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 2017/05/10 承認者 Approver Jun-ichi Suzuki 提出日 Date of Report 2017/4/26
課題番号 Project No. 2016B0130 実験課題名 Title of experiment Search for a new form of skyrmion lattice in a quenched skyrmion state of 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 Kazuki Ohishi 装置名 Name of Instrument/(BL No.) TAIKAN/BL15 実施日 Date of Experiment 2017.2.16-21

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.

Manganese silicide / MnSi / Solid (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.

MnSi is known to exhibit skyrmion lattice (SkL) state, which is a topologically-nontrivial vortex-like spin texture, in a narrow temperature and magnetic field region near the critical temperature of 29 K. It was recently reported that the SkL state in a bulk crystal of MnSi can be quenched to low temperatures by rapid cooling [H. Oike *et al*, Nat. Phys. **12**, 62 (2016)]. In the present experiment, we investigated stability of a quenched skyrmion lattice state in MnSi under rotating magnetic field by means of small angle neutron scattering (SANS) at TAIKAN.

A single crystal of MnSi was grown by the Czochralski method, and was cut into a rectangular shape with dimensions of 1*1*6 mm^3. Four electrodes were attached on the sample to probe resistivity, and to apply electric current pulses. The sample was inserted into a 4T-horizontal field magnet of MLF, which has a sample rotator on its topside.

We applied a current pulse at 10 K and 0.21 T. Temporal change of sample temperature was deduced by measuring the resistivity during the current pulse application, as shown in Fig. 1(a); the sample was heated to about 30 K, which is slightly above the critical temperature, due to the Joule heating. As soon as the electric current was turned off, the sample temperature was rapidly back to 10 K passing through the equilibrium SkL state with a cooling speed of 50 K/s.

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

By this rapid cooling, the equilibrium SkL was quenched to low temperatures. Figures 1(b) and 1(c) show the SANS patterns measured before and after the current pulse application under the magnetic field parallel to the neutron beam, respectively. A sixfold SANS pattern, which is a hallmark of the triangular SkL, was observed after the current pulse.

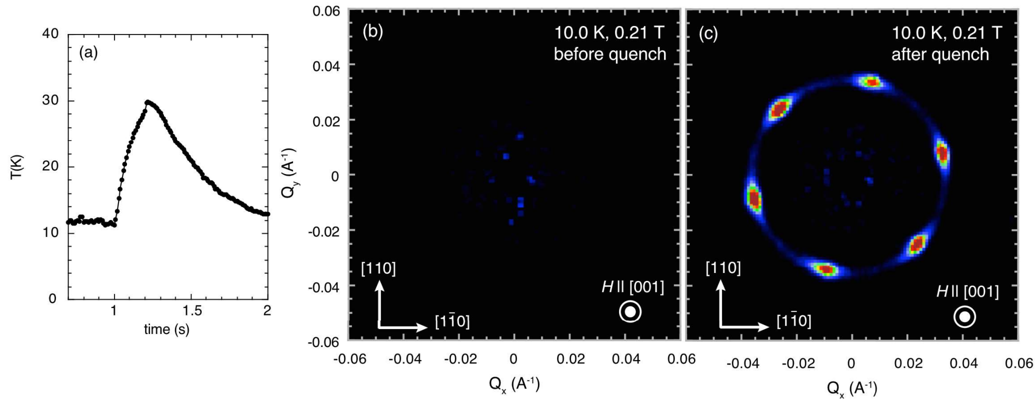

Fig. 1: (a) A temporal profile of the sample temperature, which was deduced from resistivity measurements during the current pulse application. Typical SANS profiles (b) before and (c) after the current pulse at 10 K and 0.21 T.

In the quenched SkL state, we rotated the sample by 10 degrees. We found that four of the six Bragg reflections disappeared from the scattering plane, as shown in Fig. 2(b). Subsequently, we rotated the magnet by -10 degrees using a goniometer, and found that the sixfold pattern was retrieved, as shown in Fig. 2(c). This means that the skyrmion lattice is frozen in the quenched state, and that its orientation is fixed to the crystal without following the direction of the magnetic field.

We measured SANS patterns after rapid cooling at various temperatures and rotation angles, revealing that the skyrmions lose their flexibility with decreasing temperature, although they follow the direction of the magnetic field in the equilibrium state (at high temperature). Further analyses are ongoing, and these results will be published elsewhere.

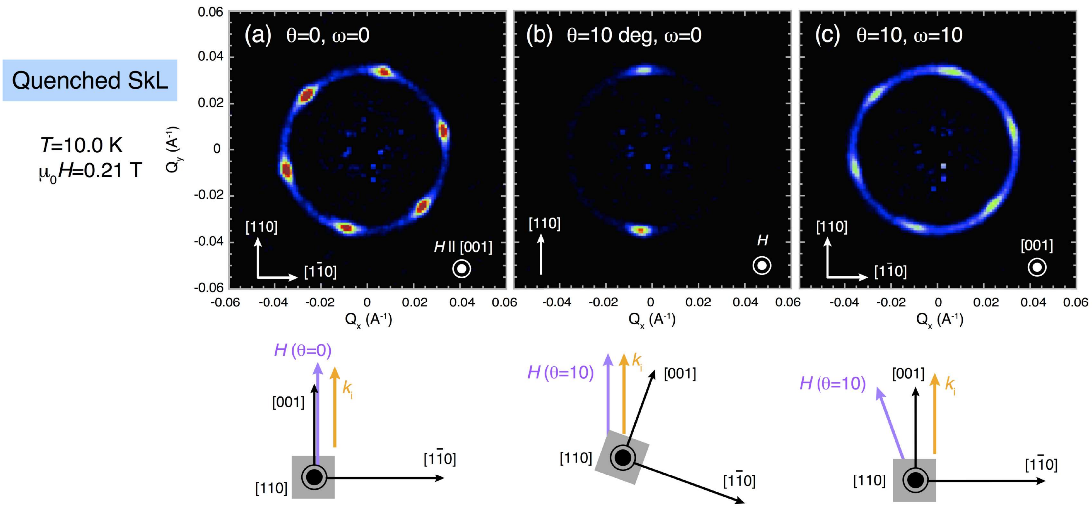

Fig. 2: SANS patterns measured after (a) rapid cooling under magnetic field parallel to the neutron beam, (b) rotating the sample by 10 degrees, and (c) rotating the magnet by -10 degrees.