Experimental Report

Proposal: **5-42-350** **Council:** 10/2012

Title: A SANS study of the flux line lattice in the superconducting phase ofnoncentrosymmetric Nb0.18Re0.82

This proposal is resubmission of: 5-42-340

Researh Area: Physics

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Samples: Nb0.18Re0.82

Instrument	Req. Days	All. Days	From	To
D33	5	3	01/03/2013	04/03/2013

Abstract:

We wish to carry out a small angle neutron scattering experiment on the noncentrosymmetric superconductor Nb0.18Re0.82 (Tc ~8.8 K). Single crystals of this material have been grown using the floating zone technique. We will aim to measure the field and temperature dependence of the symmetry of the flux line lattice formed when magnetic fields penetrate into type-II superconductors in the mixed state. We will be looking for deviations from the regular hexagonal lattice predicted by BCS theory to look for evidence of spin singlet and triplet mixing in the superconducting gap symmetry.

Non-centrosymmetric superconductors have been widely studied since they are believed to be good candidates for exhibiting unconventional gap symmetries. This is because the antisymmetric spin-orbit coupling is thought to lead to an admixture of spin singlet and triplet pairing [1]. It is of interest to examine whether this singlet-triplet mixing can lead to flux line lattices in the mixed state other than the regular hexagonal lattice predicted by BCS theory. $Nb_{0.18}Re_{0.82}$ crystallizes in the noncentrosymmetric α-Mn structure, a cubic crystal structure with space group $I\bar{4}3m$. The Re atoms all occupy noncentrosymmetric crystallographic sites. $Nb_{0.18}Re_{0.82}$ is a superconductor with a T_c of 8.8K [2]. Single crystals of $Nb_{0.18}Re_{0.82}$ were grown using the optical floating zone technique [3]. The crystals were aligned and slices were cut with the faces perpendicular to the [100] direction.

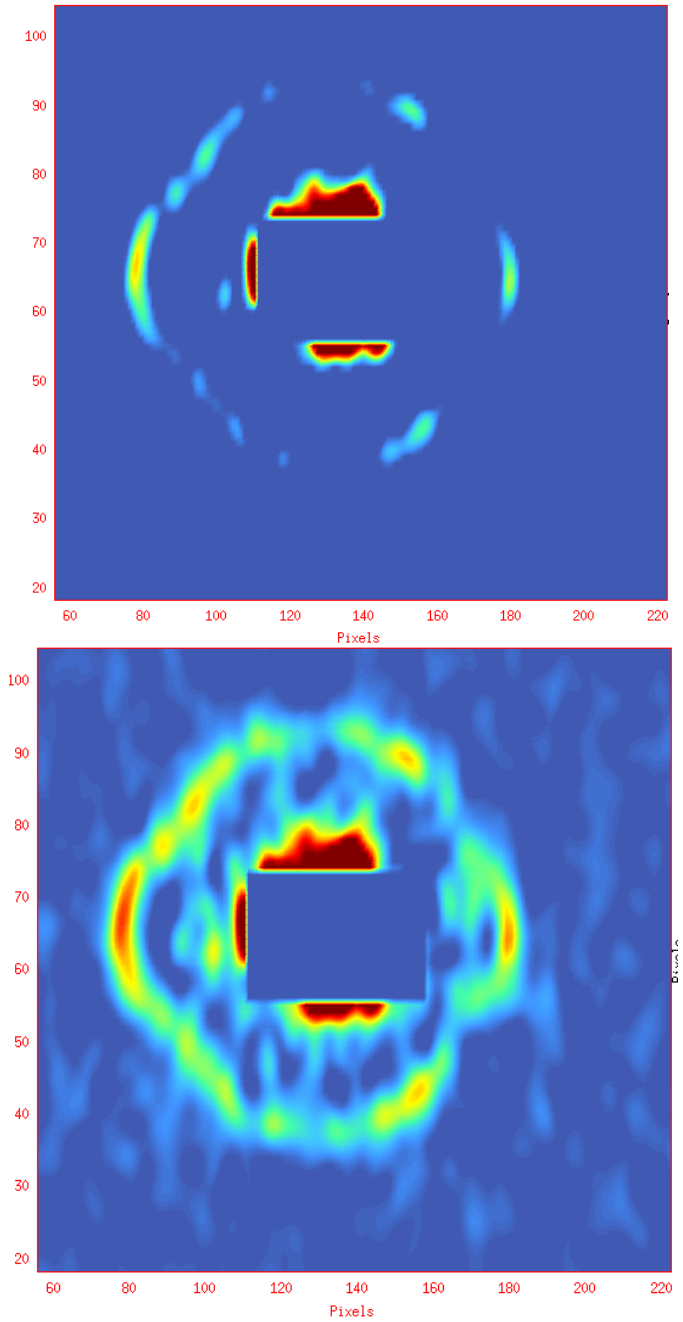

Figure 1. Small angle neutron diffraction measurements of $Nb_{0.18}Re_{0.82}$ at 2 K, with an applied field of 5000 Oe along the [100] direction.

Small angle neutron scattering measurements are shown in Fig. 1 for an applied field of 5000 Oe along the [100] direction. Firstly, it can be seen in the bottom image that there is a ring like structure in the diffraction pattern. This indicates that the flux line lattice exists in a continuous range of orientations. However, the intensity is not constant across the ring and there are six equidistant spots on the ring where there is a greater intensity. This suggests that the flux line lattice is a regular hexagon in agreement with BCS theory and although the flux line lattice has a preferred orientation with respect to the crystallographic axes, this appears to only be a weak preference.

It should be noted that this does not appear reflect a lack of crystallinity in the nuclear lattice, since both measurements using x-ray and neutron Laue measurements demonstrate the crystalline nature of the sample. Unconventional vortex dynamics have been reported to be present in the nodal non-centrosymmetric superconductor Li_2Pt_3B, where vortex avalanches have been reported in magnetization measurements [4]. Alternatively this behaviour may be related to the presence of site disorder. There are four crystallographic sites with multiplicities of 2, 8, 24 and 24. The first two are believed to be occupied entirely occupied by Nb atoms but one of the other two sites is believed to have mixed occupancy. In this case, the differences in preferred lattice orientation may be related to different arrangements of site occupancies.

[1] E. Bauer and M. Sigrist, *Non-Centrosymmetric Superconductors: Introduction and Overview*, Lecture Notes in Physics (Springer-Verlag, Berlin, Heidelberg, 2012).

[2] A. B. Karki et al., Phys. Rev. B, **83**, 144525 (2011).

[3] R. P. Singh, M. Smidman, M. R. Lees, D. M. Paul and G. Balakrishnan, J. Cryst. Growth, **361**, 129 - 131 (2012).

[4] C. F. Miclea et al., Phys. Rev. B, **80**, 132502 (2009).