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Hint for a Photo-induced Charge Order Transition in Single-Layer Manganites

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Beamline(s): X22C

The strong correlations of lattice, charge, orbital and spin degrees of freedom in the manganites cause a variety of phenomena which are, although known for years, still in the focus of solid state research. One of the more prominent features is the colossal magnetoresistance (CMR). By applying a magnetic field the low temperature charge ordered insulating state can be driven to a non ordered metallic state [1]. The effect can be understood in a model of Zener double exchange [2]. In the insulating state the electrons are localized on the Mn(3+)-sites, whith their spins coupled antiferromagnetically. The external field now causes a ferromagnetic spin alignment which increases the hopping rate of the electrons. Therefore a insulator-metal transition takes place and the charge order is destroyed.

Another possibility to induce a transition from the insulating charge ordered state is the usage of electromagnetic fields. Studies on perovskite $Pr_{0.7}Ca_{0.3}MnO_3$ (PCMO) show that irradiation with X-rays (6 - 10 keV) leads to an increase of electrical conductivity and a decrease in the charge order order parameter [3,4]. It is an interesting question wether this x-ray induced transition is accompanied by a transition into a ferromagnetic phase similar to the transition in a magnetic field.

In our study we measured the scattered intensity of the (1.5 1.5 0) charge order reflection of $La_{0.5}Sr_{1.5}MnO_4$ a manganite system where no ferromagnetic state has been observed so far, neither at low temperatures nor at high fields. The single crystalline sample has been mounted inside a closed cycle cryostate and we used an incident energy of 6.554 keV (resonant Mn-K edge). While cooling down, we found a significant decrease of the charge order intensity below 33K very similar to the observations in PCMO described above. It is, however, questionable wether this decrease in charge order intensity is accompanied by an enhancement of ferromagnetic correlations. The time dependence of the effect reveals a significant delay between the stabilization of temperature at 15K and the permanence of the scattered intensity on the other hand (Fig. 1).

Our observations can be seen as a hint for a photoinduced insulator-metal transition in half doped single layer manganites. To clear this point entirely further studies have to follow. At 15K the peak does not vanish completely, therefore the behaviour at lower temperatures has to be measured. It would also be desireable to measure the magnetic properties directly under x-ray illumination.

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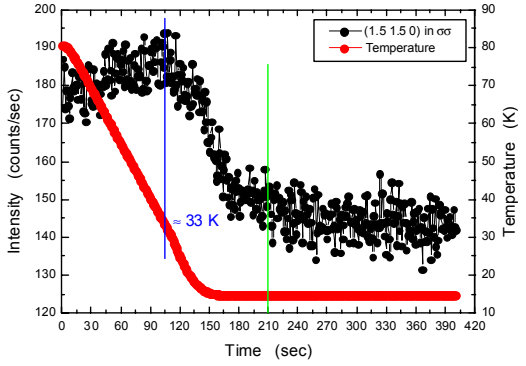

Figure1: Time dependence of the intensity of (1.5 1.5 0) charge order reflection taken while cooling down. The solid line shows the temperature. The two vertical lines indicate the onset of the decrease and the point where the intensity reaches a constant value. Apparently the temperature reaches a constant value approximately 60 sec before the intensity does.