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Second Sound and the Superfluid Jump in a Uniform Two-Dimensional Bose Gas PANAGIOTIS CHRISTODOULOU, MACIEJ GALKA, NISHANT DOGRA, Univ of Cambridge, RAPHAEL LOPES, College de France, JULIAN SCHMITT, ZORAN HADZIBABIC, Univ of Cambridge, QUANTUM GASES AND COLLECTIVE PHENOMENA - Z. HADZIBABIC TEAM — Superfluidity in two dimensions (2D), unlike its three dimensional counterpart, is associated with the pairing of vortices of opposite circulation as described by the Berezinskii-Kosterlitz-Thouless (BKT) theory, rather than the emergence of true long range order. In both cases, however, superfluidity manifests itself in the existence of two distinct hydrodynamic sound modes of low lying excitations, first and second sound. In 2D, the detection of second sound, which is directly related to the superfluid density, has remained elusive, besides tremendous efforts both in the context of liquid Helium thin films and ultracold gases. Here we report on the first observation of second sound in a 2D gas confined in a uniform trap of ultracold Bosonic ^{39}K atoms, accompanied by the simultaneous measurement of the first sound mode. To reach the collisional criteria for the two modes to appear, we tune interactions using a broad magnetic Feshbach resonance available for ^{39}K. Our results also show the sudden disappearance of second sound at high temperatures, offering a strong link with the BKT theory and its prediction of a universal jump of superfluid density at the critical temperature.

Panagiotis Christodoulou
Univ of Cambridge

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