Investigation of magnetic ordering in $Eu_{0.8}Y_{0.2}MnO_3$ using full polarization analysis at P09

A. Skaugen, D. K. Shukla, S. Francoual, J. Strempfer, DESY

Sample

- $Eu_{1-x}Y_xMnO_3$ has strong ME coupling[1]. We study a compound with $x = 0.2$.
- AFM transition temperature at $T_N = 45K$
- Weak ferromagnetism and ferroelectricity below ferroelectric transition temperature $T_C = 30K$, presumed to be due to a conical spiral magnetic structure
- Crystal structure similar to reference crystal $TbMnO_3$
- Absence of rare earth magnetism allows interference free study of Mn moments.

Experimental Setup

- Sample mounted on 6-circle diffractometer with 1.7K Cryostat
- Energy tuned by P09's High Heatload Monochromator
- Beam focused onto sample with quartz focusing mirrors
- Incident polarization η rotated by dual diamond phase plates (See Poster 289 by S. Francoual on Double Phase Retarders)
- Cu 220 analyzer crystal used for polarization analysis of scattered beam

Previous studies

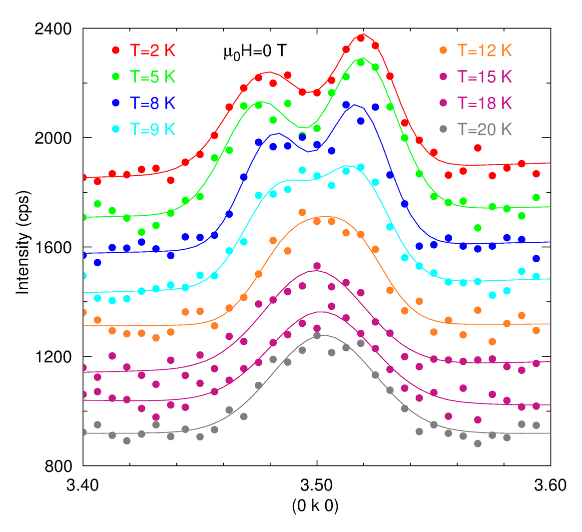

Figure 1: Studies at the BW5 beamline have established an AFM structure with half integer peaks.

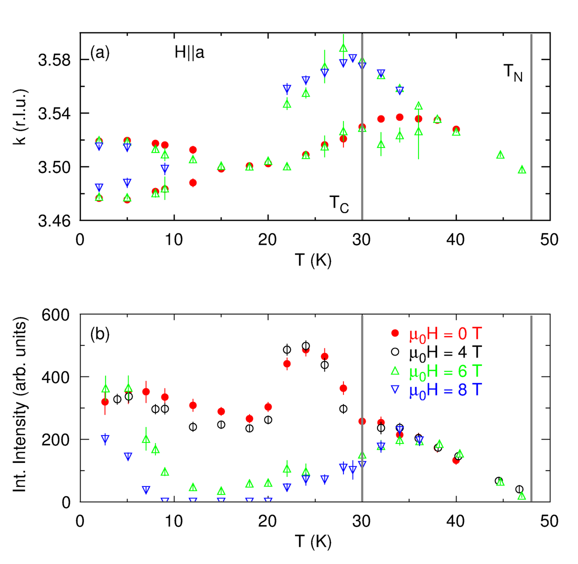

Figure 2: Temperature dependence of (0 3.5 0) taken at BW5 with magnetic field along a direction.

Stokes parameters

The Stokes parameters ($P_0 = \sqrt{P_1^2 + P_2^2 + P_3^2}$) fully describe the polarization of the x-ray beam. P_1 and P_2 describe the state of linear polarization, while P_3 is the degree of circular polarization.

References

[1] J. Hemberger et al. Phys. Rev. B 75, 035118 (2007)

[2] C. Mazzoli et al. Phys. Rev. B 76, 195118 (2007)

Results

Resonant scattering was performed at Mn K-edge.

