Absorbing state phase transition in a cold Rydberg gas

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Understanding and probing phase transitions in non-equilibrium systems is an ongoing challenge in physics. A particular instance are phase transitions that occur between a non-fluctuating absorbing phase, 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 the observation of signatures 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 laser-excited to Rydberg states under so-called facilitation conditions. This conditional excitation process competes with spontaneous decay and leads to a crossover between a stationary state with no excitations and one with a finite number of excitations. We relate the underlying physics to that of an absorbing state phase transition in the presence of a field (i.e. off-resonant excitation processes) which slightly offsets the system from criticality. We observe a characteristic power-law scaling of the Rydberg excitation density as well as increased fluctuations close to the transition point.