# Reduction of long-range antiferromagnetic order by hole doping

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The discovery of superconductivity in the layered copper oxides has stimulated the study of the magnetism in these materials, both because of its intrinsic interest and its possible role in the mechanism for high-Tc superconductivity.

The undoped parent compounds are antiferromagnetic (AF) insulators. Experimentally, the long-range AF order is rapidly destroyed when dopant holes are introduced. Upon further doping the system becomes superconducting, while short-range AF fluctuations still persist.

It is widely believed that the $CuO_2$ planes are responsible for the superconductivity. In the undoped materials, they are well described by the isotropic spin-1/2 Heisenberg model on a square lattice. Doping introduces holes, which are the charge carriers, in the magnetic lattice of copper spins. The simplest model that seems to contain the physics of the high-Tc materials is the t-J model, which describes holes moving in a Heisenberg spin system.

We study the doping dependence of the staggered magnetization of a two dimensional antiferromagnet in the t-J model, for small hole concentration at T=0 K. In this system the holes are strongly coupled to the antiferromagnetic spin array and, as a consequence, the motion of holes generates spin fluctuations, either by absorption or emission of magnons. We use the Schwinger boson representation and calculate the renormalization of the magnetization induced by the hole-magnon interaction. The spin-wave Green's functions are calculated in the self-consistent Born approximation.

It is shown that the staggered magnetization of a two dimensional antiferromagnet is strongly reduced as a function of hole doping, due to the hole-magnon interaction generated by hole motion. Hole motion introduces additional spin fluctuations which lead to the destruction of the long-range AF order. This effect is mainly due to the decay of spin waves into particle-hole excitations, which arises from the imaginary part of the spin wave self-energies generated by the hole-magnon interaction. We find that both the coherent and incoherent motion of holes lead to a decrease of the magnetization. Our results give a vanishing of the staggered magnetization for a very small hole concentration, $n_c \simeq 0.01$, which is in reasonable agreement with experimental data for the doped copper oxide superconductors.