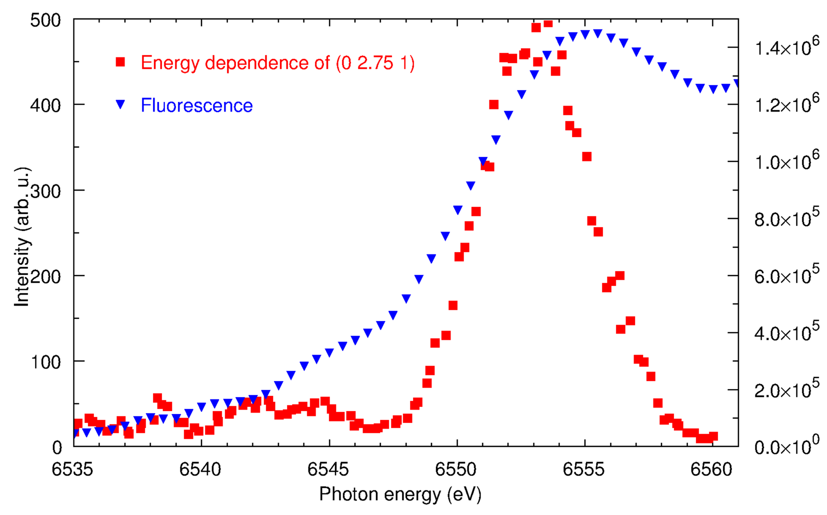

Figure 3: Magnetic peaks resonate at Mn K edge

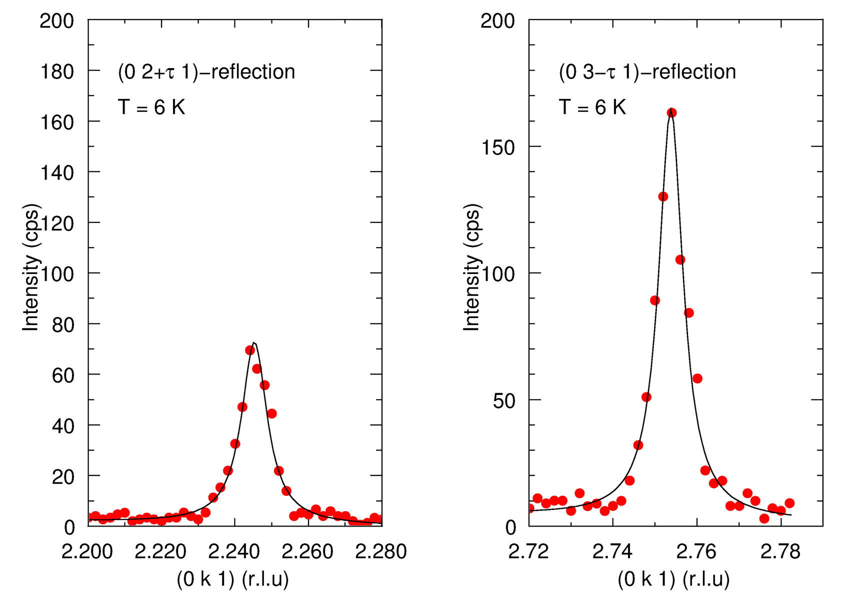

Figure 4: Magnetic peaks found at P09 correspond to a wave vector $\tau \sim 0.25$

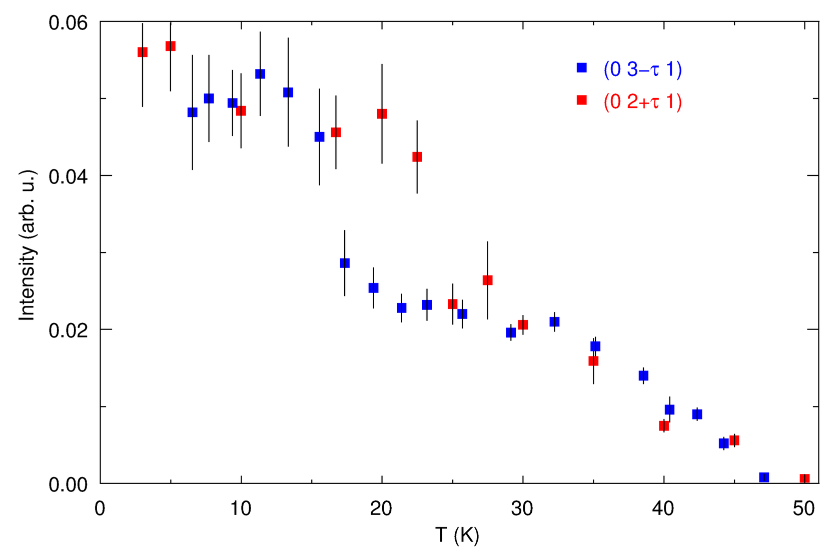

Figure 5: Temperature dependence of magnetic peaks. The y-axis has been scaled.

