TT 38: Topological Superconductors

Time: Wednesday 11:00–12:45 Location: HSZ 103

Invited Talk TT 38.1 Wed 11:00 HSZ 103

Nematic superconductivity in the superconducting doped topological insulators $Nb_xBi_2Se_3$ and $Sr_xBi_2Se_3$ — •Kristin Willa[1,2], Matthew Smylie[1,3], Roland Willa[1,2], Ulrich Welp[1], Genda Gu[4], and Wai-Kwong Kwok[1] — [1]Argonne National Laboratory, Lemont, USA — [2]Karlsruhe Institute of Technology, Karlsruhe, Germany — [3]Hofstra University, Hempstead, USA — [4]Brookhaven National Laboratory, Upton, USA

Spontaneous rotational-symmetry breaking in the superconducting state of the doped topological insulator Bi_2Se_3 has attracted significant attention as a candidate for topological superconductivity. We have studied the normal and the superconducting state of $Nb_xBi_2Se_3$ and $Sr_xBi_2Se_3$ using magnetoresistance, magnetization, penetration depth and specific heat. While no sign of a symmetry breaking of the three-fold in plane crystal symmetry is observed in the normal state, we find a clear two-fold in plane symmetry of the upper critical field in the superconducting state. This large basal-plane anisotropy of H_{c2} (Γ=3.5) is attributed to a two-component gap structure $\eta = (\eta_1, \eta_2)$. A quantitative analysis of our data excludes more conventional sources of this twofold anisotropy and gives clear evidence for nematic superconductivity and some indications for topological superconductivity in both $Nb_xBi_2Se_3$ and $Sr_xBi_2Se_3$.

TT 38.2 Wed 11:30 HSZ 103

Structurally-driven nematicity of odd-parity superconductivity in $Sr_xBi_2Se_3$ — •Aleksandr Kuntsevich, Yuri Selivanov, Victor Martovitskii, and Aleksandr Rakhmanov — P.N. Lebedev Physical Institute, 119991, Moscow, Russia

Superconductivity(SC) in doped (by Cu, Sr or Nb) topological insulator Bi_2Se_3 attracts a great deal of attention as odd-parity topological one, with an exotic nematic vector order parameter.On a structural level it is unknown where exactly the dopant atoms are located in the lattice and how this placement controls SC properties.

$Sr_xBi_2Se_3$ is the most structurally perfect member of this family, it demonstrates stability of SC, and ∼100% SC fraction. We improved the crystalline quality, showed that that SC in $Sr_xBi_2Se_3$ is induced by very low doping level, and strongly depends on the specific arrangement of Sr atoms in the host matrix [1].

We also managed to obtain purely single-block crystals. The x-ray diffraction shows that these single crystals are either weakly stretched or compressed uniaxially in the basal plane. In the SC state, the upper critical field H_{c2} has a twofold rotational symmetry and depends on the sign of the strain: in the stretched samples the maximum of H_{c2} is achieved when H is transverse to the strain axis, while in the compressed samples this maximum is observed when the field is along the strain direction. This result is naturally explained within the nematic SC coupled to the strain. This observation is a novel experimental evidence for the odd-parity SC in $Sr_xBi_2Se_3$[2].

[1] AYK *et al* Materials**12**, 3899,2019
[2] AYK *et al* PRB**100**, in press,2019

TT 38.3 Wed 11:45 HSZ 103

Transport study on bulk $PtBi_2$ and $Pt_{1-x}Rh_xBi_2$ at very low temperature — •Valentin Labracherie, Arthur Veyrat, and Joseph Dufouleur — Leibniz Institute for Solid State and Materials Research, IFW Dresden, D-01069 Dresden, Germany

Weyl Semimetals are a new class of material with chiral spin texture discovered in the last decade. They host quasiparticles with linear excitations, the Weyl fermions, which have definite spin chirality. These bulk states come as pairs of Dirac cones connected to each other at their interface with some trivial materials. Weyl fermions are expected to exhibit new effects like Fermi arcs and chiral anomaly for which electrons are pumped from one cone to the other, breaking the conservation of the chiral charge. Due to that, we have the appearance of a planar hall effect and anisotropic negative magnetoresistance when the electrical and magnetic field are aligned.

Several candidates to Weyl semimetal have also shown superconducting states at very low temperature and a lot of efforts has been made to see if these superconducting states is link to topology or not. I will present here transport measurement on $PtBi_2$, a Weyl semimetal which show a superconducting state at 0.6K and we investigate the effect of Rh doping on its superconducting properties.

