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Novel magnetic excitations in a model cuprate high-T_c superconductor[1]

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Magnetic fluctuations might be essential to the mechanism of high-temperature superconductivity in the cuprates. For a long time, such fluctuations have been theoretically regarded as arising from the antiferromagnetic correlations within the copper-oxygen layers, and experimental studies of magnetic excitation spectrum have mainly been carried out near the corresponding wave vector (1/2, 1/2). Following neutron diffraction experiments which demonstrated the universal existence of a "$q = 0$ antiferromagnetic order" in the pseudogap phase of three different cuprates [1-3], our recent inelastic neutron scattering experiments on the model compound $HgBa_2CuO_{4+\delta}$ (Hg1201) revealed the existence of unusual magnetic excitations that weakly disperse throughout the entire Brillouin zone [4,5]. Like the $q = 0$ antiferromagnetic order, the new excitations are observed in the pseudogap phase and therefore appear to be associated with the order. The excitations possess very large spectral weights at well-defined characteristic energies that are comparable to the resonance energy [6] and to those of electron-boson-coupling features observed in a wide range of cuprates, highlighting their possible influence on the electronic structure. These findings demonstrate that the pseudogap state is a distinct phase of matter rather than a mere crossover. They furthermore cast doubt on the presumed predominant importance of the wave vector (1/2, 1/2) in the magnetic excitation spectrum, and have the profound implication that a single-band description of the cuprates is insufficient.

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