J., et al., *Mon. Not. Roy. Astr. Soc.*, **480** (2018) 5475.
- [7] Zwitter, T., et al., *Mon. Not. Roy. Astr. Soc.*, **481** (2018) 645.
- [8] Žerjal, J., et al., *Mon. Not. Roy. Astr. Soc.*, (2018) astro-ph:1810.1045.

Structure of the Galaxy based on this year's Gaia satellite public data release and results of ground-based spectroscopic surveys

TOMAŽ ZWITTER

*Faculty of Mathematics and Physics
University of Ljubljana, Jadranska 19, 1000 Ljubljana
tomaz.zwitter@fmf.uni-lj.si • fiz.fmf.uni-lj.si/zwitter*

Size and accuracy of the second data release of the Gaia satellite, published in April, presents a milestone in nearly every field of research in astrophysics. After a brief summary of basic properties of this dataset I will mention some of the more important discoveries of the last months and describe how the unique properties of this data release can be augmented with ground-based observations. Synergy with the Galah spectroscopic survey, which published the largest set of chemical properties and accurate stellar radial velocities, will be discussed, with an emphasis on results of our research group.

References

- [1] Brown, A. G. A., et al., *Astronomy & Astrophysics*, **616** (2018) 1.
- [2] Buder, S., et al., *Mon. Not. Roy. Astr. Soc.*, **478** (2018) 4513.
- [3] Čotar, K., et al., *Mon. Not. Roy. Astr. Soc.*, (2018) astro-ph:1807.07977.
- [4] Kos, J., et al., *Mon. Not. Roy. Astr. Soc.*, **473** (2018) 4612.
- [5] Kos, J., et al., *Mon. Not. Roy. Astr. Soc.*, **480** (2018) 5242.
- [6] Kos, J., et al., *Mon. Not. Roy. Astr. Soc.*, **480** (2018) 5475.
- [7] Zwitter, T., et al., *Mon. Not. Roy. Astr. Soc.*, **481** (2018) 645.
- [8] Žerjal, J., et al., *Mon. Not. Roy. Astr. Soc.*, (2018) astro-ph:1810.1045.

Program Koncerta v ART KAVARNI Hotela Mercure Maribor City Center
četrtek, 13. 12. 2018, ob 19.00

Izvajalec/ Performing: Adam Kamplet

1. Johann Sebastian Bach, Italian Concerto in F major, BWV 971

- 1. Allegro

2. Ludvik van Beethoven Sonata in G Major, op. 31, no. 1

- 1. Allegro vivace

3. Robert Schumann, Etude op. 3, no. 2

4. Sergei Prokofiev, from 10 Pieces for Piano, Op. 75

- 4. Juliet as a Young Girl

- 8. Mercutio

Izvajalec/ Performing: Nejc Kamplet

1. Bela Bartok, Out of Doors, Sz. 81, BB. 89

- With Drums and Pipes, Pesante

- Barcarolla, Andante

- Musettes, Moderato

- The Nights Music, Lento

- The Chase, Presto

2. Olivier Messiaen, La Colombe from Preludes

3. Sergei Rachmaninoff, Piano Sonata no. 2 in B flat minor, 1931

- Allegro agitato

- Non allegro - lento

- Allegro molto

Nejc Kamplet has been learning piano from the age of five and is now studying for his Bachelor degree at the University of Music and Performing Arts in Graz, Austria with prof. Dr. Zuzana Niederdorfer. Some of his latest awards from the piano competitions are; third prize solo and second prize in four hands ensemble round in the 9th New York International Piano Competition under the Stecher and Horowitz Foundation, first prize in the Martha Debelli Scholarship Piano Competition in Graz, Austria; first prize in the 4th Euregio International piano Competition in Geilenkirchen, Germany; second prize in the 15th Ettlingen International piano Competition in Ettlingen, Germany; first and EMCY prize in the 6th international Young academy award in Rome, Italy; two first and special prizes in the 2nd and 3rd International piano Competitions Forum per tasti in Banska Bystrica, Slovakia; first and special prizes in the Jurica Murai International piano Comp. in Varadin, Croatia, etc. Since the age of 10, he is regularly performing in many music festivals such as Festival Ljubljana, Festival Lent, Festival Maribor, Carpe Artem, Night of Slovenian composers, Arsonore, in Slovenia and abroad. He has played as soloist with following orchestras: SNG Maribor symphonic orchestra, Festine symphonic, Chamber philharmonic orchestra Ljubljana, Banska Bystrica State opera orchestra and the Wuhan Philharmonic Orchestra in Qintai Golden Hall in China. He collaborated with conductors such as Jin Hyoun Baek, Jiri Rozen, Taejung Lee, Benjamin Pionnier, Iva Ploj Peruh, Slavko Magdi, etc. Nejc has performed on many concerts in Slovenia, Austria, Italy, Germany, China, NYC, Liechtenstein, Croatia, Slovakia, Estonia and Lithuania and has held masterclasses with world renowned musicians like J. Rouvier, R. Levin, G. Gruzman, Arie Vardi, Daejin Kim, M. Voskresensky, R. Dalibaltayan, A. Delle Vigne, A. Valdma, A. Madar, S. Gulyak, etc. Nejc made recordings for Slovenian National Television which were broadcasted multiple times and is a scholarship recipient from the Slovenian Ministry of Culture for his outstanding cultural achievements.

