PROGRAM AND ABSTRACT BOOKLET

WORKSHOP ON CRITICALITY, DYNAMICS, AND NONEQUILIBRIUM BEHAVIOR IN QUANTUM SYSTEMS

University of Évora, Portugal, 2-6 October 2023

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The Workshop

This workshop is supported by several European and US projects and research centers. Our aim is to generate a lively exchange of ideas between researchers working in distinct but interrelated fields. Advances in recent years have witnessed an exciting and promising confluence of the areas of strongly correlated many-body quantum systems, including computational condensed matter physics and quantum information theory.

Topics to be discussed at the workshop will include: quantum many-body chaos; quantum information propagation; quantum criticality; entanglement transitions and measurement of induced criticality; eigenstate thermalization, open quantum systems, and ergodicity breaking; dynamically induced ordering in correlated quantum systems; novel states of matter, topology in condensed matter and topological photonics.

This workshop is dedicated to the memory of Dionys Baeriswyl, co-organizer and promoter of many previous workshops held in Évora, and to the memory of Jaime Santos, member of the Local Committee of the Évora workshop 2012 and participant of other Évora workshops.

Previous Workshops

Previous Évora workshops have an established tradition and have been highly successful in drawing together leading researchers and young scientists in a lively and engaging intellectual environment. A UNESCO World Heritage city, beautiful medieval town of Évora is the capital of Portugals south-central Alentejo region, and the month of October is an ideal period for local excursions to explore both the city and its surroundings.

Information on previous Évora workshops of the present series may be found at:

2008: http://hawk.fisica.uminho.pt/ccqm/
2010: http://hawk.fisica.uminho.pt/qcmca/
2012: http://hawk.fisica.uminho.pt/ccqs/
2014: http://hawk.fisica.uminho.pt/cccqs/
2016: http://www.cicqs.uevora.pt
2019: http://www.odcqs.uevora.pt

Workshop site

The workshop will take place at:

Anfiteatro 131-A
Edifício do Espírito Santo
Universidade de Évora.

Approximate location:
https://maps.apple.com/?ll=38.573402,-7.904735q=Dropped%20Pint=m

The entrance to the old University building is through Rua do Cardeal Rei.

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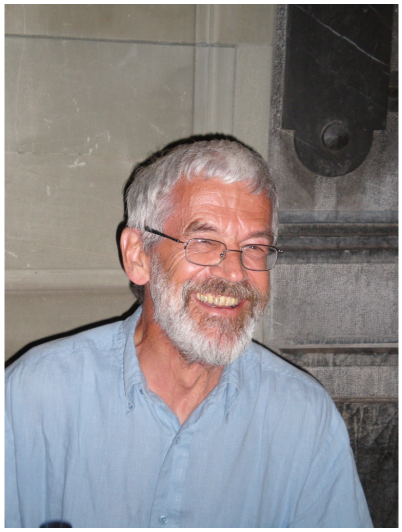
In Memoriam - Dionys Baeriswyl



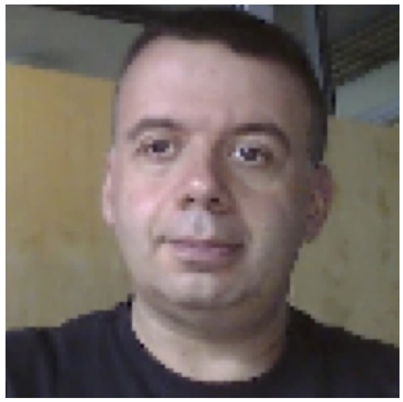
Dionys Baeriswyl, a world-renowned condensed matter theorist and a fixture of these Evora meetings for three decades, passed away on August 9, 2023 after a courageous battle with cancer.

Dionys was known primarily for his contributions to the theory of strongly correlated electron systems. In particular, he conducted fundamental work on conjugated polymers and other quasi-one-dimensional electronic systems, emphasizing early on the importance of electronic correlations in these systems. In addition, Dionys was celebrated for his work on variational wave function approaches to one- and two-dimensional correlated electron systems, applying them to the Peierls and the Mott transitions as well as to superconductivity in high-Tc cuprates. In the course of this work, Dionys introduced the variational wave function now known as the Baeriswyl wave function, which can be viewed as the strong-coupling complement to the Gutzwiller wavefunction. While the Gutzwiller wavefunction incorporates correlation effects into the free-electron state, the Baeriswyl wavefunction incorporates itinerant electron movement into a localized, strongly correlated insulating state.

In addition to his organizational and scientific contributions to the Evora meetings, Dionys organized and contributed scientifically to numerous other international meetings, with the dual goals of bringing together outstanding physicists from around the world and of contributing significantly to the scientific education of young researchers. Notable examples of this included international meetings at Gwatt (Switzerland), at the Institute for Scientific Interchange (ISI) in Torino (Italy) and at the International Institute of Physics (IIP) in Natal (Brazil). Dionys also played a leading role in the University of Fribourg (Switzerland), where he served as head of the Institute of Theoretical Physics, as Dean of the Faculty of Science, and as President of the Department of Physics. Beyond all this, Dionys was also a concert-level pianist.

In all these roles, Dionys open, friendly, and generous approach to physics and to life attracted many friends from around the globe, and their lives were all enriched by his presence. He will be sorely missed.

In Memoriam - Jaime Santos



Jaime Eduardo Vieira Silva Moutinho Santos - Jaime to his many friends - passed away suddenly on July 14, 2023. Jaime was born in April 1971, in Porto, Portugal, and had a distinguished academic career. He graduated in Physics from the Faculty of Sciences at the University of Porto and went on to a PhD in Theoretical Physics, in the field of Statistical Physics, at the University of Oxford, which was followed by post-doctoral studies in Germany.

Jaime dedicated most of his life to scientific research and, more recently, to university teaching. After several temporary posts at academic and industrial institutions, he worked at the University of Minho since 2011. His research horizons were broad, with published works ranging from Statistical Physics and Quantum Field Theory and, in recent years, to the Quantum Theory of Low-Dimensional Materials. With his deep knowledge of Quantum Mechanics and Statistics, Jaime made a major contribution to teaching Quantum Physics I and II, Complements of Quantum Mechanics, and Physical Platforms for Quantum Computing, always with dedication and care for logic and clarity of his exposition, Jaime had special and endearing human characteristics.

He was a devoted friend, with a constant concern for those in need, strong with the strong, and with an informed opinion on the most diverse social problems, all backed up by an encyclopedic knowledge. With his intelligent sense of humor, he made all those he met feel at ease.

Jaime was also a remarkably clear-sighted person, with a good understanding of his role in the world and, because of this, a modest and self-effacing person. Jaime passed away much earlier than he should have and left in the memory of those who knew him the mark of a clever, confident, good, and fair person.

Sponsors

Slovenian Research Agency (ARRS)

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Integrated Quantum Science and Technology (IQST)

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FCT Project - Quantum Non-equilibrium excitons in two-dimensional semiconductors
Through FCT-Portugal Grant No. EXPL/FIS-MAC/ 0953/2021

Centro de Física da Universidade do Minho e da Universidade do Porto
Through FCT-Portugal Grant No. UIDB/04650/2020

Center of Physics and Engineering of Advanced Materials (CeFEMA)
Through FCT-Portugal Grant No. UID/CTM/04540/2020

Faculdade de Ciências da Universidade de Lisboa
Through FCT-Portugal Grant No. UIDB/00618/2020

Câmara Municipal de Évora

PROGRAM

The lengths of both invited and contributed talks include at least 5 minutes of discussion.

Monday, 2 October

8:30 – 9:00 Registration

9:00 – 9:10 Welcome

9:10 – 9:45 Invited: **Mathias Sheurer**
Exotic many-body physics in van der Waals moiré systems

9:45 – 10:05 Contributed: **Kukka-Emilia Huhtinen**
Quantum geometry and the superfluid weight of a Bose-Einstein condensate

10:05 – 10:25 Contributed: **Eduardo B. Molinero**
Ultrafast dynamics of excitons in strong laser fields

10:25 – 10:50 Coffee break

10:50 – 11:25 Invited: **Eduardo Castro**
The role of quasiperiodicity in moiré electron systems

11:25 – 11:45 Contributed: **Henrique C. Prates**
Bose-Einstein condensates in quasi-periodic lattices: bosonic Josephson junction and multi-mode dynamics

11:45 – 12:20 Invited: **Yong P. Chen**
Quantum dynamics and quantum transport in a spintronic Bose-Einstein condensate in synthetic spaces

12:20 Lunch break

15:00 – 16:00 Invited Colloquium: **Florian Meinert**
Towards a neutral atom quantum simulator with circular Rydberg states

16:00 – 16:20 Contributed: **Chris Bühler**
Quantum fluctuations in one-dimensional supersolids

16:20 – 16:45 Coffee break

16:45: In Memoriam Session

Zoom-streamed In Memoriam Session

https://videoconf-colibri.zoom.us/j/92067541700?pwd=RzNnU1pEZjF2aWtBL3BvZzBaSUhkQT09

Meeting ID: 920 6754 1700
Password: 080066

16:45 – 17:05: In memoriam by **David K. Campbell**
Dionys Baeriswyl

17:05 17:25: In memoriam by **José M. P. Carmelo**
Dionys Baeriswyl and Évora Workshops

17:25 17:45: In memoriam by **Mikhail Vasilevskiy**
Jaime Santos

Tuesday, 3 October

9:00 – 9:35 Invited: **Sergey Denysov**
Spectral properties of noisy intermittent scale quantum circuits

9:35 – 9:55 Contributed: **Lucas Sá**
Random Lindblad dynamics: from RMT to SYK, and more in between

9:55 – 10:15 Contributed: **Madhumita Sarkar**
Tuning the phase diagram of a Rosenzweig-Porter model with fractal disorder

10:15 – 10:40 Coffee break

10:40 – 11:15 Invited: **Karol Zyczkowski**
Matrix logistic map: fractal distribution of eigenvalues and transfer of chaos

11:15 – 11:35 Contributed: **Nadir Samos**
Quantum volume, integrability and chaos

11:35 – 11:55 Contributed: **Carl Philipp Zelle**
Universal phenomenology at critical exceptional points of nonequilibrium O(N)O(N) models

11:55 – 12:30 Invited: **Aharon Kapitulnik**
Emerging phenomena at quantum phase transition: The magnetic field tuned superconductor to insulator transition

12:30 Lunch break

15:00 – 16:00 Invited Colloquium: **Shinsei Ryu**
Sachdev-Ye-Kitaev type models with dissipations

16:00 – 16:20 Contributed: **Zhao Zhang**
Entanglement phase transition in two-dimensional ground states

16:20 – 16:45 Coffee break

16:45 – Poster presentations (2 minutes each) and poster session
(Poster frame size: 180cm height from the ground x 120cm width)

Wednesday, 4 October

9:00 – 9:35 Invited: **Bogdan A. Bernevig**
Heavy-fermion physics in twisted bilayer graphene

9:35 – 9:55 Contributed: **Miguel Sánchez**
The correlated insulators of magic-angle graphene under zero and one magnetic flux quanta

9:55 – 10:30 Invited: **Tobias Stauber**
Superconductivity and chirality in graphene superlattices

10:30 – 10:55 Coffee break

10:55 – 11:30 Invited: **Jedediah Pixley**
Infinite randomness and quasiperiodic fixed points at measurement induced phase transitions

11:30 – 11:50 Contributed: **Kazuki Yamamoto**
Entanglement phase transitions in many-body localized systems under continuous measurement

11:50 – 12:25 Invited: **Sarang Gopalakrishnan**
Full counting statistics of nonequilibrium quantum systems

12:25 Lunch break

15:00 Social Program

19:30 Banquet

Thursday, 5 October

9:00 – 9:35 Invited: **Claudio Chamon**
Can black holes be both fast and thorough scramblers?

9:35 – 9:55 Contributed: **Domenico Lippolis**
Estimating the spectral density of unstable scars

9:55 – 10:15 Contributed: **Miguel Gonçalves**
Irrelevance of short-range interactions at quasiperiodic-driven ground-state localization transitions

10:15 – 10:40 Coffee break

10:40 – 11:15 Invited: **Smitha Vishveshwara**
Anyon motion and black hole-like dynamics in quantum Hall bulk geometries

11:15 – 11:35 Contributed: **Koushik Swaminathan**
Signatures of many-body localization of quasiparticles in a flat band superconductor

11:35 – 11:55 Contributed: **Bruno Amorim**
Spectral and transport properties of Weyl semimetals with vaccancies

11:55 – 12:30 Invited: **Sebastian Diehl**
Measurement induced phase transitions: from theory to observability

12:30 Lunch break

15:00 – 16:00 Invited Colloquium: **Didier Poilblanc**
Chiral spin liquids with PEPS: should we fear the no-go theorem?

