DY 11: Many-Body Quantum Dynamics II (joint session DY/TT)

Time: Thursday 10:00–11:30 Location: H2

DY 11.1 Thu 10:00 H2

Anderson localization of composite particles — •Fumika Suzuki[1], Mikhail Lemeshko[2], Wojciech Zurek[3], and Roman Krems[4] — [1]IST Austria (Institute of Science and Technology Austria) — [2]IST Austria (Institute of Science and Technology Austria) — [3]Los Alamos National Laboratory — [4]University of British Columbia

We investigate the effect of coupling between translational and internal degrees of freedom of composite quantum particles on their localization in a random potential. We show that entanglement between the two degrees of freedom weakens localization due to the upper bound imposed on the inverse participation ratio by purity of a quantum state. We perform numerical calculations for a two-particle system bound by a harmonic force in a 1D disordered lattice and a rigid rotor in a 2D disordered lattice. We illustrate that the coupling has a dramatic effect on localization properties, even with a small number of internal states participating in quantum dynamics.

arXiv:2011.06279

DY 11.2 Thu 10:15 H2

An SYK-inspired model with density-density interactions — •Johannes Dieplinger[1], Soumya Bera[2], and Ferdinand Evers[1] — [1]Institute of Theoretical Physics, University of Regensburg, D-93040, Germany — [2]Department of Physics, Indian Institute of Technology Bombay, Mumbai 400076, India

Strong electron-electron interactions are challenging to capture theoretically. A rare example of an analytically tractable model is the Sachdev-Ye-Kitaev (SYK) model, which owes its tractability to the structureless and therefore artificial design: interactions are restricted to two body terms, whose matrix elements are randomly chosen and therefore do not commute with the local density, a fundamental symmetry of realistic electron-electron interactions. We here investigate a derivative of the SYK model, restoring this fundamental symmetry [1]. It features density-density-type interactions as well as a randomized single body term. We present numerical evidence that this model has a rich phase structure, featuring two integrable phases separated by several intermediate phases, including a chaotic one. The latter exhibits several key characterstics of the SYK model including the spectral and wave function statistics and therefore should be adiabatically connected to the non-Fermi liquid phase of the original SYK model. Thus, the presented model provides a further element for bridging the SYK-model and microscopic realism.

[1] J. Dieplinger, S. Bera, F. Evers, Annals of Physics, 168503 (2021)

DY 11.3 Thu 10:30 H2

Disorder-Free Localization in an Interacting 2D Lattice Gauge Theory — •Peter Karpov[1,2], Roberto Verdel[1], Yi-Ping Huang[3], Markus Schmitt[4], and Markus Heyl[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]National Univesity of Science and Technology “MISiS”, Moscow, Russia — [3]National Tsing Hua University, Hsinchu, Taiwan — [4]University of Cologne, Cologne, Germany

Disorder-free localization has been recently introduced as a mechanism for ergodicity breaking in low-dimensional homogeneous lattice gauge theories caused by local constraints. We show that also genuinely interacting systems in two spatial dimensions can become nonergodic due to this mechanism. This is all the more surprising since the conventional many-body localization is conjectured to be unstable in two dimensions; hence the gauge constraints represent an alternative robust localization mechanism for interacting models in higher dimensions.

Specifically, we demonstrate nonergodic behavior in the quantum link model by obtaining a bound on the localization-delocalization transition through a unconventional percolation problem implying a fragmentation of Hilbert space. We study the quantum dynamics in this system by introducing the method of “variational classical networks”, an efficient representation of the wave function in terms of a network of classical spins. We show that propagation of line defects has different light cone structures in the localized and ergodic phases.

[1] P. Karpov et al, Phys. Rev. Lett. **126**, 130401 (2021).
[2] R. Verdel et al, Phys. Rev. B **103**, 165103 (2021).

DY 11.4 Thu 10:45 H2

Superradiant many-qubit absorption refrigerator — Michal Kloc[1], Kurt Meier[1], Kimon Hadjikyriakos[2], and •Gernot Schaller[3] — [1]Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland — [2]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [3]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328, Dresden, Germany

We show that the lower levels of a large-spin network with a collective anti-ferromagnetic interaction and collective couplings to three reservoirs may function as a quantum absorption refrigerator. In appropriate regimes, the steady-state cooling current of this refrigerator scales quadratically with the size of the working medium, i.e., the number of spins. The same scaling is observed for the noise and the entropy production rate.

[1] arXiv:2106.04164

DY 11.5 Thu 11:00 H2

Bose condensation of squeezed light — •Klaus Morawetz — Münster University of Applied Sciences,Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics-UFRN,Campus Universitário Lagoa nova,59078-970 Natal, Brazil

Light with an effective chemical potential and no mass is shown to possess a general phase-transition curve to Bose-Einstein condensation. This limiting density and temperature range is found by the diverging in-medium potential range of effective interaction. While usually the absorption and emission with Dye molecules is considered, here it is proposed that squeezing can create also such an effective chemical potential. The equivalence of squeezed light with a complex Bogoliubov transformation of interacting Bose system with finite lifetime is established with the help of which an effective gap is deduced. This gap phase creates a finite condensate in agreement with the general limiting density and temperature range. The phase diagram for condensation is presented due to squeezing and the appearance of two gaps is discussed. Phys. Rev. B 99 (2019) 205124

DY 11.6 Thu 11:15 H2

Interplay of thermal and plasmonic THz nonlinearities on graphene — Jeongwoo Han[1], Mattew L. Chin[2], •Stephan Winnerl[3], Thomas E. Murphy[2], and Martin Mittendorff[1] — [1]Department of Physics, University of Duisburg-Essen, 47057 Duisburg, Germany — [2]University of Maryland, College Park, MD 20740, United States of America — [3]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

Due to the linear dispersion, graphene has attracted much attention as a material platform of nonlinear optics, in particular in the infrared regime. While for higher photon energies the nonlinearities are mostly related to interband transitions and Pauli blocking, in the infrared regime intraband and thermal effects dominate. Here we present the experimental evidence of nonlinear THz absorption beyond thermal effects, i.e., plasmonic nonlinearity, by employing polarization-resolved terahertz pump-probe measurements on graphene disks. By varying the polarization between pump and probe beam, i.e., co- and cross-polarized configurations, we observe a significant polarization dependence of the pump-induced change in transmission. To quantitatively analyze this observation, we develop numerical simulation, allowing us to understand the interplay between thermal and plasmonic nonlinearities. While both contribute to the co-polarized configuration, thermal effects dominate the nonlinearity in the cross-polarized configuration.