Experimental report

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Proposal: 5-42-465 **Council:** 4/2017

Title: Searching for an unexplained vortex lattice rotation in the non-centrosymmetric superconductor Nb 0.18 Re 0.82

Research area: Physics

This proposal is a continuation of 5-42-416

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Samples: Nb0.18Re0.82

Instrument	Requested days	Allocated days	From	To
D22	0	0		
D33	4	2	23/05/2018	25/05/2018

Abstract:

We propose performing small angle neutron scattering (SANS) measurements of the magnetic vortex lattice (VL) in a single crystal sample of the non-centrosymmetric (NCS) superconductor Nb0.18Re0.82. We have observed, in a previous experiment, an unexplained rotation of the VL in another NCS superconductor Ru7B3, which is shown in Fig. 1. This rotation, driven by changing magnetic field below Tc, is not connected with any structure transition of the VL and to our knowledge has not been seen before despite a significant body of research on the VL in a multitude of systems. Further, it cannot be explained by any of the prevailing theories of the VL, and we suspect that it is connected to the NCS nature of the system. It is therefore imperative that we search for this in another NCS superconductor. We have a single crystal sample of Nb0.18Re0.82, which has produced a SANS signal from the vortex lattice in a previous experiment [1], which would therefore provide an ideal system to search for this rotation.

Experimental Report: Searching for an unexplained vortex lattice rotation in the non-centrosymmetric superconductor $Nb_{0.18}Re_{0.82}$

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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 $Nb_{0.18}Re_{0.82}$. The sample was mounted within a cryomagnet such that the magnetic field was parallel to the incoming neutron beam, and a neutron wavelength of 9 Å was used. The crystal was oriented with the magnetic field applied along the **c** axis. Background measurements were taken above T_c, and then subtracted from the in-field measurements to leave only the signal from the VL.

The purpose of this experiment was to search for a rotation of the VL as a function of changing magnetic field below T_c, which had been observed in another noncentrosymmetric superconductor: Ru_7B_3. We performed two sets of measurements: one of the VL cooled in-field, which would establish the ground-state orientation, and a second measurement at the same magnetic field, but after the field had been changed while the sample remained below T_c and then then returned to the initial value. The diffraction patterns corresponding to these measurements are shown in Fig. 1. Panel (a) presents the VL at 0.2 T after being cooled in field. The circular ring drawn on the image corresponds to the expected q for a hexagonal lattice at 0.2 T, and we can see what looks like several diffraction spots, although the VL is very disordered. We may hesitantly say that there are peaks corresponding to nearest neighbors along an **a**-axis, which is horizontal in this image. Panel (b) present the corresponding diffraction pattern at 0.2 T, but after the magnetic field was raised to 0.7 T and then returned to 0.2 T. Unfortunately, the signal here is much weaker, and the VL lacks clear Bragg peaks, indicating that the process of changing magnetic field while below T_c has disordered the lattice such that an orientation cannot be determined. This indicates that the pinning in this sample is much higher than for the Ru_7B_3 where the rotation was observed, and although we performed such measurements at several fields, all suffered from too much disorder to provide any conclusive results.

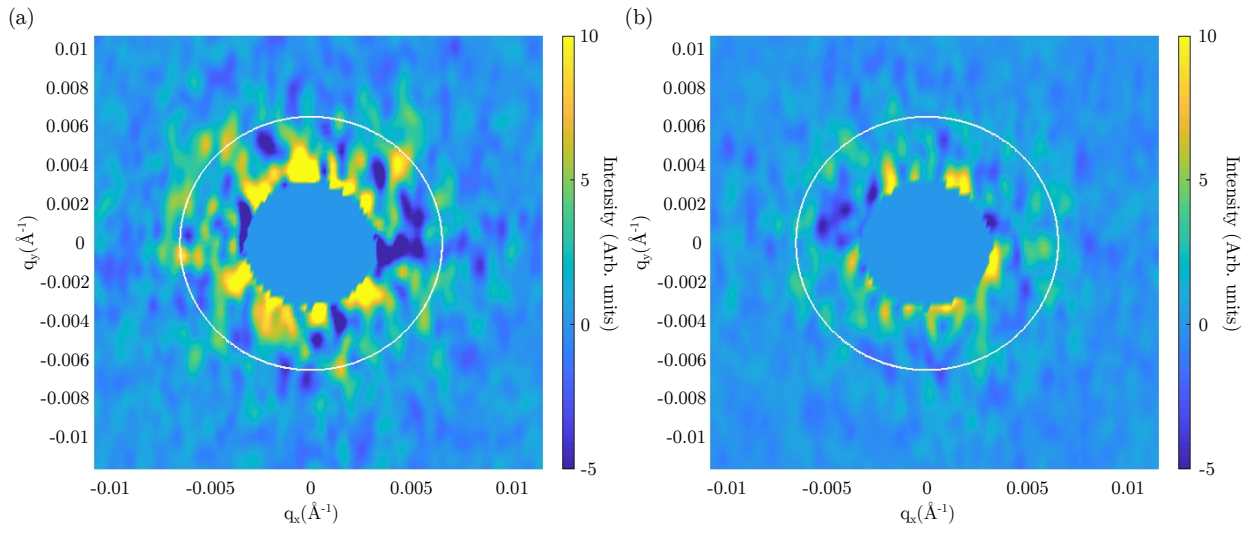

Figure 1: (a) Diffraction pattern at 0.2 T after the VL was cooled in field. (b) Diffraction pattern at 0.2 T, after the field was cycled up to 0.7 T and back to 0.2 T while below T_c.