# DY 39: Quantum matter: Chaos, correlation

Time: Wednesday 17:15–18:30 Location: H6

DY 39.1 Wed 17:15 H6

**Quantum signatures of a classical dynamical transition** — •Remy Dubertrand[1], Mathias Steinhuber[1], Juan-Diego Urbina[1], Denis Ullmo[2], Peter Schlagheck[3], Klaus Richter[1], and Steve Tomsovic[4] — [1]Institut für Theoretische Physik Universität Regensburg Universitätsstraße 31 D-93053 Regensburg — [2]LPTMS, CNRS, Univ. Paris-Sud, Universite Paris-Saclay, 91405 Orsay, France — [3]CESAM research unit, University of Liege, 4000 Liege, Belgium — [4]Department of Physics and Astronomy, Washington State University, Pullman, WA 99164-2814, USA

We consider the quantum dynamics of a coherent density wave under Bose-Hubbard model. It was recently shown [1] that the corresponding classical density undergoes a dynamical transition between an ergodic and a nonergodic regime. This is due to a dramatic change of the stability of the associated classical trajectories, when changing the ratio between hopping and onsite interaction energy. We claim in [2] that this dynamical transition can be very clearly seen through purely quantum observables. This provides with a generalisation of the seminal self-trapping transition [3] to higher dimension. A possible way to observe it in a cold-atom experiment is also discussed.

[1] S. Tomsovic, Phys. Rev. E 98, 023301 (2018)

[2] R. Dubertrand, M. Steinhuber, J.-D. Urbina, D. Ullmo, P. Schlagheck, K. Richter, S. Tomsovic, in preparation

[3] J. C. Eilbeck, P. S. Lombdahl, A. C. Scott, Physica D 16, 318 (1985)

DY 39.2 Wed 17:30 H6

**Effect of hopping correlations on localization** — Pavel Nosov[1,2,3], •Ivan Khaymovich[3], and Vladimir Kravtsov[4] — [1]Department of Physics, St. Petersburg State University, St. Petersburg 198504, Russia — [2]NRC Kurchatov Institute, Petersburg Nuclear Physics Institute, Gatchina 188300, Russia — [3]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187-Dresden, Germany — [4]Abdus Salam International Center for Theoretical Physics - Strada Costiera 11, 34151 Trieste, Italy

The standard picture of the 3d Anderson localization is known to be restored in low-dimensional systems by adding either the correlations in the diagonal disorder or long-range hopping terms.

Recently, the Anderson's picture has been argued by providing counterintuitive examples of long-ranged systems with almost all localized states even in a nominally ergodic regime. These "new" models demonstrate either critical or localized wavefunction behavior with a "mysterious" duality of decay rates [1]. These systems belong to a new universality class where the localization properties are governed by hopping correlations.

In my talk I provide general localization-delocalization principles [2] needed for such models to find a full phase diagram and uncover the role of correlations and the origin of the duality [1]. I present a new class of random Hamiltonians with translation-invariant hopping terms demonstrating the duality in the momentum and coordinate space.

[1] X. Deng et al., PRL 120, 110602 (2018). [2] P. A. Nosov, I. M. Khaymovich, and V. E. Kravtsov, arXiv:1810.01492 (2018).

DY 39.3 Wed 17:45 H6

**Logarithmic spreading of out-of-time-ordered correlators without many-body localization** — •Adam Smith[1], Johannes Knolle[1,2], Roderich Moessner[3], and Dmitry Kovrizhin[4,5] — [1]T.C.M. group, Cavendish Laboratory, Cambridge, UK — [2]Blackett Laboratory, Imperial College London, London, UK — [3]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [4]Rudolf Peierls Centre for Theoretical Physics, Oxford, UK — [5]NRC Kurchatov institute, Moscow, Russia

Out-of-time-ordered correlators (OTOCs) have received renewed attention in the studies of non-equilibrium quantum many-body dynamics. They describe information scrambling under unitary time evolution and provide a useful probe of the emergence of quantum chaos. Here we calculate OTOCs for a model of disorder-free localization whose exact mapping to free fermions allows us to study long-time behaviour in large systems. Remarkably, we observe logarithmic spreading of correlations, which is markedly different to that of both thermalizing and Anderson localized systems. While this behaviour is a signature of many-body localization, our findings are for an essentially non-interacting model. We provide an explanation for this unusual behaviour and suggest a novel Loschmidt echo protocol as a probe of correlation spreading.

DY 39.4 Wed 18:00 H6

**Information dynamics in chaotic electron systems** — •Markus Klug[1] and Sergey Syzranov[2] — [1]Karlsruher Institut für Technologie, Karlsruhe, Deutschland — [2]University of California, Santa Cruz, USA

Chaotic systems are by definition exponentially sensitive to initial conditions. The chaotic dynamics of quantum systems are characterized by Lyapunov exponents $\lambda_L$, the rates of growth of the so-called out-of-time order correlators, quantities of the form $\langle [P(t), P(0)]^2 \rangle \propto \exp(\lambda_L t)$, where $P$ is an observable, e.g. the total momentum of the electrons in a quantum dot. In this work, we compute $\lambda_L$ for electrons in the presence of neutral excitations, such as plasmons or phonons, in a weakly disordered metal. We demonstrate that the rate of exponential growth matches the rate of change of information associated with the uncertainty in the system's total momentum. Our work establishes for the first time explicit connection between quantum chaos characteristics and the rate of change of information stored in a system's observable and thus presents a way to measure $\lambda_L$ in experiments.

DY 39.5 Wed 18:15 H6

**Bloch-like oscillations in periodically driven Dirac systems** — •Vanessa Junk[1], Phillipp Reck[2], Cosimo Gorini[1], and Klaus Richter[1] — [1]Institut für Theoretische Physik, Universität Regensburg, Germany — [2]CEA, Paris-Saclay, France

Since the discovery of Floquet topological insulators [1] the scientific interest in periodically driven systems has been growing rapidly. However, there are still a lot of open questions concerning the dynamics of particles in the Floquet quasi-band structure and analogies to undriven Bloch bands.

We show that Bloch-like oscillations can be observed in a continuous Dirac system when periodically opening a mass gap. By applying an additional static electric field, a particle is driven through the resulting Floquet quasi-band structure. As this band structure is oscillatory in k-space, the position- and velocity expectation value of the particle are oscillating as well and resemble those of conventional Bloch oscillations [2]. Additionally, the characteristic features of the Floquet quasi-bands are displayed in the movement of the particle. Hence, these Floquet-Bloch oscillations could also provide a way to directly measure the quasi-band structure. On top of that, we find features of Zitterbewegung in the particle velocity caused by the Dirac character of our system.

[1] N. H. Lindner, G. Refael, and V. Galitski, Nature Physics **7**, 13368 (2016)

[2] K. Leo, P. Haring Bolivar, F. Brüggemann, R. Schwedler, and K. Köhler, Solid State Comm. **84**, 943 (1992)