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BCS-Bose crossover extended with hole cooper pairs

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Applying the generalized Bose-Einstein conden-sation (GBEC)[1] theory we extend the BCS-Bose crossover theory by explicitly including hole Cooper pairs (2hCPs). GBEC hinges on three separate new ingredients, it: a) treats CPs as *actual* bosons which as distinct from BCS pairs which strictly speaking are *not* bosons; b) includes 2hCPs on an equal footing with two-electron ones (2eCPs) ; and c) in the resulting ternary ideal boson-fermion (BF) gas natur-ally incorporates BF vertex interactions that drive forma-tion/ disintegration processes of CPs. This leads to a phase diagram with two pure phases, one with 2hCPs and the other with 2eCPs, plus a mixed phase with arbitrary proportions of 2eCPs and 2hCPs. The special-case phase when there is perfect symmetry, i.e., with ideal 50-50 proportions between 2eCPs and 2hCPs, gives the usual *unextended* BCS-Bose crossover. But the *extended* crossover predicts T_c/T_F values (with T_c and T_F the critical and the Fermi temperatures) for some well-known conventional superconductors comparing quite well with experiment and, notably, much better than BCS predictions. In turn, these results are compared with theoretical curves associated with the extended crossover for the special case of perfect symmetry holding at $n/n_f = 1$, where n is the total number particle density and nf is the number density of unbound electrons at T = 0. Remarkably, for 50-50 symmetry all extended-crossover results lie below the Bogoliubov *et al.* upper limit $\lambda_{BCS} \leq ½$, where λ_{BCS} is the dimensionless BCS coupling constant; this affords corroboration of their limit.

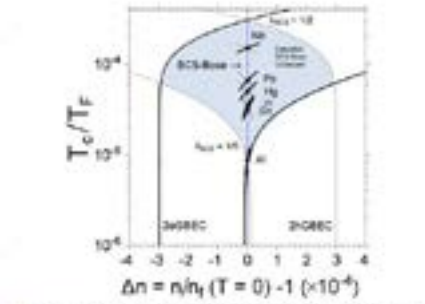

Fig. 1. Theoretical curves of extended crossover compared with experimental values of T_c/T_F for superconductors Al, Sn, In, Hg, Pb and Nb. Thick curves labeled 2eGBE/2C phase are obtained simultaneously solving a gap-like equation for 2eCPs plus the number equation; thin curves labeled 2hGBE/2C by solving a gap-like equation for 2hCPs plus the number equation. Black dots mark experimental T_c/T_F values with $\Delta n = n/n_f - 1 = 0$ where error bars fall within dot size. Top pairs of curves labeled as $\lambda_{BCS} = ½$ (the Bogoliubov et al. upper limit, with $n_{sup}/n_f = 0.002$) while bottom pairs of curves are for $\lambda_{BCS} = 1/5$ with $n_{sup}/n_f = 0.001$. These Debye-energy values scaled with Fermi energy are typical for conventional superconductors.

Biography

I Chávez, MS, is a PhD candidate in the Material Sciences and Engineering Research Program at National Autonomous University of Mexico (UNAM). He is assistant professor in the School of Sciences at UNAM. He won 3rd place in the 1st National Journalism Contest 2010, CONACyT, in Mexico with the paper entitled *"Noninteger dimensions."*

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