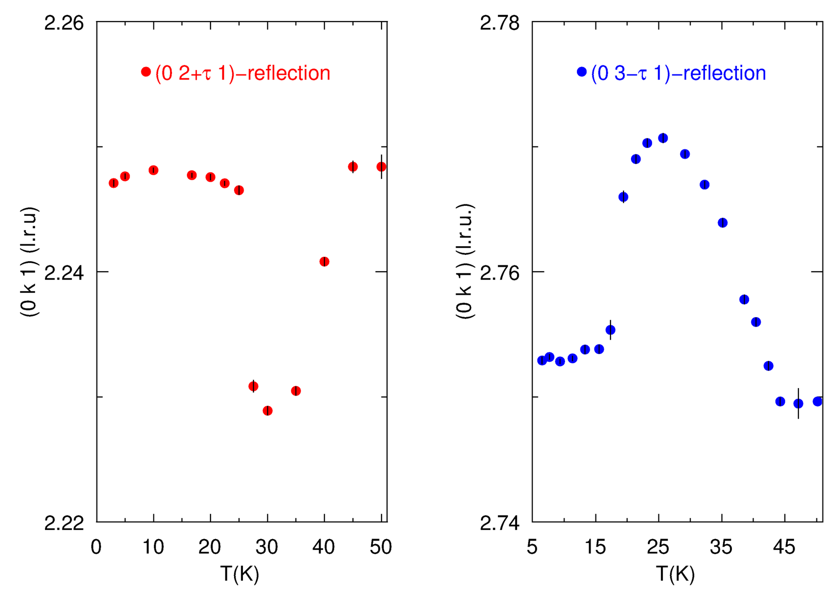

Figure 6: The magnetic wave vector τ varies in the AFM range.

Full Polarization Analysis

Fitting function for polarization dependent integrated intensities [2]:

$$I(\eta, \eta') = \frac{P_0}{2}\left(1 + P_1 \cos 2\eta' + P_2 \sin 2\eta'\right)$$

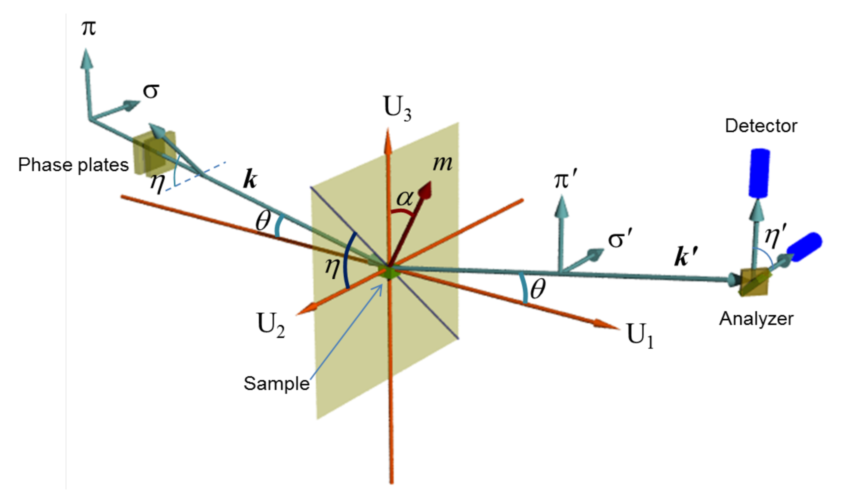

Figure 7: Scattering geometry. η denotes angle of incident polarization, while η' denotes angle of the polarization analyzer