16:00 – 16:20 Contributed: **Henrique P. Veiga**
Simulation of diffusive transport in mesoscopic disordered nano-ribbons

16:20 – 16:45 Coffee break

16:45 – Poster presentations (2 minutes each) and poster session
(Poster frame size: 180cm height from the ground x 120cm width)

Friday, 6 October

9:00 – 9:35 Invited: **Hai-Qing Lin**
Excitations, spin-charge separation, and correlation function

9:35 – 9:55 Contributed: **Ricardo Oliveira**
Incommensurability-induced enhancement of superconductivity in one dimensional critical systems

9:55 – 10:30 Invited: **Pedro Vianez**
Quadratic heat capacity and high-field magnetic phases of V5S8

10:30 – 10:55 Coffee break

10:55 – 11:30 Invited: **Xi-Wen Guan**
Quantum simulators of many-body phenomena with integrability

11:30 – 11:50 Contributed: **Goran Nakerst**
Quantum-classical correspondence and ETH in Bose-Hubbard systems

11:50 – 12:10 Contributed: **Hetényi Balázs**
Binder cumulants for a quantum geometric phase: finite size scaling and the modern theory of polarization

12:30 – 12:45 Summary and closing remarks

POSTERS

Poster Sessions I (3/10/2023) and II (5/10/2023)

	Name	Title
1	Afonso Ribeiro	Quantum liquids under environment-induced dissipation
2	Diogo Pinheiro	Measuring the Local Density of States via a Stochastic Approach
3	João Costa	Spectral and Steady State Properties of Fermionic Random Quadratic Liouvillians
4	João S. Silva	Role of Disorder in Nodal Loop Semimetals
5	Júlio Oliveira	Numerical tests of the large charge expansion
6	M. Barreiro	Quantum non-equilibrium excitons in two-dimensional semiconductors
7	N. Sobrosa	Interplay between interactions and incommensurability in 1D narrow-band moiré system
8	Rafael D. Soares	Electron-mediated entanglement of two distant macroscopic ferromagnets within a nonequilibrium spintronic device
9	R. Liquito	Interplay Between Chiral Quasi-Disorder and Topology in a 2D Second Order Topological Insulator (SOTI)
10	G. Schumm	Primary and Secondary Order Parameters in the Fully Frustrated Transverse Field Ising Model on the Square Lattice
11	L. Madail	Exotic edge states in flat-band triangulene crystals
12	A. Marques	Photonic n-root Su-Schrieffer-Heeger model
13	Yu. Bludov	Electrical detection of high-quality two-dimensional polaritonic nanoresonators at mid- and long-wave infrared
14	R. Ghosh	Entanglement witnessing of a class of Many-Body Systems via Single Basis Measurements
15	J. Pinho	From Bloch oscillations to a steady-state current in strongly biased mesoscopic devices
16	F. Lobo	Excitonic properties of hBN from a time-dependent Hartree-Fock mean-field theory
17	K. Wold	Universal spectral properties of noisy intermediate scale quantum circuits

ABSTRACTS OF THE INVITED COLLOQUIA, INVITED TALKS, AND CONTRIBUTED TALKS

Monday, 2 October

EXOTIC MANY-BODY PHYSICS IN VAN DER WAALS MOIRÉ SYSTEMS

Mathias S. Scheurer

Institute for Theoretical Physics III, University of Stuttgart, 70550 Stuttgart, Germany

When two layers of graphene are stacked on top of each other with a finite relative angle of rotation, a moiré pattern forms. Most strikingly, at so-called magic angles, the largest of which is around 1 degree, the bands around the Fermi surface flatten significantly; this enhances the density of states and the impact of electron-electron interactions. Soon after the experimental discovery in 2018 revealing that this enhancement can induce superconductivity and other, including magnetic, instabilities, it became clear that twisted bilayer graphene is only one example of an engineered van der Waals moiré system with a complex phase diagram akin to other strongly correlated materials. In this talk, I will provide a brief introduction to the rich and diverse field of moiré superlattices built by stacking and twisting graphene and other van der Waals materials. I will further present recent and ongoing projects involving a combination of analytics, numerics, machine-learning, and experiment which explore the exotic quantum many-body phases that can be stabilized in these platforms.

9h10
Mon
1

1. Poduval and Scheurer, arXiv:2301.01344.
2. Christos, Sachdev, and Scheurer, arXiv:2303.17529.
3. Scammell and Scheurer, PRL **130**, 066001 (2023).
4. Sobral, Obernauer, Turkel, Pasupathy, and Scheurer, arXiv:2302.12274.

QUANTUM GEOMETRY AND THE SUPERFLUID WEIGHT OF A BOSE-EINSTEIN CONDENSATE

K.-E. Huhtinen[1], M. Dürrnagel[2], V. Peri[3], S. D. Huber[1]

1 Institute for Theoretical Physics, ETH Zürich, Zürich, Switzerland
2 University of Würzburg, Würzburg, Germany
3 Division of Physics, Mathematics and Astronomy, California Institute of Technology, Pasadena, USA

9h45
Mon
2

Quantum geometric quantities have been related to various many-body phenomena, such as flat-band superconductivity, where the superfluid weight is proportional to the minimal integrated quantum metric [1-3]. When considering models with nontrivial topology, relationships between the quantum metric and physical quantities are interesting because they allow for the formulation of bounds in terms of topological invariants. The relevance of quantum geometry in bosonic systems has been pointed out recently [4]. However, in contrast to fermionic systems, the quantum metric at the condensation momentum plays an important role in addition to the integrated quantum metric. This hinders the possibility of connecting the superfluid weight of Bose-Einstein condensates and non-trivial topology. We investigate the role of both the quantum metric at the condensation momentum and its integral over the Brillouin zone in the superfluid weight, and determine how they limit the possibility for a stable Bose-Einstein condensate in flat bands, including those with nontrivial topology.

1. S. Peotta and P. Törmä, Nat. Comm. **6**, 8944 (2015).
2. K.-E. Huhtinen, J. Herzog-Arbeitman, A. Chew, B. A. Bernevig and P. Törmä, Phys. Rev. B **106**, 014518 (2022).
3. J. Herzog-Arbeitman, A. Chew, K.-E. Huhtinen, P. Törmä, B. A. Bernevig, arXiv:2209.00007 (2022).
4. A. Julku, G. M. Bruun and P. Törmä, Phys. Rev. Lett. **127**, 170404 (2021).

ULTRAFAST DYNAMICS OF EXCITONS IN STRONG LASER FIELDS

Eduardo B. Molinero[1], Bruno Amorim[2], Álvaro Jiménez-Galán[1], Pablo San-José[1], Misha Ivanov[3] and Rui E.F. Silva[1,3]

1. Instituto de Ciencia de Materiales de Madrid (ICMM), Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain
2. Centro de Física das Universidades do Minho e do Porto (CF-UM-UP) and Laboratory of Physics for Materials and Emergent Technologies (LaPMET), Universidade do Minho, Braga, Portugal
3. Max Born Institute, Berlin, Germany

Excitons play a key role in the linear optical response of 2D materials [1]. However, their effect in the highly nonlinear optical reactions to intense mid-infrared light has remained relatively unexplored [2]. This study delves deep into the enigma of exciton behavior under extreme laser fields. We tackle two fundamental questions: do excitons leave a discernible imprint on the nonlinear response, and can they survive such strong laser fields?

Focusing on hexagonal boron nitride as our prototypical model, we theoretically answer those questions, revealing that excitons indeed assume a major role in this process. Specifically, we illustrate their formation and stability in intense low-frequency fields, where field strengths surpass the Coulomb field binding the electron-hole pair in the exciton. Furthermore, we time-resolve their formation, showing that it takes place in a near sub-femtosecond scale. While showing these new dynamics we also propose an experimental setup to test the effect of excitons in the nonlinear optical response. 10h05 Mon 3

We further establish a parallelism between these results and the well-established physics of Rydberg states using a simple atomic model. Notably, we show that two critical physics is present in both systems: their survival to strong laser fields (akin to free-induction decay) and an enhancement depending on the exciton binding energy (reminiscent of Freeman resonances). Such similarity shows that one can obtain a many-body analog of Rydberg states, and viceversa, thereby facilitating the testing of their unique properties.

1. G. Wang *et al.* Rev. Mod. Phys. **90**, 021001 (2018) .
2. S. Y. *et al.* Rev. Mod. Phys. **90**, 021002 (2018) .

THE ROLE OF QUASIPERIODICITY IN MOIRÉ ELECTRON SYSTEMS

Eduardo V. Castro[1,2], Miguel Gonçalves[1,3], Hadi Z. Olyaei[3], Flavio Riche[3], Ricardo Oliveira[1], Rubem Mondaini[2], J. H. Pixley[4,5], Bruno Amorim[6], Pedro Ribeiro[3]

1 Centro de Física das Universidades do Minho e Porto, LaPMET, Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, 4169-007 Porto, Portugal

2 Beijing Computational Science Research Center, Beijing 100193, China

3 CeFEMA-LaPMET, Departamento de Física, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

4 Department of Physics and Astronomy, Center for Materials Theory, Rutgers University, Piscataway, New Jersey 08854, USA

5 Center for Computational Quantum Physics, Flatiron Institute, 162 5th Avenue, New York, New York 10010, USA

6 Centro de Física das Universidades do Minho e do Porto, LaPMET, Universidade do Minho, Campus de Gualtar, 4710-057 Braga, Portugal

The observation of correlated phenomena and unconventional superconductivity in twisted bilayer graphene (tBLG), a moiré system, is one of the most interesting findings in condensed matter physics in recent years. However, twisted bilayer graphene, even in a pristine form, is extremely peculiar: for most twist angles it lacks translational invariance, having instead a quasiperiodic structure. Quasiperiodicity in 1D is known to strongly impact the electronic properties. However, the role of quasiperiodicity in twisted bilayer graphene and other moiré materials has been mostly ignored so far.

In this talk, we will present recent theoretical efforts towards the understanding of the role played by quasiperiodity in moiré electron systems. We have theoretically demonstrated that quasiperiodicity in tBLG leads to the emergence of narrow band single-particle critical states (delocalized in both real and momentum space) with subbalistic transport properties [1]. Similar critical states can also occur in 1D quasiperiodic models, and we have identified several such models using a recently developed approach based on real space momentum space dualities [2, 3, 4, 5].

10h50 Mon 4

To unveil the interplay between interactions and quasiperiodicity, we resort to a 1D illustrative example to demonstrate that quasiperiodicity can radically change the ground state properties of moiré systems [6]. While narrow bands play a significant role in enhancing interactions both for commensurate and incommensurate structures, only quasiperiodicity concomitant with critical states is able to extend the ordered phase down to an infinitesimal interaction strength. In this regime, the quasiperiodic-enabled state has contributions from infinitely many wave vectors. This quasi-fractal regime cannot be stabilized in the commensurate case even in the presence of a narrow band. We will also present preliminary results indicating that quasiperiodicity can enhance superconductivity in 1D quasiperiodic models with critical phases [7].

[1] *Incommensurability-induced sub-ballistic narrow-band-states in twisted bilayer graphene*, Miguel Gonçalves, Hadi Z. Olyaei, Bruno Amorim, Rubem Mondaini, Pedro Ribeiro, and Eduardo V. Castro, 2D Mater. **9**, 011001 (2022).

[2] *Hidden dualities in 1D quasiperiodic lattice models*, Miguel Gonçalves, Bruno Amorim, Eduardo V. Castro, Pedro Ribeiro, SciPost Phys. **13**, 046 (2022).

[3] *Renormalization-Group Theory of 1D quasiperiodic lattice models with commensurate approximants*, Miguel Gonçalves, Bruno Amorim, Eduardo V. Castro, Pedro Ribeiro, arXiv:2206.13549.

[4] *Critical phase in a class of 1D quasiperiodic models with exact phase diagram and generalized dualities*, Miguel Gonçalves, Bruno Amorim, Eduardo V. Castro, Pedro Ribeiro, arXiv:2208.07886.

[5] *Short-range interactions are irrelevant at the quasiperiodic-driven Luttinger Liquid to Anderson Glass transition*, Miguel Gonçalves, J. H. Pixley, Bruno Amorim, Eduardo V. Castro, Pedro Ribeiro, arXiv:2304.09197.

[6] *Incommensurability enabled quasi-fractal order in 1D narrow-band moiré systems*, Miguel Gonçalves, Bruno Amorim, Flávio Riche, Eduardo V. Castro, and Pedro Ribeiro, arXiv: 2305.03800.

[7] *Incommensurability-Induced Enhancement of Superconductivity in One Dimensional Critical Systems*, Ricardo Oliveira, Miguel Gonçalves, Pedro Ribeiro, Eduardo V. Castro, Bruno Amorim, arXiv:2303.17656.

