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Unconventional superfluidity in spin-orbit coupled ultracold atomic Fermi gases XIA-JI LIU, Swinburne Univ of Tech, LEI JIANG, Joint Quantum Institute, NIST, HAN PU, Rice University, YAN CHEN, Fudan University , HUI HU, Swinburne Univ of Tech — Ultracold atoms has been proven to be an ideal table-top system to reveal novel states of quantum matter. The latest development of engineering synthetic spin-orbit coupling in ultracold atoms has created a new frontier that is endowed with a strong interdisciplinary character. This is a system that has a close connection to new functional materials such as topological insulators and has the potential to perform topological quantum computation based on Majorana fermions. Here we report our recent theoretical work on spin-orbit coupled atomic Fermi gases. We predict a new anisotropic state of matter which consists of exotic quasi-particles with anisotropic effective mass. In the superfluid phase, these exotic quasi-particles exhibit salient features in the momentum distribution, single-particle spectral function and spin structure factor. By applying an external Zeeman field, novel states of matter known as topological superfluids or inhomogeneous Fulde-Ferrell superfluids can form. We propose that strong non-magnetic or magnetic impurity scattering, created by a narrow dimple laser beam, can induce a universal mid-gap bound state in topological superfluids.

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