実験報告書様式（一般利用課題・成果公開利用）

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CROSS TOKAI **Experimental Report** J-PARC	**承認日** Date of Approval 2016/7/23 **承認者** Approver Jun-ichi SUZUKI **提出日** Date of Report 2016/8/2
課題番号 Project No. 2016A0215 実験課題名 Title of experiment Direct observation of uniaxial-stress-induced skyrmion state in MnSi 実験責任者名 Name of principal investigator Taro Nakajima 所属 Affiliation RIKEN Center for Emergent Matter Science	装置責任者 Name of Instrument scientist Jun-ichi Suzuki and Kazuki Ohishi 装置名 Name of Instrument/(BL No.) TAIKAN/BL15 実施日 Date of Experiment 20-25th, May, 2016

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 : Cu2OSeO3
Chemical formula : Cu2OSeO3
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.

A nanometric voltex-like spin structure, (magnetic) skyrmion, has attracted increasing attention in recent condensed matter physics research [1,2]. Because this magnetic vortex can be controlled by means of a variety of external stimuli; for example, by flowing or injecting (spin-polarized) electric current [3,4]. Therefore, the skyrmions are expected to be applicable for new spintronic devices and/or information storage devices in the future.

Quite recently, we have found another methodology to control skyrmion phase, that is, application of uniaxial stress. In the previous experiment at TAIKAN (proposal No. 2014B0102), we performed small angle neutron scattering (SANS) measurements on a single crystal of MnSi, which is a typical skyrmionic compound, under applied magnetic field and uniaxial stress. We revealed that the skyrmion state is suppressed by the application of uniaxial stress parallel to the magnetic field [5]. We also performed magnetic susceptibility measurements on MnSi, revealing that the skymion phase is enlarged by applying uniaxial stress perpendicular to the magnetic field [5].

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

In the present study, we applied this technique, i.e., uniaxial-stress-control of skyrmion state, to another skyrmionic compound Cu_2OSeO_3. We performed SANS measurements on Cu_2OSeO_3 under applied magnetic field and uniaxial stress at the TAIKAN instrument (BL15) in MLF of J-PARC.

A single crystal of Cu_2OSeO_3 was cut into a rectangular shape with dimensions of 2.5 * 2.5 * 1 mm^3, and was placed in a uniaxial stress cell, which was also used in our previous SANS experiment on MnSi [5]. The uniaxial-stress cell was loaded into the horizontal field cryomagnet installed in MLF. The uniaxial stress (σ) was applied along the [110] direction, and the incident neutron beam was parallel to the [1-10] or [001] directions, as shown in Figs. 1(a) and 1(b).

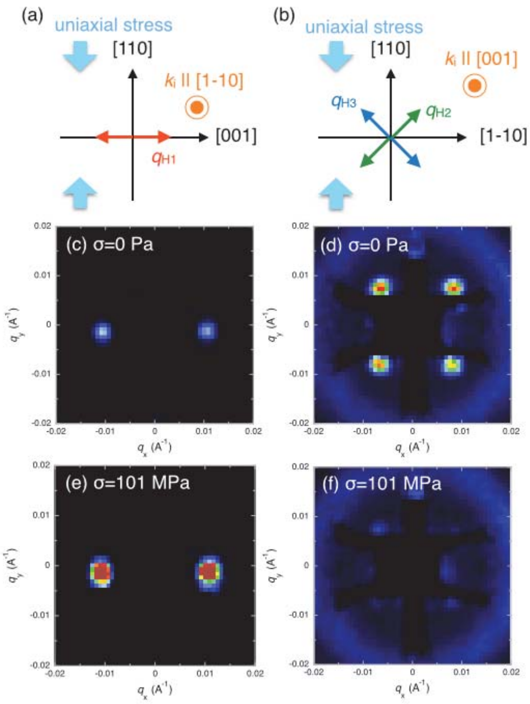

Fig. 1: [(a), (b)] Schematic diagrams showing the directions of the q-vectors, incident neutron beam, uniaxial stress, and crystallographic axes. [(c)-(f)] SANS patterns measured at [(c), (d)] 0 Pa, and [(e), (f)] 101 MPa.

Before going into the skyrmion phase, we investigated uniaxial stress effects on a helical magnetic phase, which is the ground state of this compound. In a previous study, it was reported that the q-vectors in the helical magnetic phase are parallel to the <100> direction of the chemical lattice [6], and therefore there are 3 magnetic domains having the q-vectors of (q,0,0), (0,q,0) and (0,0,q). We found that the application of σ favors the magnetic domain with the q-vector of (0,0,q), which is perpendicular to σ, while it suppresses the other two domains, as shown in Figs. 1(c)-1(f).

Keeping these results in mind, we investigated uniaxial-stress effects on the skyrmion state in Cu_2OSeO_3. We measured temperature dependence of the SANS patterns under magnetic field and σ, revealing that the equilibrium skyrmion phase is extended toward low temperatures with increasing σ. Moreover, when the sample was cooled with σ and magnetic field, a metastable skyrmion state was realized at low temperatures. This metastable skyrmion state still remained even after removing σ at low temperatures. By repeating the magnetic-field and uniaxial-stress cooling, we established a metastable state diagram, which shows that the metastable skyrmion state spreads in a wide range of temperature and magnetic field. Further analyses are ongoing, and these results will be published elsewhere.

References

[1] Muhlbauer *et al.*, Science **323**, 915 (2009), [2] N. Nagaosa and Y. Tokura, Nat. Nanotech. **8**, 899 (2013), [3] X. Z. Yu *et al.*, Nat. Comm. **3**, 988 (2012), [4] N. Romming *et al.*, Science **341**, 636 (2013), [5] Y. Nii, T. Nakajima *et al.*, Nat. Commun. **6**, 8539 (2015), [6] S. Seki *et al.*, Phys. Rev. B **85**, 220406R (2012).