実験報告書様式（一般利用課題・成果公開利用）

（ ※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。 ）

CROSS TOKAI **Experimental Report** J-PARC	承認日 Date of Approval 2014/6/24 承認者 Approver Kaoru Shibata 提出日 Date of Report 2014/6/24
課題番号 Project No. 2013B0051 実験課題名 Title of experiment Low-energy collective excitations of skyrmion lattice in Cu2OSeO3 実験責任者名 Name of principal investigator Taku J Sato 所属 Affiliation Tohoku University	装置責任者 Name of Instrument scientist Kaoru Shibata 装置名 Name of Instrument/（BL No.） DNA（BL-02） 実施日 Date of Experiment 3.31-4.6

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.

Name of sample: Cu2OSeO3
Chemical formula: Cu2OSeO3
Physical Form: 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.

Low-energy collective excitations of skyrmion lattice in Cu_2OSeO_3

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Skyrmion gives rise to emergent electromagnetic phenomena, *e.g.*, topological Hall effect, and is a current topic in basic condensed matter physics, as well as in technological application for "spintronics". Recent SANS and Lorentz microscopy experiments detect formation of triangular lattice of the skyrmions in small-q helimagnets, such as MnSi and Cu_2OSeO_3, under weak external magnetic field. As one possibility of manipulating skyrmion lattice, dynamics under electromagnetic wave (microwave) has been studied. Theoretically, three spin-wave modes were predicted using Landau-Lifshitz-Gilbert analysis; two modes are at ~1 GHz with out-of-plane component circulating clockwise and counterclockwise, and were observed recently in the ESR measurements. The other one is breathing-type mode, which has not been observed in the microwave technique. The microwave technique detects the dynamics at long-wavelength limit, i.e. Q = 0, and hence information on the dispersion relation of such collective motion is missing.

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

Here, we propose neutron low-Q and low-energy inelastic experiment to investigate the Q-dependence of the collective excitations. Since the characteristic energy is in the 1 GHz region, which corresponds to 4 micro eV, we definitely need a very high energy resolution spectrometer. Hence, we performed the inelastic scattering experiment at DNA, a nearly-backscattering inverted-geometry spectrometer with perfect Si 111 analyzers.

The experiment was performed with self-made sample stick inserted into the standard closed-cycle refrigerator of DNA. The Si 111 reflection was selected as the analyzer reflection. The slit of the pulse shaping chopper is selected to be 3 cm. The sample was set to the sapphire plate at the beam position, with the [110] axis of the crystal being parallel to the incident neutron beam direction. Also attached to the stick is the small electromagnetic coil which produces up to H = 500 Oe at the sample position. The magnetic field direction was parallel to the incident beam direction, too. Temperature of the sample was monitored using a temperature sensor placed on the sapphire plate. Sample temperature was checked after the beam experiment; it was found that the actual sample temperature was approximately 0.5 K higher than the reading of the temperature sensor on the sapphire plate used in the beam experiment. (This has to be taken care of when viewing the following experimental results.)

Figure 1(left) shows the inelastic scattering spectrum observed at T = 40 K and H = 0 Oe, where the system is in the helical phase. Also shown in Fig. 1(right) is the inelastic spectrum measured at T = 65 K and H = 0 Oe, where the system is in the paramagnetic phase. No significant difference was observed in the two figures. We have also checked the inelastic spectrum in the skyrmion phase, however, significant difference cannot be seen there, too. Hence, we conclude that with the present statistics we cannot detect the low-energy excitations from Cu_2OSeO_3. Larger sample volume with higher incident flux is the key for the future successful experiment.

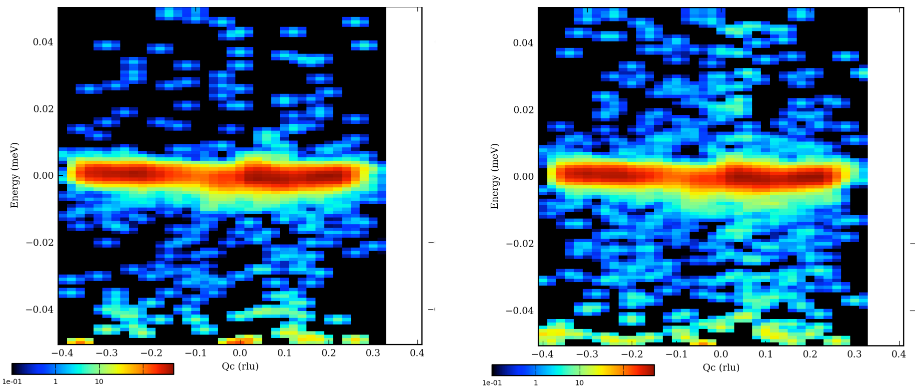

Fig. 1: (Left) Neutron inelastic scattering spectrum observed at T = 40 K and H = 0 Oe.

(Right) Similar inelastic spectrum observed at T = 65 K and H = 0 Oe.

The right is at the phase of Para.