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Field-induced magnetism in a high-temperature superconductor

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Many physical properties of the high-temperature (high-T_c) superconductors are two-dimensional phenomena derived from their square planar CuO_2 building blocks. This is especially true of the magnetism from the copper ions electronically connected to each other via the p-orbitals of intervening oxygen atoms. As mobile charge carriers enter these CuO_2 layers, the antiferromagnetism of the parent insulators, where each copper spin is antiparallel to its nearest neighbours, evolves into a fluctuating state where the spins show tendencies towards magnetic order of a longer periodicity. For certain charge carrier densities, the quantum fluctuations are sufficiently suppressed to yield static long-period order and external magnetic fields also induce such order. Here we show, using neutron scattering measurements, that in contrast to the chemically-controlled order in superconducting $La_{2-x}Sr_xCuO_4$, the field-induced order is actually three-dimensional, implying significant magnetic linkage between the CuO_2 planes. The results are important because they reveal the presence of three-dimensional magnetic couplings which survive into the superconducting state, and coexist with the crucial inter-layer couplings responsible for the three-dimensional superconductivity.