Localization in Materials with Several Conducting Bands to Enhance Superconductivity

A. Vagov[1], V. Neverov[1,2], A. Lukyanov[1,2], A. Krasavin[1,2], M. Croitoru[1], and A. Shanenko[1]

[1]*HSE University, 101000 Moscow, Russia*
[2]*Institute National Research Nuclear University MEPhI, Moscow 115409, Russia*

Strong disorder exerts two opposing effects on a superconducting material [1]. On one hand, it leads to localization of electrons and Cooper pairs, resulting in spatial fragmentation of the condensate state. It enhances the local density of single-particle states, increasing the binding energy of Cooper pairs and the critical temperature at which the condensate state appears. On the other hand, it destroys the long-range coherence, suppressing superconductivity and reducing the corresponding critical temperature. This work demonstrates that if such a disordered superconductor is coupled to a clean or weakly disordered conducting material, the long-range coherence is restored via the proximity effect. As a result, the coexistence of the two subsystems combines the advantages of the high critical temperature of the disordered superconductor and the global supercurrent of the clean one. This synergy effect is robust and can occur in superconducting multi-band and heterostructures, whether they are disordered or have artificial superstructures.

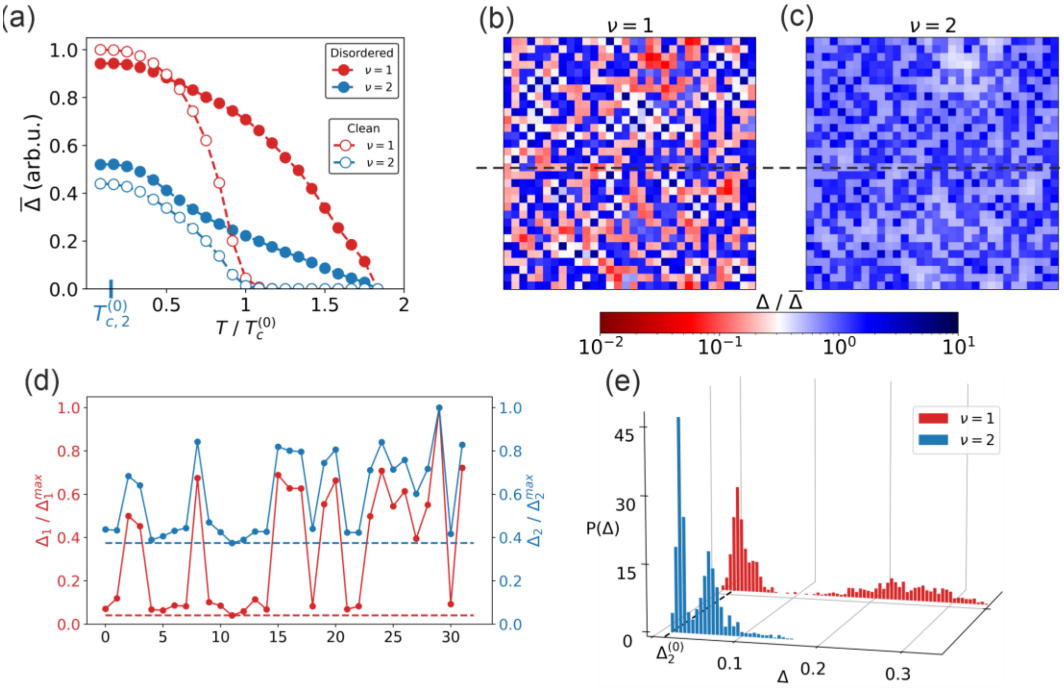

Figure: *(a) Temperature dependence of the sample-averaged gap function for the strong band (red) and the weak band, showing results for the cases when strong band is disordered (filled circles) and in its clean limit (empty circles). Low temperature $T_{c,2}^{(0)}$ is the critical temperature of the second band in the absence of inter-band coupling. (b)--(c) Colour density plot with the spatial distribution of the band gap function. (d) Profile of the gap function for strong band (red) and weak band (blue), calculated along the dashed lines shown in panels (b) and (c). (e) Histograms of the absolute value of the gap function for the strong band (red) and the weak band (blue).*

References

1. A. Vagov et al., Comm. Physics **5**, 177 (2022)