TT 38.4 Wed 12:00 HSZ 103

^{125}Te NMR studies of 1T-$MoTe_2$ under pressure -Towards superconductivity mediated by Weyl Fermions — •H. Yasuoka[1], T. Fujii[1,2], K.M. Ranjith[1], M.O. Ajeesh[1], M. Schmidt[1], T. Mito[2], M. Nicklas[1], C. Felser[1], A. Mackenzie[1], and M. Baenitz[1] — [1]MPI for Chemical Physics of Solids, D-01187 Dresden, Germany — [2]School of Science, University of Hyogo Hyogo, Japan

1T-$MoTe_2$ is claimed to be one of the type-II Weyl semimetals, and has attracted much attention due to its exotic physical properties stemming from the topological (line nodal) band structure where the electron and hole pockets are touching at the Fermi energy. One of the most preeminent features is the occurrence of superconductivity which is stabilized under pressure up to around T_c=7K. In order to understand the superconductivity, we have employed the ^{125}Te NMR technique under pressure (up to 2.17 GPa) and measured the NMR line profile and nuclear magnetic relaxation, determining the Knight shift and low lying magnetic excitations. Using the same NMR tuning circuit, we have also measured the pressure and temperature (T) dependences of the resonant frequency, and extracted the T-dependence of the upper critical field H_{c2}. The results are not in accord with simple WHH model, but are well fit to an empilical formula, $H_{c2}(T) = H_{c2}(0)[1 - \frac{T}{T_c}]^{\alpha}$. By doing this, we obtained $H_{c2}(0)$=1.50T, T_c= 3.81K, and α=1.1 at 2.17 GPa. A superconducting signature has been observed in $K(T)$ and $1/T_1T(T)$ at around 2.5 K (2.17GPa, 0.46T). We present detailed NMR results and try to explore the superconductivity from the microscopic point of view.

TT 38.5 Wed 12:15 HSZ 103

Strongly correlated superconductor with polytypic 3D Dirac points — Sergei Borisenko[1], •Volodymyr Bezguba[1,2], Alexander Fedorov[1,3], Yevhen Kushnirenko[1], Vladimir Voroshnin[3], Mihai Sturza[1], Saicharan Aswartham[1], and Alexander Yaresko[4] — [1]IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany — [2]Kyiv Academic University, 03142 Kyiv, Ukraine — [3]Helmholtz-Zentrum Berlin fur Materialien und Energie — [4]Max-Planck-institute for Solid State Research, Heisenbergstrasse 1, 70569 Stuttgart, Germany

Topological superconductors should be able to provide essential ingredients for quantum computing, but are very challenging to realize. Spin-orbit interaction in iron-based superconductors opens the energy gap between the p-states of pnictogen and d-states of iron very close to the Fermi level, and such p-states have been recently experimentally detected. Density functional theory predicts existence of topological surface states within this gap in $FeTe_{1-x}Se_x$ making it an attractive candidate material. Here we use synchrotron-based angle-resolved photoemission spectroscopy and band structure calculations to demonstrate that $FeTe_{1-x}Se_x$ (x=0.45) is a superconducting 3D Dirac semimetal hosting type-I and type-II Dirac points and that its electronic structure remains topologically trivial.

TT 38.6 Wed 12:30 HSZ 103

Phase-tunable second-order topological superconductor — •Selma Franca, Dmitri Efremov, and Ion Cosma Fulga — IFW Dresden and Würzburg-Dresden Cluster of Excellence ct.qmat, Helmholtzstr. 20, 01069 Dresden, Germany

Two-dimensional second-order topological superconductors (SOTSCs) have gapped bulk and edge states, with zero-energy Majorana bound states localized at corners. Motivated by recent advances in Majorana nanowire experiments, we propose to realize a tunable SOTSC as a two-dimensional nanowire array. We show that the coupling between the Majorana modes of adjacent wires can be controlled by phase-biasing the device, allowing one to access a variety of topological phases. We characterize the system using scattering theory, which provides access to its transport properties and its topological invariants. The setup is robust against disorder, both in the nanowires themselves and in the Josephson junctions formed between adjacent wires. Further, we identify a parameter regime in which an initially trivial system is rendered topological upon adding disorder, providing an example of a second-order topological Anderson phase.