The Higgs amplitude mode in a superfluid of Dirac fermions

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We study the Higgs amplitude mode in the s-wave superfluid state on the honeycomb lattice [1]. The attractive Hubbard model on the honeycomb lattice was found to exhibit a quantum phase transition between semi-metal and s-wave superfluid phases [2]. We find evidence for a stable Higgs amplitude mode below the two-particle continuum together with a gapless Anderson-Bogoliubov (AB) mode in the vicinity of the quantum critical point. We also find stable collective modes which have "Cooperon" and exciton character in the semi-metal phase. These collective modes are accommodated within a window in the two-particle continuum, which arises as a consequence of the linear Dirac dispersion on the honeycomb lattice. Cooperon and exciton smoothly evolve across the quantum critical point and hybridize into the Higgs mode and the AB mode following Cooperon condensation. We discuss possibility of observing the Higgs mode by Bragg spectroscopy measurements.

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