EXCESS CONDUCTIVITY AND POSSIBLE PSEUDOGAP STATE IN FeSe SUPERCONDUCTORS

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The temperature dependence of the excess conductivity σ′(T) [1, 2] in three polycrystalline samples of the $FeSe_{0.94}$ superconductor prepared by various technologies [3] was studied. Obtained from the measurements, the temperature dependences of the parameter Δ*(T) which in cuprates is associated with a pseudogap, were analyzed in the model of local pairs. At high temperatures, all three samples exhibit a high narrow maximum Δ*(T) at T_{s1} ~ 250 K, typical of magnetic superconductors. Below T ≈ 225 K, the dependences Δ*(T) become different. In almost the entire temperature range below Ts1, sample S2, prepared by the solid-state reaction method and not containing impurities, shows Δ*(T) typical of Fe-pnictides. An exception is the interval from the temperature of the structural transition T_s = 85 K to T_c, where Δ*(T) exhibits an atypical broad maximum. An analysis of the obtained dependence suggests the discovery of a pseudogap in this $FeSe_{0.94}$ sample below T_s. Samples S1 containing 4 wt.% Ag and S3, with a nominal composition, but containing non-superconducting inclusions of the hexagonal phase, both obtained by partial melting, show identical Δ*(T), but different from S2. They reveal a number of features that correlate with temperatures at which features are observed on M(T) and the Hall coefficient $R_H(T)$ changes sign several times with decreasing T, indicating a change in the type of charge carriers in FeSe. The dependence Δ*(T) of sample S3 below Ts has practically no maximum, since non-superconducting impurities of the hexagonal phase prevent the formation of paired fermions in S3 near T_c. As a consequence, S3 has a minimum density of local pairs $\langle n_\uparrow n_\downarrow \rangle$ = 0.26, determined by comparing $\Delta^*(T_G)/\Delta_{max}$ near T_c with the Peters – Bauer theory [4], and the dependence Δ*(T) does not follow the theory. S1 has a maximal $\langle n_\uparrow n_\downarrow \rangle$ = 0.47, most likely due to the influence of Ag impurities. S2 does not contain impurities, and found $\langle n_\uparrow n_\downarrow \rangle \approx 0.3$ is the same as in $YBa_2Cu_3O_{7-\delta}$ [5]. Importantly, both dependencies Δ*(T) for S1 and S2 follow the theory in a wide temperature range.

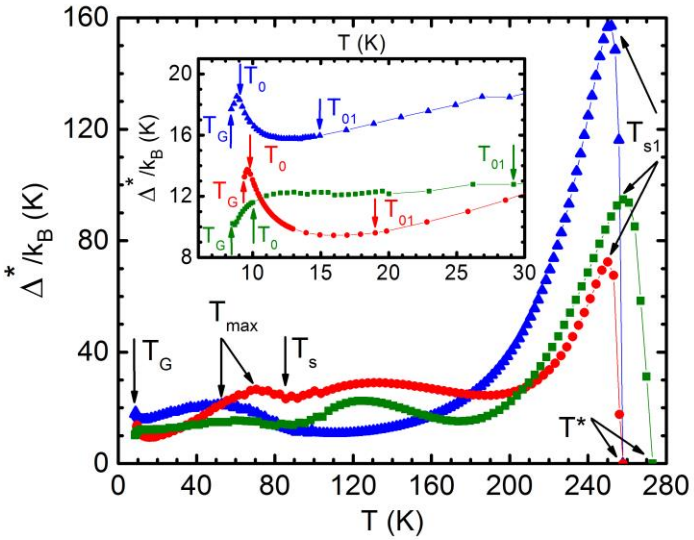

Fig. 1. Temperature dependences of possible pseudogap state Δ*(T) in three polycrystalline $FeSe_{0.94}$ samples of the $FeSe_{0.94}$ superconductor prepared by various technologies (S1 – red circles, S2 – blue triangles, S3 – green squares). Insert: The same dependence for the temperature interval $T_G < T < T_{01}$. The arrows show all characteristic temperatures. Solid lines are to guide the eye.

[1] A. L. Solovjov, in *Superconductors - Materials, Properties and Applications*, edited by A. Gabovich (InTech, Rijeka, 2012), Chap. 7, p. 137.
[2] A. L. Solovjov and V. M. Dmitriev, Low Temp. Phys. **32**, 99 (2006).
[3] E. Nazarova, N. Balchev, K. Nenkov, K. Buchkov et al. Supercond. Sci. Technol. **28**, 025013 (2015)
[4] R. Peters and J. Bauer, Phys. Rev. B **92**, 014511 (2015).
[5] A. L. Solovjov, E. V. Petrenko, L. V. Omelchenko, R. V. Vovk, I. L. Goulatis, A. Chroneos, Scientific Reports **9**, 9274 (2019).