ESRF	**Experiment title:** Study of multiferroic TbMn2O5 through polarization analysis of magnetic resonant x-ray scattering	**Experiment number**: HE-2598
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Shifts: 18	**Local contact(s)**: Dr Javier Herrero-Martin	*Received at ESRF:*

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Report:

The diverse range of physical properties observed across the multiferroic RMn_2O_5 series (R = rare-earth, Bi or Y) [1] makes clear the significance of the role of the rare-earth ion in this system, an understanding of which is of key importance. For example, $DyMn_2O_5$ exhibits one of the largest magneto-electric couplings [2] and $TbMn_2O_5$ undergoes a complete electric polarization reversal in applied fields of 2 T [3].

Full x-ray polarization analysis is a novel technique developed at ID20, ESRF, that measures the incident polarization dependence on the polarization of the scattered beam. It has been successful in unravelling multipole resonances in K_2CrO_4 [4] and in modeling competing domain contributions within $NpRhGa_5$ [5]. We have employed this technique for the first time to measure the spin orientation of electrons in specific bands of the terbium ion in $TbMn_2O_5$, selected by tuning to the resonant enhancement of the magnetic diffraction signal at the terbium L_{III} edge. The observation of two resonances that originate from excitations into both the Tb 5d and 4f states has enabled us to probe the spin polarization (by nearest neighbour manganese ions and the terbium 4f electrons) of the 5d states, and the magnetic structure of the terbium sublattice existing in the partially filled 4f states. This work has culminated in the publication of a Physical Review B article (see below). Not only does this paper describe the magnetic structure of the rare-earth in $TbMn_2O_5$, key to furthering our understanding of this system; it more importantly has shown a new approach to determining an ion and band specific magnetic structure, excellently complementing well established neutron techniques.

This work is now being considered by ID20 as an ESRF highlight for the forthcoming annual report.

On the following page we present the abstact of the Physical Review B article. The full reference of this article is as follows:

Determination of magnetic order of the rare-earth ions in multiferroic $TbMn_2O_5$, R. D. Johnson, S. R. Bland, C. Mazzoli, T. A. W. Beale, C-H. Du, C.Detlefs, S. B. Wilkins and P. D. Hatton, Phys. Rev. B **78**, 104407 (2008)

PHYSICAL REVIEW B **78**, 104407 (2008)

Determination of magnetic order of the rare-earth ions in multiferroic $TbMn_2O_5$

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We have employed resonant x-ray magnetic scattering to specifically probe the magnetic order of the rare-earth ions in multiferroic $TbMn_2O_5$. Two energy resonances were observed, one originated from the E1-E1 dipolar transition and the other from the E2-E2 quadrupolar transition. These resonances directly probe the valence 5*d* band and the partially occupied 4*f* band, respectively. First, full polarization analysis, which is a measurement of the scattered polarization as a function of incident polarization, confirmed a spin polarization of the terbium valence states (probed by the E1-E1 transition) by the Mn^{4+} spin density in the commensurate phase. Second, full polarization analysis data were collected in the low-temperature incommensurate and commensurate phases when tuned to the E2-E2 resonance. By employing a least-squares fitting procedure, the spin orientations of the terbium ion sublattice were refined.

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