“Interplay of charge density wave and multiband superconductivity in layered quasi-two-dimensional materials: The case of 2H-NbS_2 and 2H-$NbSe_2$”

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Abstract

Despite intense efforts on all known quasi-two-dimensional superconductors, the origin and exact boundary of the electronic orderings, particularly charge density waves and superconductivity, are still attractive problems with several open questions. Here, in order to reveal how the superconducting gap evolves, we report on high quality complementary measurements of magneto-optical imaging, specific heat, magnetic susceptibility, resistivity measurements, Andreev spectroscopy, and London penetration depth $\lambda_{ab}(T)$ measurements supplemented with theoretical calculations for 2H-$NbSe_2$ and 2H-NbS_2 single crystals. The temperature dependence of $\lambda_{ab}(T)$ calculated from the lower critical field and Andreev spectroscopy can be well described by using a two-band model with *s*-wave-like gaps. The effect of pressure on the superconducting gap of both systems illustrates that both bands are practically affected. Upon compression, the Fermi surfaces do not change significantly, and the nesting remains almost unaffected compared to that at ambient condition. However, a strong bending in the upper critical fields (H_{c2}) curves is obtained under pressure and support the presence of a strong Pauli paramagnetic effect. In $NbSe_2$, using a two-band model with *s*-wave-like gaps, the temperature dependence H_{c2} (T) can be properly described. In contrast to that, the behavior of Hc_2 for NbS_2 is ruled by the spin paramagnetic effect. The estimated values of the penetration depth at T = 0K confirm that $NbSe_2$ and NbS_2 superconductors depart from a Uemura-style relationship between T_c with $\lambda^{-2}{}_{ab}$ (T), the in-plane superconducting penetration depth.

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