Impact of Magnetic Fields on Ordered States in $La_{7/8}Sr_{1/8}MnO_3$

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Abstract No. geck4786
Beamline(s): **X22B**

Introduction: Doped perovskite manganites are currently the subject of intense investigations because their rich physics and possible applications. In particular, interaction and ordering of the charge, orbital, lattice and spin degrees of freedom are argued to be crucial for the understanding of the unusual physical properties of these materials.

Methods and Materials: Resonant x-ray scattering is ideally suited for the investigation of the ordered phases, allowing exploration of the symmetry and structure of the different order parameters. In the case of $La_{7/8}Sr_{1/8}MnO_3$ we have measured the temperature, field and azimuthal dependence of the intensity of the corresponding superlattice reflections, which are enhanced due to the anisotropy of the electronic susceptibility tensor at resonance. This anisotropy is not a direct consequence of the orbital order, but it is mediated through the oxygen displacements of Jahn-Teller distortions connected to the orbital ordering[1].

Results: One result of our crystallographic study, concerns the field dependence of the charge order (CO) superstructure reflection at T=165 K > T_{CO}≈150 K. It has been found, that the application of a magnetic field induces a first order phase transition into the charge ordered state, indicating that the charge ordering is stabilized by external magnetic fields. This behavior stands in clear contradiction to the pure double exchange model, where parallel spin alignment leads to delocalized charge carriers. This shows, that the CO state is not dominated by one order parameter alone and demonstrates the presence of strong correlations.

Another interesting result follows from the study of the structural phase transition at T_{JT} in an external field of 11 Tesla. In zero field this phase transition takes place at T_{JT}≈270 K and is discontinuous[2], showing a pronounced temperature hysteresis. In contrast to this discontinuous behavior, we observed a continuous transition in high fields. This means, that with increasing field the transition changes from discontinuous to continuous. The strong diffuse background found in this measurement strongly suggests, that fluctuations might play an important role for this effect.

Furthermore, an observation was made concerning the metastability of the ordered phase at low temperatures[3]: The irradiation effect below 30 K was found to be field dependent. Figure 1 shows the time dependent intensity of the charge order reflection with and without magnetic fields. It can be seen, that the time dependence of the intensity is considerably affected by external fields. The reduction of the intensity with time is slower in a magnetic field of 9 Tesla, than in zero field. This means, that the charge ordered phase is stabilized against the phase induced by irradiation when the magnetic field is applied.

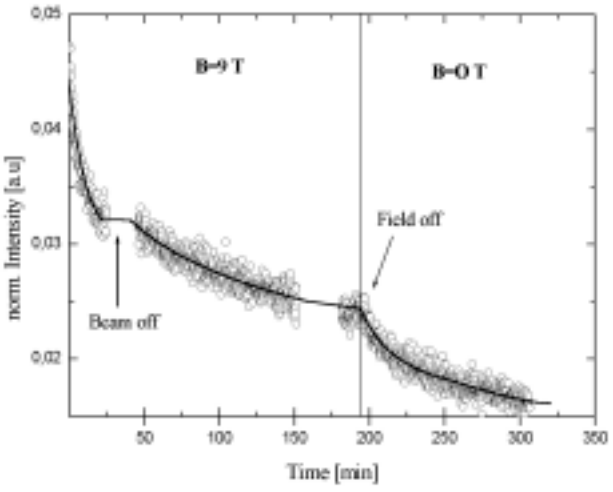

Figure 1. Normalized intensity of the (4 0 1/2) charge order reflection at T=4.2 K. Without magnetic field the decrease of the intensity with time is enhanced. (The line is just a guide to the eye).

Conclusions: The strong influence of external magnetic fields on different ordering phenomena was observed. Therefore, crystallographic studies as a function of magnetic field provide further important information about the strong correlations present in this material. Moreover we could show, that the metastability at low temperatures, i.e the irradiation effect, is also field strongly dependent.

References: [1]M.v.Zimmermann *et al.* cond-mat/0007231; M.Benfatto *et al.* Phys. Rev. Lett. **83**, 636 (1999*)*;

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[3] V. Kiryukhin *et al.,* Phys.Rev.B **59***,* R6581 (1999)