Q 6: Quantum Effects (Disorder and Entanglement)

Time: Monday 11:00–13:00 Location: f342

Invited Talk Q 6.1 Mon 11:00 f342

Hilbert space structure of eigenstates in many-body quantum systems — •Alberto Rodríguez — Departamento de Física Fundamental, Universidad de Salamanca, E-37008 Salamanca, Spain

Basic features of a quantum system, such as its dynamical behaviour or its stability to perturbations, depend crucially on the statistical properties of its spectrum and eigenstates. In this talk, we will explore the characterization of the eigenstate structure in Hilbert space for interacting particles, borrowing the tools from multifractal analysis, which has a long history in the field of Anderson localization. We will discuss to which extent such formalism is able to unveil the complexity of many-body eigenstates and capture the existence of different 'phases' in the system [1-3], touching also upon the underlying connection with the emergence of spectral chaos [4].

[1] J. Lindinger, A. Buchleitner, A. Rodríguez, PRL 122, 106603 (2019).
[2] D. J. Luitz, F. Alet, N. Laflorencie, PRL 112, 057203 (2014).
[3] N. Macé, F. Alet, N. Laflorencie, PRL 123, 180601 (2019).
[4] A. R. Kolovsky, A. Buchleitner, Europhys. Lett., 68, 632 (2004).

Q 6.2 Mon 11:30 f342

Extending the SSH Model Beyond Nearest Neighbour Interactions — •Ciarán McDonnell[1] and Beatriz Olmos[2] — [1]Centre for the mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, School of Physics and Astronomy, University of Nottingham, University Park, Nottingham, NG7 2RD, UK. — [2]Auf der Morgenstelle 14 72076 Tübingen

The Su-Schrieffer-Heeger (SSH) model was first used to describe the transport dynamics of polyacetylene in 1979. The nearest neighbour model has since effectively described the dynamics in a wide range of systems. These systems as a result can exhibit topological phases and are known as topological insulators. Little work has been done to extend the SSH model beyond the nearest neighbour regime, with none of the work extending beyond three nearest neighbours. We use a nanofiber waveguide coupled to two-level atoms to theoretically explore an arbitrary number of interactions. We first look at the case where the system is chiral symmetric find a general criterion for the topological phases of the system and find the corresponding edge states. We then extend to the non-chiral symmetric case and investigate how this affects the presence of edge states.

Q 6.3 Mon 11:45 f342

Bose-Einstein Condensation of Light in Disordered Nano Cavities at Room Temperature — •Andris Erglis[1] and Andrea Fratalocchi[2] — [1]Institute of Physics, Albert-Ludwigs University of Freiburg, Germany — [2]PRIMALIGHT, King Abdullah University of Science and Technology (KAUST), Saudi Arabia

Bose-Einstein condensation is a macroscopic occupation of bosons in the lowest energy state. For atoms, temperatures near absolute zero kelvin are required to observe this phenomenon. For photons, condensation has been demonstrated at room temperature, requiring a large number of particles and very complicated setup.

Here we study the possibility of observing BEC of light at room temperature without a constraint on the number of photons in the system by leveraging disorder in a dielectric material. We demonstrate that photons in a disordered cavity with any initial statistical distribution in the steady state will reach thermal equilibrium and undergo Bose-Einstein condensation if the temperature is sufficiently reduced. At this point the photons follow a Boltzmann distribution. The analysis is carried out by using time-dependent quantum Langevin equations, complemented by a thermodynamic analysis. Both approaches give the same expression for the critical temperature of condensation. We demonstrate that the temperature is related to the losses of the system. By only varying the strength of disorder, it is possible to change the critical temperature of the phase transition, thus making condensation possible at room temperature. This work opens up the possibility to create new types of light condensate by using disorder.

