ISTA

Physical Sciences Seminar

The breakdown of photon blockade: a first-order dissipative quantum phase transition

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A nonequilibrium phase transition in a damped-driven open quantum system is a transition between two robust steady states controlled by an external parameter. In second-order transitions the change is abrupt at a critical point, whereas in first-order transitions the two phases can coexist in a critical hysteresis domain. Here, I present a first-order dissipative quantum phase transition, whose microscopic basis is that the photon blockade in a driven Jaynes-Cummings system (single atom coupled to a single mode of a resonator) is broken with increasing drive power [1,2]. The observed experimental signature is a bimodal phase-space distribution with varying weights controlled by the drive strength. Alternatively, in the time domain, a bistable signal is obtained, with switching times separated by orders of magnitudes from any microscopic timescales of the system, and reaching up to seconds [3]. We identify a well-defined thermodynamic limit, where the bistability solution develops into the first-order phase transition. The bistability can be regarded as a finite-size signature of the phase transition, and we can calculate the finite-size scaling exponent numerically [4]. Importantly, even in the thermodynamic limit, the stability of phases originates from the discrete spectrum of the small quantum system, the switching being induced by the continuous weak measurement of the system by the environment. At the end of the talk, I will sketch the simulation tool used for these studies, that is C++QED: a framework for simulating open quantum dynamics [5,6] conceived for supercomputing environments.References: [1] A. Dombi et al. Eur. Phys. J. D 69, 60 (2015) [2] H. J. Carmichael, Phys. Rev. X 5, 031028 (2015) [3] J. M. Fink et al. Phys. Rev. X 7, 011012 (2017) [4] A. Vukics et al. Quantum 3, 150 (2019) [5] A. Vukics, Comp. Phys. Comm. 183, 1381-1396 (2012) [6] https://github.com/vukics/cppqed

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Heinzel Seminar Room / Office Bldg West (I21.EG.101)

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