（ ※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 2015/11/09 承認者Approver TAKEDA Masayasu 提出日Date of Report 2015/11/08
課題番号 Project No. 2014A0086 実験課題名 Title of experiment Investigation of an anomalously large 90 degree interlayer exchange coupling in ferromagnetic/nonmagnetic/ferromagnetic trilayers using the polarized neutron reflectometry 実験責任者名 Name of principal investigator TAKEDA Masayasu 所属 Affiliation Japan Atomic Energy Agency	装置責任者 Name of responsible person TAKEDA Masayasu 装置名 Name of Instrument/（BL No.） SHARAKU(BL17) 実施日 Date of Experiment 2014/5/18 10:00 ～ 2014/5/24 10:00

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.

Co_2MnSi(CMS)/Cr/CMS trilayers on a Si substrate

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.

We proposed a series of experiments to decisively determine the alignment of the ferromagnetic moments in the magnetic multilayers showing interlayer exchange coupling such as Co_2MnSi(CMS)/Cr/CMS, Fe/Cr/Fe, and CoFe/Cr/CoFe, and to reveal the influence of the material of the magnetic and nonmagnetic layer, the thickness of the nonmagnetic layer, interfacial roughness, and so on. In this experiment, we investigated an exotic 90º couplings in a CMS/Cr/CMS trilayer on a MgO substrate at the first step.

Polarized neutron reflectivity measurements were performed on BL17 with a spin analyzer after and before the sample to separate the spin-flip and the non-spin flip channel in the reflection process. The reflection with the spin-flip indicates a canted magnetic moments inside the sample against the direction of an external magnetic field. If the 90º coupling is realized in the sample, the spin-flip reflectivity is appeared in a reflectivity profile. External magnetic fields of 50 Oe and 10 kOe were applied parallel to the sample plane. The latter field is enough strong to saturate the sample magnetization. Therefor we should not see the reflectivity with the spin-flip under the magnetic field of 10 kOe.

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

We spent most of our beam time to investigate origin of unexpected behaviors of polarized neutron devices, and could not fix them even when we almost consumed the beam time. Therefore we decided to manually measure the four polarized neutron reflectivities (R_{++}, R_{+-}, R_{-+}, and R_{--}): We fixed states of two spin-flippers during the measurements. The states of the spin-flippers are normally switched by a software automatically during measurements. We also had to revise the analysis software and to write a new software which combined the separated data of for different measurements.

Anyway we successfully detected the change of the magnetic structures induced by external magnetic fields as shown in Fig. 1 (left) under a strong magnetic field of 10 kOe and (right) under a weak magnetic field of 50 Oe. A distinct spin-flip components of the reflectivity are observed in the profile under a weak magnetic. field where the 90° coupling is predicted by the magnetization measurements. However, what strange is that the spin-flip components also appeared in the saturated state as shown in Fig. 1 (left).At the moment, we have no idea about this non-spin-flip component. In addition, we have not found the parameters which completely reproduce the observed profiles yet even for the reflectivity profile under the weak magnetic field. We are now carefully checking whether this difficulty comes from inappropriate data handling or not. The troubles of the polarized neutron devices make it complicated and difficult to locate the source of the problem.

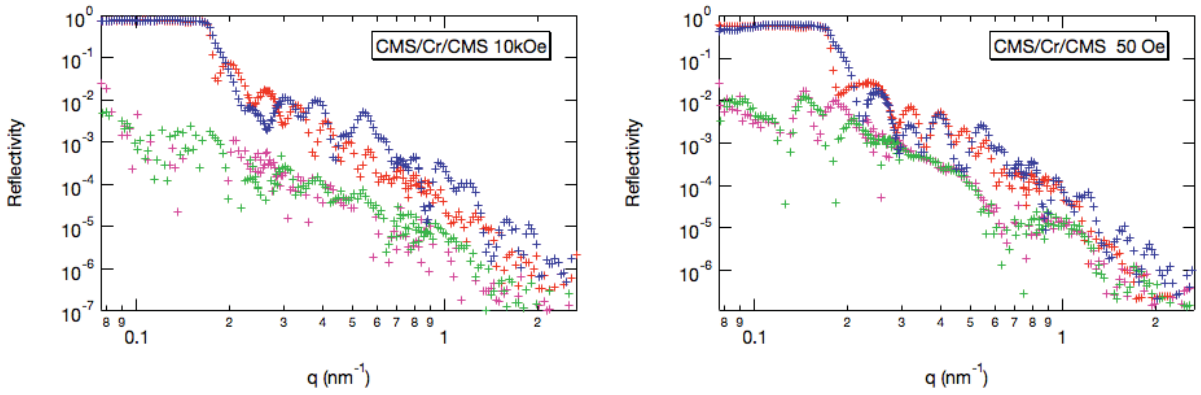

Fig. 1 Results of the polarized neutron reflectivity measurements of Co_2MnSi/Cr/Co_2MnSi trilayer on a MgO substrate under a magnetic field of 10 kOe (left), and 50 Oe (right). Blue and red curves are no-spin-flip component and green and pink ones are spin-flip component of the reflectivity.