Q 6.4 Mon 12:00 f342

Observation of Non-Hermitian Anderson Transport — •Sebastian Weidemann[1], Mark Kremer[1], Stefano Longhi[2], and Alexander Szameit[1] — [1]Experimental Solid State Optics Group, Institute of Physics, University of Rostock, Germany — [2]Dipartimento di Fisica, Politecnico di Milano, Piazza L. da Vinci 32, Milano I-20133, Italy

It was a major breakthrough for the understanding of conductance in solids when Anderson showed that stochastic imperfections in crystalline lattices can result in self-trapping of a single electron via quantum interference. For the underlying mechanism, called Anderson localization, disorder is described by random changes only in the real part of the potential. We take a new perspective within the study of disorderd systems by asking whether the concepts of localization and transport carry over to the more general context of open systems when random changes occur also in the imaginary part of the potential. To this end we employ light propagation in a photonic lattice with tunable dissipation as a model system. The controllable dissipation allows to realize nearly arbitrary complex potentials. Our theoretical and experimental findings reveal a novel non-Hermitian transport mechanism: The imaginary disorder not only leads to a fully localized eigenmode spectrum like in the Hermitian case, but also causes surprising transport dynamics that is characterized by ultra-far jumps and a restoration of ballistic spreading. Beyond the experimental observation of this „Anderson Transport“, we provide a theoretical explanation by giving the analytical solution for a corresponding chain model.

Q 6.5 Mon 12:15 f342

Constructing a Light Funnel with the non-Hermitian Skin Effect — •Mark Kremer[1], Sebastian Weidemann[1], Tobias Helbig[2], Tobias Hofmann[2], Alexander Stegmaier[2], Martin Greiter[2], Ronny Thomale[2], and Alexander Szameit[1] — [1]Institut of Physics, University of Rostock, Albert-Einstein-Straße 23, 18059 Rostock, Germany — [2]Department of Physics and Astronomy, Julius-Maximilians-Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

The interaction of physical systems with the environment were often considered undesired, until it was demonstrated that certain loss distributions can lead to intriguing effects, like enhanced sensing, or mode selective laser cavities. However, most of these works, especially in optics, introduce non-Hermiticity by applying tailored loss profiles, thereby restricting it to a subset of physical models. In our work, we realize non-Hermiticity by coupling anisotropy – an often neglected degree of freedom. In a periodic lattice with such anisotropic coupling, the incorporation of an interface causes all eigenmodes to localize at this interface. This *non-Hermitian skin effect* is an interesting aspect of the current debate about the validity of the bulk boundary correspondence. We experimentally implement the skin effect with a large-scale photonic mesh lattice and demonstrate the collapse of all eigenmodes at the interface, with no delocalized bulk modes remaining. As a result, the system acts as a funnel for light: Any wave packet, regardless of its original position in the lattice, is routed to the interface and remains there indefinitely.

Q 6.6 Mon 12:30 f342

Mode-independent quantum entanglement for light — •Jan Sperling[1], Armando Perez-Leija[2], Kurt Busch[2], and Christine Silberhorn[1] — [1]University of Paderborn, Warburger Str. 100, 33098 Paderborn, Germany — [2]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany

Optical mode transformations, such as beam-splitter operations, can significantly alter the entanglement properties of quantum states of light. For example, such global unitary maps can generate entanglement from initially separable states, and vise versa. In this talk, we report on the construction of families of photonic states with the unique property that their entanglement is in fact preserved under arbitrary mode transformations. We develop tools to characterize the specific features of the resulting multi-photon and multi-mode states of quantum light. In contrast to most examples of optical implementations of entangled states, the type of entanglement we introduce offers a new resource of quantum correlations for quantum communications which is robust even under global mode transformations.

Q 6.7 Mon 12:45 f342

Quantum manybody systems with neural networks — •Felix Behrens, Stefanie Czischek, Martin Gärttner, and Thomas Gasenzer — KIP, Heidelberg

The idea of connecting artificial neural networks and quantum mechanics gained a lot of interest over the last years. A representation of arbitrary quantum many-body states using a specific kind of artificial neural network, the restricted Boltzmann machine, has been introduced in [1]. With a generative model approach, any state can be represented. In the framework of Positive Operator Valued Measures (POVM), time evolution eg. following Heisenberg equation, can be represented for a probability distribution. We implement this ansatz with standard machine learning techinques for Restricted Boltzmann Machine (RBM). Given some, hypothetically measured, data, the RBM facilitates fast sampling from the underlying probability. Those samples can in principle be used for a Monte-Carlo like integration of the time evolution and for measuring any operator. The next qurstion to ask is, how statistical noise in the RBM implementation violates physical constraints on the state and its expectation values and how to restrict the RBM representation to its physical subspace. [1] Juan Carrasquilla, arXiv:1810.10584, Oct 2018.