Experimental report

02/09/2022

Proposal: 5-41-1079 **Council:** 4/2020

Title: The vortex lattice transition at high fields in Y0.85Ca0.15Ba2Cu3O7

Research area: Physics

This proposal is a new proposal

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Samples: Ca-doped YBCO

Instrument	Requested days	Allocated days	From	To
D33	4	4	15/03/2021	19/03/2021

Abstract:

Vortex lattice studies on YBa2Cu3O7 have shown that at high fields, up to 25 T, the associated form factor does not decrease as rapidly as expected. To explore this further, we have studied a Ca-doped variant of this compound. Doping with Ca leaves the copper-oxygen chain structures unchanged, allowing us to explore the effect of doping without having to account for changes due to the disruption of the Cu-O chains. We have collected data up to 25 T on a 15% doped sample at EXED/HFM at HZB. We wish to complement these measurements at intermediate fields at D33 using the 17 T magnet to complete our comparison with the parent compound.

Experimental Report
Instrument: D33
Experiment Number: 4-05-754

Title: The vortex lattice transition at high fields in $Y_{0.85}Ca_{0.15}Ba_2Cu_3O_7$

Experiment Date: 15/03/2021 – 19/03/2021

Experimental Team: Emma Campillo, Alistair Cameron, Ahmed Alshemi, Lingjia Shen, Alex Holmes, Hazuki Furukawa, Ted Forgan, Elizabeth Blackburn

Local Contact: Bob Cubitt, Nina Steinke

Introduction

Vortex lattice studies on YBa2Cu3O7 have shown that at high fields up to 25 T, the associated form factor does not decrease as rapidly as expected. To gather further information about this phenomenon, we have studied a Ca-doped variant of this compound. Doping with Ca leaves the copper-oxygen chain structures unchanged, allowing us to explore the effect of doping without having to account for changes due to the disruption of the Cu-O chains. To explore this, we examined data from a 4% doped sample and a 15% doped sample. In this experiment, we collected data on the 15% sample that had been studied up to 25 T at EXED/HFM at HZB, and so at ILL we complemented this with data collected during this experiment at intermediate fields between 11 T and 17 T on D33 to complete our comparison with the parent compound, using the 17 T magnet.

Results

The data obtained from this experiment are included in a paper containing data on the 15%, collected at PSI, ILL and HZB, together with data on the 4% doping measured at ILL. This paper is presently available on the arXiv [1], and is currently under review. The abstract of this paper is reproduced here.

> We present small angle neutron scattering studies of the magnetic vortex lattice (VL) in $Ca_{0.04}Y_{0.96}Ba_2Cu_3O_7$ up to a field of 16.7 T, and $Ca_{0.15}Y_{0.85}Ba_2Cu_3O_7$ up to 25 T. We find that the series of vortex lattice structure transitions have shifted down in field relative to those reported for the undoped compound. We attribute this mainly to the weakening of the 1-D superconductivity in the Cu-O chains by the disorder introduced by doping. The hole doping by calcium is also expected to alter the Fermi velocity and it reduces the upper critical field of the system. The high-field structure of the vortex lattice is similar to recent measurements on the parent compound in fields of 25 T, which indicates that the fundamental *d*-wave nature of the superconducting gap is unchanged by calcium doping. This is corroborated by the temperature dependence of the VL form factor which also shows the same *d*-wave behaviour as observed in other cuprates. We also find evidence of Pauli paramagnetic effects in the field dependence of the VL form factor.

[1] A. Cameron & E. Campillo *et al.*, arXiv : 2208.06706 (2022) - https://arxiv.org/abs/2208.06706