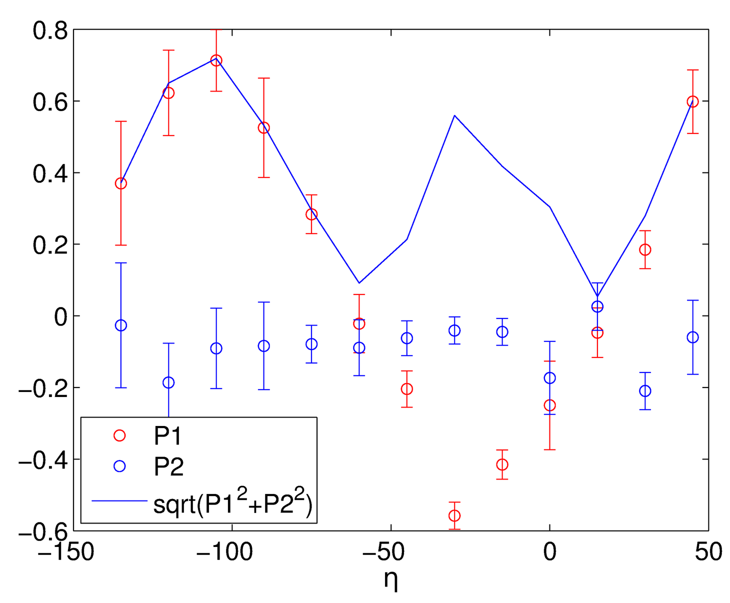

Figure 8: Stokes' paramaters for (0 2+τ 1) reflection

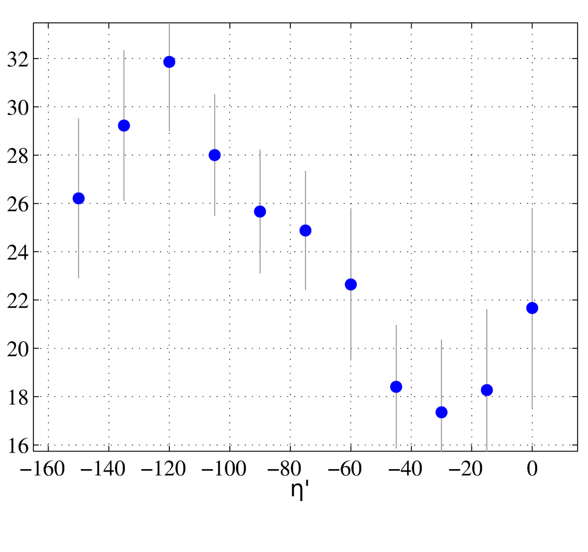

Figure 9: η' dependence of (0 2+τ 1) reflection with circular left incident polarization

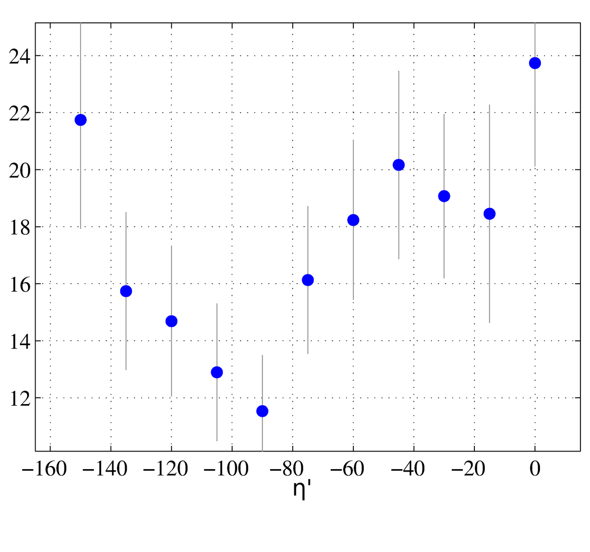

Figure 10: Same as fig. 9, with circular right incident polarization

The Stokes parameters of the scattered beam were extracted by measuring the integrated intensities for varying η and η'. The η dependence of P_1 and P_2 indicate a helicoidal SDW structure of the Mn moments, rather than a conical spiral as previously hypothesized. Absence of azimuthal variation in the intensity of the magnetic signal supports this interpretation. For linearly polarized light, according to the definition of the Stokes parameters, the value of $\sqrt{P_1^2 + P_2^2}$ should be constantly equal to unity. The fact that it varies in this measurement indicates some induced circular polarization of the reflected beam. The difference between left and right circular incident light is as yet unexplained.

Acknowledgments

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