Transition from $s_{\pm}$ to s_{++} order parameter driven by disorder in Iron Based Superconductors

Daniele TORSELLO[1,2], Gianluca GHIGO[1,2], Giovanni UMMARINO[1,3], Laura GOZZELINO[1,2], Makariy TANATAR[4,5], Ruslan PROZOROV[4,5], Paul CANFIELD[4,5]

[1]*Politecnico di Torino, Department of Applied Science and Technology, 10129 Torino, Italy*
[2]*Istituto Nazionale di Fisica Nucleare, Sezione di Torino, 10125 Torino, Italy*
[3]*National Research Nuclear University, MEPhI, Moskva 115409, Russia*
[4]*Ames Laboratory, Iowa State University, Ames, Iowa 50011, USA*
[5]*Department of Physics & Astronomy, Iowa State University, Ames, Iowa 50011, USA*

We employed a microwave resonator technique [1-2], that allows us to determine the London penetration depth and the critical temperature, to show evidence of disorder-driven $s_{\pm}$ to s_{++} order parameter symmetry transition in $Ba(Fe_{1-x}Rh_x)_2As_2$ single crystals, where disorder was induced in the form of defects generated by 3.5-MeV proton irradiation.

This transition is expected in the presence of high levels of disorder that drives the system toward the convergence of the gaps values, and its signature was found as the predicted [3], but not yet observed [4], discontinuity in the low-temperature values of the London penetration depth.

These experimental observations are validated by multiband Eliashberg calculations in which the effect of disorder is accounted for in a suitable way. Our model reproduced exactly the experimental T_cs and semi-quantitatively the superfluid densities, with the $s_{\pm}$ to s_{++} symmetry transition at the expected disorder level [5].

Furthermore, we find that the low temperature electrodynamic properties of the superconductor drastically change upon entering the s_{++} state: the quasiparticle conductivity strongly increases and becomes monotonous in tempreature, the surface reactance drops whereas the surface resistance increases slightly [6].

These observations combined with the possibility of selective irradiation of portions or patterns of a large crystal or film could open the way to the study of interfaces between multiband superconductors with different pairing states and the development of novel devices.

References

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E-mail: daniele.torsello@polito.it