Charge dynamics in the presence of coherent lattice distortions in manganites

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The goal of the experiment was to study the electronic response of the charge order in manganites in the presence of coherent lattice distortions (coherent phonon). To achieve this it was the measure the time evolution of the (0 0 ½) reflection after the excitation of an optical pulse of 1/8 doped (La/Sr)MnO$_3$ at the Mn and/or O L$_{2,3}$ and K edges, respectively. The optical pulse creates a coherent phonon, as seen in the optical pump-probe experiment. That phonon has a frequency of approximately 3 THz. This requires a time resolution, that is usually limited by the jitter between the optical and the x-ray laser pulses, to be better than 200 fs.

This experiment at FLASH was performed with 3rd harmonic undulator radiation to cover the required resonant x-ray energies. The UHV x-ray diffraction chamber was supplied by the HZB group. To test the time resolution, a SiN film was used to cross correlate the optical and the x-ray pulses. The analysis of the optical reflectivity resulted in a time resolution which was larger the 350 fs. This was clearly insufficient for the observation of the coherent modulation of the superlattice reflection at resonance. Moreover, it was significantly more difficult to calibrate the energy of the x-rays than anticipated. As the scattering signal might have been weaker than expected, we used another manganite sample of type (La/Sr)$_2$Mn$_2$O$_7$, where the resonance is wider and the scattering signal larger. In this sample, we found the structural and magnetic reflection more easily. However, even with a clear magnetic diffraction signal, the energy calibration remained challenging due to the missing calibration foil setup. The pump-probe effect on the magnetic reflection is shown in Figure 1. We observe a clear decrease of magnetic scattering intensity after the optical excitation. There is also a clear indication of a strong fluence dependence of the magnetic scattering, with a strong fluence dependence of the decay time after the optical excitation. Such a strong dependence is not really expected, and further data interpretation is still in progress.

In summary, the experiment showed that the aim of the proposal is feasible. It requires though an improved time resolution, improving the jitter between optical and x-ray laser pulses or an improved time arrival monitoring system.

![Figure 1: Time dependence of the (001) magnetic reflection of (La/Sr)$_2$MnO$_2$O$_7$ taken around the Mn L$_{2,3}$ edges.](image-url)