Cuprate Electronic Phase Diagram for Superconductivity Using a Modified Boson-Fermion-Gossamer Model to Describe Competing Orders

Richard H. Squire[ξ] , Norman H. March[*†]

[ξ] Department of Chemistry, West Virginia University
Institute of Technology University
Montgomery, WV 25303, U

[*] Department of Physics, University of Antwerp (RUCA), Groenborgerlaan 171,
B-2020 Antwerp, Belgium
and
Oxford University, Oxford, England

ABSTRACT

We present arguments that suggest that the nature of the experimentally observed "preformed pair" in the Cuprates could be considered to have a similar function to an experimentally observed circular charge 2e density wave (2e-DW) isolated on a fulleride molecule. The electron binding (hole binding in Cuprates) is stronger than a typical BCS Cooper pair. The superconducting dome in both cases is explained by a reinterpretation of the condensed phase version of the modified BFM [1] which includes both Feshbach resonance-type and BCS superconducting terms, a 2e-DW and a CDW in a highly correlated manner. The two particle collective mode contains a singularity due to a Feshbach resonance (tuned by doping), causing a breakdown of the Migdal theorem and creating a quantum critical point (QCP). As a result of vertex corrections, there is a fundamental change in the nature of the superconductivity in the dome region due to the formation of a 2e-DW density wave ("preformed pair"), often discussed since the work of Nozieres and Schmitt-Rink [2] which we claim has been experimentally observed in both fullerides and Cuprates. The 2e-DW has a dual role: it suppresses BCS superconductivity as the doping diminishes, producing a quantum phase transition between BCS and more BEC-like (or Feshbach resonance) superconductivity (FRSC) which we claim is the Gossamer "powerful attractive force." It is also responsible for the pseudogap formation at very low doping where the 2e-DW moves out of resonance with the complementary CDW causing the superconducting phase ("dome") to diminish. Experimental evidence supports this interpretation in both HTSC and the fullerides. The QCP is speculated to be at or near the closing of the Mott insulator gap. Interestingly enough, the model suggests a different microscopic mechanism for a RVB-like theory. A phase diagram for the entire Cuprate superconducting ("dome") region is presented and discussed.