DY 47: Quantum Chaos and Coherent Dynamics (joint session DY/TT)

Time: Thursday 15:00–17:45 Location: A 151

DY 47.1 Thu 15:00 A 151

Probing the anisotropic scattering model in ultrapure Delafossites — •Linus Holeschovsky, Carsten Putzke, and Philip Moll — Max-Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany

Anisotropic scattering models have been used to describe the strange metal phase of overdoped cuprates. They stem from the idea of two distinct, k-dependent live-times of quasi-particles. This description is one among many trying to explain the strange metal phase and remains highly debated. On the other hand, the ultrapure delafossite PdCoO2 and PtCoO2 show two distinct quantum coherence lengths that can be explained by two different scattering times. These delafossite are particularly interesting due to their extremely long mean free path and moderate electronic correlation. This gives access to underlying physical properties, which can be theoretically explained within well-established theoretical models.

In this study, angle-dependent magnetic oscillation is used to investigate the anisotropic scattering time in microstructured PdCoO2 and PtCoO2. Specifically, a two-axis rotator is used to probe the coherence peak of interlayer transport in different crystallographic directions, which is particularly sensitive to scattering times. The anisotropy and temperature dependence of the scattering time can therefore be mapped on the Fermi surface. In this talk, we emphasize how the relative simplicity and textbook-like behavior of the delafossite materials make them prime candidates to probe physical models otherwise difficult to verify but were proposed in more complex materials.

DY 47.2 Thu 15:15 A 151

Semiclassical structure of resonance states in chaotic scattering — Roland Ketzmerick, •Florian Lorenz, and Jan Robert Schmidt — TU Dresden, Institute of Theoretical Physics, Dresden, Germany

We introduce a classical multifractal measure that describes resonance states with decay rate γ in the semiclassical limit. This measure (i) maximizes an entropy-like quantity and (ii) is conditionally invariant with the same decay rate γ. It is derived from a local random vector model and replaces previous approximate approaches. This supports the recently proposed factorization conjecture, that resonance states are a product of a classical measure and universal fluctuations [1]. These results are numerically demonstrated for optical microcavities.

[1] R. Ketzmerick, K. Clauß, F. Fritzsch, and A. Bäcker, Chaotic resonance modes in dielectric cavities: Product of conditionally invariant measure and universal fluctuations, Phys. Rev. Lett. **129**, 193901 (2022).

DY 47.3 Thu 15:30 A 151

Quasiclassical description of out-of-time-ordered correlators — •Thomas Michel[1], Juan Diego Urbina[2], and Peter Schlagheck[1] — [1]CESAM Research Unit, University of Liège, 4000 Liège, Belgium — [2]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

Out-of-time-ordered correlators (OTOCs) are quantum objects that can be used as a probe for quantum chaos. They characterise information scrambling, more specifically, how a local operator commute with another local operator that is time-evolved. We present a quasiclassical formalism of OTOCs using the semiclassical van Vleck-Gutzwiller propagator in combination with the diagonal approximation. For short time, we recover the same result as with the Wigner-Moyal formalism, yielding an initial exponential growth of the correlator. For long times and fully chaotic dynamics, this quasiclassical formalism yields a finite saturation value of the OTOC. However, as we verified in Bose-Hubbard systems, this quasiclassical saturation value is found to be small compared to the actual quantum OTOC saturation threshold. This finding shows the importance of effects beyond quasiclassical physics related to trajectory pairs with small-angle crossings, as was pointed out in Ref. [1].

[1] 1.Rammensee, J., Urbina, J.-D. & Richter, K. Many-Body Quantum Interference and the Saturation of Out-of-Time-Order Correlators. Phys. Rev. Lett. 121, 124101 (2018).

DY 47.4 Thu 15:45 A 151

A semiclassical approach to mode entanglement in Bose-Hubbard systems — •Sebastian Hörhold, Juan Diego Urbina, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany

Entanglement is the fundamental mechanism behind phenomena as equilibration and decoherence [1] in many-body systems. Degrees of freedom of bosonic theories, describing for example cold atoms in optical lattices, are represented by complex matter fields at each lattice point and one speaks then of mode entanglement. In a semiclassical approach [2] based on interfering mean-field paths in Fock space, describing mode entanglement becomes rather cumbersome [3] as the path integral is constructed by using product states.

The aim of our work is to incorporate entanglement at the level of the path integral, similar to what has been done for matrix product states in spin systems [4]. We address then whether the effective classical description, closely related to the time-dependent variational approach [5], captures the emergence of entanglement.

[1] M. Rigol, V. Dunjko and M. Olshanii, Nature 452, 854-858
[2] K. Richter, J. D. Urbina and S. Tomsovic, J. Phys. A: Math. Theor. 55 453001
[3] S. Tomsovic et al., Phys. Rev. A 97, 061606(R)
[4] A. G. Green et al., arXiv:1607.01778v1
[5] J. Haegeman et al., arXiv:1103.0936v2

DY 47.5 Thu 16:00 A 151

Chaotic escape dynamics in the vicinity of hyperbolic fixed points — •Alexander Hempel, Jonas Stöber, and Arnd Bäcker — TU Dresden, Institute of Theoretical Physics, Dresden, Germany

For an ensemble of orbits started in the vicinity of a hyperbolic fixed point in the area-preserving standard map, we find a slow, non-exponential decay of the survival probability. We show that this is governed by the stable and unstable manifolds which form a partial barrier enclosing a resonance zone. The re-entrance of orbits into the resonance zone and the statistics of transit times leads to a simple model, which explains the initial decay of the survival probability. Furthermore we briefly discuss quantum mechanical consequences.

