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15:00

XHQ Seminar Room E1-096

Superconductivity in multiband superconductors with small Fermi energies

by

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Recent observation of superconductivity in multiband systems such as iron-based superconductors (FeSe), Nb doped $SrTiO_3$, and oxide interfaces with superconducting gaps being of the order of their Fermi energies brought these materials into the orbit of a long-standing discussion about the interplay between superconductivity and the formation of the bound pair of two fermions. This issue has been discussed in the condensed matter context for the single band systems such as cuprates, and also for optical lattices of ultracold atoms. The phenomenon in which bound pairs of fermions form at a higher T_{ins} and condense at a smaller T_c is often termed Bose-Einstein condensation (BEC) because the condensation of preformed pairs (i.e., the development of a macroscopic condensate) bears a direct analogy with BEC of bosons in a Bose gas.

In my talk I will consider the interplay between superconductivity and formation of bound pairs of fermions in multi-band 2D fermionic systems (BCS-BEC crossover). In two spatial dimensions a bound state develops already at weak coupling, and BCS-BEC crossover can be analyzed already at weak coupling, when calculations are fully under control. We found that the behavior of the compensated metal with one electron and one hole bands is different in several aspects from that in the one-band model. There is again a crossover from BCS-like behavior at EF>>E0 (E0 being the bound state energy formation in a vacuum) to BEC-like behavior at EF<< E0 with Tins > Tc. However, in distinction to the one-band case, the actual Tc, below which long-range superconducting order develops, remains finite and of order Tins even when EF = 0 on both bands. The reason for a finite Tc is that the filled hole band acts as a reservoir of fermions. The pairing reconstructs fermionic dispersion and transforms some spectral weight into the newly created hole band below the original electron band and electron band above the original hole band. A finite density of fermions in these two bands gives rise to a finite Tc even when the bare Fermi level is exactly at the bottom of the electron band and at the top of the hole band.