Magnetic Excitations in Strongly Correlated Electrons
J. Phys. Soc. Jpn. **69** (2000) Suppl. B. pp. 114-121

Impurities and Defects as Probes of the Original Magnetic Properties of the Cuprates

H. Alloul[*,+], J. Bobroff[*], A. MacFarlane[*], P. Mendels[*] and F. Rullier-Albenque[+,&].
[*] *Laboratoire de Physique des Solides, UMR 8502 CNRS, Université Paris-Sud 91405, Orsay (France)*
[+] *LSI/CEA/CNRS Ecole Polytechnique, 91128 Palaiseau,(France).*
[&] *Present address: SPEC/CEA, Orme des Merisiers, 91191 Gif-sur-Yvette (France)*
(March 22, 2000)

Substitutional impurities in the CuO_2 planes of the cuprates allow us to probe the electronic properties of the host material. The pseudo-gap in the underdoped regime is unmodified far from the impurities even though T_c is greatly reduced. In the overdoped regime, it is not detected above T_c and the data in presence of impurities seems to imply that the pseudo-gap and T_c lines cross each other. The spin polarisation induced by magnetic impurities has an oscillatory staggered behaviour reflecting the existing AF correlations between the Cu spins. Its influence on the NMR spectra opens a way to determine the $\mathbf{q}$ dependence of the static spin susceptibility and the T dependence of the AF correlation length. NMR measurements demonstrate that non-magnetic impurities such as Zn or Li induce a local moment behaviour which results from staggered magnetism on the near neighbour copper sites. Li NMR shift data allow to measure accurately the susceptibility associated with these local moments. It is found to display a Kondo like $(T+\Theta)^{-1}$ dependence, with a Kondo Θ which increases abruptly near optimal doping.
The magnetism revealed by spin-less sites can be understood on theoretical grounds in the case of undoped quantum spin systems. The present results reflect the influence of oxygen hole carriers on the AF correlations between hole spins in the cuprates. Another manifestation of this coupling is the large scattering of the carriers by spin-less impurities detected in transport properties. Resistivity measurements on single crystals with point defects created by electron irradiation allow to demonstrate that the residual resistivity and the reduction of T_c due to these defects are in agreement with scattering in a d-wave superconductor, and that the concentration of carriers remains the concentration n_h of doped holes even in the overdoped regime. The large scattering due to spin-less defects should be related to the Kondo like resonance peak detected with local magnetic probes.