TT 93: Superconductivity: (General) Theory

Time: Thursday 16:30–18:00 Location: HSZ 201

TT 93.1 Thu 16:30 HSZ 201

Symmetry-protected topological invariant and Majorana impurity states in time-reversal invariant superconductors — •Lukas Kimme[1], Timo Hyart[2], and Bernd Rosenow[1] — [1]Institut für Theoretische Physik, Universität Leipzig, D-04103 Leipzig, Germany — [2]Instituut-Lorentz, Universiteit Leiden, Post Office Box 9506, 2300 RA Leiden, The Netherlands

We address the question of whether individual nonmagnetic impurities can induce zero-energy states in time reversal invariant superconductors, and define a class of symmetries which guarantee the existence of such Majorana states for a specific value of the impurity strength [1]. These symmetries allow the definition of a position space topological $\mathbb{Z}_2$ invariant, which is related to the standard bulk topological $\mathbb{Z}_2$ invariant. Our general results are applied to the time reversal invariant p-wave phase of the doped Kitaev-Heisenberg model [2], where we also demonstrate how a lattice of impurities drives a topologically trivial system into the non-trivial phase and even causes gapless topological superconductivity. Finally, signatures of impurity states in the spin-susceptibility are described.

[1] L. Kimme, T. Hyart, and B. Rosenow, arXiv:1308.2496
[2] T. Hyart, A. R. Wright, G. Khaliullin, and B. Rosenow, Phys. Rev. B 85, 140510(R) (2012).

TT 93.2 Thu 16:45 HSZ 201

Flat bands at surfaces of nodal topological superconductors: Spin polarization and charge currents — •Carsten Timm[1], Philip M. R. Brydon[2,1], and Andreas P. Schnyder[3] — [1]Institute of Theoretical Physics, Technische Universität Dresden, Dresden, Germany — [2]Condensed Matter Theory Center, University of Maryland, College Park, USA — [3]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany

Noncentrosymmetric superconductors with strong spin-orbit coupling generically show coexisting singlet and triplet pairing. If the superconducting gap has nodes on the Fermi surface, the system exhibits topologically protected flat surface bands. Employing exact diagonalization of lattice models and quasiclassical methods, we show that the flat-band states are strongly spin polarized. Since the spin polarization is odd in momentum, the surface states acquire a chiral dispersion if the superconductor is brought into contact with a ferromagnet. These chiral states carry a large charge current. We compare the results to a fully gapped topological superconductor.

TT 93.3 Thu 17:00 HSZ 201

Plasmons, gauge invariance and mass in non-centrosymmetric superconductors — •Nikolaj Bittner[1], Dietrich Einzel[2], Ludwig Klam[1], and Dirk Manske[1] — [1]Max–Planck–Institut für Festkörperforschung, Heisenbergstraße 1, D–70569 Stuttgart, Germany — [2]Walther–Meißner–Institut für Tieftemperaturforschung, Walther–Meißner–Straße 8, D–85748 Garching, Germany

We present for the first time a comprehensive, gauge–invariant description of the order parameter collective modes in the recently discovered non–centrosymmetric superconductors (NCS). The gauge mode (*Nambu–Goldstone Boson*, $\omega_{\rm G}$), common to all superconductors, and the new collective mode (*Leggett mode*, $\omega_{\rm L}$), which usually occurs in ordinary two–band superconductors, were specified by employing (Nambu–)matrix kinetic theory in the clean limit. Moreover, we investigate the dispersion and the general role of these collective excitations in NCS systems. In particular, the subtle interplay between the gauge mode and the Leggett mode is analyzed in view of the validity of the charge conservation law. The long–range Coulomb interaction is seen to introduce the condensate plasma frequency $\omega_{\rm P}$ into the description of NCS and to distinguish between the order parameter collective modes $\omega_{\rm G}$ and $\omega_{\rm L}$ with respect to their participation in the Anderson–Higgs mechanism [1,2]. In contrast to ordinary two–band superconductors, the possibility of a mass–less Leggett mode can be predicted to occur in NCS, which simulates the existence of a second gauge mode.

