The Thin Film Phase Diagram of $La_{2-x}Sr_xCuO_4$

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It has been shown that $La_{2-x}Sr_xCuO_4$ (LSCO) thin films can be produced with superconducting transition temperatures, T_c, exceeding the bulk values substantially [1,2]. There is an ongoing debate about the mechanism of the increased T_c, where oxygen intake and strain or among the possible mechanisms. Whereas superconducting properties are relative easily accessable via transport and magnetization measurements, little to nothing is known about the magnetic part of the phase diagram for thin film cuprates due to the lack of suitable experimental methods. Low energy μSR (LE-μSR) is the ideal method to investigate the extremely underdoped side of the hole doped phase diagram of the cuprates, namely in the antiferromagnetic (AF) and the so called "cluster spin glass" phase (CSG) [3,4]. Motivated by recent experiments on canonical spin glasses [5] (e.g. CuMn) were we found a pronounced change in the spin dynamics, both as function of the thickness as well as as function of the distance to the vacuum interface, we wanted to see how the CSG state of LSCO is comparing to the observed canonical spin glass properties. The measurements gave the following surprising results: whereas the antiferromagnetic ground state seems to be robust in respect to slight compressive strain, the electronic state of the slightly higher doped region $x \geq 0.02$ is not. Already at very high temperature a gradual freezing sets in which results in a partial, most likely short-range ordered, state at low enough temperature. This has to be contrasted to the bulk data where only a freezing (CSG) at low temperature is observed. Furthermore, the temperature dependence of the various asymmetries rather is pointing towards a phase-separated magnetic groundstate for doping levels between the AF and the superconducting phase. In contrast to the canonical spin glass case, no substantial change in the spin dynamics across the film thickness is found.

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