Fermion Condensate - The New State of Matter

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In many Fermi systems and compounds at zero temperature a phase transition happens that leads to a quite specific state called fermion condensation. As a signal of such a fermion condensation quantum phase transition serves unlimited increase of the effective mass of quasiparticles that determines the excitation spectrum and creates flat bands [1]. We have theoretically carried out a systematic study of the phase diagrams of strongly correlated heavy-fermion compounds, including heavy-fermion metals, high temperature superconductors, insulators with strongly correlated quantum spin liquid, quasicrystals, and two dimensional Fermi systems (like 3He), and have demonstrated that these diagrams have universal features. The obtained results are in good agreement with experimental facts. We have shown both analytically and using arguments based entirely on the experimental grounds that the data collected on these very different heavy-fermion compounds have a universal scaling behavior, and these materials with strongly correlated fermions can unexpectedly have a uniform behavior in spite of their microscopic diversity. Thus, the quantum critical physics of different heavy-fermion compounds is universal, and emerges regardless of the underlying microscopic details of compounds. This uniform behavior, induced by the universal quantum critical physics, allows us to view it as the main manifestation of the new state of matter. Our theoretical analysis of numerous experimental facts shows that the theory of fermion condensation develops completely good description of the non-Fermi liquid behavior of heavy-fermion compounds. Moreover, the fermion condensate can be considered as the universal reason for the non-Fermi liquid behavior observed in various heavy-fermion compounds [1,2].

1. V.R. Shaginyan, M.Ya. Amusia, A.Z. Msezane, and K.G. Popov, Phys. Rep. 492, 31 (2010).
2. M.Ya. Amusia, K.G. Popov, V.R. Shaginyan, and W.A. Stephanowich, Theory of HeavyFermion Compounds, Springer Series in Solid-State Sciences 182, (2015).