Universal behavior of the magnon gaps in doped quasi-2D antiferromagnets

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Many cuprate compounds at low doping exhibit long-range antiferromagnetic (AF) order, e.g., $La_{2-x}Sr_xCuO_4$ (LSCO). In the Néel phase these materials can be effectively described as anisotropic quasi-2D Heisenberg antiferromagnets, where holes are represented by dipole fields linearly coupled to the background magnetization current. Small Dzyaloshinskii-Moriya (DM) and XY anisotropies are responsible for opening of the magnon gaps which in LSCO rapidly decrease with doping and close at the AF phase boundary $x_c \sim 0.02$.

Within the framework of the anisotropic quantum non-linear σ-model (QNLσM) we calculate doping dependence of the magnon gaps and obtain a good agreement with experiments on LSCO. It is shown that the reduction of the magnon gaps relative to their $x = 0$ value weakly depends on the anisotropies of the parent compound. Since the DM gap is highly sensitive to rare-earth element doping, this prediction could be tested on $La_{2-x-y}Eu_ySr_xCuO_4$ (LESCO) and $La_{2-x-y}Nd_ySr_xCuO_4$ (LNSCO).