High T$_c$ Superconductivity and metastability

Julius Ranninger[1]

[1] *Institut NEEL, CNRS and Unversite Joseph Fourier,*
BP 38042, Grenoble-Cedex 9, France

The persistent superfluid (resistance-less) flow in superconductors is assured by electromagnetic gauge invariance breaking. In the low temperature BCS superconductors this arises from a normal state, which presents a highly polarizable Fermi liquid, susceptible to Bose-Einstein condense Cooper pairs into a phase correlated macroscopic quantum state. In a field theoretical approach this is expressed as spontaneous symmetry breaking of an infinitely degenerate quantum vacuum - the parent state of the superconductor, which presents a Higgs field. The elementary excitations of it are the Higgs amplitude mode and the Nambu-Goldstone phase mode of the condensate. The latter, being irrevocably coupled via gauge relations to the gauge of the electromagnetic field, thereby generates a longitudinal component of the vector field. It is that which acts as the stabilizing factor of persistent currents - solely controlled by their inertia. In high T$_c$ superconductors the corresponding parent state is not an infinitely degenerate quantum vacuum, described by a Fermi liquid and the usual collective modes are not simply Goldstone modes. We view this state to arise from an intrinsic metastability of those materials and describe it in terms of spin-singlet pairs popping in and out of existence of a Fermi liquid background. Formulating such a scenario in terms of a generic Boson-Fermion model, the charged fermionic and bosonic excitations become effectively interchangeable. On the basis of a functional integral approach to such a scenario, analogous to a Ginzburg-Landau formulation of BCS, we highlight its salient features which emerge as a direct consequence of metastability and in particular the phase-separation driven transition between a Bose-glass, composed of localized diamagnetic pairs, and their condensed superpfluid state, monitored by a change in doping.