Max-Planck-Institut für Struktur und Dynamik der Materie

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Superconductivity of alkali doped fullerides: the case of Cs_3C_{60}

During the last two decades intercalated fullerides have been widely investigated, due to their attractive physical properties, in particular the superconductivity (SC) at relatively high T_c of A_3C_{60}, (A is an alkali atom) [1]. Despite SC of A_3C_{60} is clearly mediated by "on-ball" C_{60} phonons, these compounds cannot be simply rationalized in the framework of BCS/Migdal-Eliashberg theory, but the presence of electronic correlations must be taken into account for the detailed description of their electronic properties [2].

Recently, the hyper-expanded fulleride Cs_3C_{60} has being attracting strong scientific interest. In fact, in this new material it is possible to switch between the antiferromagnetic (AF) insulating ground state to a superconducting one simply by applying a moderate hydrostatic pressure [3], while preserving the same disorder-free A15 cubic structure (T_c=38 K at ~7 kbar) and representing hence a unique situation for investigating the interplay between phonon SC and electron correlations. Moreover, the presence of a clear Mott- transition and the observation of a "bell-shaped" dependence of T_c on the applied pressure indicates that A15-Cs_3C_{60} is a "model-system" for studying the SC mechanism in high-Tc superconductors.

We performed a detailed study of the electronic properties of Cs_3C_{60} by means of solid state NMR spectroscopy under pressure. Cs_3C_{60} is invariably prepared as a mixture of three polymorphs, simple cubic (A15), face centered cubic (fcc) and body centered orthorhombic (bco). We found for the first time that also fcc-Cs_3C_{60} displays a Mott transition under pressure towards a high T_c superconducting state [4], suggesting that the inter-ball distance, rather than the crystal structure, is the driving parameter for the onset of SC in Cs_3C_{60}. ON the other hand the different structures affect the magnetic order, as below p_c, the magnetic ground state is quite different in the two phases. Clear evidences of the presence of electronic correlations near the Mott transition emerged by NMR spin lattice relaxation T_1 measurements across p_c, which cannot be explained in a simple BCS scenario [5]. The increasing correlations near the Mott transition seem not to be detrimental to superconductivity, on the contrary the repulsive electron interactions were found to even reinforce electron-phonon coupling, being responsible for the large measured T_c value [6].

References:
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[3] A.Y. Ganin et al., Nat. Mater. 7, 367 (2008).
[4] Y. Ihara et al., Phys. Rev. Lett. 104, 256402 (2010).
[5] Y. Ihara et al. Europhys. Lett. 94, 37007 (2011).
[6] P. Wzietek et al., Phys. Rev. Lett. 112, 066401 (2014).

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