Study of collective orbital excitations in Ti L-edge RIXS spectra of the low-dimensional Mott insulator TiOCl

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Collective orbital excitations ('orbitons') represent a new class of - in principle - dispersive electronic excitations, which result from crystal field excitations in $3d^1$ transition metal compounds, which in turn are strongly affected by the Mott-Hubbard physics of these materials. While such dd-excitations can be nicely detected in resonant inelastic x-ray scattering (RIXS), a clear experimental proof of their itinerant (i.e., wave-like) character through their energy-momentum-dispersion has remained a big challenge. Schlappa et al. reported the observation of orbiton dispersions in a one-dimensional (1D) cuprate, using high-resolution RIXS [1]. With our study, we try to establish their interpretation of spinon-orbiton separation for another 1D system, namely the 1D Mott insulator TiOCl. The nice thing about TiOCl against other d^1 (or d^9) systems is the fact that the orbital degeneracy in the d-manifold is completely lifted, resulting in well-separated crystal-field excitations which we have studied by RIXS before [2]. We used the high-resolution RIXS setup at BL07LSU and took a series of RIXS spectra under resonance conditions (hv=458.2eV, see dashed line in Fig. 1) favorable for the second highest dd excitation to become as intense as possible. The spectra were recorded at different polar angles of the sample in such a way that the momentum transfer parallel to the 1D direction of the crystal varied in a controlled way. Thereby the orbiton dispersion could be traced. Although we were able to measure high-resolution spectra with good statistics it turned out that - as can be seen in Fig. 2 - the accessible momentum range with the fixed 90-degree geometry was not high enough to observe a significant dispersion.

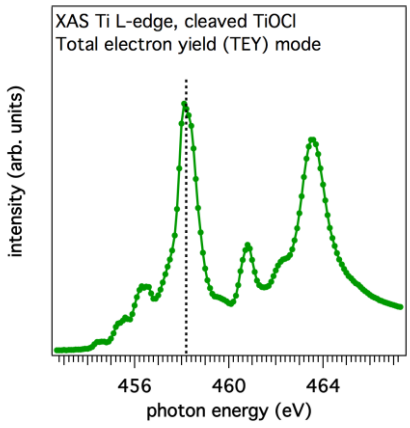

Figure 1: X-ray absorption spectra oft he cleaved TiOCl crystal. Photon energy for RIXS measurements is marked by dashed line

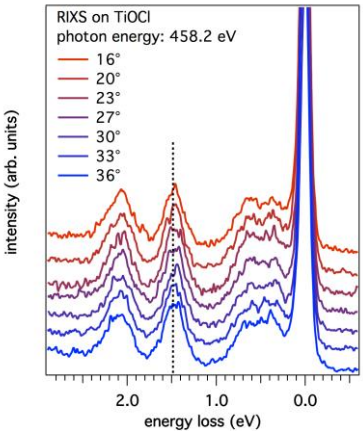

Figure 2: RIXS spectra of the cleaved TiOCl crystal for different polar angles. As it can be seen, no dispersion of the second highest dd excitation can be observed

References

[1] J. Schlappa et al., Nature 485, 82 (2012)
[2] S. Glawion et al., Phys. Rev. Lett. 107, 107402 (2011)