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Exploring cavity-mediated long-range interactions in a dilute quantum gas RENATE LANDIG, RAFAEL MOTTL, FERDINAND BRENNECKE, Institute for Quantum Electronics, ETH Zurich, Switzerland, KRISTIAN BAUMANN, Department of Applied Physics, Stanford University, USA, TOBIAS DONNER, TILMAN ESSLINGER, Institute for Quantum Electronics, ETH Zurich, Switzerland — We report on the observation of a characteristic change in the excitation spectrum of a Bose-Einstein condensate and increased density fluctuations due to cavity-mediated atom-atom interactions. Increasing the strength of the interaction leads to a softening of an excitation mode at finite momentum, preceding a superfluid to supersolid phase transition. The observed behavior is reminiscent of a roton minimum, as predicted for quantum gases with long-range interactions. We create long-range interactions in the BEC using a non-resonant transverse pump beam which induces virtual photon exchange via the vacuum field of an optical cavity. The mode softening is spectroscopically studied across the phase transition using a variant of Bragg spectroscopy. At the phase transition a diverging density response is observed which is linked to increased density fluctuations. Using the cavity dissipation channel we monitor these fluctuations in real-time and identify the influence of measurement backaction onto the critical behavior of the system.

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