15 min. break

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Higher-order exceptional points in waveguide-coupled microcavities — •Julius Kullig[1], Daniel Grom[1], Sebastian Klembt[2], and Jan Wiersig[1] — [1]Institut für Physik, Otto-von-Guericke-Universität Magdeburg, Magdeburg, Germany — [2]Physikalisches Institut and Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, University of Würzburg, Würzburg, Germany

Open quantum and wave systems exhibit fascinating and exotic behavior described by non-Hermitian physics. A key feature of such systems are exceptional points (EPs) in the parameter space. At these EPs the eigenvalues of the Hamiltonian become degenerate and simultaneously the corresponding eigenstates coalesce. Consequently, the system has interesting chiral eigenstates and is highly sensitive to external perturbations. A hot topic of current research is the creation of high-order EPs, where more than two eigenstates coalesce. In this talk, we present an intuitive and robust implementation of high-order EPs in photonic structures consisting of waveguide-coupled microring cavities. Combining the unidirectional coupling from the waveguide with mirror-induced asymmetric backscattering, we can increase the order of the EPs even further. Furthermore, we demonstrate that our setup allows for an easy realization of non-generic perturbation schemes.

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Non-Hermitian mesoscopic optics in coupled microcavities — •Tom Rodemund[1], Síle Nic Chormaic[2], and Martina Hentschel[1] — [1]Institute of Physics, Chemnitz University of Technology, Chemnitz, Germany — [2]Okinawa Institute of Science and Technology Graduate University, Okinawa, Japan

Coupled cavities are of interest as they expose qualitatively new effects, such as non-Hermitian properties, that are not accessible using an individual cavity. Here, we study two coupled two-dimensional microdisk cavities of circular and deformed (limaçon) shape, which are in the focus of interest due to their high emission directionality [1].

We investigate their coupling-induced properties as a function of intercavity distance and identify characteristic coupling regimes, with clear signatures of the presence of another cavity even deep in the weak couling regime. For deformed coupled microcavities, the asymmetry of the intercavity coupling implies non-Hermitian properties prominently evident in the chirality of the coupled cavity modes. We use an analytical model to explain our findings and reveal the direct connection between coupling asymmetry and the resulting sense of rotation of the coupled modes. This could prove useful for future applications such as far-field emission control of coupled cavities.

[1] Kreismann et al., *Phys. Rev. Res.* **1** 033171 (2019)

DY 47.8 Thu 17:00 A 151

Tuning phase space and far-field emission in anisotropic bilayer-graphene cavities — •Lukas Seemann[1], Angelika Knothe[2], and Martina Hentschel[1] — [1]Technische Universität Chemnitz, 09107 Chemnitz, Germany — [2]Universität Regensburg, 93040 Regensburg, Germany

Ray-wave correspondence is a well-known tool in optics. Its generalization to Fermi electron optics in 2D materials allows for the description of ballistic charge carrier transport, e.g. in gate-defined cavities [1]. Here we focus on bilayer graphene (BLG) with a trigonal warped Fermi line. Its anisotropic disperion relation with three preferred propagation directions implies an electron dynamics in BLG cavities that differs significantly from the optical case [2]. In this work we investigate the interplay of momentum and real space asymmetries by combining the anisotropic dispersion relation with a deformed cavity. We investigate the resulting charge carrier dynamics in o'nigiri shaped cavities where the latter provides the same C3 symmetry as the BLG Fermi line. We study its signatures in phase space and explain how it translates into the far-field. Its properties can be fine-tuned by choosing appropriate material parameters for the BLG system, by the cavity geometry, and the tilt angle between BLG lattice and cavity axis which opens a broad venue for applications.

[1] J.-K. Schrepfer, S. Chen, M.-H. Liu, K. Richter, and M. Hentschel, Phys. Rev. B 104, 155436 (2021)
[2] Lukas Seemann, Angelika Knothe, and Martina Hentschel Phys. Rev. B 107, 205404 (2023)

DY 47.9 Thu 17:15 A 151

Non-abelian invariants in periodically-driven quantum rotors — •Volker Karle, Areg Ghazaryan, and Mikhail Lemeshko — Institute of Science and Technology Austria, Am Campus 1, 3400 Klosterneuburg

This presentation explores the role of topological invariants in the non-equilibrium dynamics of periodically-driven quantum rotors, inspired by experiments on closed-shell diatomic molecules driven by periodic, far-off-resonant laser pulses. This approach uncovers a complex phase space with both localized and delocalized Floquet states. We demonstrate that the localized states are topological in nature, originating from Dirac cones protected by reflection and time-reversal symmetry. These states can be modified through laser strength adjustments, making them observable in current experiments through molecular alignment and observation of rotational level populations. Notably, in scenarios involving higher-order quantum resonances leading to multiple Floquet bands, the topological charges become non-Abelian. This results in the remarkable finding that the exchange of Dirac cones across different bands is non-commutative, enabling non-Abelian braiding, paving the way for the study of controllable multi-band topological physics in gas-phase experiments with small molecules, as well as for classifying dynamical molecular states by their topological invariants.

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Unveiling out of time correlators in stochastic operator variance — •Aritra Kundu — Univeresity of Luxembourg

This study introduces the stochastic operator variance (SOV) as a tool for investigating quantum systems influenced by noise. We present a protocol that utilizes noise to probe out-of-time-order correlators and extract the Lyapunov exponent in a noisy quantum chaotic system. We demonstrate SOV in both quantum and classical realms by introducing a stochastic version of the Lipkin-Meshkov-Glick (LMG) model. We further examine analytical and numerical demonstrations of a stochastic LMG Hamiltonian undergoing energy dephasing. In the classical limit, we provide analytical results for the Lyapunov exponents. This research contributes to understanding the interplay between noise and quantum dynamics for benchmarking near-term noisy quantum devices.