ESRF	**Experiment title:** Determination of the q-dependence of orbital waves in lanthanum manganite	**Experiment number**: HS2001
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Names and affiliations of applicants (* indicates experimentalists):

H. Requardt (ESRF) *

J.E. Lorenzo (Cristallographie-CNRS)*

Report:

Collective orbital excitations, orbitons, can be expected in systems with strong electron correlations, such as manganites. Indeed, E. Saitoh et al (Nature **410** (2001) 180) reported the observation of orbital excitations in $LaMnO_3$ by Raman scattering in the energy range between 100meV and 200meV at sample temperatures from 9K up to the orbital ordering transition temperature (T_{oo}=780K) of the system.

The purpose of our experiment was to observe these orbital excitations by the means of high-energy resolution inelastic X-ray scattering (IXS) in the above range of energy transfers and determine the orbiton dispersions. To favor the detection of the presumed very weak orbiton signal the measurements were concentrated on low momentum- (Q-)transfers, where the form factor of the electrons is highest, and at low temperature (T_{sample}=20K).
To allow for a comparison between the low-temperature state (with orbitons) and a high-temperature state (without orbital ordering) we chose a doped manganite sample, $La_{0.86}Sr_{0.14}MnO_3$, with an orbital ordering temperature lowered into the temperature range accessible to the closed-cycle refridgerator used for sample cooling in this experiment.

The measurements have been performed on the ID28 IXS-spectrometer using the Si888 main-monochromator backscattering reflection (15817eV) providing an experimental energy resolution of 6.5meV. The sample with a thickness of 48μm was mounted with its (H, K, 0)-plane in the horizontal scattering plane. Inelastic scattering spectra were collected between (H, K, L) = (0, 0, 0) and (1, 0, 0) and with energy transfers ranging from –10meV up to 240meV covering the elastic line, lattice phonon contributions and the energy range reported for the orbitons. Spectrometer-settings at in higher Brillouin-zones (1, 0, 0), (2, 0, 0) and (3, 0, 0) were scanned to have an experimental basis to separate the lattice excitations from the orbital excitations. From these high-Q measurements the inelastic contributions up to about 80meV could be attributed to lattice

phonons in agreement with reported lattice dispersion curves on $LaMnO_3$ (W. Reichhardt and M. Braden, Physica B 263-264 (1999) 416).

A beamstop was installed to reduce the experimental background which was monitored on an empty sample chamber to allow a more reliable treatment of the spectra with their very low intensity above energy transfers of 100meV.

The figure below shows the collected low-Q spectra (H = 0.175,... 0.933) after careful background subtraction. From the Raman-data reported by E. Saitoh et al. and calculated model dispersions (S. Ishikara et al., Phys.Rev. B **55** (1997) 8280 and J. van den Brink, Pys.Rev.Lett. **87** (2001) 217202) a triple-peak structure should be expected between 100meV and 200meV at the lowest momentum transfers (i.e. closest to the Brillouin-zone centre (0, 0, 0)) merging into a two-peak structure towards the Brillouin-zone boundary at (0.5, 0, 0). However, non of these features could be observed in our experiment.

So far, this cannot be interpreted as an absence of orbital excitations, although it underlines the extremely low scattering intensity, i.e. dynamic structure factor, at the energy-transfer and momentum-transfer range studied here.

However, fits of the inelastic spectra revealed that a major part of the intensity detected above 100meV has to be attributed to the very long tails of the energy-resolution limited elastic line which is created by the disorder in the system due to the Sr-doping of the sample. This long tail is due to the essentially Voigt-profile shaped elastic line and reduces significantly the contrast between the signal looked for and the other contributions to the spectrum.

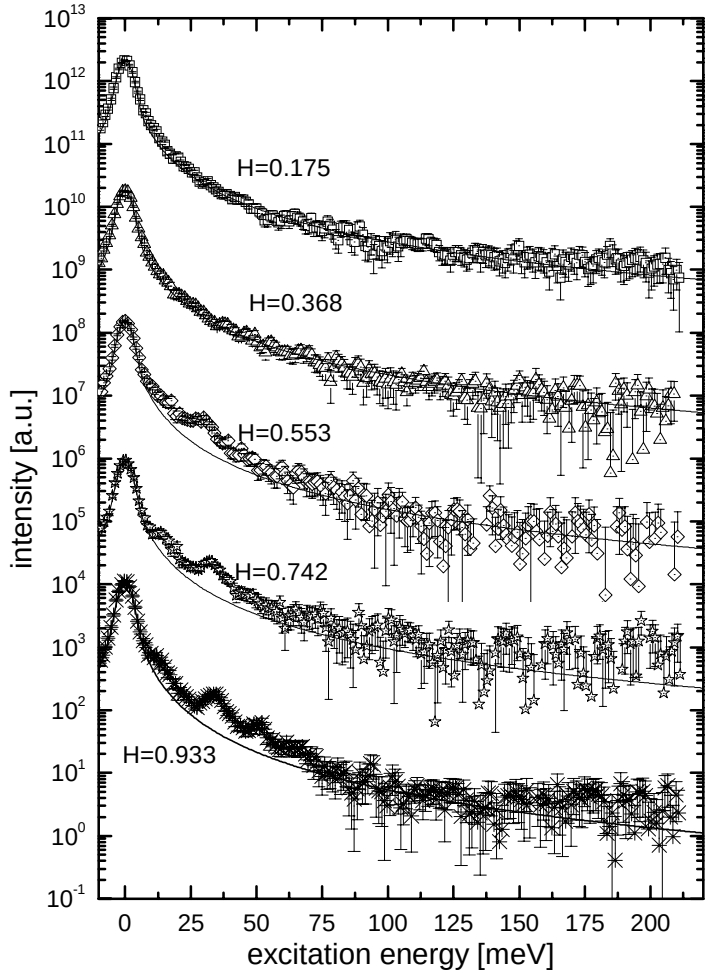

Fig.: IXS spectra in of $La_{0.86}Sr_{0.14}MnO_3$ along the [H, 0, 0]-direction, H = 0,...1, after careful background subtraction. T_{sample} = 20K. The full lines indicate the experimental energy resolution profile fitted to the elastic lines in the spectra. The structures up to 80meV are attributed to lattice phonons. Note the absence of any features at energy transfers above about 100meV but also the fact that the scattered intensity in this energy range can essentially be ascribed to the far tails of the elastic line.