Experimental report

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Proposal: 5-42-416 **Council:** 4/2016

Title: Measurements of the magnetic vortex lattice in the noncentrosymmetricsuperconductor Ru7B3

Research area: Physics

This proposal is a continuation of 5-42-397

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Samples: Ru7B3

Instrument	Requested days	Allocated days	From	To
D33	4	5	07/09/2016	12/09/2016

Abstract:

We propose performing small angle neutron scattering (SANS) measurements of the magnetic vortex lattice (VL) in a single crystal of the non-centrosymmetric (NCS) superconductor Ru7B3. NCS superconductors are of significant interest to the condensed matter community, as the crystal structure breaks inversion symmetry, leading to novel superconducting states with unusual properties. These have been predicted to have a significant effect on the VL within these materials, with the s+p-wave order parameter predicted for NCS leading to a strong anisotropy in the electronic states around the vortex. We have a large single crystal of Ru7B3, prepared with the enriched 11B isotope, on which we performed SANS measurements using D33 last year. The single-domain VL was seen to rotate with decreasing field, which has not been seen in any other superconducting material or predicted by any of the prevailing theories of the VL structure. We propose to fully map out this VL rotation with field.

Experimental Report: Measurements of the magnetic vortex lattice in the noncentrosymmetric superconductor Ru_7B_3

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Using the small angle scattering instrument D33, we performed measurements of the magnetic vortex lattice (VL) in the non-centrosymmetric superconductor Ru_7B_3. The sample was mounted in a dilution refrigerator and placed within a cryomagnet such that the magnetic field was parallel to the incoming neutron beam, and neutron wavelengths between 10 and 14 Å were used. The crystal was oriented such that the magnetic field could be applied at any angle within the **ac** plane. Magnetic field was applied at base temperature, and the VL was imaged by rocking the sample, with magnetic field, around the angles corresponding to the Bragg conditions of the first order VL reflections. Background measurements were taken in zero field at base temperature, and then subtracted from the in-field measurements to leave only the signal from the VL.

The purpose of this experiment was to further investigate the unusual rotation of the VL with respect to the crystal that took place under a change in magnetic field, which was observed in the previous experiment. When cooling the sample through T_c in an applied magnetic field, the VL selects a single orientation as is common with many superconductors (Fig. 1(a)). However, if the magnetic field is decreased while the sample is below T_c the VL rotates (Fig. 1(b)), which has not been seen before. We determined that this rotation only occurs under the application of magnetic field either parallel or nearly parallel to the **a** axis, and the initial and final states of the rotation are shown in Fig. 1. We mapped the rotation as a function of change in magnetic field at both base temperature and 1.1 K ($\approx 0.5\ T/T_c$), finding it to saturate at around 25°. Furthermore, we investigated the VL structure and form factor as a function of magnetic field applied along the **a** axis, finding no structural changes as a function of field although the form factor displays unusual behaviour which cannot be explained with the London model.

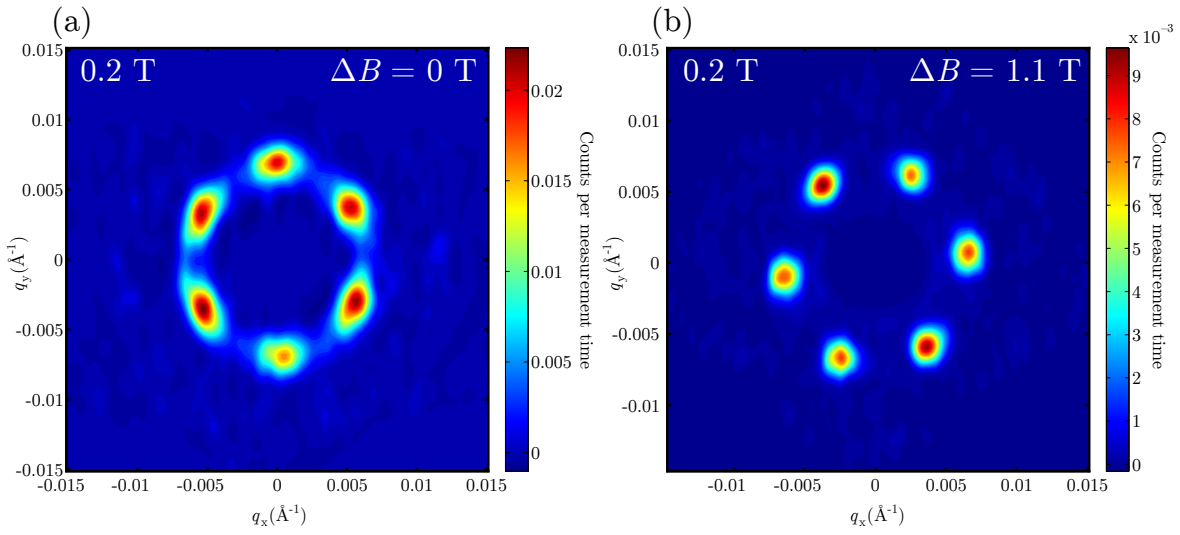

Figure 1: (a) Diffraction pattern at 0.2 T after the application of field from 0 T at base temperature. (b) The same measurement at 0.2 T after the magnetic field has been decreased by 1.1 T while at base temperature.