Studying absorbing-state phase transitions in a cold Rydberg gas

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Phase transitions in non-equilibrium systems have been extensively studied in recent years but continue to pose challenges. One example of such a phase transition is that between a non-fluctuating absorbing phase [1], e.g., an extinct population, and one in which the relevant order parameter, such as the population density, assumes a finite value. Here we report on experimental studies of such a non-equilibrium phase transition in an open driven quantum system. In our experiment, rubidium atoms in a quasi one-dimensional cold disordered gas are excited to Rydberg states by the facilitation mechanism [2]. This conditional excitation process (which in the present work occurs in the incoherent regime and can thus be described by a rate equation) competes with spontaneous decay and leads to a crossover between a stationary state with no excitations and one with a finite number of Rydberg excitations as a function of the driving strength [3] (see figure). We observe a characteristic power-law scaling of the Rydberg excitation density (inset of figure) as well as increased fluctuations close to the transition point (dashed line in the figure). Our study [4] paves the road towards future investigations into the largely unexplored physics of non-equilibrium phase transitions in open many-body quantum systems, both in the semi-classical (incoherent) and in the quantum (coherent) regime.

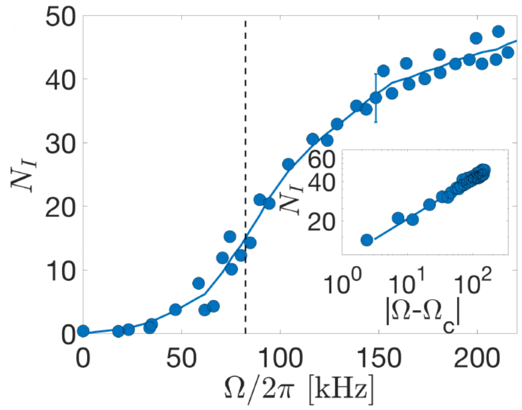

Figure 1. Number of Rydberg excitations N_I as a function of driving strength Ω.

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