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Direct Evidence of Two Superconducting Gaps in $FeSe_{0.5}Te_{0.5}$: SnS-Andreev Spectroscopy and Lower Critical Field

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We report a comprehensive study of the two-gap superconducting state of $FeSe_{0.5}Te_{0.5}$ single crystals with $T_C \approx 14$ K. Using a combination of a bulk probe, lower critical field measurements, and a local probe, intrinsic multiple Andreev reflection effect (IMARE) spectroscopy (realized by a break-junction technique), we directly determined two superconducting gaps, $\Delta_L = 3.3 \pm 0.3$ meV and $\Delta_S = 1.0 \pm 0.1$ meV, and their temperature dependences. The BCS-ratio for the large gap $2\Delta_L/k_BT_C \approx 5.6 > 3.5$ exceeds the weak-coupling BCS limit and indicates a strong coupling in the bands where Δ_L is developed below T_C. The H_{c1} and IMARE experimental data are self-consistent and well-described in the framework of the two-band model. Considering two effective bands, we used the BCS-like model based on Moskalenko and Suhl equations with a renormalized BCS-integral in order to estimate electron-boson coupling constants λ_{ij} $(i, j = 1, 2)$. We show that zero Coulomb repulsion suggested in $s^{\pm}$ theoretical model is inadequate to describe the two-gap superconducting state of $FeSe_{0.5}Te_{0.5}$. For a reasonable value of Coulomb pseudopotentials $\mu^* = 0.2$ we estimated $\lambda_{11} = 0.5$, $\lambda_{22} = 0.42$, $\lambda_{12} = 0.32$, $\lambda_{21} = 0.21$ ("1" is associated with the "driving" effective band, "2" – with the "driven" one). The set of λ_{ij} indicates a strong intraband coupling, whereas interband interaction is moderate and about 1.7 weaker.

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