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 2014/10/8 承認者 Approver Ryoichi Kajimoto 提出日 Date of Report 2014/8/29
課題番号 Project No. 2014A0096 実験課題名 Title of experiment Magnetic excitation and its relevance to ferroelectricity in multiferroic materials of $YMn_{2-x}Ga_xO_5$ 実験責任者名 Name of principal investigator Hiroyuki KIMURA 所属 Affiliation Tohoku University	装置責任者 Name of Instrument scientist Ryoichi KAJIMOTO 装置名 Name of Instrument/(BL No.) BL-01 実施日 Date of Experiment 2014/4/24-2014/4/28

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.

$YMn_{2-x}Ga_xO5$, x = 0.12 single crystals

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.

YMn_2O_5 (YMO) system shows successive magnetic phase transitions with decreasing temperature, of which phases are 2-Dimensionally modulated Incommensutare Magnetic (2DICM), Commensurate Magnetic (CM), and Low-Temperature 2DICM (LT-2DICM) phases. Ferroelectricity is realized in CM and LT-2DICM phases. Last year we have measured spin excitation spectra of YMO in 2DICM, CM, and LT-2DICM phase using chopper spectrometer 4SEASONS. Upon Ga-substitution with x = 0.12, $YMn_{2-x}Ga_xO_5$ (YMGO) system shows only two incommensurate magnetic phases (2DICM and LT-2DICM) and CM phase disappears[1]. Although the disappearance of CM phase was attributed to the change of competing magnetic interactions between Mn spins due to the substitution of non magnetic Ga ions, the details has been not clarified yet.

In this experiment, we carried out the measurement of spin excitations for YMGO system and compared with those for YMO system to make clear microscopically how the non-magnetic impurity affects the magnetic interactions and why the CM phase disappears due to Ga substitution.

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

Spin excitations of YMGO were measured by multi-E_i method with E_i = 44.93, 21.40, 12.48, and 8.16 meV. Horizontal scattering plane was parallel to *a*– and *c*–axis ((*H* 0 *L*) reciprocal zone). The data were taken at T = 5 K (LT-2DICM, Ferroelectric phase) and T = 30 K (2DICM phase, Paraelectric phase). It was found that in LT-2DICM phase, as shown in Figure 1, well defined spin wave propagating along the *b*–axis were observed in YMO, while the spin wave in YMGO became broader in both energy and Q_b // k space. On the contrary, the spin dispersion along the *c*–axis is almost Ga-independent. The results indicate that upon non-magnetic Ga-substitution, the magnetic interaction along the *b*–axis is strongly disturbed while the interaction along the *c*–axis does not change so much. Previous study have shown that only Mn^{3+} cite in YMO can be substituted by Ga^{3+} ion, in which Mn^{3+} spins play dominantly the magnetic interaction in *ab*–plane[1]. Detailed analysis for deriving the spin Hamiltonian for both YMO and YMGO is now in progress.

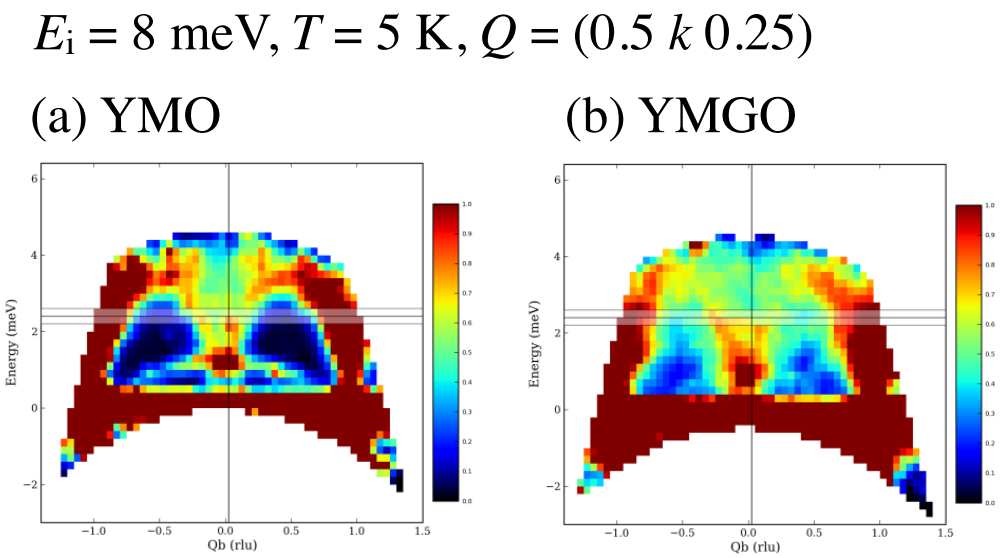

Figure 1: Spin excitation spectra as functions of Energy (vertical) and Q_b // k (horizontal) for (a) YMO and (b) YMGO taken at T = 5 K.

References

[1] H. Kimura et al., PRB 87 (2013) 104414.