Q 15: Quantum Effects: Disorder

Time: Monday 17:00–18:15 Location: f442

Q 15.1 Mon 17:00 f442

Perturbative approach to the effective dynamics of disordered quantum systems — •Chahan Kropf, Clemens Gneiting, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, D-79104, Freiburg, Deutschland

The ensemble average dynamics of disordered quantum systems can be effectively described by quantum master equations [1]. In the cases of spectral disorder and of isotropically disordered eigenvector distributions one can derive master equations which are valid for arbitrary times. Furthermore, in the limit of short-times, an explicit form valid for any disorder distribution can be derived [2]. We will show how this latter result can be expanded to longer time scales by using perturbation theory – which is needed to diagonalize the Hamiltonians of the single realizations of the disorder – prior to the ensemble average. As an example, we will discuss the validity of this approach for a specific application to the Anderson model.

[1] C. Kropf, C. Gneiting, and A. Buchleitner, arXiv:1511.08764 (2015)

[2] C. Gneiting, F. R. Anger, and A. Buchleitner, arXiv:1508.07187 (2015).

Q 15.2 Mon 17:15 f442

Many-Body Localization and Discrete Spectrum Imply Simple Dynamics — •Deniz Stiegemann[1], Pieter Naaijkens[2], and Tobias Osborne[1] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany — [2]Department of Mathematics, University of California, Davis, USA

In a quantum spin lattice, the time-evolution is usually generated by a local Hamiltonian, e.g. consisting of nearest-neighbour interactions. We prove that if a system exhibits strong dynamical localization and has a discrete and non-degenerate spectrum, then the local Hamiltonian can be replaced with a modified Hamiltonian which consists of pairwise commuting terms. This modified Hamiltonian still generates the same dynamics as the original local Hamiltonian, and there is a trade-off between the smallest gap in the spectrum and the degree of locality of the modified Hamiltonian. We discuss the result for both finite and infinite systems.

Q 15.3 Mon 17:30 f442

Analytical description of wave packet expansion in a one dimensional disordered potential — •Juan Pablo Ramirez Valdes, Andreas Buchleitner, and Thomas Wellens — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3a, 79104 Freiburg, Germany

We present an analytic description of the asymptotic disorder-averaged probability density of an initially strongly confined wave packet in a one-dimensional weak, random potential with finite correlation length. At long times, the expansion of the wave packet comes to a halt due to destructive interferences leading to Anderson localization, the signature of which is the exponential decay of the energy eigenfunctions. But in the case of a wave packet, there is an additional element in the description: the asymptotic state is determined by the superposition of partial waves with different energies E. Using diagrammatic techniques, it is possible to calculate the asymptotic state at fixed energy E [1]. Combining this result with a self-consistent equation for the spectral density of the wave packet [2], we derive an analytical expression for the asymptotic average density, which is compared with the results of numerical simulations.

[1] V. L. Berezinskii, Sov. Phys. JETP 38, 620 (1974).

[2] Bertrand I. Halperin, Phys. Rev. 139, A104 (1965).

Q 15.4 Mon 17:45 f442

Optimal currents of indistinguishable fermions — •Mattia Walschaers[1,2], Andreas Buchleitner[2], and Mark Fannes[1] — [1]Instituut voor Theoretische Fysica, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium — [2]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, D-79104 Freiburg, Germany

We study currents of indistinguishable particles, in disordered systems far from equlibrium. Our goal is to identify fundamental bounds to the particle flow, and design principles to saturate these bounds. In the fermionic case, for weak coupling between system and reservoirs, we introduce a symmetry-based mechanism to enhance the flow. This mechanism is broadly applicable provided the inter-particle interactions are small with respect to quantum statistical effects.

Q 15.5 Mon 18:00 f442

Unitary 2-designs and Decoupling with Random Diagonal-Unitary Matrices — Yoshifumi Nakata[1], •Christoph Hirche[1], Ciara Morgan[2], and Andreas Winter[1] — [1]Física Teòrica: Informació i Fenòmens Quàntics, Universitat Autònoma de Barcelona, ES-08193 Bellaterra (Barcelona), Spain — [2]School of Mathematics and Statistics, University College Dublin, Belfield, Dublin 4. Ireland

We investigate unitary 2-designs and decoupling, two of the most important primitives in quantum Shannon theory, with random diagonal-unitaries. We first show that the alternate application of random diagonal-unitaries in the Pauli-Z and -X bases constitutes a unitary 2-design after a number of repetitions, implying that the process achieves decoupling. We then go on to show that even fewer repetitions are sufficient for achieving decoupling at the same rate as that with Haar random unitaries. We also provide a simple quantum circuit that implements a unitary 2-design and achieves decoupling, which is partitioned into a constant number of commuting parts.