Incidence of electronic correlations on the Superconductivity near the Mott transition of alkali fullerides

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Most investigations on correlated electron systems deal with the interplay of magnetism and superconductivity (SC). Indeed in many families of compounds in which electronic correlations (EC) are of importance, the phase diagrams exhibit magnetic phases proximate with a SC phase. It is often thought that the ECs are at the origin of the superconducting pairing.

Here we address a specific case of SC in the A_3C_{60} compounds [1], where A is an alkali metal. Former extensive investigations mainly by NMR techniques, have led one to consider that a BCS electron-phonon mechanism prevails[2], suggesting a negligible incidence of ECs. However further detailed studies of A_nC_{60} compounds with $n = 1, 2, 4$ [3] , [4] gave evidences that their electronic properties cannot be explained by a simple band filling of the C_{60} molecular level. This could only be ascribed to the influence of ECs and of Jahn-Teller Distortions of the C_{60} ball, which favour evenly charged C_{60} molecules [3].

The discovery of two Cs_3C_{60} isomeric compounds Cs_3C_{60} which exhibit a transition with pressure from a Mott insulator to a SC state clearly emphasize the importance of ECs [5], [6]. Using pressure (p) as a single control parameter of the C_{60} balls lattice spacing, one can now study the evolution of the SC properties when the corelations are increased towards the critical pressure p_c of the Mott transition.

We have used ^{13}C and ^{133}Cs NMR data taken on the $A15$-Cs_3C_{60} cubic phase, just above $p_c = 5.0(3)$ kbar, where the SC T_c displays a dome shape with decreasing cell volume [7]. From the T dependence below T_c of the nuclear spin lattice relaxation rate $(T_1)^{-1}$ we determine the electronic excitations in the SC state, that is 2Δ, the gap value. The latter is found to be largely enhanced with respect to the BCS value established in the case of dense A_3C_{60} compounds. It even increases slightly with decreasing p towards p_c, where T_c decreases on the SC dome, so that $2\Delta/k_BT_c$ increases regularly upon approaching the Mott transition. These results bring clear evidence that the increasing correlations near the Mott transition are not significantly detrimental to SC. They rather suggest that repulsive electron interactions might even reinforce electron-phonon SC, being then partly responsible for the large T_c values, as proposed by theoretical models taking the ECs as a key ingredient [8].

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