BOSE-EINSTEIN CONDENSATES IN QUASI-PERIODIC LATTICES: BOSONIC JOSEPHSON JUNCTION AND MULTI-MODE DYNAMICS

Henrique C. Prates[1], Dmitry A. Zezyulin[2] and Vladimir V. Konotop[1]

[1] *Centro de Física Teórica e Computacional e Departamento de Física, Faculdade de Ciências, Universidde de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal*
[2] *ITMO University, St. Petersburg 197101, Russia*

The dynamics of two interacting spatially localized Bose-Einstein condensates (BECs) is a basic problem in the physics of cold atoms, with the double-well trap being a typical example the so called bosonic Josephson junction (BJJ). An alternative setting is that of quasi-periodic potentials, namely a bichromatic optical lattice with the constituent sublattices having incommensurate periods. We show that below the mobility edge the localised states are distributed nearly homogeneously in the space, allowing to obtain an alternative realisation of the BJJ, whose coherent oscillations display beatings, switching and self-trapping in the weakly nonlinear regime. These phenomena can be observed for different pairs of modes, which are localised due to interference rather than due to the walls of the confining trap, providing a more general implementation of the BJJ. Furthermore, by considering several modes coupled by the nonlinearity, we investigate the four-mode dynamics, mimicking the dynamics in four-well potentials. The results obtained using few-mode approximations are compared with the direct numerical simulations of the one-dimensional Gross-Pitaevskii equation.

11h25
Mon
5

11h45
Mon
6

QUANTUM DYNAMICS AND QUANTUM TRANSPORT IN A SPINTRONIC BOSE-EINSTEIN CONDENSATE IN SYNTHETIC SPACES

Yong P. Chen [1,2]

1 Department of Physics and Astronomy and School of Electrical and Computer Engineering and Purdue Quantum Science and Engineering Institute, Purdue University, West Lafayette, IN 47907 USA
2 Institute of Physics and Astronomy, Aarhus University, Aarhus-C, Denmark

I will review and describe our experiments studying and controlling spin-dependent quantum dynamics and quantum transport in an atomic (87Rb) Bose-Einstein condensate (BEC), where different spin states can be addressed and coupled to induce synthetic spin-orbit coupling (SOC) and/or synthetic dimensions. We study the transport of BEC in the synthetic band structures generated by the SOC as well as by Floquet-engineering, and demonstrate spin-resolved atomic beam splitters and two-pathway interferometers (in the energy-momentum space) based on tunable Landau-Zener transitions [1,2]. By performing a Òquantum quenchÓ in a SOC BEC, we induce head-on collisions between two spinor BECs (realizing a quantum gas collider) and study spin transport and how it is affected by SOC, revealing rich phenomena arising from the interplay between quantum interference and many-body interactions [3]. We have further realized a (bosonic) topological state with band crossings protected by nonsymmorphic symmetry, by creating a synthetic cylinder with combined physical and synthetic dimensions and also synthetic magnetic fluxes, where the BEC acquires (in the absence of any externally imposed optical lattice) an emergent crystalline order that we reveal by observing topological Bloch oscillations, mimicking motion on a Mobius strip [4]. Finally, treating the laser and microwave complex coupling parameters between different spin states as a parameter space, we can realize topological defects (monopoles, nodal lines, nodal rings) and associated quantum dynamics in high dimensions using quantum quench experiments. Our versatile experimental system can be a rich playground to study physics of interests to AMO physics, condensed matter physics, and even high energy physics, as well as a platform to develop quantum engineering and quantum simulation.

1. A. Olson *et al.*, Tunable Landau-Zener transitions in a spin-orbit coupled Bose-Einstein condensate, Phys. Rev. A. **90**, 013616 (2014).
2. A. Olson *et al.*, Stueckelberg interferometry using periodically driven spin-orbit-coupled Bose-Einstein condensates, Phys. Rev. A. **95**, 043623 (2017).
3. C. Li *et al.*, Spin Current Generation and Relaxation in a Quenched Spin-Orbit Coupled Bose-Einstein Condensate, Nature Communications **10**, 375 (2019).
4. C. Li *et al.*, "A Bose-Einstein Condensate on a Synthetic Hall Cylinder", PRX Quantum **3**, 010316 (2022).

TOWARDS A NEUTRAL ATOM QUANTUM SIMULATOR WITH CIRCULAR RYDBERG STATES

F. Meinert

5th Institute for Physics and Center for Integrated Quantum Science and Technology, University of Stuttgart, 70550 Stuttgart, Germany

Highly excited low-L Rydberg atoms in configurable mircotrap arrays have recently proven highly versatile for exploring quantum many-body systems with single particle control. We aim to increase the coherence time of the Rydberg platform by using high-L circular Rydberg states, which promise orders of magnitude longer lifetimes compared to their low-L counterparts. I will report on the status of a new experimental apparatus for realizing arrays of trapped and long-lived circular Rydberg atoms at room temperature. To this end, we have prepared single Strontium atoms inside a suppression capacitor made from indium tin oxide (ITO). The capacitor is designed to stabilize the circular Rydberg atoms against detrimental black-body radiation, while keeping excellent high-NA optical access for visible light. I will report on our progress to laser-excite Rydberg singlet F-states via a three-photon scheme followed by transfer into circular Rydberg states.

15h00
Mon
7

QUANTUM FLUCTUATIONS IN ONE-DIMENSIONAL SUPERSOLIDS

Chris Bühler, Tobias Ilg, Hans Peter Büchler

Institute for Theoretical Physics III and Center for Integrated Quantum Science and Technology, University of Stuttgart, Stuttgart, Germany

16h00
Mon
8

In one dimension, quantum fluctuations prevent the appearance of long-range order in a supersolid, and only quasi-long-range order can survive. We derive this quantum critical behavior and study its influence on the superfluid response and properties of the solid. The analysis is based on an effective low-energy description accounting for the two coupled Goldstone modes. We find that the quantum phase transition from the superfluid to the supersolid is shifted by quantum fluctuations from the position where the local formation of a solid structure takes place. For current experimental parameters with dipolar atomic gases, this shift is extremely small and cannot be resolved yet, i.e., current observations in experiments are expected to be in agreement with predictions from mean-field theory based on the extended Gross-Pitaevskii formalism.

1. C. Bühler, Phys. Rev. Research **5**, 033092 (2023)
2. T. Ilg, Phys. Rev. A **107**, 013314 (2023) .

Tuesday, 3 October

SPECTRAL PROPERTIES OF NOISY INTERMITTENT SCALE QUANTUM CIRCUITS

K. Wold[1], P. Ribeiro[2], S. Denisov[1]

1 Department of Computer Science, OsloMet Oslo Metropolitan University, N-0130 Oslo, Norway
2 CeFEMA, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisboa, Portugal

9h00
Tue
1

Present quantum computing platforms allows for unitary description on very limited size- and time-scales. Open quantum system theory offers a framework to capture the functioning of these noisy intermediate scale quantum (NISQ) computer prototypes beyond the unitary horizon. We treat variational circuits, implemented on IBM Quantum platform, as quantum channels and extract their spectra by using a Pauli string-based protocol and machine learning technique. The spectra obtained for randomly sampled circuits closely reproduce spectra of the recently introduced ensemble of Kraus maps. We demonstrate how the parameters of the ensemble can be related to the parameters of circuit implementations. Our results highlight the present-day NISQ computers as already established flexible platforms to conduct experimental studies of open quantum systems.

RANDOM LINDBLAD DYNAMICS: FROM RMT TO SYK, AND MORE IN BETWEEN

Lucas Sá[1], Antonio M. García-García[2], Tomaž Prosen[3], Pedro Ribeiro[1,4], Jacobus J. M. Verbaarschot[5], and Jie Ping Zheng[2]

[1] *CeFEMA, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal*
[2] *Shanghai Center for Complex Physics, School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China*
[3] *Department of Physics, Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia*
[4] *Beijing Computational Science Research Center, Beijing 100193, China*
[5] *Center for Nuclear Theory and Department of Physics and Astronomy, Stony Brook University, Stony Brook, New York 11794, USA*

Understanding the far-from-equilibrium dynamics of dissipative quantum systems, where dissipation and decoherence coexist with unitary dynamics, is an enormous challenge. Often, the only realistic approach is to forgo a detailed microscopic description and search for signatures of universal behavior shared by collections of many distinct, yet sufficiently similar, complex systems. In this talk, we will give an overview of the recent application of (non-Hermitian) random matrix theory to open quantum systems, the simplest description of which neglects any memory effects of the environment, and leads to the so-called Lindblad equation. We discuss the spectral features, relaxation timescales, and steady states of three representative Lindbladians of increasing physical relevance: random matrix theory (RMT) Lindbladians [1], random open free fermions [2], and dissipative Sachdev-Ye-Kitaev (SYK) models [3,4]. For systems with single-body quantum chaos (RMT and quadratic Lindbladians), we establish the universality of their steady states and a perturbative scaling of their spectral gap with dissipation strength. Quadratic Lindbladians additionally display a phase with nonergodic features and suppressed dissipation. For the strongly-interacting SYK model, we find the relaxation to be dissipation-driven (pertubative) only for strong dissipation (and compute it analytically), while it is chaos-driven, with an anomalously large gap, at weak dissipation.

9h35
Tue
2

1. L. Sá, P. Ribeiro, and T. Prosen, J. Phys. A **53**, 305303 (2020).
2. J. Costa, P. Ribeiro, A. De Luca, T. Prosen, and L. Sá, arXiv:2210.07959 (2022).
3. L. Sá, P. Ribeiro, and T. Prosen, Phys. Rev. Res. **4**, L022068 (2022).
4. A. M. García-García, L. Sá, J. J. M. Verbaarschot, and J. P. Zheng, Phys. Rev. D **107**, 106006 (2023).

TUNING THE PHASE DIAGRAM OF A ROSENZWEIG-PORTER MODEL WITH FRACTAL DISORDER

Madhumita Sarkar[1], Roopayan Ghosh[2], Ivan Khaymovich[3]

1 Department of Theoretical Physics, Jožef Stefan Institute, SI-1000, Ljubljana, Slovenia

2 Department of Physics and Astronomy, University College London, Gower Street, WC1E6BT, London

3 Nordita, Stockholm University and KTH Royal Institute of Technology Hannes Alfvéns väg 12, SE-106 91 Stockholm, Sweden and Institute for Physics of Microstructures, Russian Academy of Sciences, 603950 Nizhny Novgorod, GSP-105, Russia.

9h55 Tue 3

Rosenzweig-Porter (RP) model has garnered much attention in the last decade, as it is a simple analytically tractable model showing both ergodic–nonergodic extended and Anderson localization transitions. Thus, it is a good toy model to understand the Hilbert-space structure of many body localization phenomenon. In our study, we present analytical evidence, supported by exact numerical computations, that demonstrates the controllable tuning of the phase diagram in the RP model by employing on-site potentials with a non-trivial fractal dimension instead of the conventional random disorder. We demonstrate that doing so extends the fractal phase and creates unusual dependence of fractal dimensions of the eigenfunctions. Furthermore, we study the fate of level statistics in such a system and analyze the return probability of a wave packet localized at a single site to provide a dynamical test-bed for our theory.

MATRIX LOGISTIC MAP: FRACTAL DISTRIBUTION OF EIGENVALUES AND TRANSFER OF CHAOS

Karol Życzkowski[1,2] and Łukasz Pawela[3]

1 Institute of Physics, Jagiellonian University, Kraków, Poland
2 Center for Theoretical Physics, Polish Academy of Sciences, Warszawa, Poland
3 Institute of Theoretical and Applied Informatics, Polish Academy of Sciences, Gliwice, Poland

The standard logistic map, $x' = ax(1-x)$, serves as a paradigmatic model to demonstrate how apparently simple non-linear equations lead to complex and chaotic dynamics. We introduce and investigate its matrix analogue defined for an arbitrary matrix X of a given order N with bounded operator norm. It is shown that for any initial ensemble of positive hermitian matrices with a continuous level density supported on the interval $[0,1]$, the asymptotic spectral distribution converges to the invariant measure of the logistic equation. A particular case of the model, in which the logistic parameter a is replaced by a positive matrix related to a graph, generalizes the known model of coupled logistic maps. Associating such a matrix with a given graph, we demonstrate the gradual transfer of chaos between subsystems corresponding to vertices of a graph and coupled according to its edges [1].

10h40
Tue
4

1. Ł. Pawela and K. Życzkowski, Matrix logistic map: fractal spectral distributions and transfer of chaos, preprint arXiv:2303.06176

QUANTUM VOLUME, INTEGRABILITY AND CHAOS

Nadir Samos [1], Rodrigo Pereira [1], Pedro Sacramento[1] and Pedro Ribeiro[1]

1 CeFEMA, LaPMET, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

11h15
Tue
5

Quantum Volume is a figure of merit for quantum processors implementing gate-based quantum computation. In this work, we explore how it depends on the architecture and size of the circuit, its expressibility, and the nature of unavoidable unitary noise. We present recent numerical and analytical results for different random quantum circuits.

