The paper "Superfluidity in system with fermion condensate" (V. A. Khodel and V. R. Shaginyan, (1990))

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In the paper submitted in April of 1990, a new type of phase transition is introduced [1]. This phase transition occurs as the effective mass of quasiparticles diverges, $M^* \to \infty$, that is the fermions get very heavy. Beyond the point of the phase transition a fermion condensate (FC) arises in new phase: The energy $\varepsilon(p)$ of quasiparticles with momenta $p_i < p < p_f$ are equal to the chemical potential μ, becoming flat or dispersionless, with $p_i < p_F < p_f$ and p_F is the Fermi momentum [1]. Thus, the foundation of a new theory of strongly correlated Fermi-systems has been laid and the FC theory has emerged, while the Landau theory ceases to operate in that case [1]. The main novelty is that the quasiparticle distribution $n(p)$ in the region $p_i < p < p_f$ does not coincide with that of ideal Fermi gas, and is given by the variation condition $\delta E(n)/\delta n(p) = \mu$, where $E(n)$ is the Landau functional. Analysis of the FC state, carried out by G. E. Volovik, has shown that systems with FC represent a new class of Fermi liquid characterized by their own topological structure, and can be viewed as topological protected [2–4]. It has been shown that FC emerges in 1D fermions located in the core of quantized vortices, e.g. in ^{3}He superfluid, and leads to room-temperature superconductivity [3, 4]. Nonetheless, the FC state has been evaluated and criticized by P. Nozières, who have suggested that the lifetime τ of quasiparticles hopelessly small making the observations of FC state problematic [5]. On the other hand, P. Nozières has taught us how one can transport the FC behavior to finite temperatures T; and a careful study has demonstrated that $\tau \propto 1/T$ [6, 7]. Further investigations has also shown that properties of systems with FC, or located near the phase transition, are sharply different from those of common Fermi-systems.

As a result, the FC theory has proposed explanations of numerous important experimental facts and paved the way for much subsequent research in the condensed matter physics of strongly correlated Fermi-systems represented by heavy-fermion (HF) metals and high-temperature superconductors [4, 8, 9], quantum spin liquids [10], quasicrystals [11], and two-dimensional Fermi-systems [12, 13]. With regard to experimental facts observed in the physics of strongly correlated systems, it is necessary to revise many sections of the traditional physics of solid state and liquids. At the same time there are effects that are absent in the physics of solid state. For example, violation of the particle-hole symmetry, the asymmetry in the tunneling conductivity measured on HF metals, violation of the Wiedemann-Franz law, etc. The most various strongly correlated Fermi-systems have the identical universal scaling behavior other than the observed behavior of common metals and Fermi-liquids. Such behavior, explained within the FC theory, signals that a new state of matter, possessing unique properties, may be realized by these systems. Thus, it turns out that the FC theory offers an unexpectedly simple and complete description of strongly correlated Fermi-systems [1–14].

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