MAR11-2010-000344

Abstract for an Invited Paper
for the MAR11 Meeting of
the American Physical Society

How spins become pairs: Composite pairing and magnetism in the 115 heavy fermion superconductors

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The highest temperature heavy fermion superconductors are found in the 115 family: $CeMIn_5$ (M=Co,Ir,Rh) and $PuMGa_5$ (M=Co,Rh) [1], where the heavy quasiparticles are only partially formed by the time they pair. The internal structure of the pair is thus just as important as the forces holding it together. We show that the heavy fermion condensate necessarily contains two d-wave components condensed in tandem: pairs of heavy quasiparticles on neighboring sites and composite pairs consisting of two electrons bound to a single local moment. These two components draw upon the antiferromagnetic and two-channel Kondo interactions, respectively, to cooperatively enhance the superconducting transition temperature, as we demonstrate within a symplectic-N solution [2,3] of the two-channel Kondo-Heisenberg model [4]. Additionally, the tandem condensate is electrostatically active, which we predict will result in a superconducting shift in the electronic quadrupolar frequency, as measured in Mossbauer spectroscopy.

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