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。）

MLF Experimental Report	提出日 Date of Report April, 20 2015
課題番号 Project No. 2014B0259 実験課題名 Title of experiment Magnetic excitations in the spin-2 kagome lattice antiferromagnet $Cs_2LiMn_3F_{12}$ 実験責任者名 Name of principal investigator Hidekazu Tanaka 所属 Affiliation Tokyo Institute of technology	装置責任者 Name of responsible person Kenji Nakajima 装置名 Name of Instrument/（BL No.） AMATERAS (BL14) 実施日 Date of Experiment March 7 to 10, 2014

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.

$Cs_2LiMn_3F_{12}$

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.

$Cs_2LiMn_3F_{12}$ is expected to be described as an S=2 kagome-lattice antiferromagnet (KLAF). This compound crystallizes in a hexagonal structure, $R\bar{3}$ [1], which is closely related to the structure of $Cs_2Cu_3SnF_{12}$ [2]. The lattice parameters are a=7.440 Å and c=17.267 Å [1]. Magnetic Mn^{3+} ions with S = 2 form a uniform kagome layer parallel to the c plane. Owing to the Jahn-Teller effect, MnF_6 octahedra are elongated along the principal axes that are parallel to the c plane. Because the electron orbitals $d(3z^2{-}r^2)$ of Mn^{3+} are not directly linked through the p orbital of F^- ion, the nearest neighbor superexchange interaction in the kagome layer is small, i.e., J/k_B = 4.4 K [3] in contrast to J/k_B = 240 K in $Cs_2Cu_3SnF_{12}$ [2,4]. $Cs_2LiMn_3F_{12}$ undergoes magnetic ordering at T_N = 2.1 K [3]. Below T_N, the magnetic specific heat has a large component proportional to T^2, which indicates two-dimensional antiferromagnetic nature. To investigate the magnetic structure in the ordered phase, we first performed neutron powder diffraction and found that observed magnetic reflections can be indexed in terms of neither q=0 structure nor $\sqrt{3}\times\sqrt{3}$ structure. Best description of the magnetic structure is given by an ordering vector $\boldsymbol{q}$ = (1/3 0 0). There is no information on magnetic excitations in $Cs_2LiMn_3F_{12}$.

In this experiment, we measured magnetic excitations in $Cs_2LiMn_3F_{12}$ using a cold-neutron diskchopper

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

spectrometer AMATERAS (BL14) installed at J-PARC, Japan. Sample was mounted such that the crystallographic a^* and c^* axes are to be horizontal. The wave vector $\boldsymbol{k}_i$ of incident neutron was set to be parallel to the c^* axis and the scattering intensities along the c^* axis was integrated, assuming good two-dimensionality. Sample was cooled down to 0.3 K using 3He closed-cycle refrigerator. Excitation data were collected at T = 0.3, 3, 5, 10, 30 and 60K.

Figure 1(a) shows contour maps of scattering intensity along the $\boldsymbol{Q} = (h\ 0\ 0)$ measured at T = 0.3 K with (a) E_i = 7.743 meV. The feature of the magnetic excitations is that the excitations are dispersionless. This behavior is much different from the largely dispersive excitations observed in other KLAFs with the ordered ground state such as $Cs_2Cu_3SnF_{12}$ [4] and $KFe_3(OH)_6(SO_4)_2$ [5]. In $Cs_2LiMn_3F_{12}$, strong excitation is observed for $0.6 \le h \le 1.2$ at E = 1.7 meV. This energy corresponds to the energy expected for the zone boundary if the magnetic excitations obey the classical spin-wave theory. Figure 1(b) shows the excitation spectra integrated for $0.5 \le h \le 1.0$. At T = 0.3 K, one strong and two weak excitations are observed at E = 1.7 meV, and 4.5 and 6.5 meV, respectively. With increasing temperature, the excitations are damped and their energies decrease. From these excitation data, we infer that excitations of spin cluster with the size of the chemical unit cell is dominant in $Cs_2LiMn_3F_{12}$.

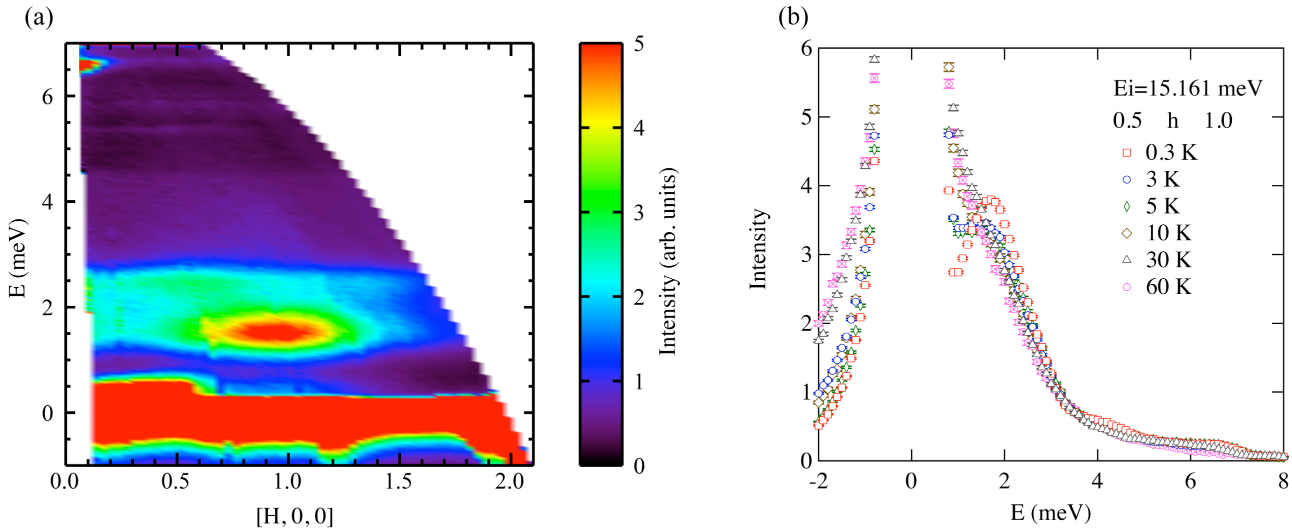

Fig. 1: (a) Contour maps of scattering intensity along the $\boldsymbol{Q} = (h\ 0\ 0)$ measured at T = 0.3 K with E_i = 7.743 meV. (b) The excitation spectra measured with E_i = 15.161 meV at various temperatures. Scattering intensities are integrated for $0.5 \le h \le 1.0$.

References

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[4] T. Ono *et al.*: J. Phys. Soc. Jpn. **83** (2014) 043701.
[5] K. Matan *et al.*: Phys. Rev. Lett. **96** (2006) 247201.