Quantum Mechanical Model of a Pre-formed Cooper Pair in Fulleride Superconductivity

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There continues to be enormous interest in the BCS - BEC crossover – home to fulleride and high temperature copper oxide superconductors. Last year we reported a connection made between the fulleride crossover and "cold" atom Fermion-Boson crossover theory [1]. While the ground and singly excited states remain continuous, the two-particle bound state goes through a Feshbach resonance, tuned by doping. This causes a breakdown of the Migdal theorem, thereby transforming the nature of the superconductivity from a "standard BCS" interaction to a mode dominated by the pre-formed Cooper pair due to necessary vertex corrections near the resonance. The physical nature of the Cooper (or "molecular") pairs also changes as the previously suggested location [1] of a critical point in the fulleride phase diagram is passed. According to this model, pre-formed pairs and an excited state critical point are both present.

We discuss these features and present arguments to establish a model of the pre-formed pair and discuss our view that the pre-formed pair has been experimentally observed, as is the case in other insulator-metal transitions [2].

[1] R. H. Squire and N. H. March, Intern. J. Quant. Chem.107, 3013 (2007).
[2] M. D. Stewart, A. Yin, J. M. Xu, J. M. Valles, Science 318, 1273 (2007)