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UNIVERSAL PHENOMENOLOGY AT CRITICAL EXCEPTIONAL POINTS OF NONEQUILIBRIUM $O(N)$O(N) MODELS

Carl Philipp Zelle, Romain Daviet, Achim Rosch, Sebastian Diehl

Institute for theoretical physics, University of Cologne

In thermal equilibrium the dynamics of phase transitions is largely controlled by fluctuation-dissipation relations: On the one hand, friction suppresses fluctuations, while on the other hand the thermal noise is proportional to friction constants. Out of equilibrium, this balance dissolves and one can have situations where friction vanishes due to antidamping in the presence of a finite noise level. We study a wide class of $O(N)$ field theories where this situation is realized at a phase transition, which we identify as a critical exceptional point. In the ordered phase, antidamping induces a continuous limit cycle rotation of the order parameter with an enhanced number of $2N - 3$ Goldstone modes. Close to the critical exceptional point, however, fluctuations diverge so strongly due to the suppression of friction that in dimensions $d < 4$ they universally either destroy a preexisting static order, or give rise to a fluctuation-induced first order transition. This is demonstrated within a non-perturbative approach based on Dyson-Schwinger equations for $N = 2$, and a generalization for arbitrary N, which can be solved exactly in the long wavelength limit. We show that in order to realize this physics it is not necessary to drive a system far out of equilibrium: Using the peculiar protection of Goldstone modes, the transition from an xy magnet to a ferrimagnet is governed by an exceptional critical point once weakly perturbed away from thermal equilibrium.

11h35
Tue
6

EMERGING PHENOMENA AT A QUANTUM PHASE TRANSITION: THE MAGNETIC FIELD-TUNED SUPERCONDUCTOR TO INSULATOR TRANSITION

A. Kapitulnik[1,2], Xinyang Zhang2

1 Departments of Physics Stanford University, Stanford, CA 94305, USA.

2 Departments of Applied Physics Stanford University, Stanford, CA 94305, USA.

11h55

Tue

7

The magnetic-field tuned superconductor-to-insulator transition (H-SIT) is a paradigmatic quantum phase transition and, along with the quantum-Hall liquid-to-insulator transitions (QHIT), is among the best experimentally studied ones. However, in the transition and the proximate ground-state phases, it has consistently exhibited features that are seemingly at odds with the generally accepted theoretical expectations. First, a clear evidence for particlevortex duality at the H-SIT is observed, with associated evidence that the proximate insulating phase is a "Hall insulator" phase, previously observed near the QHIT [1], thus supporting the existence of the correspondence between the two problems implied by the composite boson theory. Furthermore, where this transition collapses, a robust metallic ground states suggestive of a failed superconductors has attracted much attention in recent years because it presents a fundamental challenge to the standard theory of electron fluids [2]. Meanwhile, observations of analogous metallic phases arising from "ailed insulators" are often overlooked in analysis of similar data. Aiming to reconcile observations of both regimes in strongly granular two dimensional films, we propose a unified understanding of these seemingly different anomalous metallic phases by drawing connections to resistive-capacitive-shunted Josephson junction arrays [3]. Effects of quantum phase/charge fluctuations and macroscopic quantum tunneling are invoked to understand the anomalous metallic phase, thus advancing fundamental understandings of metals beyond the standard Fermi liquid theory.

1. Nicholas P. Breznay, Myles A. Steiner, Steven A. Kivelson, Aharon Kapitulnik, Self-Duality and a "Hall Insulator" phase near the Superconductor-to-Insulator Transition in indium-oxide films," PNAS 113, 280 (2016).

2. Aharon Kapitulnik, Steven A Kivelson, Boris Spivak, "Anomalous metals–failed superconductors," Rev. Mod. Phys. 91, 011002 (2017).

3. Xinyang Zhang, Alexander Palevski, Aharon Kapitulnik, "Anomalous metals: from "failed superconductor" to "failed insulator"," PNAS 119, e2202496119 (2022).

SACHDEV-YE-KITAEV TYPE MODELS WITH DISSIPATIONS

S. Ryu[1]

1 Department of Physics, Princeton University, USA

The Sachdev-Ye-Kitaev (SYK) model serves as a paradigmatic model for exploring many-body quantum chaos and has found extensive application in the study of strongly correlated matter characterized by non-quasiparticle excitations. In this work, we present an extension of the SYK model that incorporates Lindbladian jump operators. Analogous to the original SYK model, our generalized model remains solvable in the regime of a large number of fermion flavors. Our investigation reveals a spectrum of intriguing phenomena in terms of its relaxation time and a dynamic phase transition. Furthermore, we study the symmetry classification of many-body Lindbladians in fermionic systems, shedding light on the rich interplay between symmetry and dynamics.

15h00
Tue
8

ENTANGLEMENT PHASE TRANSITION IN TWO-DIMENSIONAL GROUND STATES

Zhao Zhang[1], Israel Klich[1]

1 Department of Physics, University of Oslo, Oslo, Norway
2 Department of Physics, University of Virginia, Charlottesville, VA

16h00
Tue
9

Height models and random tiling are well-studied objects in classical statistical mechanics and combinatorics that lead to many interesting phenomena, such as arctic curve, limit shape and Kadar-Parisi-Zhang scaling. We introduce quantum dynamics to the classical hexagonal dimer, and six-vertex model to construct frustration-free Hamiltonians with unique ground state being a superposition of tiling configurations subject to a particular boundary configuration. An internal degree of freedom of color is further introduced to generate long range entanglement that makes area law violation of entanglement entropy possible. The scaling of entanglement entropy between half systems is analysed with the surface tension theory of random surfaces and under a q-deformation that weighs random surfaces in the ground state superposition by the volume below, it undergoes a phase transition from area law to volume scaling. At the critical point, the scaling is $L \log L$ due to the so-called "entropic repulsion of Gaussian free fields conditioned to be positive. An exact holographic tensor network description of the ground state is give with one extra dimension perpendicular to the lattice. We also discuss an alternative realisation with six-vertex model, inhomogeneous deformation to obtain sub-volume intermediate scaling, and possible generalisations to higher dimension.

1. Z. Zhang, I. Klich, SciPost Physics **15** (2), 044.
2. Z. Zhang, I. Klich, arXiv:2210.01098.

Wednesday, 4 October

HEAVY-FERMION PHYSICS IN TWISTED BILAYER GRAPHENE

B. Andrei Bernevig

Department of Physics, Princeton University, Princeton, New Jersey 08544, USA

9h00
Wed
1

Twisted bilayer graphene (TBG) has shown two seemingly contradictory characters: (1) quantum-dot-like behavior in STM indicates that electrons are localized; (2) the transport experiments suggest the itinerant character. Two features can both be captured by a topological heavy-fermion model, in which the topological conduction electron bands couple to the local moments[1]. We study the local-moment physics and the Kondo effect in this model. We demonstrate that, at the integer fillings (nu=-2,-1,0,1,2), the RKKY interactions stabilize ferromagnetic states satisfying a U(4) Hunds rule [2]. However, at non-integer fillings, the Kondo effect becomes relevant [3], and Kondo resonance appears in the spectral function. Moreover, via our heavy-fermion model, we investigate the transport properties of the TBG. We show that the carriers of the system can be separated into incoherent f electrons and coherent c electrons. The coherent c electrons dominate the behaviors of the Seebeck and produce a fully negative Seebeck coefficient at the positive fillings.

THE CORRELATED INSULATORS OF MAGIC-ANGLE GRAPHENE UNDER ZERO AND ONE MAGNETIC FLUX QUANTA

Miguel Sánchez Sánchez

Instituto de Ciencia de Materiales de Madrid CSIC, Madrid, Spain

9h35 Wed 2

Magic angle twisted bilayer graphene (MATBG) hosts a plethora of electronic phases, from superconductivity to strange metals. We report self-consistent Hartree-Fock simulations of MATBG in the setting of a tight-binding model, under perpendicular magnetic fields of 0 and 26.5 T, corresponding to zero and one quantum of magnetic flux per moiré unit cell. The doping is set to $-2, 0$ and 2 electrons per unit cell, where correlation-induced gaps have been detected[2]. We observe Kramers intervalley order competing with spin ferromagnetism at zero field, and correlated insulators with different Chern numbers at 26.5 T. Our results include lattice-scale effects, such as the Hubbard on-site energy, that are not present in continuum theories.

1. arXiv preprint at arXiv:2308.01997 (2023)
2. Nature **574**, pages 653657 (2019)

SUPERCONDUCTIVITY AND CHIRALITY IN GRAPHENE SUPERLATTICES

T. Stauber[1], J. González[2], G. Gómez-Santos[3]

1 Instituto de Ciencia de Materiales de Madrid, CSIC, E-28049 Madrid, Spain

2 Instituto de Estructura de la Materia, CSIC, E-28006 Madrid, Spain

3 Departamento de Física de la Materia Condensada, Instituto Nicolás Cabrera and Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, E-28049 Madrid, Spain

9h55 Wed 3

Twisted bilayer graphene has attracted much attention due to its novel electronic and optical properties [1]. Here, I will present our recent theoretical results on the superconducting phase that emerges in this system due to electron-electron interaction via the Kohn-Luttinger mechanism [2]. I will also discuss the Drude response relevant for some plasmonic properties and focus on its chiral aspect [3].

1. Yuan Cao, Valla Fatemi, Shiang Fang, Kenji Watanabe, Takashi Taniguchi, Efthimios Kaxiras, and Pablo Jarillo- Herrero, ?Unconventional superconductivity in magic- angle graphene superlattices,? Nature 556, 43 ? 50 (2018).
2. J. González and T. Stauber, "Ising superconductivity induced from valley symmetry breaking in twisted trilayer graphene", to appear in Nature Communications, arXiv:2110.11294.
3. T. Stauber, M. Wackerl, P. Wenk, D. Margetis, J. González, G. Gómez-Santos, and J. Schliemann, "Neutral magic-angle bilayer graphene: Condon instability and chiral resonances", to appear in Small Science, arXiv: 2209.00958

INFINITE RANDOMNESS AND QUASIPERIODIC FIXED POINTS AT MEASUREMENT INDUCED PHASE TRANSITIONS

Jed Pixley[1]

1 Department of Physics and Astronomy, Center for Materials Theory, Rutgers University, Piscataway, NJ 08854 USA

We will discuss the universal nature of measurement induced phase transitions (MIPTs) in random quantum circuits when the measurement profile follows a static profile. First, the measurement induced transition is shown to be unstable to static but spatially random perturbations and the transition flows off to an infinite randomness fixed point. Second, the nature of several distinct quasiperiodic profiles will be studied and non-Pisot structures will be used to tune between irrelevant and relevant perturbations at the MIPT. In the latter case, the transition flows to an infinite quasiperiodic fixed point where the entanglement scaling is dictated by the wandering exponent of the quasiperiodic profile. The nature of these transitions are computed using large scale Clifford simulations and will be shown to be well described by real space renormalization group calculations.

10h55
Wed
4

ENTANGLEMENT PHASE TRANSITIONS IN MANY-BODY LOCALIZED SYSTEMS UNDER CONTINUOUS MEASUREMENT

Kazuki Yamamoto[1], Ryusuke Hamazoki[2]

1 Department of Physics, Tokyo Institute of Technology, Tokyo, Japan

2 Nonequilibrium Quantum Statistical Mechanics RIKEN Hakubi Research Team, RIKEN Cluster for Pioneering Research, RIKEN iTHEMS, Saitama, Japan

11h30 Wed 5

Localization, which is typically induced by disorder, is an exotic phenomenon where a quantum state fails to spread over the entire Hilbert space. Recently, measurement is utilized as another mechanism to localize a quantum state in nonunitary quantum circuits and continuously monitored systems, which exhibit novel quantum phenomena dubbed measurement-induced phase transitions (MIPTs). However, while both the disorder and the measurement localize the wave function and suppress the entanglement spreading, it is still not clear whether they exhibit the same localization properties.

In this talk, we study the localization properties of continuously monitored dynamics and associated MIPTs in disordered quantum many-body systems on the basis of the quantum trajectory approach [1]. By calculating the fidelity between random quantum trajectories, we demonstrate that the disorder and the measurement can lead to dynamical properties distinct from each other, although both have a power to suppress the entanglement spreading. In particular, in the large-disorder regime with weak measurement, we elucidate that the fidelity exhibits an anomalous power-law decay before saturating to the steady-state value. Furthermore, we propose a general method to access physical quantities for quantum trajectories in continuously monitored dynamics without resorting to postselection. It is argued that this scheme drastically reduces the cost of experiments. Our results can be tested in ultracold atoms subject to continuous measurement.

1. K. Yamamoto and R. Hamazaki, Phys. Rev. B **107**, L220201 (2023).

FULL COUNTING STATISTICS IN CHAOTIC AND INTEGRABLE DYNAMICS

S. Gopalakrishnan[1]

1 Department of Electrical and Computer Engineering, Princeton University, Princeton, NJ, USA

Abstract: Experiments with ultracold gases and digital quantum simulators can take simultaneous snapshots of all the particles in a system. Unlike conventional response experiments, these snapshots encode arbitrarily high-order correlation functions. It is natural to ask what new information these high-order correlations contain. I will present solvable models, as well as experimental data, showing how these new probes can elucidate (and disprove) certain proposed mechanisms for many-body dynamics.

11h50
Wed
6

Thursday, 5 October

CAN BLACK HOLES BE BOTH FAST AND THOROUGH SCRAMBLERS?

