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The Higgs amplitude mode in superfluids of Dirac fermions SHUNJI TSUCHIYA, Department of Physics, Faculty of Science, Tokyo University of Science, RAMACHANDRAN GANESH, Institute for Theoretical Solid State Physics, IFW Dresden, TETSURO NIKUNI, Department of Physics, Faculty of Science, Tokyo University of Science — Motivated by recent developments of cold atom experiments in optical lattices, we study collective modes of atomic Dirac fermions on the two-dimensional honeycomb lattice. The attractive fermion Hubbard model on the honeycomb lattice was found to exhibit the quantum phase transition at half-filling between a semimetal with massless Dirac fermion excitations and a simple s-wave superfluid phase.¹ We calculate collective modes in superfluid phase as well as in normal phase in the vicinity of the quantum critical point within the generalized random phase approximation. We find evidence for a undamped gapful Higgs amplitude mode below the two-particle continuum, together with a gapless Anderson-Bogoliubov (AB) mode in superfluid phase. As approaching the quantum critical point from the superfluid side, the energy gap of the Higgs mode decreases and eventually the Higgs mode and AB mode become degenerate at the quantum critical point. In the normal phase, we find that these collective modes split into Cooperon and exciton excitations that are particle-particle and particle-hole bound states, respectively. We discuss possibilities of observing these collective modes in optical lattice experiments.

¹E. Zhao and A. Paramekanti, Phys. Rev. Lett. 97, 230404 (2006).

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