Experimental Report

Proposal: **5-42-343** **Council:** 4/2012

Title: Pinning-free behaviour of the FluxLine Lattice in fully-oxygenated YBCO7

This proposal is continuation of: 5-42-256

Researh Area: Physics

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Samples: detwinned YBa2Cu3O7

Instrument	Req. Days	All. Days	From	To
D33	5	5	28/11/2012	03/12/2012

Abstract:

We have previously made observations of the very high-field, high-temperature behaviour of flux lines in an YBCO sample, obtaining results that were nearly ideal. However, the results from this previous sample were affected by pinning from a low concentration of oxygen vacancies. We are subjecting our high-purity crystals to a prolonged high-pressure oxygen anneal, to bring them fully to the O7 concentration, in order to obtain intrinsic results for the flux line lattice structure approaching the melting transition, and the temperature- and field-dependence of the flux lattice distortion and the superfluid density.

Report on experiment 5-42-343: Investigations into the vortex lattice of de-twinned YBCO

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The experiment was performed on two mosaics of single crystal de-twinned $YBa_2Cu_3O_7$, both between 20 and 30 mg in mass. Sample one had undergone no further treatment since being de-twinned, whilst the second sample had undergone a re-oxygenation procedure after de-twinning, since interim experiments had observed the possibility that the oxygen content was not quite constant and full across the mosaic. This experiment was undertaken to investigate the possible differences between the results taken before and after the re-oxygenation process, and between each sample, as well as to investigate the dependence of the vortex lattice on the angle between the applied field and **c** axis of YBCO.

Measurements were taken in applied fields of between 1 and 16 T, with the field applied either parallel to the **c** axis of the crystal or rotated about the **b** axis at angles up to 50 degrees. For all measurements the flux lattice was prepared by the oscillation field cool (OFC) method, where the field is applied above T_c, and a slight modulation of the field was applied as the flux lattice was cooled, with the field held fixed when the sample had cooled to the required temperature. For scans in temperature, data was taken either by OFC to the required temperature, or by OFC to base temperature with data taken on warming.

Investigations into the vortex lattice structure and form factor as a function of temperature was undertaken at 10 and 16 T on sample one and at 10 T on sample two. Data shows that whilst the VL structure may show some hysteresis between scans taken on warming and cooling, no hysteresis was observed in the VL form factor. Further, differences in behaviour were noted between the old sample and the re-oxygenated one, indicating that the re-oxygenation process has improved the sample quality. Investigations into the vortex lattice melting were undertaken on sample one at 12 and 16 T as well as on the re-oxygenated sample at 10 T, showing the same behaviour between the samples. Low field characterisation of the flux lattice was done on sample 2 to investigate the effects of the re-oxygenation process on the sample in a well understood domain. We observed an increase in vortex lattice pinning, as the low field results showed a large degree of disorder, shown in fig. 1. This was seen to disappear at higher fields, indicating that we had observed an increase in the number of weak pinning centres in the material.

The vortex lattice structure was also investigated as a function of angle between the applied field and the **c** axis for rotations around the **b** axis of the crystal. The structure of the vortex lattice was seen to change as a function of angle between the applied field and the **c** axis, with the axial ratio of the

ellipse on which the diffraction spots that the VL sits increasing with the angle of applied field. Further, evidence of a structure transition can be seen in these data, with evidence of a second VL domain observed in fig. 2.

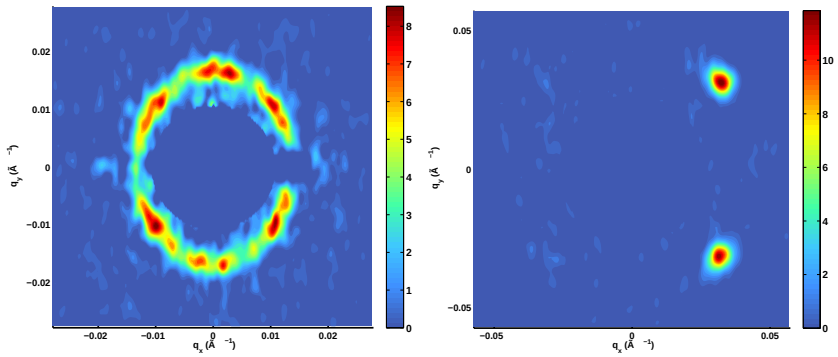

Figure 1: Left - Figure showing the diffraction pattern from the vortex lattice in an applied field of 1T. Right - Figure showing the right side of the diffraction pattern from the vortex lattice in an applied field of 10 T, where only the right side of the VL has been imaged to save experimental time. It can be seen that the low field VL is more disordered than its high field counterpart, indicating that the sample possesses weak vortex pinning.

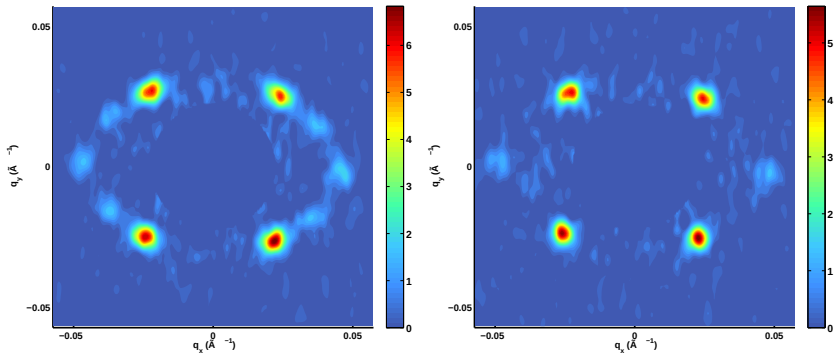

Figure 2: Diffraction patterns in an applied field of 6 T at base temperature. Left: diffraction pattern where the angle between the applied field and **c** axis is 30°. Right: diffraction pattern where the angle has been increased to 40°. The vortex lattice shows continued distortion as the angle between the applied field and **c** axis is increased.