（ ※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。）

# MLF Experimental Report	提出日 Date of Report
課題番号 Project No. 2014a0130 実験課題名 Title of experiment Interlayer Sliding Motion of Spin-ladder Sr14Cu24O41 Compound 実験責任者名 Name of principal investigator Paul Gregory Freeman 所属 Affiliation LQM, EPFL, Lausanne, Switzerland	装置責任者 Name of responsible person Kenji Nakajima, Seiko Kawamura 装置名 Name of Instrument/（BL No.） BL-14 実施日 Date of Experiment 05.11.14 – 12.11.14

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

$Sr_{14}Cu_{24}O_{41}$ – single crystal

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

In the 1970s new normal phonon modes were predicted to occur in ioninc materials with incommensurate layers that slide past each other, thiat is equivalent to electronic plasmon modes in metals[1]. Direct observation of such a mode has proved elusive. Our recent THz spectroscopy measurements on $Sr_{14}Cu_{24}O_{41}$ indicated a mode consistent with an interlayer sliding motion phonon[2]. In this proposal we undertook a four dimensional study of the low energy phonon dispersion to directly observe this phonon mode.

To measure the phonon excitation spectrum we took advantage of scanning the omega rotation of the sample and Repetition Rate Multiplication (RRM) techniques. With the crystal a axis vertical the sample rotation allowed the measurement of phonon dispersion along all crystal symmetry axis.

Due to the incommensurate structure along the c axis where 7 ladder spacings approximately equal 10 chain spacings large incident neutron energies are required to access large wavevectors, but with a high energy resolution. Intial measurements were required to

2. 実験方法及び結果（つづき） Experimental method and results (continued)

identify the best instrumental setting. In one RRM setting it was possible to measure the phonons dispersing from the zone centre of; the ladder structure at (0, 0, 14) with, Ei = 10.0 meV, the chain structure at (0, 0, 20) with Ei = 22 meV. Additionally phonons at smaller wavevectors where measured with Ei =5.7 meV to complement previously taken data. A single setting saved counting time so that data could be additionally taken a 125 K. The data also provide the most complete diffraction measurement of the incommensurate Bragg reflections in Sr14Cu24O41.

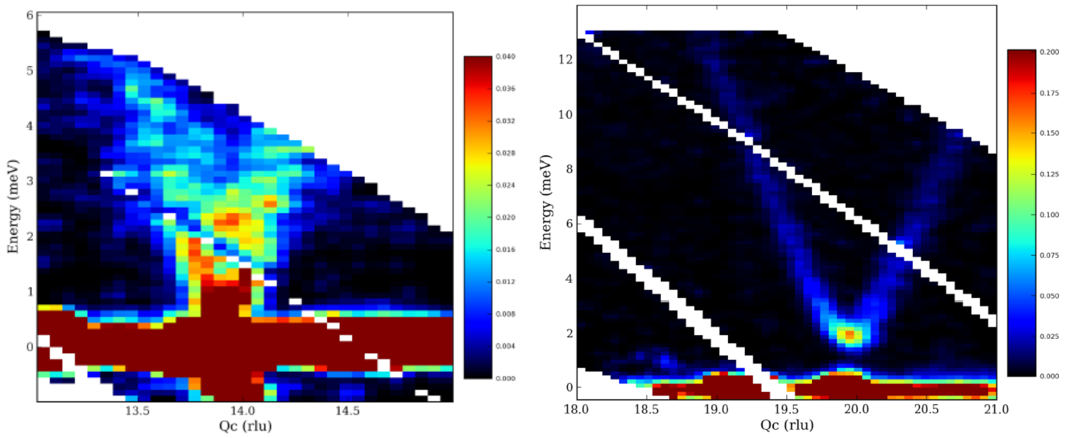

Figure: Left: Phonon excitations dispersing away from a wavevector associated with the ladder structure. Multiple modes exist at the zone centre, with the phonons strongly disperses in all directions of reciprocal space. Right: Gapped phonon excitations dispersing away from a wavevector associated with the chain structure along the c-axis. Thee phonons form the chain layer have a 1meV bandwidth along the other two crystal axis.

From the ladder structure at (0 0 14) we see phonons that disperse strongly in all directions from 2 modes: one gapless and one with a 2 meV gap. At (0, 0, 20) the phonons from the chain structure show a phonon with a 2 meV gap that disperses strongly only along the c-axis. A detailed analysis of the temperature dependence modes dispersion is required to determine if it can be consistently linked with the modes observed in the THZ spectroscopy.

The results of this project provide a complete measurement of the ground state phonon structure of Sr14Cu24O41, and at a second temperature. We envisage an additional experiment on a lower resolution triple axis spectrometer to record a more detailed temperature dependence at specific wavevectors, to map the temperature evolution between the data sets taken on Amateras. From this we will determine the existence or not of a sliding motion phonon in Sr14Cu24O41.

[1] G. Theodorou and T. M. Rice Phys. Rev. B **18**, 2840 (1978)

[2] V. K. Thorsmole *et al*, Phys. Rev. Let. **108**, 217401 (2012)