Ising pairing in superconducting $NbSe_2$ atomic layers

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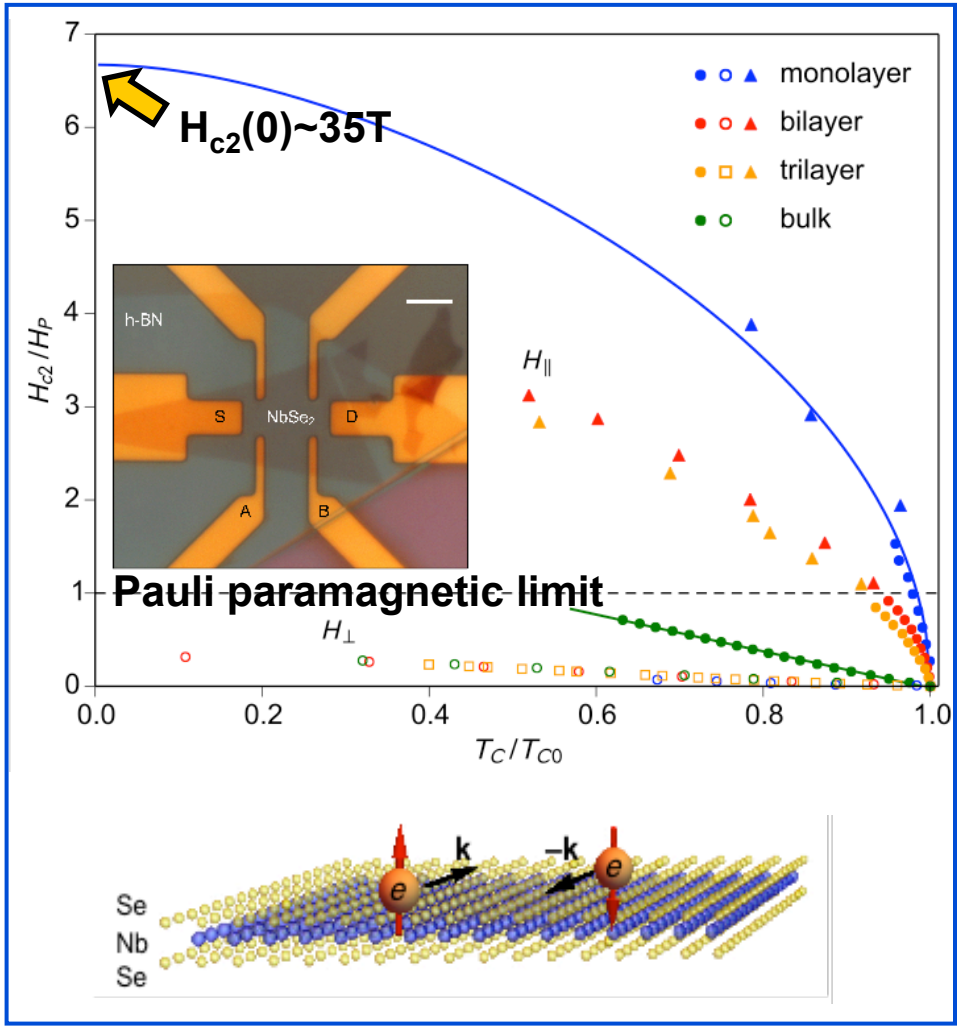
Funding Grants: G.S. Boebinger (NSF DMR-1157490); K.F. Mak (DOE DESC0013883); J. Shan (DOE DESC0012635, NSF DMR-1410407); K. T. Law (HKUST3/CRF/13G, CIG); L. Forro (Swiss NSF); Z. Wang (NSF DMR-1420451)

Effects of spin-orbit interactions (SOIs) on superconductivity (SC), which can lead to unconventional pairing symmetries and topological SC, have attracted tremendous recent interest. Most of the recent studies have focused on inducing SC in non-superconducting materials with strong SOIs. Here we examine the effects of SOIs on SC in $NbSe_2$, a superconducting material with strong SOIs, down to the monolayer limit.

The maximum magnetic field to which conventional SC can survive is known as the Pauli paramagnetic limit. Monolayers of $NbSe_2$, however, have upper critical fields that extrapolate to ~35T, a six-fold violation of the Pauli paramagnetic limit (dashed line in the phase diagram). Probing such high upper critical fields calls for state-of-the-art low-temperature, high magnetic field electrical transport measurement facilities in the MagLab. The observed ultrahigh upper critical fields can be understood as a result of the very strong SOIs in inversion asymmetric $NbSe_2$ monolayers, which lock the electron spins to the out-of-plane direction and produce Cooper pairs with effective Ising spins. *The applied in-plane magnetic field, therefore, has little effect in its attempt to polarize the Ising-like out-of-plane spins in the in-plane direction.*

These effects are stronger as the sample is thinned from bulk, to trilayer, to bilayer, and ultimately to the monolayer limit. *As such, this study is important in the search for unconventional SC in the exact two-dimensional limit.*



Facilities: DC field, 31T, Cell 9 top loading cryostat

Citation: ***Ising pairing in superconducting NbSe2 atomic layers,*** X. Xi, Z. Wang, W. Zhao, J.-H. Park, K.T. Law, H. Berger, L. Forro, J. Shan, and K.F. Mak, **Nature Physics doi:10.1038/nphys3538 (2015)**