Adam Kamplet (2003) has been learning piano from the age of five and is now studying at the University of Music and Performing Arts in Graz, Austria with prof. Mag. Dr. Zoltn Fzessry, he is also attending the third grade at the Conservatory of Music and Ballet in Maribor in class with prof. Planinka Ati and the first grade of II. gimnazija Maribor. Some of his latest awards from the piano competitions are:

- April 2018, XVIII International piano competition Alexandre Scriabine, Paris, first award and first place
- April 2018, London, Royal Albert hall, performance in Elena Cobb star prize winners concert
- January 2018, 7th International piano competition Ivan Rijavec in Rogaska Slatina, first award and first place
- May 2017, 5th international piano competition San Don di Piave, first award and first place
- March 2017, 46th Tamsig, competition of young musicians of Slovene Republic, piano trio, golden award, 3rd place and special award for the best performance of a composition of the Slovene composer Robert Kamplet, Misterioso
- February 2017, Belgrade, international piano competition Davorin Jenko, second award, eighth place out of 37 in his category
- February 2017, piano trio, golden award and first place at the 20th regional competition of young musicians of tajerska and Pomurje in Ormo
- January 2017, 6th International piano competition Ivan Rijavec in Rogaska Slatina, first award and first place.

Program Koncerta v ART KAVARNI Hotela Mercure Maribor City Center
petek, 14. 12. 2018, ob 19.00

Izvajalec/ Performing: Godalni kvartet Al Fine / String quartet Al Fine

1. G. Tartini: Sonata št. 3

- Andante

- Allegro

2. W. A. Mozart: Divertimento v D-duru KV136

- Allegro

- Andante

- Presto

3. E. Elgar: Chanson de Matin

4. V. Parma: Godalni kvartet v A-duru

- Allegro Moderato

- Adagio

- Tempo di valse lento

- Finale: Adagio - Allegro vivace

5. J. Hurwitz/R. Longfield: La La Land

6. C. Gardel: Por una Cabeza

7. S. Joplin: Easy winners

Godalni kvartet **Al Fine**

Po končanem študiju inštrumenta na ljubljanski Akademiji za glasbo se nobenemu od članov kvarteta ni zdelo, da bi na glasbeni poti že prišel do konca. Vsak po svoje so se izobraževali, izpopolnjevali, nabirali solistične, komorne, orkestrske in pedagoške izkušnje.

V letu 2017 so se združili v kvartet **Al Fine** ("do konca"). Verjamejo namreč, da bo pot do konca bolj pestra, barvita in bogata, če jo prehodijo skupaj. Skupaj muzicirajo in ustvarjajo, skupaj iščejo najlepši zven in najboljšo idejo, skupaj vztrajajo na poti do konca in skupaj podajajo naprej posebno moč glasbe da odpira čustva, privablja spomine in ideje ter nas tako vse dela bolj človeške.

Tudi če pot ne bo vedno rožnata, jim pogum in elan vliva prepričanje, da je v slogi moč in bo tako na koncu vse dobro. **Al fine – All Fine.**

Kvartet se je v času skupnega muziciranja večkrat javno predstavil in med drugim pripravil več samostojnih večerov. Energije in idej mu ne primanjkuje, navdušenje nad skupno igro pa se po vsakem koncertu stopnjuje. Kvartet Al Fine sestavljajo:

Violinistka Urška Trček Lenarčič

je z odliko diplomirala na ljubljanski Akademiji za glasbo in vzporedno končala tudi študij muzikologije. Znanje in koncertne izkušnje je nabirala v mnogih komornih sestavih in orkestrih (klavirski trio, godalni kvartet in kvintet, Ljubljana International Orchestra, Orkester SF, Orkester RTV) ter nastopila na številnih koncertih in festivalih doma in v tujini (Festival Bled, Koncertni cikel Festine, festival St. Johns Smith Square v Londonu). Znanje prenaša na mlade glasbenike na GŠ Trebnje in GŠ Vrhnika.

