Abstract Submitted
for the MAR07 Meeting of
The American Physical Society

Identifying Collective Modes in $d_{x^2-y^2}$-wave Superconductors via Impurities ROY NYBERG, DIRK MORR, ENRICO ROSSI, University of Illinois-Chicago — We demonstrate that magnetic impurities can be employed to identify the nature of collective modes in the cuprate superconductors. Specifically, we show that a magnetic impurity in an external magnetic field pins an antiferromagnetic collective mode, thus inducing to a local spin-density wave (SDW), i.e., a magnetic droplet. Using a scattering $\hat{T}$-matrix formalism, we find that the presence of such a droplet significantly changes the local electronic structure of the $d_{x^2-y^2}$-wave superconductor. In particular, it suppresses the local density of states (LDOS) inside the droplet on the energy scale of the superconducting gap without inducing an impurity states inside the gap. Moreover, the spin-resolved LDOS exhibits characteristic differences on the two sublattices of the antifferomagnetic droplet. This effect, together with the spatial dependence of the LDOS provides inside into the characteristic momentum of the mode as well as its correlation length. Since these features are absent for other collective modes such as phonons or charge-density waves, our study provides future experiments with the possibility to identify the nature of collective modes.

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Date submitted: 02 Dec 2006 Electronic form version 1.4