

(※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。)

<b>TOKAI CROSS</b> <b>Experimental Report</b> 	提出日 Date of Report 2013/6/5
実験課題番号 Project No. 2013A0052 実験課題名 Title of experiment Direct observation of magnon and spin-orbit exciton in Sr <sub>2</sub> IrO <sub>4</sub> 実験責任者名 Name of principal investigator Masaki Fujita 所属 Affiliation Institute for Materials Research, Tohoku University	装置責任者 Name of Instrument scientist Ryoichi Kajimoto 装置名 Name of Instrument/(BL No.) 4SEASONS 利用期間 Dates of experiments 2013/4/4-4/8

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.
<p>Sr<sub>3</sub>Ir<sub>2</sub>O<sub>7</sub> single crystals</p>

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.
<p>Sr<sub>3</sub>Ir<sub>2</sub>O<sub>7</sub> is known to be a Mott insulator with spin-orbit entangled magnetic state carrying the effective total angular moment <math>J_{\text{eff}}=1/2</math>. Therefore, a new root for the emergence of high-<math>T_c</math> superconductivity is expected in iridate oxides. Quite recently, RIXS measurement on Sr<sub>3</sub>Ir<sub>2</sub>O<sub>7</sub> single crystal clarified that the excitations consist of a magnon band below 300 meV and a higher magnetic mode (spin-orbit exciton with <math>J_{\text{eff}}=3/2</math>) exists around 600 meV. Thus, the INS measurement is now indispensable to clarify the inherent magnetism in iridate oxide by the complementary study. In order to study the novel dynamics of magnetic moment composed of spin and orbital, we performed the first high-energy neutron scattering</p>

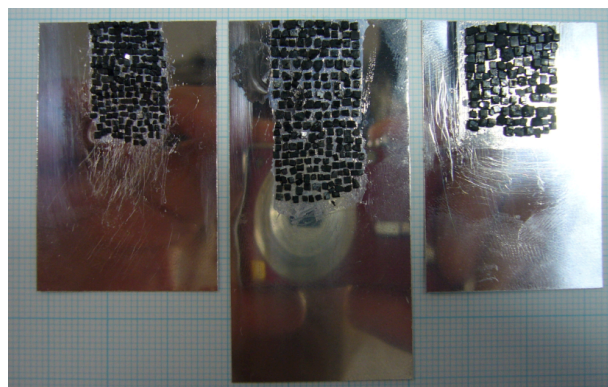


Fig. 1. Picture of assembled crystals of Sr<sub>3</sub>Ir<sub>2</sub>O<sub>7</sub>.

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

measurement on iridate oxide.

For the experiment, we prepared single crystals by flux-method and about 500 crystals with the total mass of 2.1 grams were assembled on Al-plates. The picture of assembled samples is shown in Fig. 1. First, we tried to measure the spin-orbit exciton around 600 meV with utilizing high-energy neutrons. However, due to a relatively high background in the low-angle detector bank, any reliable magnetic signal was extracted. Then, we lowered the incident energy to see the one magnon excitation below 200meV. Signal was collected for 2 days with the identical experimental set-up at 4K. As seen in Fig. 2, excitation was successfully observed by neutron scattering measurement in the energy range between  $\sim 100$ meV and  $\sim 180$ meV for the first time. In the figure, the spectra are sliced along  $h$ -direction through  $(0.5, 0.5)$  and  $(-0.5, -0.5)$ , which are antiferromagnetic zone center (ZC) and fold at  $h=0$ . There is no well-defined magnetic signal below  $\sim 80$ meV around the ZC, indicating a large gap in the spin excitation spectrum. The preliminary result of analysis revealed that the dispersion relation and the intensity distribution are consistent with those reported from RIXS measurement (Fig. 3). Therefore, our result clearly demonstrates that the magnetic signal in iridates can be detected by using high-energy neutrons, for which the absorption effect is reduce and neutron scattering measurement at J-PARC enables us to study further details of magnetic excitations in the sub-eV region. We note that there was a relatively strong momentum-independent background around 180 meV. This signal was observed even in the empty run.

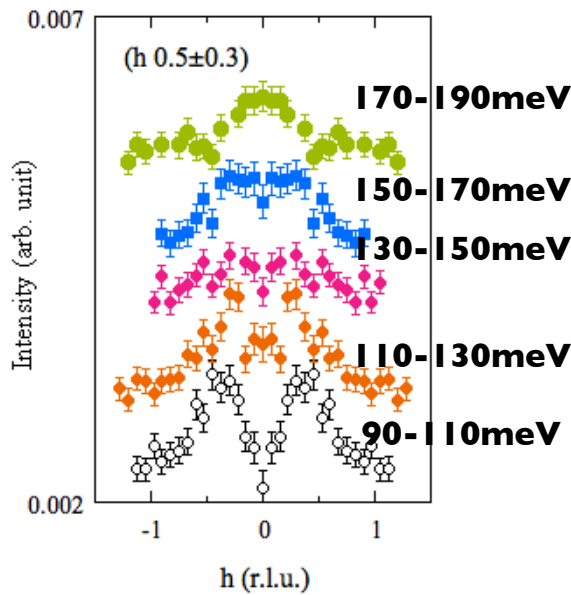


Fig. 2. Constant-energy spectra slices at several energies for  $\text{Sr}_3\text{Ir}_2\text{O}_7$ .

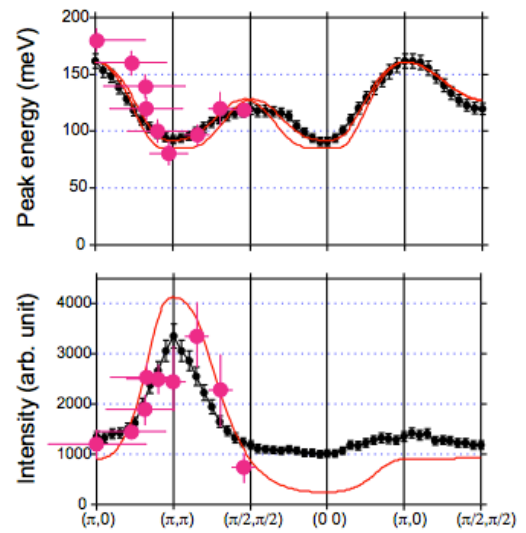


Fig. 3. Momentum-dependence of peak-position and intensity in  $\text{Sr}_3\text{Ir}_2\text{O}_7$ . Black circles are the results obtained by RIXS.