MAR06-2005-000773

Abstract for an Invited Paper
for the MAR06 Meeting of
the American Physical Society

Effect of Spin Fluctuations on Electron-Phonon Superconductivity[1]

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Most of our intuition regarding conventional superconductivity is derived from the McMillan formula. What are often believed to be generic properties of the Eliashberg equations, in reality hold only in the regime where the McMillan formula is applicable. I will show how common beliefs, such as a monotonic relation between the reduced gap and the coupling constant, or an exponential behavior of the NMR relaxation with the gap as the activation parameter, fail for more complicated spectral functions. Most interestingly, I will demonstrate that our conventional wisdom totally fails us in the rapidly developing field of superconductors near a magnetic instability. In particular, I will derive (and test against numerical solutions of the Eliashberg equations) an analogue of the McMillan formula, fully accounting for the pair-breaking effect of spin fluctuations, and will show that these *increase* the phonon isotope effect, sometimes by as much as a factor of two. This is counterintuitive and opposite to the effect of the high-energy Coulomb interactions (the so-called Coulomb pseudopotential). I will also discuss the possibility of observing this effect in specific materials, such as $MgCNi_3$. This work has been done in collaboration with Oleg Dolgov (MPI Stuttgart) and Alexander Golubov (U. Twente).

[1]I acknowledge the hospitality of the Max Planck Institute in Stuttgart where much of this work has been done.