Probing Zener polaron order in half-doped manganite epitaxial thin films

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The nature of charge and orbital order in half-doped manganites has been a topic of continual controversy since the prediction of a Zener-polaron state (bond-centered order). [1] Such a scenario challenges the previously accepted picture of ion-centered charge and orbital order. In a recent soft x-ray resonant diffraction experiment we have identified a distinct circular light dependence of the magnetic and orbital reflection in thin films of Pr₁₋ₓCaₓMnO₃ (PCMO, 0.3<x<0.5). This unexpected observation is an indicator for a symmetry breaking, as would be expected for Zener polaron (ZP) order. We therefore propose an experiment to study this effect in thin films of PCMO with resonant hard x-ray diffraction, which gives a clear signature for the existence of ZP order due to the absence of interference with magnetic diffraction, which complicates the interpretation of the soft x-ray experiments. This will shed light on the fundamental behavior of such order, and may also pave the way to future control of ZP order through epitaxial strain.

Correspondingly, our experiment concentrated on the study of superlattice reflections of the same type but also extended to those of the charge order. In particular we used the full polarization control of P09 to study additionally the energy dependence of the reflections. Two types of reflections sensitive to orbital and charge ordering have been investigated in detail on the epitaxially single crystalline film of Pr₀.₅Ca₀.₅MnO₃. As shown in Figure 1, the energy dependence has particular different behavior for different incident circular lights, which directly relates to the phases of the structure factor. This allows for a direct test of the structural models and the ordering patterns. Moreover, there is also a residual dependence of the circular incident light that we now try to understand in more detail. It is very likely that a detailed analysis (in progress) of these data will allow us to understand more precisely if there is a Zener polaron state in this system.

Figure 1: Energy dependence of charge reflection (050) a) different incident circular and different linear outgoing polarizations, b) difference for averaged outgoing polarization c) and d) analogues for the orbital (0 7/2 0) reflection.

References