Claudio Chamon[1], Eduardo R. Mucciolo[2], Andrei E. Ruckenstein[1], Zhi-Cheng Yang[3,4]

1 Physics Department, Boston University, Boston, Massachusetts 02215, USA
2 Department of Physics, University of Central Florida, Orlando, Florida 32816, USA
3 School of Physics, Peking University, Beijing 100871, China
4 Center for High Energy Physics, Peking University, Beijing 100871, China

Black holes are conjectured to be the fastest scramblers of information in nature, with a scrambling time, τ_{sc}, that scales logarithmically with the number of degrees of freedom of the system, $\tau_{sc} \sim \log n$. At the same time, recent work suggests that resolving some of the long-standing information paradoxes inherent in the quantum description of evaporating black holes requires cryptographic level scrambling of information. The implication is that black holes are effective generators of computational pseudorandomness, i.e., that they generate pseudorandom quantum states that cannot be distinguished from Haar-random by an observer with polynomial resources. The simple point made in this talk is that, when analyzed in the context of universal 2-qubit-gate-based random quantum circuits - which are generally employed as simple models of black hole dynamics - these two conjectures are inconsistent with one another. More precisely, we argue that $\log n$-depth 2-qubit-gate-based random quantum circuits that match the speed limit for scrambling, conjectured for black holes, cannot produce computational pseudorandomness. Finally, we introduce the notion of "inflationary" quantum (IQ) gates, realized either as special 3-qubit gates or a subset of 2-qu$d$it-gates in $U(d^2)$, with $d \geq 3$ and d prime. We argue that producing pseudorandom quantum states with $\log n$-depth random quantum circuits requires the use of circuits comprising of these special IQ gates.

9h00
Thu
1

ESTIMATING THE SPECTRAL DENSITY OF UNSTABLE SCARS

D. Lippolis

Institute for Applied Systems Analysis, Jiangsu University, Zhenjiang 212013, China

9h35 Thu 2

In quantum chaos, the spectral statistics generally follows the predictions of random matrix theory (RMT). A notable exception is given by scar states, that enhance probability density around unstable periodic orbits of the classical system, therefore causing significant deviations of the spectral density from RMT expectations. In this work [1,2], the problem is considered of both RMT-ruled and scarred chaotic systems coupled to an opening. In particular, predictions are derived for the spectral density of a chaotic Hamiltonian scattering into a single- or multiple channels. The results are tested on paradigmatic quantum chaotic maps on a torus.

1. D. Lippolis, EPL **126**, 10003 (2019).
2. D. Lippolis, J. Phys. A: Math. Theor. **55**, 324001 (2022).

IRRELEVANCE OF SHORT-RANGE INTERACTIONS AT QUASIPERIODIC-DRIVEN GROUND-STATE LOCALIZATION TRANSITIONS

Miguel Gonçalves[1,5], Jedediah H. Pixley[2,3], Bruno Amorim[4], Eduardo V. Castro[5,6], Pedro Ribeiro[1,6]

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2 Department of Physics and Astronomy, Center for Materials Theory, Rutgers University, Piscataway, New Jersey 08854, USA

3 Center for Computational Quantum Physics, Flatiron Institute, 162 5th Avenue, New York, New York 10010, USA

4 Centro de Física das Universidades do Minho e do Porto (CF-UM-UP), Laboratório de Física para Materiais e Tecnologias Emergentes (LaPMET), Universidade do Minho, 4710-057 Braga, Portugal

5 Centro de Física das Universidades do Minho e Porto, Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, 4169-007 Porto, Portugal

6 Beijing Computational Science Research Center, Beijing 100193, China

9h55 Thu 3

We show that short-range interactions are irrelevant around gapless ground-state delocalization-localization transitions driven by quasiperiodicity in interacting fermionic chains [1]. In the presence of interactions, these transitions separate Luttinger Liquid and Anderson glass phases. Remarkably, close to criticality, we find that excitations become effectively non-interacting. By formulating a many-body generalization of the method developed in Ref. [2] to capture the transitions between Luttinger Liquid and Anderson glass, we carry out very accurate calculations of critical points and find that the correlation length critical exponent takes the non-interacting value. We also show that other critical exponents, such as the dynamical exponent and a many-body analog of the fractal dimension are compatible with the exponents obtained at the non-interacting critical point. Remarkably, we find that the transitions are accompanied by the emergence of a many-body generalization of the hidden dualities found in Ref. [3]. Finally, we show that in the limit of vanishing interaction strength, generic short-range interactions are irrelevant at the non-interacting critical point.

1. arXiv:2304.09197.
2. arXiv:2206.13549.
3. SciPost Phys. **13**, 046 (2022).

ANYON MOTION AND BLACK HOLE-LIKE DYNAMICS IN QUANTUM HALL BULK GEOMETRIES

Smitha Vishveshwara[1], Barry Bradlyn[1], Suraj Hegde[1], Varsha Subramanyan[1,3]

1 Department of Physics, University of Illinois, Urbana, Illinois, USA

2 Institute of Theoretical Physics and Wurzburg-Dresden Cluster of Excellence ct.qmat, Technische Univeristat Dresden, Dresden, Germany

3 Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico, USA

10h40 Thu 4

The recent interferometric and beam-splitter experiments signaling the presence of anyons in quantum Hall systems has created of resurgence of interest in the topic. Here, I will present a theoretical description of coherent state bulk anyons and their signatures in two particle correlators. I will demonstrate how a saddle potential, for instance created in a pinched point contact geometry, can model a beam-splitter. Anyon dynamics in such a potential reflects Hanbury-Brown Twiss correlations that can directly probe fractional statistics. I will also illustrate how the same setting can probe dynamics akin to that found in the astrophysical realm of black holes. Specifically, point-contact geometries can exhibit phenomena parallel to Hawking-Unruh radiation and black hole quasinormal modes associated with ringdowns in gravitational wave detection.

1. S. Hegde, V. Subramanyan, B. Bradlyn, and S. Vishveshwara, Phys. Rev. Lett **123**, 156802 (2019). Dedicated to C. V. Vishveshwara
2. V. Subramanyan, S. Hegde, S. Vishveshwara, and B. Bradlyn, Annals of Physics **435**, 168470 (2021) . Special issue on P. W. Anderson 3. V. Subramanyan, H. Hansson, S. Vishveshwara, In Preparation (2023)

SIGNATURES OF MANY-BODY LOCALIZATION OF QUASIPARTICLES IN A FLAT BAND SUPERCONDUCTOR

Koushik Swaminathan[1], Paula Tadros[2], Sebastiano Peotta[1]

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2 Department of Physics and Astronomy, University of Turku, FI-20014 Turku, Finland

11h15
Thu
5

We construct a class of exact eigenstates of the Hamiltonian obtained by projecting the Hubbard interaction term onto the flat band subspace of a generic lattice model. These exact eigenstates are many-body states in which an arbitrary number of localized fermionic particles coexist with a sea of mobile Cooper pairs with zero momentum. By considering the dice lattice as an example, we provide evidence that these exact eigenstates are in fact manifestation of local integrals of motions of the projected Hamiltonian. In particular the spin and particle densities retain memory of the initial state for a very long time, if localized unpaired particles are present at the beginning of the time evolution. This shows that many-body localization of quasiparticles and superfluidity can coexist even in generic two-dimensional lattice models with flat bands, for which it is not known how to construct local conserved quantities. Our results open new perspectives on the old condensed matter problem of the interplay between superconductivity and localization [1].

1. Koushik Swaminathan, Poula Tadros, and Sebastiano Peotta. arXiv:2302.06250 (2023).

SPECTRAL AND TRANSPORT PROPERTIES OF WEYL SEMIMETALS WITH VACCANCIES

J. P. Santos Pires[1,2], S. M. João[1,2], Aires Ferreira[3], B. Amorim[4], J. M. Viana Parente Lopes[1,2]

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Weyl semimetals are characterized by band-crossing points that come in pairs, with each node being described by a Weyl equation in three dimensions. As such, Weyl semimetals constitute a condensed matter realization of Weyl fermions from particle physics. In contrast with their particle physics counterpart, Weyl semimetals are invariably subject to disorder. It was initially thought that Weyl semimetals were robust against disorder (modeled as a random on-site potential) [1]. For this model of disorder, a semimetal-to-metal quantum phase transition was predicted to occur at a finite disorder strength, with the density of states (DoS) at the Weyl node acting as an order parameter. This picture was later revised and the most common view now is that rare regions in a random potential landscape induce localized rare states, which give origin to a non-zero, but exponentially small, nodal DoS for any disorder strength [2].

11h35 Thu 6

Another possible model of disorder are vacancies. These type of defects naturally occur in the growth process of Weyl semimetals [3]. In this contribution, we will present theoretical efforts to understand the effect of lattice vacancies in time-reversal invariant Weyl semimetals. We have demonstrated, analytically and numerically, that isolated lattice vacancies host zero energy localized states that decay as r^{-2}, and are robust against perturbations [4]. By performing high precision calculations, using the QuantumKITE software [5], we have shown that in the presence of a finite concentration of vacancies, a peak in the DoS develops at the Weyl node. Interestingly, this is accompanied by the emergence of a sequence of subsidiary resonances at finite energy. We have shown that these resonances result from quasi-localized states, with low spectral sensitivity to applied magnetic fields and a suppressed quantum diffusivity [6]. The latter affects the longitudinal DC conductivity, which is shown to yield reduced values whenever the Fermi energy lies at a subsidiary resonance. Finally, a clear signature of vacancy-induced states is also found in the linear optical response of Weyl semimetals, which provides a way to unambiguously detect them, with no need to tune the bulk Fermi energy.

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3. J. Buckeridge et al. Phys. Rev. B **94**, 180104 (2016).
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6. J. P. Santos Pires, S. M. João, Aires Ferreira, B. Amorim, and J. M. Viana Parente Lopes, Phys. Rev. Lett. **129**, 196601 (2022).

MEASUREMENT INDUCED PHASE TRANSITIONS: FROM THEORY TO OBSERVABILITY

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The quest for phases and phase transitions in general non-unitary quantum dynamics has been spotlighted by the recent discovery of measurement-induced phase transitions. They result from the competition of deterministic Schrödinger and random measurement dynamics, and surface in a qualitative change of the entanglement structure.
Here we first introduce instances of entanglement transitions in fermion systems, between a regime of logarithmic entanglement growth, and a quantum Zeno regime obeying an area law. We identify the relevant degrees of freedom driving the phase transition in terms of an effective field theory. This yields a physical picture in terms of a depinning from the measurement operator eigenstates induced by unitary dynamics, and places it into the BKT universality class.
In standard quantum mechanical observables however, these transitions are masked due to the degeneracy of measurement outcomes. We then point out a general route of gently breaking this degeneracy – pre-selection – which makes such transitions observable in state-of-the-art quantum platforms without modifying any of the universal properties. It reveals an intriguing connection to quantum absorbing state transitions.

11h55
Thu
7

1. O. Alberton, M. Buchhold, S. Diehl, Entanglement Transition in a Monitored Free-Fermion Chain: From Extended Criticality to Area Law , Phys. Rev. Lett. **126**, 170602 (2021)
2. M. Buchhold, Y. Minoguchi, A. Altland, S. Diehl, Effective Theory for the Measurement-Induced Phase Transition of Dirac Fermions , Phys. Rev. X **11**, 041004 (2021)
3. M. Buchhold, T. Müller, S. Diehl, Revealing measurement-induced phase transitions by pre-selection , arxiv:2208.10506.

CHIRAL SPIN LIQUIDS WITH PEPS: SHOULD WE FEAR THE NO-GO THEOREM ?

Didier Poilblanc[1],

1 Laboratoire de Physique Théorique, C.N.R.S and University of Toulouse, France

15h00
Thu
8

Doubts have been raised on the representation of chiral spin liquids exhibiting topological order in terms of projected entangled pair states (PEPSs). Starting from a simple spin-1/2 chiral frustrated Heisenberg model on the square lattice, we show that a faithful representation of the chiral spin liquid phase is in fact possible in terms of a generic *bosonic* PEPS upon variational optimization [1]. We find a perfectly chiral gapless edge mode and a rapid decay of correlation functions at short distances consistent with a bulk gap, concomitant with a gossamer long-range tail originating from a PEPS bulk-edge correspondence. For increasing bond dimension, (i) the rapid decrease of spurious features – SU(2) symmetry breaking and long-range tails in correlations – together with (ii) a faster convergence of the ground state energy as compared to state-of-the-art cylinder matrix-product state simulations involving far more variational parameters, prove the fundamental relevance of the PEPS ansatz for simulating systems with chiral topological order. Similar results and conclusions are also obtained for a similar model on the Kagome lattice [2]. As a consequence of the topological obstruction for non-interacting chiral Gaussian PEPS [3], very weak gossamer tails are also observed in the correlation functions of *fermionic* projected entangled pair state ansatze [4], suggesting that the no-go theorem for chiral PEPS is universal but does not bring any practical limitation.