[1] P. W. Anderson, Phys. Rev. **130**, 439 (1963)
[2] P. Higgs, Phys. Rev. Lett. **13**, 508 (1964)

TT 93.4 Thu 17:15 HSZ 201

Phonon-mediated pairing in the new superconductor Ta_2PdS_5: A first principles study — •Rolf Heid and Klaus-Peter Bohnen — Institut für Festkörperphysik, Karlsruher Institut für Technologie

Recently, a new layered chalcogenide superconductor $Ta_2Pd_xS_5$, $x \approx 1$, with a T_c of 6 K was discovered and classified as a type-II s-wave superconductor [1]. The presence of the heavy $5d$ element Ta and the observation of a large upper critical field well above the estimated Pauli limit led to speculations of a strong influence of spin-orbit coupling on the superconducting state. A subsequent electronic-structure calculation classified this material as an anisotropic multiband metal [2]. From a comparison of the bandstructure density of states and the measured specific heat, a strong-coupling scenario with a coupling constant larger than 2 was inferred.

Here we address the question of a strong-coupling scenario for Ta_2PdS_5 within a first principles approach. We present results for the electronic bandstructure, phonon dispersion, and the phonon-mediated pairing interaction obtained via density-functional perturbation theory. We will also discuss the relevance of spin-orbit coupling for these quantities.

[1] Y. F. Lu et al., arXiv:1308.3766
[2] D. J. Singh, Phys. Rev. B 88, 174508 (2013)

TT 93.5 Thu 17:30 HSZ 201

Electron-phonon coupling of light-actinides: effect of spin-orbit coupling — Paola González-Castelazo[1], •Omar De la Peña-Seaman[1], Rolf Heid[2], and Klaus-Peter Bohnen[2] — [1]Benemérita Universidad Autónoma de Puebla (BUAP), Institute of Physics (IFUAP), México — [2]Karlsruher Institut für Technologie (KIT), Institut für Festkörperphysik (IFP), Germany

The physics of actinide metals is quite complex and rich due to the behavior of $5f$ electrons in the valence region: it goes from itinerant on the early stages of the actinide series to highly localized for the elements with a higher number of $5f$ electrons involved. In addition, in this systems should be mandatory the inclusion of spin-orbit coupling (SOC). However, only in few cases on electronic and lattice dynamical properties the SOC has been taking into account, while for the electron-phonon (e-ph) coupling such analysis has not been performed so far. Thus, as a first approach we have systematically studied the SOC influence on the full-phonon dispersion and the e-ph coupling for the simplest light-actinide metals: Ac and Th. These elements have been studied within the framework of density functional perturbation theory, using a mixed-basis pseudopotential method. The full-phonon dispersion as well as the Eliashberg spectral function and the electron-phonon coupling parameter have been calculated with and without SOC. The observed effects of SOC in the full-phonon dispersion and Eliashberg function are discussed in detail, together with an analysis of the differences on the electronic properties due to the SOC inclusion in the calculations.

TT 93.6 Thu 17:45 HSZ 201

Electromagnetic response of strongly disordered superconductors — •Götz Seibold[1], Lara Benfatto[2], Claudio Castellani[2], and Jose Lorenzana[2] — [1]BTU Cottbus-Senftenberg, Germany — [2]University of Rome 'La Sapienza', Italy

By including fluctuations beyond the Bogoljubov-de Gennes approach we investigate the static and dynamical properties of current correlations in the attractive Hubbard model with strong on-site disorder. In the static limit we find a strong renormalization of the superfluid stiffness due to the occurence of quasi one-dimensional percolative current patterns which connect superconducting islands. Moreover we show that for strongly disordered superconductors phase modes acquire a dipole moment and appear as a subgap spectral feature in the optical conductivity.