Tracking the confinement-induced hybridization of the Higgs mode in a strongly interacting superfluid

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1 Abstract

Superconductivity in quantum-confined systems has attracted significant attention due to the implications for both fundamental science and technological development. Confinement modifies the dimensionality of the system, density of states, and critical temperature of superconductors, as the coherence length and the superconducting gap approaches the natural scales of length and energy imposed by the system size. A deep understanding of how confinement influences the superconducting pairing properties and its order parameter dynamics out of equilibrium is a theoretical challenge [1,2,3].

In my talk, I will show how strong confinement in a neutral fermionic superfluid affects the order parameter dynamics along the BEC-BCS crossover. By performing trap modulation spectroscopy in a highly oblate Fermi gas, we reveal a well-defined excitation of the order parameter throughout the entire crossover. On the BCS regime, the resonance position follows twice the pairing gap Δ, signaling a stable Higgs mode. Approaching the strongly correlated regime the mode energy drops below the pairing gap and finally approaches twice the trap frequency on the BEC regime. We interpret our results as hybridization and transition of the Higgs mode into the lowest excitation connected with the trap corresponding to a spatial coherent excitation of the order parameter. This excitation vanishes when approaching the critical temperature of the superfluid, where the order parameter is expected to disappear. The experimental evidence together with an effective field theory deepens our understanding of the stability of the Higgs mode in the absence of particle-hole symmetry and its interplay with confinement.

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