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SIMULATION OF DIFFUSIVE TRANSPORT IN MESOSCOPIC DISORDERED NANO-RIBBONS

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16h00 Thu 9

Electron propagation across a disordered two-dimensional conductor is recognized to go from ballistic to localized through a middle stage of diffusive transport where a local conductivity can be defined. I will start by reviewing some key aspects of numerical mesoscopic quantum transport simulations. A strong emphasis on the Landauer approach will be given since it provides a very clear distinction between the transport regimes by fixing the disorder strength and varying the width and length of the sample. The recognition of each regime would be evident from the dependence of the two-terminal Landauer conductance on the geometrical dimensions of the device, but establishingan intuitive transport picture seems to be limited in its scope, as reaching mesoscopic systems isdifficult due to poor numerical scaling with the samples cross-section. Therefore, I will present an alternative method from which we can extract the conductance of a disordered nano-ribbon from the non-equilibrium quasi-steady-state current driven by a sudden bias of the sample within a partition-free mesoscopic device coupled to finite metallic contacts. Furthermore, I will discuss how the introduction of a spatial modulation within the leads profile enables time-resolved transport simulations of mesoscopic systems. This technique is shown for two-dimensional systems and is the key to effectively reveal the emergence of a diffusive transport regime

Friday, 6 October

EXCITATIONS, SPIN-CHARGE SEPARATION, AND CORRELATION FUNCTION

Hai-Qing Lin

School of Physics, Zhejiang University

Quasi-particles play important role in condensed matter physics and result in many emergent novel phenomena. In this talk, we discuss collective excitations in one-dimension as exemplified by antiferromagnetic Heisenberg model and -function interacting Fermi gas (Yang-Gaudin model). Using the thermodynamic Bethe Ansatz (TBA) formalism, we analytically derive universal properties of the models with arbitrary interaction strength, and present a rigorous understanding of spin-charge separation, a unique feature predicted by the Tomonaga-Luttinger liquid (TLL) theory. We show that a dimensionless quantity, the Wilson Ratio (WR), elegantly characterizes quantum liquid phase diagram. For the TLL phase, WR = 4Ks remains almost temperature independent, where Ks is the Luttinger parameter. Based on the exact low-lying excitation spectra, we further evaluate the spin and charge dynamical structure factors (DSFs). The peaks of the DSFs exhibit distinguishable propagating velocities of spin and charge as functions of interaction strength, which can be observed by Bragg spectroscopy with ultracold atoms. Combining quantum integrable theory with numerics, we propose a reliable technique to exactly compute the spectral function of 1D many-body models at large scales and demonstrate the technique on the Lieb-Liniger gas.

9h00

Fri

1

INCOMMENSURABILITY-INDUCED ENHANCEMENT OF SUPERCONDUCTIVITY IN ONE DIMENSIONAL CRITICAL SYSTEMS

Ricardo Oliveira[1], Miguel Gonçalves[2], Pedro Ribeiro[2,3]
Eduardo V. Castro[1,3], Bruno Amorim[4]

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9h35 Fri 2

The quantum phases of quasiperiodic quantum matter have attracted a great deal of interest in recent years due to cold atom experiments on Bose glasses and manybody localization (MBL) on the one hand, and the remarkable phenomena observed in moiré systems, that are generically quasiperiodic, on the other. However, the study of interactions in quasiperiodic systems, is still in its early stages. In this work, we show that incommensurability can enhance superconductivity in one dimensional quasiperiodic systems with s-wave pairing. As a parent model, we use a generalized Aubry-André model that includes quasiperiodic modulations of the potential and the hoppings. In the absence of interactions, the model contains extended, critical and localized phases for incommensurate modulations. Our results reveal that in a substantial region inside the parent critical phase, there is a significant increase of the superconducting critical temperature compared to the extended phase. We also analyse the results for commensurate modulations with period close to the selected incommensurate one. We find that while in the commensurate case, the scaling of the critical temperature with the interaction strength follows the weak-coupling BCS prediction for a large enough system size, it scales algebraically in the incommensurate case within the critical and localized parent phases. These qualitatively distinct behaviors lead to a significant incommensurability-induced enhancement of the critical temperature in the weak and intermediate coupling regimes, accompanied by an increase in the superconducting order parameter at zero temperature.

1. R. Oliveira, M. Gonçalves, P. Ribeiro, E. V. Castro, and B. Amorim, arXiv:2303.17656 (2023).

QUADRATIC HEAT CAPACITY AND HIGH-FIELD MAGNETIC PHASES OF V_5S_8

P. M. T. Vianez[1], C. A. Sônego[1,2], H. Li[1], M. N. Ali[3], J. C. Lashley[1], G. G. Lonzarich[1], M. A. Avila[2], S. E. Rowley[1]

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2 CCNH, Universidade Federal do ABC, Santo André, São Paulo, Brazil
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Strongly correlated electron systems are known to host a variety of exotic phenomena and novel quantum phases. The transition-metal chalcogenide system, V_XS_8, is of particular interest, for it displays a wide range of behaviour on changing the stoichiometry, from a charge density wave metal ($x = 4$) to an antiferromagnet ($x = 5, 6$) and even, a paramagnet ($x = 8$). Here, we focus on V_5S_8, where magnetic interactions between the vanadium d-electrons lead to an antiferromagnetic phase. The Néel temperature, T_N, is observed to be of about 32 K, with the effective magnetic moment of $2.62\,\mu_B$/V, obtained from Curie-Weiss, being significantly greater than that previously measured via NMR, neutron scattering, and magnetisation [1-3]. 9h55
We further present resistivity $R(T)$, magnetisation $M(H)$, magnetoresistance $R(H)$, and heat capacity Fri
c_p data up to 35 T in field and down to millikelvin temperatures revealing, in addition to a prominent 3
spin-flop feature at ~ 4.5 T [4], a new magnetic phase at fields above 7 T, in agreement with a model of two sublattices with frustrated inter- and intra-sublattice spin couplings [5]. Finally, we report the observation of an unexpected quadratic temperature dependence of the heat capacity at low temperatures which is independent of applied magnetic field. We find that this behaviour is consistent with an unconventional phonon spectrum which is linear in wavevector in the c direction but quadratic in the $a - b$ plane, indicating a form of geometrical elastic criticality.

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2. S. Funahashi, H. Nozaki, I. Kawada, *Journal of Physics and Chemistry of Solids* **42**, 1009 (1981).
3. M. Nakanishi, *et al.*, *Journal of Magnetism and Magnetic Materials* **221**, 301 (2000).
4. W. J. Hardy, *et al.*, *ACS Nano* **10**, 5941 (2016).
5. C. A. Sônego, P. M. T. Vianez, *et al.*, arXiv: 2305.06175 (2023)

QUANTUM SIMULATORS OF MANY-BODY PHENOMENA WITH INTEGRABILITY

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2 Department of Physics and Astronomy, Rice University, USA
3 School of Physics, Zhejiang University, China

10h55
Fri
4

For a long time exactly solvable models were considered to be mathematical toy models. However, this impression was changed over the past two decades due to advanced quantum engineering of genuine many-body systems using ultracold atoms. In particular, some prototypical exactly solvable YangÐBaxter systems have been successfully realized allowing us to confront elegant and sophisticated exact solutions of these systems with their experimental counterparts. Such new experimental systems provide novel and useable quantum simulators of unique many-body phenomena with integrability.
In this talk, we will show a quantum simulator of Yang-Gaudin model [1] , which remarkably provides a determinant observation of the Luttinger theory of spin-charge separation in the trapped 1D ultracold Fermi gas [2].

1. Ruwan Senaratne, Danyel Cavazos-Cavazos, Sheng Wang, Feng He, Ya-Ting Chang, Aashish Kafle, Han Pu, Xi-Wen Guan*, Randall G. Hulet*, Science **376**, 1305 (2022).
2. Feng He, Yu-Zhu Jiang, Hai-Qing Lin*, Randall G. Hulet, Han Pu, Xi-Wen Guan*, Phys. Rev. Lett. **125**, 190401 (2020).

QUANTUM-CLASSICAL CORRESPONDENCE AND ETH IN BOSE-HUBBARD SYSTEMS

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2 Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden, Germany

We consider a quantum many-body system the Bose-Hubbard model on a few sites which has a classical limit, and which is neither strongly chaotic nor integrable but rather shows a mixture of the two types of behavior. We compare quantum measures of chaos (eigenvalue statistics and eigenvector structure) in the quantum system, with classical measures of chaos (Lyapunov exponents) in the corresponding classical system. As a function of energy and interaction strength, we demonstrate a strong overall correspondence between the two cases. In particular, we consider the scaling of eigenstate-to-eigenstate fluctuations of expectation values (ETH fluctuations) in the classical limit. We demonstrate that, for larger lattices, the scaling of fluctuations of physical midspectrum eigenstates follows the ideal (Gaussian) expectation, but for smaller lattices, the scaling occurs via a different exponent.

11h30
Fri
5

1. G. Nakerst, M.Haque, Phys. Rev. E **103**, 042109 (2021) .
2. G. Nakerst, M.Haque, Phys. Rev. E **107**, 024210 (2023).

BINDER CUMULANTS FOR A QUANTUM GEOMETRIC PHASE: FINITE SIZE SCALING AND THE MODERN THEORY OF POLARIZATION

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1 Department of Theoretical Physics, Budapest University of Technology and Economics, Budapest, Hungary
2 Department of Physics, Bilkent University, Ankara Turkey

11h50 Fri 6

The modern theory of polarization casts the dielectric polarization as a geometric phase (Zak-Berry phase). Due to the fact that this quantity is not a simple operator expectation value, traditional finite size scaling approaches are not applicable to it. In systems where a local order parameter exists, the Binder cumulant (a ratio of statistical cumulants) is guaranteed to locate classical and quantum phase transition points via the finite size scaling hypothesis. In this talk, it will be shown that the so-called gauge invariant cumulants associated with the geometric phase can be used to construct the analog of the Binder cumulant for adiabatic cycles. The formalism is general, in the sense that such "Berry-Binder cumulants" can be constructed for any adiabatic cycle with isolated degeneracy points, and they take particular finite values at gap closure. We apply the formalism to the location of gap closure points in a variety of systems in one and two dimensions, including topological, disordered, and correlated systems. Our approach is sensitive to gap closure, even in cases where the Fermi surface is down by two dimensions compared to the dimension of the system (Dirac points in graphene or the topological Haldane model). We also develop a renormalization scheme based on the modern polarization theory, and apply it to disordered systems in one, two, and three dimensions. In one and three dimensions our approach concurs with the famous "gang-of-four" results, in two dimensions we run into system size limitations, but our preliminary results are not inconsistent with the scaling theory of localization. Time permitting, I will also discuss recent work on the connection between quantum geometric tensors and the cumulants.

[1]: B. Hetényi and B. Dóra, "Quantum phase transitions from analysis of the polarization amplitude", Phys. Rev. B 99 085126 (2018).
[2]: B. Hetényi, S. Parlak, and M. Yahyavi, "Scaling and renormalization in the modern theory of polarization: application to disordered systems", Phys. Rev. B 104 214207 (2021).
[3]: B. Hetényi and S. Cengiz, "Geometric cumulants associated with adiabatic cycles crossing degeneracy points: Application to finite size scaling of metal-insulator transitions in crystalline electronic systems" 106 195151 (2022).

ABSTRACTS OF THE POSTER PRESENTATIONS

Poster sessions I and II

QUANTUM LIQUIDS UNDER ENVIRONMENT-INDUCED DISSIPATION

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2 Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Quantum liquids are exotic phases of strongly correlated matter that remain seemingly disordered down to zero temperature. Nevertheless, their local degrees of freedom are highly correlated. These elusive phases are often fragile and may become unstable under certain perturbations. Determining their stability to the coupling of environment degrees of freedom is therefore critical to understand under which conditions these states may be observed.

With this motivation, we have started to study spin and bosonic quantum liquids coupled to dissipative bosonic baths. In the absence of standard tools, we have purposefully developed a quantum Monte Carlo algorithm with worm updates tailored to simulate dissipative baths. In this poster, we present our method and report our first results for a one-dimensional Bose-Hubbard model where each site is coupled off-diagonally to an ohmic bath, allowing for both energy and particle exchanges. PS 1

While in isolation, Bose-Einstein condensation in one dimension is forbidden by the Mermin-Wagner theorem. The liquid state of the isolated chain, sometimes called a quasi-condensate, shows quasi-long range order, with power-law decaying correlations predicted by Luttinger's liquid theory. In contrast, we find that any coupling to the bath stabilizes off-diagonal long-range order and a finite condensation fraction.

These findings show that ohmic environments destabilize the quasi-condensed state and suggest that experimental observations of the quantum liquid state in these kinds of environments are poised to fail.

MEASURING THE LOCAL DENSITY OF STATES VIA A STOCHASTIC APPROACH

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PS 2

The Local Density of States (LDoS) carries deep information about quantum systems. One of the interests of this quantity is the study of localization via the typical density of states and the distribution of the LDoS. This quantities requires the computation of the LDoS in many lattice sites for a precise result. Researchers have been using the Kernel Polynomial Method for the computation of this quantity which requires $\mathcal{O}(L^2)$ calculations, where L is the size of the system.

In this work we provide a new method that allows the computation of the LDoS in the whole lattice of the system requiring only $\mathcal{O}(L)$ calculations, thus unlocking simulations of very large systems, with the Kernel Polynomial Method originating in the ideas of the calculation of the Density of States (DoS) with the aid of random vectors.

