FERMION CONDENSATION: A STRANGE IDEA SUCCESSFULLY EXPLAINING BEHAVIOR OF NUMEROUS OBJECTS IN NATURE

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S u m m a r y

Strongly correlated Fermi systems are among the most intriguing, best experimentally studied, and fundamental systems in physics. These are, however, in defiance of theoretical understanding. The ideas based on the concepts like Kondo lattice and involving quantum and thermal fluctuations at a quantum critical point have been used to explain the unusual physics. Alas, being suggested to describe one property, these approaches fail to explain the others. This means a real crisis in theory suggesting that there is a hidden fundamental law of nature, which remains to be recognized. A theory of fermion condensation quantum phase transition, preserving the extended quasiparticles paradigm and intimately related to the unlimited growth of the effective mass as a function of the temperature, magnetic field, etc., is capable to resolve the problem. We discuss the construction of the theory and show that it delivers theoretical explanations of the vast majority of experimental results in strongly correlated systems such as heavy-fermion metals and quasi-two-dimensional Fermi systems. Our analysis is placed in the context of recent salient experimental results. Our calculations of the non-Fermi liquid behavior, the scales, and thermodynamic and transport properties are in good agreement with the heat capacity, magnetization, longitudinal magnetoresistance, and magnetic entropy obtained in remarkable measurements on the heavy-fermion metal $YbRh_2Si_2$. Using two-dimensional ^{3}He as an example, we demonstrate that the main universal features of its experimental temperature T - density x phase diagram resemble those of the heavy-fermion metals. We propose a simple expression for the effective mass, describing all diverse experimental facts on the ^{3}He in the unified manner and demonstrating that the universal behavior of the effective mass coincides with that observed in heavy-fermion metals.