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Observation of critical behavior at the dissipative Dicke phase transition RENATE LANDIG, RAFAEL MOTTL, FERDINAND BRENNECKE, Institute for Quantum Electronics, ETH Zurich, Switzerland, KRISTIAN BAUMANN, Department of Applied Physics, Stanford University, TOBIAS DONNER, TILMAN ESSLINGER, Institute for Quantum Electronics, ETH Zurich, Switzerland — We experimentally study critical behavior at the Dicke quantum phase transition, realized by coupling the external degree of freedom of a Bose-Einstein condensate to the light field in a high-finesse optical cavity. We use the natural dissipation channel of the cavity to observe density fluctuations of the gas in real time. The corresponding measurement backaction introduces additional fluctuations in the atomic gas and changes the critical behavior of the system. A correlation analysis of the light exiting the cavity reveals the diverging time scale of the fluctuation dynamics, in agreement with the experimentally observed mode softening in the excitation spectrum. This analysis also allows us to extract a damping rate for the external degree of freedom of the atoms. We quantitatively compare our measurements with a theoretical model taking into account both cavity and atomic dissipation channels. Our experiment allows for a high degree of control of all parameters and constitutes a model system for the investigation of non-equilibrium phase transitions. Future directions of the experiment include Bose-Hubbard physics with cavity-mediated long-range interactions and self-organization in lower dimensions.

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