Magnetic order out of disorder in the cuprate

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Abstract

The cuprates are the parent materials for high temperature superconductivity; many of them become superconductors upon doping. In the absence of doping, cuprates are usually antiferromagnetic insulators. Understanding the magnetism should supply insight into the relevant electronic interactions in these systems.

The physics of the cuprates is believed to be dominated by the CuO_2 planes, which are weakly coupled. To leading order, the magnetism is described by the spin-1/2 quantum Heisenberg model, which results from superexchange. However, the specific magnetic structures of the different cuprates can be explained only by adding symmetry breaking terms. In some cases, such terms follow from spin-orbit interactions. In other cases, even such anisotropies are insufficient at the mean-field level; the average interactions are still isotropic. In many of those situations, fluctuations break this symmetry, and choose easy axes for the spins.

In many cuprates, the spins belong to different sub-lattices, with a vanishing mean-field coupling between them. Again, fluctuations help remove this apparent frustration, and participate in determining the magnetic order.

The present talk will review some of the above situations, explaining how the fluctuations generate order. The effects will be demonstrated through the example of $Sr_2Cu_3O_4Cl_2$, which exhibits two magnetic transitions, related to two subsets of copper spins. Detailed experiments have confirmed that the second transition is dominated by quantum fluctuations. These fluctuations lift the classical degeneracy, and yield Ising criticality.