SPECTRAL AND STEADY STATE PROPERTIES OF FERMIONIC RANDOM QUADRATIC LIOUVILLIANS

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We study spectral and steady-state properties of generic Markovian dissipative systems described by quadratic fermionic Liouvillian operators of the Lindblad form. The Hamiltonian dynamics is modeled by a generic random quadratic operator, i.e., as a featureless superconductor of class D, whereas the Markovian dissipation is described by M random linear jump operators. By varying the dissipation strength and the ratio of dissipative channels per fermion, $m = M/(2N_F)$, we find two distinct phases where the support of the single-particle spectrum has one or two connected components. In the strongly dissipative regime, this transition occurs for $m = 1/2$ and is concomitant with a qualitative change in both the steady-state and the spectral gap that rules the large-time dynamics. Above this threshold, the spectral gap and the steady-state purity qualitatively agree with the fully generic (i.e., non-quadratic) case studied recently. Below $m = 1/2$, the spectral gap closes in the thermodynamic limit and the steady-state decouples into an ergodic and a nonergodic sector yielding a non-monotonic steady-state purity as a function of the dissipation strength. Our results show that some of the universal features previously observed for fully random Liouvillians are generic for a sufficiently large number of jump operators. On the other hand, if the number of dissipation channels is decreased the system can exhibit nonergodic features, rendering it possible to suppress dissipation in protected subspaces even in the presence of strong system-environment coupling.

PS 3

ROLE OF DISORDER IN NODAL LOOP SEMIMETALS

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Weyl nodal loop (WNL) semimetals are topological semimetals where the valence and conduction bands linearly touch along one-dimensional loops in momentum space. A manifestation of their non-trivial topology is the presence of surface (drumhead) edge states on surfaces parallel to the loop plane, which are induced by chiral symmetry. Here we will discuss the fate of WNL semimetals under two distinct types of disorder: chiral disorder, which preserves chiral symmetry, and Anderson diagonal disorder, breaking that symmetry. For the case of Anderson diagonal disorder, a previous result established the robustness of the semimetal phase [1] (though with multifractal properties) till a diffusive metal sets in at a critical disorder strength. Since chiral symmetry is broken, a winding number cannot be defined, and the surface states (SSs) of the WNL semimetal are no longer topologically protected. We have shown [2] that weak disorder mixes the
PS drumhead states of the WNL semimetal, leading to an algebraic decay of these states into the bulk and a
4 broadening of the low energy density of SSs. This behavior persists with increasing disorder until the bulk semimetal-metal transition occurs, after which the zero energy SSs hybridize with bulk states and become extended into the bulk.

For the chiral symmetric off-diagonal disorder case [3], weak disorder induces a diffusive metal at zero energy and enhances the number of topological SSs, confirmed by the enhancement of both the winding number and the low energy density of SSs of the open system. The topological SSs are exponentially localized along the direction perpendicular to the nodal loop, and acquire a multifractal structure in the remaining real-space directions. This is a novel topological metal hosting topological multifractal SSs. As disorder increases, the number of SSs decreases, algebraically or exponentially, depending on how disorder is introduced.

1. M. Gonçalves, P. Ribeiro, E. V. Castro, and M. A. N. Araújo, Phys. Rev. Lett. 124, 136405 (2020).
2. João S. Silva, M. A. N. Araújo, M. Gonçalves, P. Ribeiro, and E. V. Castro, Phys. Rev. B 107, 045146 (2023).
3. João S. Silva, E. V. Castro, M. A. N. Araújo, P. Ribeiro, and M. Gonçalves, (in preparation)

NUMERICAL TESTS OF THE LARGE CHARGE EXPANSION

Júlio Oliveira[3,4,5], José Matos[3,4,5,6], J. M. Viana Parente Lopes[3,4,5], João Penedones[6] and Gabriel Cuomo[1,2]

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6 Fields and Strings Laboratory, Institute of Physics, École Polytechnique Fédéral de Lausanne (EPFL), Route de la Sorge, CH-1015 Lausanne, Switzerland

Understanding some critical phenomena requires a thorough understanding of Conformal Field Theory(CFT). However, for more than two spacetime dimensions, CFTs are infamously challenging to solve. In the past, methods were used to get around this issue by expanding the action around a solvable analytical limit. The most famous is the large-N limit for interacting theories with an SU(N) global symmetry. Importantly, these are theories that give rise to quantum confinement being so considered suitable toy-models for realistic quantum chromodynamics. PS 5

Hellerman et. al (1505.01537) suggested that, in the large charge sector, a CFT with U(1) global symmetry could be described by a universal effective action. Now, seven years later, we were able to obtain numerical evidence supporting their conjecture. Using Monte-Carlo, we were able to perform measurements for the, previously unknown, conformal dimensions of operators with charge 12 up 20 as well as the first ever measurements of the OPE coefficients in the 3d O(2) model (2305.00499).

1. Hellerman et. al, 1505.01537 (2015);
2. Grabiel Cuomo, 2103.01331 (2021);
3. Cuomo et. al, 2305.00499 (2023) .

QUANTUM NON-EQUILIBRIUM EXCITONS IN TWO-DIMENSIONAL SEMICONDUCTORS

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Recently isolated monolayer semiconducting transition metal dichalcogenides (STMD), such as MoS_2, $MoSe_2$, WS_2 and WSe_2, are direct band semiconductors with gaps in the visible range and strong light-matter interactions, which make them ideally suited to optoelectronic applications such as photo-detectors, light-emitting diodes (LED), solar cells, and single-photon quantum emitters.

Due to their low dimensionality, quantum mechanical effects play an important role in describing the physics of those systems. In particular, since two-dimensional STMDs have a reduced Coulomb screening, excitons play a major role in several physical phenomena present in STMD based optoelectronic devices, such as their optical properties in the visible range.

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Therefore, since excitons play such an important role in STMD based devices, it is essential to understand their behavior in these systems to further develop optoelectronic technology.

Thus, our objective is to study excitonic electroluminescence in STMD based devices, which typically occurs when subjected to non-equilibrium conditions, such as applying a bias voltage.

In particular, we study the coherent generation of excitons in STMD based devices placed under non-equilibrium conditions, focusing on the impact excitation mechanism.

To this end, we develop a quantum formalism based in non-equilibrium Green's functions to describe the inelastic current arising from the emission of bosons [1], particularizing it to the exciton case. From this formalism, we are able to determine the exciton emission rate as a function of the applied voltage and to characterize the effect of exciton emission on I-V curves in optoelectronic devices based on two-dimensional STMDs.

INTERPLAY BETWEEN INTERACTIONS AND INCOMMENSURABILITY IN 1D NARROW-BAND MOIRÉ SYSTEM

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Quasi-periodicity is a current hot topic in condensed matter systems since it drastically changes the nature of the single particle eigenstates. Even in 1D systems, the states suffer a transition from extended to critical or localized. Here we study the fate of those states in the presence of electron-electron interactions. We consider a 1D tight-binding model with sinusoidal modulated nearest-neighbours hoppings with nearest neighbour repulsion. To study those interactions, we employ a variational mean- field approach. Studying the charge distribution across the lattice we find out that the critical states generate a quasi-fractal charge density wave (CDW) for any finite interaction strength, U, in the incommensurate case, with a high number of wave vectors contributing to the charge order. Increasing U there is a transition to a CDW with much less wave vectors characterized by a peak in the localization length in the wave vector space. On the other hand, in the periodic limit at high potential strength, there is a transition between a gapless state to a Periodic-Moiré CDW with the period of the potential. At sufficiently high U, there is no major difference between the periodic and quasi-periodic cases

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ELECTRON-MEDIATED ENTANGLEMENT OF TWO DISTANT MACROSCOPIC FERROMAGNETS WITHIN A NONEQUILIBRIUM SPINTRONIC DEVICE

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In the last twenty years, quantum information theory has provided a whole new set of tools for the investigation of condensed matter systems. In particular, the study of various entanglement measurements has produced a new perspective that is helping to unveil and characterize exotic quantum phases of matter, especially strongly-correlated systems that can have their Hilbert space ergodicity broken by many-body localization [1] and often feature long-range entanglement [2] in space. Entanglement has been seen as a common property of the microscopic quantum systems which is washed out by thermal fluctuations in macroscopic systems at room temperature. However, over the years several experiments [3-4] have shown the possibility to entangle macroscopic systems at long distances [5]. In this contribution, we present early simulation results that demonstrate the arisal of quantum entanglement between two mesoscopic large spin-¡ Heisenberg ferromagnetic chains that are mutually coupled by a local interaction with the spin of a spin-unpolarized single-electron pulse propagating across a longer one-dimensional tight-binding chain [6]. This effect is driven by a quantum spin-transfer torque effect [6-7] in which flowing electronic spins can exchange angular momentum with localized quantum spins of a magnetic material even when they are collinear but antiparallel. The results were obtained using an efficient and heavily parallelized implementation of the Chebyshev expansion for the time-evolution operator [8], which is then used to evolve the full many-body state from an initial tripartite state. The dynamical build-up of mixed-state entanglement between the FM layers is quantified by calculating the mutual logarithmic negativity, entanglement entropy and mutual information over time. The scaling with system size is also analyzed in an effort to ascertain the robustness of our predictions under realistic experimental conditions. Finally, use the entanglement negativity to explore many-body entanglement patterns in smaller sub-blocks. In doing so, we also compute entanglement negativity between pairs of spins (from different distinct ferromagnetic layers), pairs of pairs, and so forth. This allows the characterization in structure of the many-body entanglement.

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Acknowledgements: Work supported by FCT (Portugal) through the Strategic Funding No. UIDB/04650/2020, Projects No. POCI-01-0145-FEDER-028887 (J.P.S.P. and J.M.V.P.L), as well as the PhD Grant No. PD/BD/142774/2018 (J.P.S.P.). P.M. and B.K.N. were supported by the U.S. National Science Foundation (NSF) Grant No. ECCS 1922689. A.F. acknowledges support from the Royal Society through a Royal Society University Research Fellowship. R.D.S acknowledges support from the Fundação Calouste Gulbenkian through a New Scientific Talent in Physics Fellowship.

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INTERPLAY BETWEEN CHIRAL QUASI-DISORDER AND TOPOLOGY IN A 2D SECOND ORDER TOPOLOGICAL INSULATOR (SOTI)

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In this work we explore the effects of a quasi-periodic potential modulation in the 2D BBH model [1] using numerical exact methods that allow us to explore the topological phase diagram, localization and spectral properties of the system. We were the first to show the appearance of this novel phase of matter which we entitle quasi-periodic second order topological insulating phase (QP-SOTI). We demonstrate that topological phases ($|\gamma| < 1$) are robust to this modulation and that the quasi-periodic potential can induce TPT from $q_{xy} = 0$ into $q_{xy} = 0.5$, even when starting in a trivial phase ($|\gamma| > 1$). We achieve this by computing the bulk and boundary topological indexes. Furthermore, these new QP-SOTI phases are shown to have far different localization and spectral properties than their disordered SOTI counterparts. Unlike chiral disorder, where gapless HOTAI phases are observed [2-3], QP-SOTI phases are shown to be always gapped, with a TPT occurring in the common gap closing and opening mechanism. Regarding localization, we show that these novel phases have mixed localization properties spamming from ballistic to critical and even fully localized states at the gap-edge. We conclude our work by opening the boundaries and studying the bulk boundary correspondence, showing that, just as in the clean limit, zero energy corner modes remain robust in every topological phase.

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PRIMARY AND SECONDARY ORDER PARAMETERS IN THE FULLY FRUSTRATED TRANSVERSE FIELD ISING MODEL ON THE SQUARE LATTICE

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Using quantum Monte Carlo simulations and field-theory arguments, we study the fully frustrated (Villain) transverse-field Ising model on the square lattice. We consider a primary spin order parameter and a secondary dimer order parameter, which both lead to the same phase diagram but detect Z_8 and Z_4 symmetry, respectively. The spin order parameter scales with conventional exponents both in the critical phase at temperatures $T > 0$ and at the $T = 0$ quantum critical point, while the dimer order parameter requires more detailed investigations of the applicable low-energy theories; the height model at $T > 0$ and the $O(2)$ model in 2+1 dimensions at $T = 0$. Relating the microscopic order parameters to operators in the effective models, we predict the secondary critical exponents, which we confirm by quantum Monte Carlo simulations. The relationships between the primary and secondary order parameters have not been previously discussed of this context and provide useful insight more broadly for spin models whose low-energy physics involves dimer degrees of freedom.

EXOTIC EDGE STATES IN FLAT-BAND TRIANGULENE CRYSTALS

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Triangulenes with a lateral dimension of n-benzenes feature $n-1$ zero modes with C_3 symmetry. It has been recently shown that in triangulene honeycomb lattices with a unit cell formed by a pair of triangulenes with dimensions n and m form $n+m-2$ narrow bands that are associated to the zero modes. These two-dimensional triangulene crystals provide a generalization of the graphene honeycomb two-band model to the case of fermions with internal pseudospin degree of freedom, with C_3 symmetry. The resulting $n+m-2$ bands have several non-trivial features, such as coexisting graphene-like Dirac cones with flat bands, both at zero and finite energy, as well as robust degeneracy points where flat-band and a parabolic band meet at the Γ-point. Here we explore the edge states of this class of crystals and we find several types of edge states absent in graphene, associated to the non-trivial features of the 2D bands. First, we find dispersive edge states associated to the finite-energy flat-bands, that occur both at the armchair and zigzag termination. Second, in the case of non-centrosymmetric triangulene crystals that lead to a $S=1$ Dirac band, we have a bonding-antibonding couple dispersive edge states, localized in the same edge so that their splitting is reduced as their localization increases, opposite to the conventional behavior of couples of states localized in opposite edges. Third, for the $[4,4]$ crystal, that host a gap separating a pair of flat conduction and valence bands, we find non-dispersive edge states with $E=0$ in all edge terminations, that reveal this system as a two-dimensional topological crystalline insulator.

