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Report:

Vanadium sesquioxide, V_2O_3, considered as a Mott-Hubbard metal-insulator [1], has been the object of intense study from both theoretical [2] and experimental [3] point of view in the last few decades. This compound has an interesting phase diagram, with an antiferromagnetic insulator phase (AFI) at low temperatures, and a paramagnetic metallic phase (PM) above the Néel temperature ($T_N \approx 150$ K).

Recently, a new formulation of resonant x-ray Bragg diffraction by non-centrosymmetric materials was proposed by S.W. Lovesey et al. [4] and applied to V_2O_3. The purpose of this experiment has been to separate the contribution to scattering from the parity-odd E1-E2 mechanism, by measuring Bragg reflections where the parity-even E2-E2 contribution is predicted to be negligible.

The aim of this experiment has been to perform measurements on different space-group forbidden Bragg reflections at low temperature in the monoclinic phase. Together with energy profiles and azimuthal dependence, we measured the polarization dependence at a fixed azimuthal point by varying the incident linear polarization with a phase plate setup. In this way, we can measure the Stokes parameters of the secondary beam as a function of both incident and scattered linear polarization angle, without cutting or moving the crystal. The great advantage is that the crystal is not moved in the observation, and data is collected on one micro-domain of the crystal. This method can resolve resonances that are very close in energy, playing on their relative phase shifts [5].

For this experiment we have used a 2.8% Cr-doped $(V_{1-x}Cr_x)_2O_3$ (x=0.028) single crystal. Measurements were performed in the monoclinic phase at a temperature T=150 K.

Measurements of the dependence of the Stokes parameters of the secondary beam with the angle of incident linear polarization of $(1,0,-2)_m$ reflection using the phase plate have been collected, showing the appearance of an important degree of circular polarization, (indicated by the lower panel of Fig. 1 where the degree of circular polarization is estimated from the Stokes parameters P_1 and P_2 of the secondary beam as $1-P_1^2-P_2^2$). The dependence of polarization measurements with energy was recorded, showing no apreciable dependence with the energy (see Fig. 1).

Energy profiles were also measured in the $(1,0,-2)_m$ reflection at different azimuthal points (Fig. 2). An important result obtained in this experiment is the fact that measurements of the energy profile in the $(1,0,-2)_m$ reflection shows the presence of two features separated by approximately 2 eV which could be related to crystalline electronic field energy transfer.

It is important to stress that intensity in $(1,0,-2)_m$ can be attributed to an E1-E2 transition with almost negligible parity-conserving contributions (E1-E1 and E2-E2). The intensity coming from parity-even transitions, is almost absent, as it is weighted by a global multiplicative factor depending on crystallographic parameters and the Miller indices of the reflection [4] that is neglectable in the case of $(1,0,-2)_m$ reflection. The measurements in $(1,0,-2)_m$ reflection will be a direct challenge to ab-initio calculations of the electronic structure of vanadium sesquioxide.

References

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Fig. 1. Linear incident polarization dependence of the Stokes parameters of the secondary beam P_1 and P_2 in the reflection $(1,0,-2)_m$. Measurements were made at different energies. The azimuthal angle used was $\psi = -31.1^o$. Origin of the azimuthal angle $(0,1,0)_m$ reflection was taken in the plane of scattering.

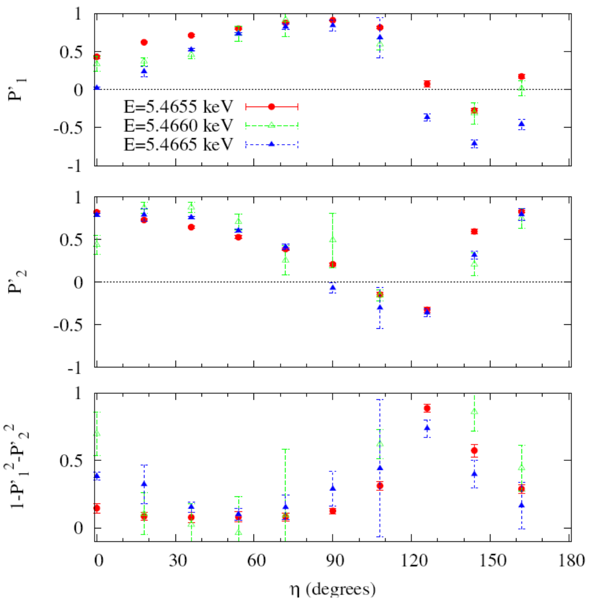

Fig. 2. Energy profiles measured at the reflection $(1,0,-2)_m$ at different azimuthal points $\psi = -31.1^o$ and $\psi = 49^o$.