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Magnetic Structure and Highly Unusual In-field Behaviour of D-type Erbium Disilicate

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Despite their promising optical properties, little is known of the polymorphic rare-earth disilicates (RE2Si2O7) due to their complex structural phase diagram. The magnetic rare-earth ions within the majority of the disilicates are arranged in a distorted honeycomb structure, giving potential for fundamental magnetism interest.

For the monoclinic D-type Er2Si2O7, initial predictions of a magnetic order below 1.8 K with a proposed q = 0 four-sublattice antiferromagnetic arrangement of the magnetic moments [1] have been recently confirmed via powder neutron diffraction measurements [2]. The highly anisotropic magnetisation curves were understood by the use of simple Monte-Carlo simulations however, the presence of a magnetic plateau at 1/3 of the magnetic saturation, disagreed with the theoretical model [1]. Here, both polycrystalline and single crystals of D-type Er2Si2O7 have been synthesised [3] and investigated using powder and single crystal neutron scattering techniques as well as magnetisation measurements.

Our $H \parallel a$ single crystal magnetisation measurements reveal a plateau at 1/3 of magnetic saturation, accompanied by a significant increase of the magnetic unit cell. Fig. 1 illustrates the dramatic change in the single crystal neutron diffraction patterns when the narrow plateau stabilisation is reached. Magnetic diffuse features along the k and l directions suggest shorter-range magnetic correlations on the plateau along b^* and c^*.

The magnetic non-integer peaks indexed as (0, k+1/2, l+1/2), (0, k+1/3, l) and (0, k+2/3, l), where k and l are integers during the plateau imply a change in the size of the unit cell. This change from the confirmed zero-field four-sublattice structure to the larger unit cell accommodates for the surprising 1/3 plateau. We also report that our magnetic excitations in the ordered state, observed via inelastic neutron scattering, suggest an almost ideal Ising system. The dispersionless low-energy excitations low temperature spectrum also demonstrates Ising-like behaviour in lower and higher fields and significantly softens on the magnetisation plateau.

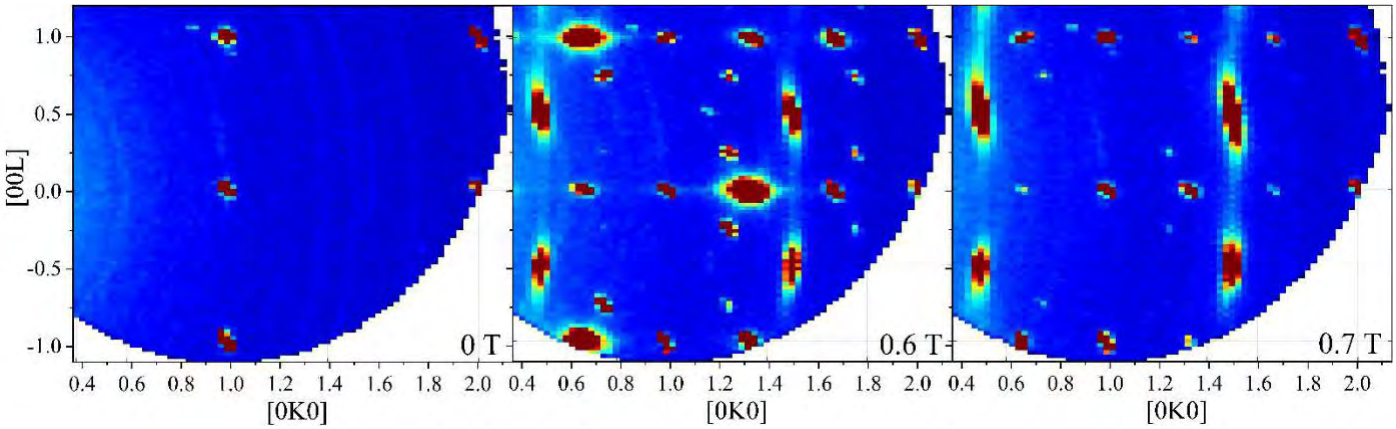

Figure 1. Intensity maps of single crystal in-field neutron diffraction of Er2Si2O7 measured on IN5 at ILL, with $H \parallel a$. Magnetic q=0 peaks are observed at zero-field until the magnetisation plateau region is reached. The plateau then stabilises at 0.6 T, accompanied by additional magnetic peaks with fractional, non-integer indices. Remnants of the diffuse scattering remain above the plateau region as seen in 0.7 T, until saturation. Some of these non-integer peaks are not resolution limited, suggesting shorter-range magnetic correlations.

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