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PHOTONIC n-ROOT SU-SCHRIEFFER-HEEGER MODEL

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We propose a scheme to design a novel class of high-root topological insulators of arbitrary degree [1]. The method is based on using connected loop modules of unidirectional couplings, rendering the system non-Hermitian by default. The resulting models display striking features such as (i) a generalized chiral symmetry, (ii) a proliferation of equidistant topological states in the complex energy spectrum, and (iii) a novel kind of ring energy gap. We then show how the required unidirectional couplings can be realistically implemented in lattices of coupled ring resonators with balanced gain and loss. Specifically, the resonant main rings are coupled through antiresonant link rings defined by a split structure, with the upper optical path of these link rings displaying modulated gain and the lower half an equal amount of modulated loss [2], leading to highly asymmetric couplings between main rings. The validity of the mapping onto photonic lattices is benchmarked by simulating different roots of the Su-Schrieffer-Heeger model (SSH), focusing in particular on the cubic-root ($\sqrt[3]{SSH}$) and quartic-root models ($\sqrt[4]{SSH}$), showing near-perfect agreement with the underlying theory.

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ELECTRICAL DETECTION OF HIGH-QUALITY TWO-DIMENSIONAL POLARITONIC NANORESONATORS AT MID- AND LONG-WAVE INFRARED

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One of the most captivating properties of polaritons is their capacity to confine light at the nanoscale. This confinement is even more extreme in two-dimensional (2D) materials. Although 2D polaritons have been investigated by optical measurements[1], their effective spectrally resolved electrical detection using far-field infrared photocurrent spectroscopy remain unexplored, while using it can give a potential advantage, where 2D material acts simultaniously both as polariton-sustaining element and as photodetector. Hereing we propose practical realization of such a conception - an electro-polaritonic approach. We present an electro-polaritonic approach by combining high-quality polaritonic nanoresonators and the photodetector in the same device. We use metallic nanorods to produce hybrid nanoresonators with 2D polaritonic media for mid and long-wave infrared ranges, which we electrically detect using a graphene pn-junction. These nanoresonators present a record lateral confinement and high-quality factors up to 200, enabling them to display prominent peaks in the photocurrent spectrum. Additionally, we exploit the geometrical and gate tunability of these nanoresonators to investigate their impact on the photocurrent spectrum. This work opens a venue for investigating this highly tunable and complex hybrid system, as well as its potential usage in compact platforms for sensing and photodetection applications: sensing molecules and gases, hyperspectral imaging and optical spectrometry, as well as their integration with silicon technology[2].

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ENTANGLEMENT WITNESSING OF A CLASS OF MANY-BODY SYSTEMS VIA SINGLE BASIS MEASUREMENTS

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Detecting entanglement in many-body quantum systems is crucial but challenging, typically requiring multiple measurements. In this work, we establish the class of states where measuring connected correlations in just *one* basis is sufficient and necessary, provided the appropriate basis and observables are chosen. It is some prior information about the state, although not enough to reveal the state or its entanglement, that enables our one basis methodology to work. We show the possibility of one observable entanglement detection in a variety of systems, including those without conserved charges, such as Rydberg atoms or Transverse Ising model, via quantum quenches. This provides a much simpler pathway of detection than previous works. It also shows improved sensitivity from mutually unbiased basis (MUB) detection techniques.

FROM BLOCH OSCILLATIONS TO A STEADY-STATE CURRENT IN STRONGLY BIASED MESOSCOPIC DEVICES

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It has long been known that quantum particles moving in a periodic lattice and subject to a constant force field undergo an oscillatory motion that is referred to as Bloch oscillations (BOs) [1,2]. However, it is also known that, under quite general conditions, a biased mesoscopic system connected to leads should settle in a steady-state regime characterized by a constant electric current (described by the Landauer formula) [3,4]. These two observations naturally lead to the question: do BOs survive in some manner in mesoscopic devices in the presence of a constant electric field? To answer this question, we explore the interface between these two regimes in two-terminal devices and demonstrate theoretically that BOs can actually be observed in such apparatuses as a transient phenomenon, which relaxes for long times to a steady-state current that agrees with the Landauer formula. Furthermore, we also combine analytical and numerical time-evolution results for a one-dimensional tight-binding model of a biased two-terminal mesoscopic system, in order to characterize the decay times of the transient BOs and establish the conditions under which they can occur.

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EXCITONIC PROPERTIES OF HBN FROM A TIME-DEPENDENT HARTREE-FOCK MEAN-FIELD THEORY

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In this work we perform a generic derivation on how collective excitations emerge from a many-body system of interacting particles within a time-dependent Hartree-Fock mean-field theory at zero-temperature. To this end, we study the linear response of the system's reduced density matrix in a many-body perturbation theory and demonstrate that it can be expressed in terms of a generalized eigen-problem of the effective two-particle Hamiltonian of the electron-hole interaction. We then specify this formalism for the case of a crystal system and an atomistic electron-electron interaction, structuring the generalized eigen-problem in terms of the Bloch momentum and spin degrees of freedom. At last, we apply this theory to the case of hexagon boron nitride structures in a nearest-neighbor tight-binding model for the electronic Bloch states. We then solve the generalized eigen-problem numerically and obtain the excitonic states energies and wave-functions. Also, we comment on the role of screening in the Hartree and Fock interaction, on the numerical details of the generalized eigen-problem and on the reliability of the Tamm-Dancoff approximation.

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UNIVERSAL SPECTRAL PROPERTIES OF NOISY INTERMEDIATE SCALE QUANTUM CIRCUITS

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Present-day noisy intermediate-scale quantum (NISQ) computing platforms allow for implementing unitary circuits only on very limited size- and time-scales. While universal properties of random unitary circuits have been analyzed in detail, the question what happens to these unversilaties in the NISQ realm remains open. To answer the question, we implement different variational circuits on the IBM Quantum platform and model these implementations as quantum channels. To find parameters of the channels, we perform series of tomography-like experiments and process the results with a machine learning algorithm. We demonstrate that the spectra of the recovered channels exhibit universal properties typical to a recently introduced ensemble of quantum maps, which allows for a complete analytical evaluation. Our results establish novel connections between NISQ computing, machine learning, and random matrix theory, and highlight the present-day quantum computer prototypes as flexible experimental platforms to explore phenomena of Dissipative Quantum Chaos.

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Évora and how to reach it

Évora is located in the south of Portugal, about 130 km east of Lisbon. The monumental feature of Évora - together with its picturesque aspect - made UNESCO include its historic centre in its list of cultural heritage of mankind.

Follow this link (City of Évora) to find more:
http://www2.cm-evora.pt/guiaturistico/Ingles/itinerary.htm

Find below information about the connections Lisbon-Évora and Évora-Lisbon both by train or bus.

By bus:

From the Lisbon International Airport you should take the metro red line, which is the only line available, to the end of the line (São Sebastião station). There you should change to the blue line, Amadora Este direction, and leave at Sete Rios Station (two metro stations).

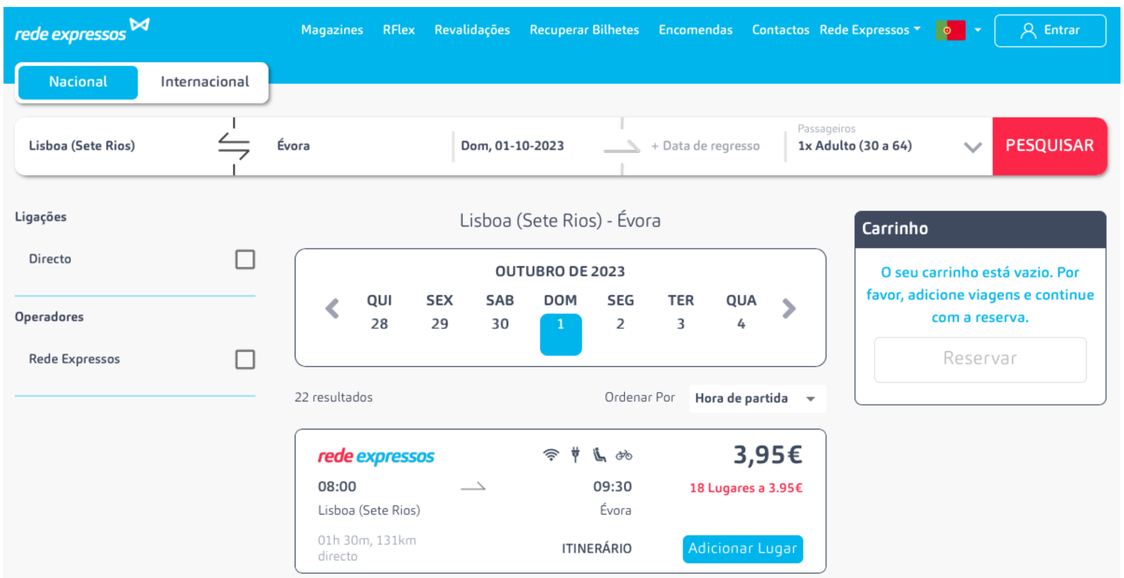
At the bus station in Sete Rios you can take a direct bus to Évora. The journey will last approximately 1h40. This is the address of the Bus Station:

RNE - Rede Nacional de Expressos, Lda
Terminal Rodoviario de Sete Rios
Praça Marechal Humberto Delgado - Estrada das Laranjeiras
1500-423 LISBOA

Bus Timetables

In the link below you will find departure and arrival timetables to and from Évora:

https://rede-expressos.pt/pt/horarios-bilhetes



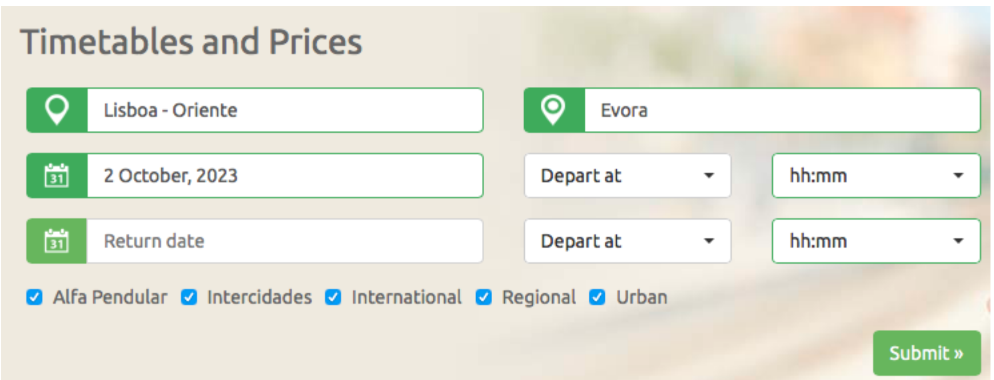
By train:

From the Lisbon International Airport you should take the metro red line, which is the only line available, to the Oriente metro station (three metro stations). At the Oriente Railway Station you can take an intercity train to Évora. The journey will last approximately 1h.30.

Train Timetables

In the link below you will find departure and arrival timetables to and from Évora:

https://www.cp.pt/sites/passageiros/en/train-times



Wireless

HOW TO CONNECT TO WIRELESS NETWORK:

1st STEP:

1- Enable **Wireless connection**

2- Manually add **Wireless Network or Network Profile**

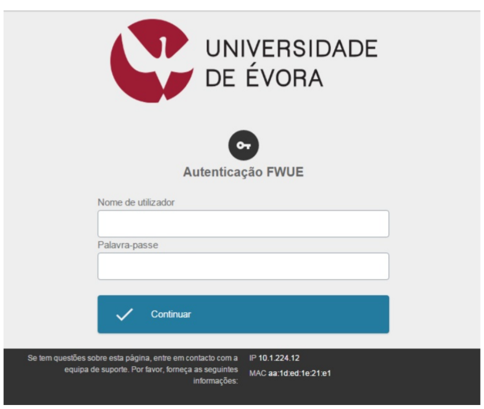
3- Configurations:

network's name: **FWUE**
security: **None** or **No Authentication (Open)**
select: **Start this connection automatically**
select: **Connect even if the network is not broadcasting**

2nd STEP:

Turn on your web browser.

The first time you enter FWUE the Internet access is disabled. When trying to access any page will be redirected to the following page:



The access credentials are::

USERNAME: cdnbqs
PASSWORD: UEvora3319

After entering the credentials a second screen appears. It is not strictly necessary to restart the browser, it is only a recommendation to ensure compability.

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