Violinistka Neža Piry

je z odliko diplomirala na ljubljanski Akademiji za glasbo ter med študijem kot članica tria *Irenema* prejela študentsko Prešernovo nagrado AG za odlične dosežke v komorni glasbi. Izkušnje in znanje, ki jih je nabrala na koncertnih odrih in tekmovanjih, je dopolnila s pedagoškim izpopolnjevanjem doma in v tujini ter pridobila Willems pedagoško diplomu. Kot profesorica violine deluje na GC E. Willems.

Peter Kranjec,

ki v kvartetu igra violo, je diplomiral iz violine na Akademiji za glasbo v Ljubljani in se po končanem študiju dve leti izpopolnjeval na Univerzi za upodabljačo umetnost na Dunaju. Med študijem je aktivno sodeloval v različnih zasedbah in orkestrih ter se

izpopolnjeval na glasbenih seminarjih doma in v tujini. Pridobljeno znanje posreduje naprej na GŠ Domžale in GŠ Franca Šturma v Ljubljani, z mladimi pa z veseljem sodeluje tudi kot vodja mladinskega godalnega orkestra v Ljubljani.

Violončelistka Urša Kržič

je končala študij violončela na Akademiji za glasbo v Ljubljani. Kot članica klavirskega tria GUD je nastopila na številnih državnih in mednarodnih tekmovanjih in koncertnih prireditvah, se izpopolnjevala na priznani podiplomski šoli komorne igre Tria di Trieste ter za izjemne dosežke prejela študentsko Prešernovo nagrado AG. Sodelovala je tudi s komornim zborom Vokalna akademija Ljubljana, s katerim je osvojila veliko zborovsko nagrado Evrope. Svoje znanje predaja učencem GŠ Vrhnika.

String Quartet Al Fine

The **violinist Urška Trček Lenarčič** graduated from the Academy of Music in Ljubljana with a summa cum laude designation. She also studied musicology at the Faculty of Arts in Ljubljana. She has been a member of numerous orchestras, such as the Ljubljana International Orchestra and the Radio and Television Symphony Orchestra Slovenia. She has appeared at many festivals in Slovenia and abroad, at the Bled Festival, at the London Festival of Baroque Music and others. As a musician, she passes her musical knowledge to younger generations as well she is a teacher at music schools in Trebnje and Vrhnika.

The **violinist Neža Piry** graduated from the Academy of Music in Ljubljana with honours. During her studies, she was awarded the prestigious Prešeren award of the Academy of Music of Ljubljana for outstanding achievements in chamber music. She complemented her knowledge and experience gained through concert performances and competitions by broadening her pedagogic skills in Slovenia and abroad. She currently works as a teacher at the Music center E. Willems.

After graduating in violin from the Academy of Music in Ljubljana, the **violinist Peter Kranjec** enhanced his musical skills at the University of Music and Performing Arts in Vienna. During his studies, he was a member of various ensembles and orchestras. He also perfected his musical knowledge and performing skills at masterclasses in Slovenia and abroad. He passes his knowledge to children at the Music School Domžale and the Franc Šturm Music School in Ljubljana. He is also the conductor of a youth string orchestra in Ljubljana.

The **cellist Urša Kržič** graduated from the Academy of Music in Ljubljana, as well, and specialized herself in chamber music at the prestigious post-graduate chamber music school Tria di Trieste in Italy. For her outstanding achievements in chamber music, she was awarded the Prešeren award of the Academy of Music in Ljubljana. She is currently a teacher at the Music School Vrhnika.

After finishing their studies at the Academy of Music of the University of Ljubljana, the four academically trained musicians standing in front of you did not really feel as if they had reached the end. Each of them found their own way of continuing their education, seeking improvement, and gaining experience of teaching and performing as a soloist, as a member of an ensemble or an orchestra.

The musicians have formed a quartet and named it **Al Fine** – which in translation means to the end because they believe that the path leading to the end will be more varied, more colourful and richer if they follow it together. Together, the members of Al fine play and create music. Together, they search for THE most beautiful sound and the best musical idea. Together, they persist in going to the end, even though the path is not always easy, because they believe that unity is strength and that, in the end, everything will be all right. **Al fine – all fine**. They believe that, together, they pass a special power of music to the audiences, the power of stirring emotions, evoking memories and generating ideas, which makes everyone more human.

The quartet has played in a number of public concerts. The musicians are full of energy and their motivation for chamber music increases after every concert.

Kazalo / Contents

Organizatorji / Organizing Committee	1
Predgovor	2
Foreword	3
Seznam udeležencev / Participants list	4
Urnik / schedule	8
Povzetki / Abstracts	11
1. Koncert / 1st Concert	78
2. Koncert / 2nd Concert	81
Kazalo / Contents	86