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Interplay between anisotropic multiband superconductivity and unconventional electronic order in Pd chalcogenides

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The Fe pnictides and chalcogenides often display the coexistence of multiband superconductivity with electronic or magnetic order. For instance, the pressure-induced suppression of the orbital order of FeSe leads to antiferromagnetism and to an enhanced superconducting transition temperature T_c. The superconducting phase-diagram of these compounds under an external magnetic field tend to display anomalous phase boundaries as, for example, a linear dependence of the upper critical field $H_{c2}(T)$ on temperature which, in FeSe is claimed to result from an additional superconducting phase at the highest fields and lowest temperatures. Motivated by these compounds, a few years ago we reported the discovery of superconductivity in Pd and chalcogenide based compounds [1,2] like $Nb_2Pd_{0.81}S_5$. These compounds display extremely large $H_{c2}(T)$ accompanied by a temperature dependent superconducting anisotropy [1,2] akin to what is observed in Fe based superconductors which is claimed to result from multi-band superconductivity. Point contact spectroscopy [3] does provide evidence for multiple superconducting gaps in some of these compounds, while $H_{c2}(\mathrm{T}) \propto T$ is detected in $Ta_4Pd_3Te_{16}$ [4]. Remarkably, one observes anomalies in the resistivity [2] and in thermodynamic variables [5] indicating that superconductivity is preceded by some type of subtle electronic order which apparently does not affect the geometry of their Fermi surfaces [5]. We also find that Pd acts as a tuning parameter, i.e. an increase in its fraction within $Nb_3Pd_xSe_7$ increases its T_c albeit leading to an extremely anisotropic superconducting state whose $H_{c2}(\mathrm{T})$ display a $T^{1/2}$ dependence in the neighborhood of T_c, as observed in monolayer $NbSe_2$ [6] or in the surface of ionic liquid gated MoS_2 [7]. This indicates that superconductivity in these single-crystals is two-dimensional in character but unlikely to result from spin momentum locking [6,7]. Here, we review and discuss the properties of this family of superconductors.

References-

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