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

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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 (AF) to the superconducting states of the cuprates. Because of technical limitations, however, the experimental investigation of doped cuprates has been largely focused on low energy excitations (<100 meV) in a small range of momentum space. Here we use RIXS to show that a large family of superconductors, encompassing the model compound $\text{YBa}_2\text{Cu}_3\text{O}_7$, exhibits damped spin excitations - paramagnons - with dispersions and spectral weights similar to those of magnons in undoped AF cuprates over much of the Brillouin zone. This is in excellent agreement with the spin excitations obtained by exact diagonalization of the t - J Hamiltonian on finite-sized clusters. A numerical solution of the Eliashberg equations based on our experimental findings for $\text{YBa}_2\text{Cu}_3\text{O}_7$ reproduces its TC 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.

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