Ten Possible Reasons Why High-T_c Superconductivity is Stalled

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Standard assumptions commonly made in the microscopic theory of superconductivity are submitted as premises that are, at best, questionable, and that, in our opinion, have stalled progress in the field. Among these is the belief that a maximum critical temperature of about 45 kelvin is achievable via the electron-phonon interaction between electrons (or holes) needed to overcome the repulsive Coulomb interaction. This is required to produce pairing between charge carriers. Because of the ceiling of 45 K, it is then assumed that higher T_cs require excitons or magnons or plasmons or purely-electronic mechanisms. Another widespread tenet is that Bose-Einstein condensation (BEC) is unrelated to the superconducting condensate, mainly because the (Cooper) (CPs) pairs that are essential for such a condensate are not bosons as they do no obey the usual

Bose commutation relations. A corollary of this is that BEC is impossible in 2D, anyway, even though all cuprate superconductors are quasi-2D.

The greatest confusion, it seems, involves the very nature of CPs. In BCS theory CPs with nonzero center-of-mass momenta (CMM) are entirely neglected. The original 1956 Cooper problem involved only pairs of electrons (2e-CPs) above the Fermi surface of an ideal Fermi gas (IFG) sea, and completely neglected hole pairs (2h-CPs) below that surface. Thus, negative-energy stable (i.e., stationary) bound states $E_0 = -2\hbar\omega_D/(e^{2/\lambda} - 1) \underset{\lambda\to 0}{\longrightarrow} -2\hbar\omega_D e^{-2/\lambda}$ were obtained for the 2e-CPs, where ω_D is the maximum (Debye) frequency of a lattice phonon and λ is a dimensionless coupling parameter. Taking both 2e- & 2h-CPs into account, however, the purely-imaginary energy $E_0 = \pm i2\hbar\omega_D/\sqrt{e^{2/\lambda}-1}$ was found by Bogoliubov *et al.* (1958), by Abrikosov *et al.* (1961), as well as by Schrieffer (1964). It is this result, and not the fact that 2e-CPs are bound no matter how weak the (attractive) interaction between electrons, that is the true "Cooper pair instability." It forces one to either abandon the CP concept—without which superconductivity can most probably *not* occur—or to replace the IFG sea by a different kind of sea, or zero-order-ground-state as a starting point. As regards the non-zero CMM behavior of CPs, it can be shown that they do not propagate in the presence of a Fermi sea like $\hbar^2 K^2/4m$, with $K \equiv k_1 + k_2$, as they would *in vacuo*, but rather like $E_0 - E_K = \frac{1}{2} v_F \hbar K$ as stated originally, without proof, by Schrieffer (1964) and further, that this linearity is distinct from the sound mode in an ideal Fermi gas with soundspeed $v_F/\sqrt{3}$. A clear distinction can be made between BCS pairs which do not obey Bose commutation relations, and CPs which obey Bose statistics so that they can indeed undergo BEC.

Finally, recent numerical results are presented that show how room-temperature superconductivity can be achieved within a BEC scenario without abandoning electron-phonon dynamics.