Manifestation of fermion condensation in the Fermi liquids of different origin

W. Stefanowicz[1]

[1] *Institute of Physics, University of Opole, Oleska 48, 45-052 Opole, Poland*

One of the most fruitful concepts of modern solid state physics is a paradigm of quasiparticles. The prolific application of quasiparticle paradigm is the Landau theory of Fermi liquid (LFL), where the description of a complex system of strongly interacting electrons and ions had been reduced to a gas of low-energy interacting excitations. However, in the end of XX-th century, there has been a growing body of theoretical and experimental studies showing that the conventional quasiparticle picture, adopted in LFL theory is not always correct. The body of these "strange" experimental facts is commonly attributed to as non-Fermi liquid (NFL) behaviour.

The common approaches to describe the NFL behaviour in the strongly correlated fermion systems can be summarized by the phrase, that Landau quasiparticles become heavy and die. The other approach [1-3] has been suggested, in which the Landau quasiparticles also acquire very high (actually infinite) effective mass, but then survive changing their properties drastically. The essence of the approach is that Pomeranchuk conditions of LFL stability do not encompass all possible types of instability. This channel corresponds to the situation (related to the properties of Landau interaction amplitudes) when quasiparticle effective mass diverges. In this case, to avoid the unphysical situation with negative effective mass, the Fermi surface alters its topology [2] so that the substance undergoes so - called fermion condensation quantum phase transition (FCQPT) [1,3], leading to possibility of "fermion condensation" (FC), i.e. to the situation, where the fermions can occupy the same quantum state very similar to Bose-Einstein condensation.

In contrast to the standard Landau Fermi liquid (LFL) result that the quasiparticle effective mass is independent of external parameters like temperature, external magnetic field, pressure etc, the quasiparticle in FC state have their mass dependent on the above parameters. Latter dependence in the systems with FC can be considered as the universal reason for the NFL behavior observed in Fermi-liquids with very different microscopic structure like heavy-fermion metals, quasicrystals, magnetic insulators with quantum spin liquids and high-Tc superconductors.

[1] V. A. Khodel, V. R. Shaginyan, *Superfluidity in system with fermion condensate*, JETP Lett. v. **51**, p. 553 (1990).

[2] G. E. Volovik, *A new class of normal Fermi liquids*, JETP Lett. v. **53**, p. 222 (1991).

[3] M. Ya. Amusia, K. G. Popov, V. R. Shaginyan, and V. A. Stephanovich, *Theory of Heavy-Fermion Compounds - Theory of Strongly Correlated Fermi-Systems*, Springer Series in Solid-State Sciences **182**, (2014).