TT 45: Superconductivity: (General) Theory

Time: Wednesday 15:00–16:45 Location: H21

TT 45.1 Wed 15:00 H21

Density Functional Theory for Superconductors — •Antonio Sanna, Andreas Linscheid, and E.K.U. Gross — Max-Planck Institute for Microstructure Physics, Halle

Superconducting density functional theory (SCDFT) is a fully parameter-free approach to superconductivity. We review the method discussing the main theoretical advantages and disadvantage of the approach as compared to standard Green's functions methods. We present results for several conventional and unconventional superconductors, and in particular we will discuss the special case of surface superconductivity considering the case of Pb on Si(111). Then we will report on the most recent extensions of the method: to incorporate in a correct way the Migdal's theorem; compute the excitation spectrum; describe a coexistence with magnetism.

TT 45.2 Wed 15:15 H21

Two-particle self-consistent approach to unconventional superconductivity — •Junya Otsuki — Department of Physics, Tohoku University, Sendai, Japan — Theoretische Physik III, Zentrum für Elektronische Korrelationen und Magnetismus, Universität Augsburg

A non-perturbative approach to unconventional superconductivity is developed based on the idea of the two-particle self-consistent (TPSC) theory[1]. An exact sum-rule which the momentum-dependent pairing susceptibility satisfies is derived. Effective pairing interactions between quasiparticles are determined so that an approximate susceptibility should fulfill this sum-rule, in which fluctuations belonging to different symmetries mix at finite momentum. The mixing leads to a suppression of the $d_{x^2-y^2}$ pairing close to the half-filling, resulting in a maximum of T_c away from half-filling.

[1] J. Otsuki, Phys. Rev. B **85**, 104513 (2012).

TT 45.3 Wed 15:30 H21

Response and collective modes in two–band superconductors — •Nikolaj Bittner[1] and Dietrich Einzel[2] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, D-70569 Stuttgart, Germany — [2]Walther-Meißner-Institut für Tieftemperaturforschung, Bayerische Akademie der Wissenschaften, Walther-Meißner-Straße 8, D-85748 Garching, Germany

We present a systematic study of the response properties of two–band (multi–gap) superconductors with conventional and unconventional spin–singlet pairing correlations. Particular emphasis is on the existence, the dispersion and the general role of a new massive order parameter collective mode, the so–called Leggett mode, which arises as a consequence of interband pairing correlations. The subtle interplay between the gauge mode or Nambu–Goldstone Boson and the Leggett mode is studied in view of both the validity of the charge conservation law and the participation in the Higgs mechanism. The occurrence of the Leggett–mode is analyzed with respect to its experimental observability in all physically relevant spin-independent collisionless response functions like the Lindhard density response, the dielectric function, the supercurrent response (condensate dynamic conductivity) and the electronic Raman response. Possible applications of this theory include systems like various cuprates, MgB_2, pnictides and non–centrosymmetric superconductors.

TT 45.4 Wed 15:45 H21

Establishing Theoretically the Capacity of Resonant Inelastic X-ray Scattering to Probe the Phase and Excitations of the Superconducting Order Parameter — •Pasquale Marra[1], Steffen Sykora[1], Krzysztof Wohlfeld[1], and Jeroen van den Brink[1,2] — [1]Institute for Theoretical Solid State Physics, IFW Dresden, D-01069 Dresden, Germany — [2]Department of Physics, TU Dresden, D-01062 Dresden, Germany

The capability to probe the dispersion of elementary spin, charge, orbital, and lattice excitations has positioned Resonant Inelastic X-ray Scattering (RIXS) at the forefront of photon science. Here we develop the scattering theory for RIXS on superconductors, calculating its momentum-dependent scattering amplitude. Considering unconventional superconductors with different pairing symmetries and, in particular, evaluating the theoretical RIXS spectra for cuprate and pnictide-like systems, we show that the low-energy scattering is strongly affected by the superconducting gap and coherence factors. This establishes RIXS as a tool to disentangle pairing symmetries and to probe the elementary excitations of unconventional superconductors.

TT 45.5 Wed 16:00 H21

Effects of randomness on the critical temperature in quasi-1D and quasi-2D superconductors — •Enver Nakhmedov[1,2], Oktay Alekperov[2], and Reinhold Oppermann[1] — [1]Institut für Theoretische Physik, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Institute of Physics, Azerbaijan National Academy of Sciences, H. Cavid str. 33, AZ1143 Baku, Azerbaijan

Effects of non-magnetic disorder on the critical temperature Tc and on diamagnetism of quasi-1D and quasi-2D superconductors (SCs) are reported. The organic SCs are modeled as superconducting wires or layers connecting each others through the Josephson coupling. The Josephson energy is considered to be random parameter with Gaussian distribution. The phase of the order parameter is averaged over thermodynamic fluctuations as well as over disorder by employing the replica method. We show that the randomness destroys phase coherence between wires in quasi-1D SCs and that Tc vanishes discontinuously at a critical disorder-strength. Nevertheless the disorder of arbitrary high strength in quasi-2D organic SCs can not destroy completely the superconducting phase. The interplay between disorder and quantum phase fluctuations is shown to result in quantum critical behavior at T=0 in quasi-1D SCs, which manifests itself as a superconducting-normal metal phase transition of first-order at a critical disorder strength. The parallel and transverse components of the penetration-depth are evaluated. They diverge at different critical temperatures, which correspond to pair-breaking and phase-coherence breaking respectively. Our theory agrees well with the experimental measurements.

TT 45.6 Wed 16:15 H21

Stability of super-currents and condensates in type I superconductors — •Klaus Morawetz[1,2,3], Pavel Lipavsky[4], Bretislav Sopik[4], and Michael Maennel[1] — [1]Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — [2]International Institute of Physics (IIP), Av. Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — [3]Max-Planck-Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [4]Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, 12116 Prague 2, Czech Republic

Excitations of Cooper pairs into non-condensed bound pairs are similar to excitations of true bosons out of the Bose-Einstein condensate. Using the Landau criterion of superfluidity we evaluate the critical current above which these pair-excitations would lead to a finite resistivity. The predicted value strongly depends on the chosen approximation. The Kadanoff-Martin theory which is in many aspects equivalent to the BCS theory, leads to zero critical velocity, what is in conflict with the mere existence of super-currents. In contrast, the T-matrix with multiple scattering corrections provides the critical velocity of pair excitation which is $\sqrt{3}$-times larger than the critical velocity of pair breaking. This agrees with the experimentally well established fact that super-currents in type I superconductors are limited by pair breaking, not by pair excitation.

TT 45.7 Wed 16:30 H21

Vacuum phonon squeezing in femtosecond-laser excited noble metals — •Fairoja Cheenicode Kabeer, Eeuwe S. Zijlstra, and Martin E. Garcia — Universität Kassel, Kassel, Germany

The interaction of a femtosecond-laser pulse with a material can either strengthen or weaken the interatomic potential, which may give rise to many interesting ultrafast structural phenomena. Using electronic-temperature dependent density functional theory we demonstrate that the noble metals copper and silver show laser-induced bond hardening and that this can be used to achieve vacuum phonon squeezing. For the squeezed states we predict optimal squeezing factors at the L-point longitudinal mode which are orders of magnitude greater than what has been achieved so far[1].

[1] G. A. Garrett et al., Science 275, 1638 (1997)