Comparable energy scales of superconducting charges and spin fluctuations in unconventional superconductors: implications on condensation and pairing

Y.J. Uemura

Physics Department, Columbia University, New York, NY 10027, USA

An "effective Fermi energy" ϵ_F of superconducting carriers can be derived from measurements of the magnetic field penetration depth and the superfluid density n_s/m^* (superconducting carrier density / effective mass). Accumulated results of n_s/m^* in cuprate, FeAs, organic BEDT, A_3C_{60} and heavy fermion $CeCoIn_5$ systems exhibit a strong correlation between T_c and the charge energy scale ϵ_F [1]. This feature has been discussed as a support for Bose-Einstein condensation of pre-formed pairs. On the other hand, another strong correlation exists between T_c and the spin fluctuation energy scale $\hbar\omega_{SF}$ which represents the strength of the exchange coupling J, as was noticed by Moriya and Ueda [2]. This feature has been discussed as a support for BCS condensation mediated by antiferromagnetic magnons. Co-existence of these two different correlations indicates that the spin energy J is comparable to the condensing charge energy ϵ_F, and suggests a resonant behavior in condensation and pairing. This is a key to understanding highly unusual non-BCS like behaviors of the superfluid density in the overdoped / pressurized regions of these systems. We will discuss this energy-scale phenomenology by showing the most recent experimental data on the superfluid density in various FeAs and $CeCo(In,Sn)_5$ systems.

[1] Y.J. Uemura, Physica B404 (2009) 3195.
[2] T. Moriya and K. Ueda, Rep. Prog. Phys. 66 (2003) 1299.

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