Phonon fluctuations in a Bose-Einstein condensate

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We present an in situ study of phonon excitations in a Bose-Einstein condensate. The dispersion relation is measured with high precision, revealing a minimum in the group velocity at finite wave number [1]. Furthermore, we observe the Planck distribution of thermal phonons [2]. This observation provides an important confirmation of the basic nature of these quantized excitations. In the case of slow cooling, it is found that a phonon state can be prepared and detected, whose population is on the order of the maximum possible Hawking radiation. In addition, the density fluctuations are seen to increase with increasing temperature, in contrast to the bunching effect. This is due to the non-conservation of the number of phonons. For rapid cooling, when the quench time drops below the measured thermal equilibration time, the phonon temperature is out of equilibrium with the surrounding thermal cloud. In this case, a Bose-Einstein condensate is not as cold as previously thought. We also apply our k-space technique above the critical temperature, allowing us to make the first calibrated measurement of the bunching phenomenon in a 3D Bose gas, with no free parameters [3]. The measurement confirms the role of the exchange symmetry and the Hanbury Brown–Twiss effect in the bunching.

[1] "Phonon Dispersion Relation of an Atomic Bose-Einstein Condensate", I. Shammass, S. Rinott, A. Berkovitz, R. Schley, and J. Steinhauer, Phys. Rev. Lett. **109**, 195301 (2012).

[2] "Planck Distribution of Phonons in a Bose-Einstein Condensate", R. Schley, A. Berkovitz, S. Rinott, I. Shammass, A. Blumkin, and J. Steinhauer, Phys. Rev. Lett. **111**, 055301 (2013).

[3] "Observing Atom Bunching by the Fourier Slice Theorem", A. Blumkin, S. Rinott, R. Schley, A. Berkovitz, I. Shammass, and J. Steinhauer, Phys. Rev. Lett. **110**, 265301 (2013).