EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Charge Ordering in NaxCoO2	**Experiment number**: 28-01-714
Beamline:	**Date of experiment**: from: 23/03/05 to: 30/03/05 and 15/05/05 21/05/05	**Date of report**: 24/10/06
Shifts: 18	**Local contact(s)**: Dr. Simon Brown	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Prof. Peter Hatton*

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Report:

Experimental time was first schelduled for March 2005. A major vacuum problem occurred on the machine within 24hrs of the beamtime starting, as such the experiment was rescheduled for June 2005.

The beamtime was awarded for studying possible charge ordering in $NaxCoO_2$. Although this ordering had been suggested to exist through theoretical studies, no experimental proof has been realised. High quality single crystals were obtained, and a thorough search through reciprocal space was conducted. Despite extensive searching for a number of days, at various temperatures, no sign of charge ordering was seen. The crystals are particularly difficult to grow, and although these were the best available, there quality limited the intensity of the main Bragg peaks, and as such will have reduced the intensity of any possible charge order signal.

As a backup; with the agreement of beamline staff, we decided to look at the highly doped bilayer manganite $La_{0.6}Sr_{2.4}Mn_20_7$. This manganite had recently been grown for us, and is of particular interest, as it occurs in the phase diagram, where there has previously been measured a long range order hole. As such, any observation of long range order would be highly significant.

Upon cooling the crystal, superlattice reflections were observed at (0.175,0.175,10) and (0.35,0,35,0) corresponding to the positions expected for orbital and charge ordering. Polarisation analysis was conducted on both peaks (Fig. 1). This suggested that the signal charge ordering is dipole (spherically symmetric) in nature. By contrast, the orbital order peak exists in both polarisation channels, suggesting some anisotropy and a quadrupole nature.

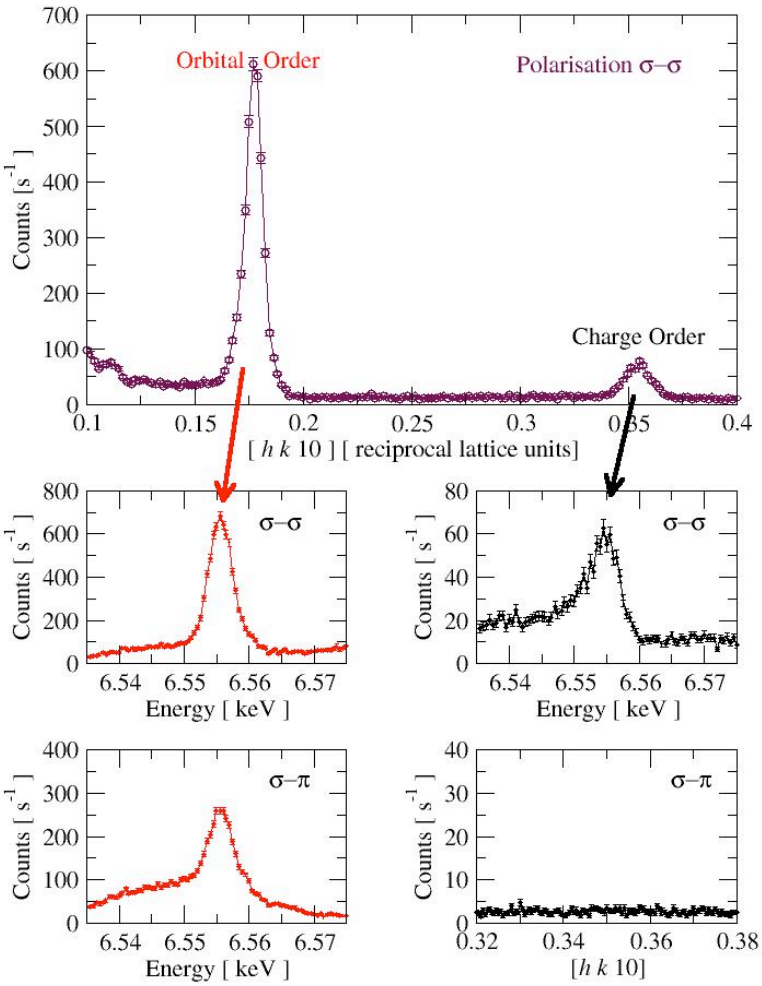

Fig 1. (*upper*) Reciprocal space scan showing the charge and orbital order reflections. The charge ordering is seen to resonate purely in the σ-σ channel, whereas the orbital order resonates in both polarisation channels.

In order to investigate the anisotropy of the orbital order reflection, we measured the azimuthal dependence of the reflection (Fig 2). This was measured over 360º which was made possible by a complex re-configuration of the diffractometer. The azimuthal dependence can be compared to a simulated dependence for a bistripe and Wigner crystal. Although these simulations provide similar results, it is marginally closer to the bistripe model.

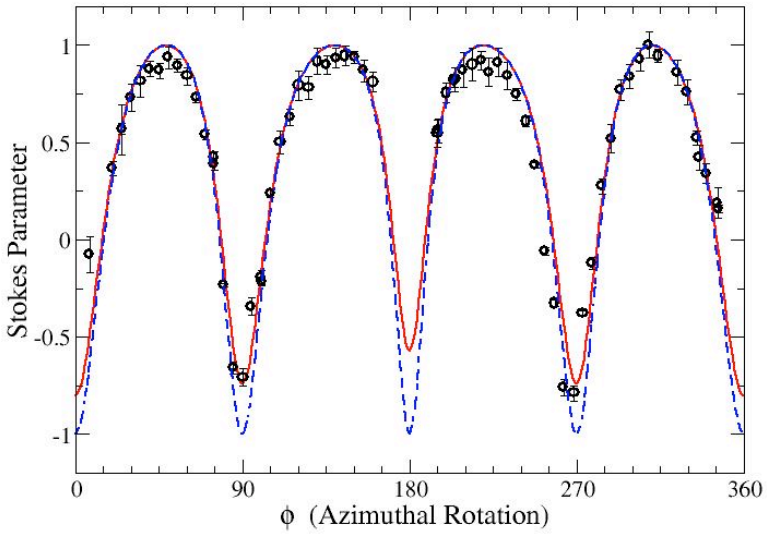

Fig 2 Azimuthal dependence of the orbital order reflection (open circles). The simulated azimuthal dependence according to the bistripe (red solid) and Wigner crystal (blue dashed) are superimposed.

This experiment was highly successful and we are preparing the results for submission to Physical Review B.