Comment on "Al NMR Local Probe of Local Moments Induced by an Al impurity in High-T_c Cuprate $La_{1.85}Sr_{0.15}CuO_4$"

In a recent Letter, Ishida *et al.* [1] reported the observation of the ^{27}Al NMR in $La_{1.85}Sr_{0.15}CuO_4$, in which the Cu site has been substituted by "nonmagnetic" aluminum. This experiment is quite analogous to a previous report of an experiment done in our group in Orsay, on the ^{89}Y near neighbor resonance of Zn substituted on the Cu(2) site in $YBa_2Cu_3O_{6.6}$ ($YBCO_{6.6}$) [2]. The interesting observation is the appearance of a Curie contribution to the susceptibility in these systems, which we could show from the hyperfine field analysis in $YBCO_{6.6}$ to be localized on the four Cu in plane near neighbors to the substituted Zn.

Of course the fact that "nonmagnetic impurities" induce a large decrease of T_c in the cuprate superconductors is an important problem which has been underlined since the early times of the high-T_c superconductivity discovery [3]. Its understanding might be linked with the actual symmetry of the order parameter.

It is of course natural then to question the role of the induced moments, and to wonder whether magnetic pair breaking, *a la* Abrikosov-Gor'kov theory through their exchange coupling J with the conduction holes, plays any role. This was done by our group [2] and by Ishida in Ref. [1]. A large difference of appreciation appears, as in our case we did not give too much significance to the numbers derived for J, except for their order of magnitude, which led us to conclude that the influence of these magnetic properties should not be considered as negligible, even in $YBCO_7$. On the contrary Ishida *et al.* analyze in detail their data with the classical model derived for magnetic impurities in noble metal hosts. We think that it is not realistic to draw conclusions *neither on the superconductivity mechanism, nor on the symmetry of the order parameter,* from such a quantitative analysis. The occurrence of strongly antiferromagnetic (AF) correlations, the anomalous absence of contribution of the doped holes to the susceptibility forbid to consider the underlying spin fluid as a simple Fermi liquid. The actual theoretical developments are not yet at a stage which allows one to treat the impurity problem quantitatively.

Of course one needs to use some theoretical guidelines and an *sd* exchange model can be used *as a zero order approximation, if the results are not then overinterpreted.* However, it is our opinion that, within this oversimplified framework, a basic error has been done in Ref. [1], as they consider that the induced moments on the Cu sites are *independent fluctuating entities,* which scatter independently the conduction holes. We have rather always considered, on the contrary, that the perturbation induced by the impurity is a quantum state which extends over at least these four neighbors, and that the induced moment behaves as a *single entity.* This is in opposition with the idea promoted by Ishida *et al.* who state that the AF spin correlations are destroyed near the Zn or Al impurity. The very fact that local magnetism appears on the Cu near Zn or Al is proof that correlations are stronger. In a naive picture this could occur if holes are partly expelled from the neighborhood of the Zn. There are some indications that for Zn substituted samples the oxygen content cannot be increased up to seven as for pure $YBCO_7$, which would imply a slight underdoping [4], while magnetic properties far from the Zn are near those of a well overdoped system. Even if this naive chemical effect is not valid, a more direct evidence for larger correlations in the vicinity of the Zn is derived from inelastic neutron scattering experiments performed recently in Saclay [5] both in the underdoped and optimally doped states. Here, it has been shown that a strong low energy scattering at the AF wave vector which does not exist in the pure system occurs in Zn substituted samples, and persists below T_c. These low energy excitations should be related with the magnetic fluctuations we detected from the short ^{89}Y spin lattice relaxation of the Zn near neighbors [2]. Therefore, at least in underdoped systems, the *induced spins on the Cu are correlated,* with a correlation length which exceeds the lattice constant. These AF couplings correspond to a ferromagnetic correlation for the four Cu moments near Zn or Al. It follows that the analysis done in [1] assuming independent moments is not reliable and that the 50 K Weiss temperature deduced from the susceptibility measurements is somewhat puzzling. In the case of $YBCO_7$:Zn, no such Weiss temperature can be deduced from the susceptibility data [6].

The criticism done here does not put into question the beauty of the experiment of Ishida *et al.* [1] which evidences that our observation performed in $YBCO_7$:Zn extends to other cuprates as well. The fact that suppression of a spin induces moments on the neighboring sites is certainly strong further evidence that the CuO_2 planes are correlated electronic systems and that their magnetic properties, which have been studied at length by NMR and neutron scattering experiments, are indeed quite original.

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