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Intense paramagnon excitations in a large family of high-temperature superconductors

MATHIEU LE TACON, Max Planck Institute for Solid State Research

Motivated by the search for the mechanism of high-temperature superconductivity, an intense research effort has been focused on the evolution of the spin excitation spectrum upon doping from the antiferromagnetic insulating to the superconducting states of the cuprates. Because of technical limitations, however, the experimental investigation of doped cuprates has been largely focused on excitations with energies $\leq$ **100** meV in a small range of momentum space [1]. Here we take advantage of the recent developments of high-resolution resonant inelastic x-ray scattering [2,3] to show that a large family of superconductors, encompassing the model compounds $YBa_2Cu_4O_8$ and $YBa_2Cu_3O_7$, exhibits damped spin excitations - or paramagnons - with dispersions and spectral weights closely similar to those of magnons in undoped, antiferromagnetically ordered cuprates over much of the Brillouin zone. The results are in excellent agreement with the spin excitations obtained by exact diagonalization of the $\mathbf{t-J}$ Hamiltonian on finite-sized clusters. A numerical solution of the Eliashberg equations based on the experimental spin excitation spectrum of $YBa_2Cu_3O_7$ reproduces its superconducting transition temperature $\mathbf{T_c}$ within a factor of two. The discovery of a well-defined, surprisingly simple spin excitation branch over a wide range of doping levels thus strongly supports magnetic Cooper pairing models for the cuprates [4].

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