Experimental Report

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実験課題番号 Project No.

2012I0101

実験課題名 Title of experiment

Improvement of the Performance of 4SEASONS to Provide an Advanced Experiment Environment for Users

実験責任者名 Name of principal investigator

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装置名 Name of Instrument/（BL No.）

BL01

利用期間 Dates of experiments

2012/04/24 21:00 – 2012/04/26 09:00
2012/04/28 11:00 – 2012/05/07 11:00
2012/10/31 21:00 – 2012/11/03 11:00
2012/11/22 11:00 – 2012/11/23 11:00
2012/12/18 11:00 – 2012/12/19 11:00
2013/02/28 11:00 – 2013/03/02 11:00

1．研究成果概要（試料の名称、組成、物理的・化学的性状を明記するとともに、実験方法、利用の結果得られた主なデータ、考察、結論、図表等を記述してください。

Outline of experimental results (experimental method and results should be reported including sample information such as composition, physical and/or chemical characteristics.

We performed several test measurements to evaluate the potential of 4SEASONS. The results should provide important information for users to estimate experimental conditions for their measurements.

1. Test measurements of small samples

In order to evaluate the lower limit of sample volume on 4SEASONS, we performed test measurements of small samples. First, we tried to decrease the size of sample of a cupurate oxide superconductor. Since the magnetic excitations from S = 1/2 spins of Cu ions in this system show very weak signals, several tens of grams of samples, consisting of more than 5-6 pieces of crystals, are required for inelastic neutron scattering so far. In this study, we tried to measure the magnetic excitations in only one piece (ϕ7 mm × 35 mm) of crystal of $La_{1.72}Sr_{0.18}CuO_4$. This compound shows two-dimensional (2D) magnetic excitations around $\boldsymbol{Q}$ = (h±1/2, k±1/2) where h and k are integers (in the tetragonal notation) [1]. We utilized the incident energy (E_i) of 205 meV and the measurement temperature was 5 K. Figure 1 shows the inelastic scattering spectrum at $\hbar\omega$ ~ 130 meV. We could observe clear magnetic excitation signals at H = ±0.5 even in this high ω region, where the scattering intensity should be much suppressed.

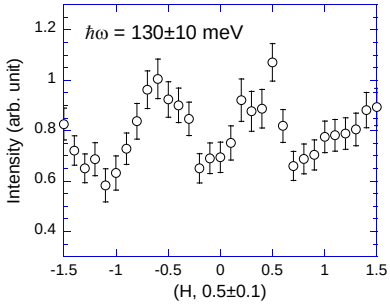

Fig. 1. Magnetic excitation spectrum of $La_{1.72}Sr_{0.18}CuO_4$ at 5 K measured with E_i = 205 meV. The spectrum is cut along the [1 0] direction at $\hbar\omega$ = 130±10 meV. The size of the crystal is ϕ7 mm × 35 mm, and the measurement time was ~ 1.5 days when the power of the accelerator was ~200 kW.

Next, we performed a measurement of excitations in a 3D system with a small crystal. In order to map the 3D excitation spectrum in a 4D space of $\boldsymbol{Q}$-ω using a chopper spectrometer, the most popular measurement technique is to rotate a crystal continuously. However, this type of measurement consumes much measurement time or requires a large sample. We performed the rotating-crystal measurement of a crystal of $Nd_{0.25}Sr_{0.75}MnO_3$ which has a pseudo-cubic crystal structure. In this compound, an antiferromagnetic ordering of Mn spins

(nominal magnetic moment per Mn ion is 3.25 μ_B) is formed below T_N = 295 K, and it shows 3D spin wave excitations [2]. The dimension of the crystal is ϕ12 mm × 15 mm, which is much smaller than that usually used for this type of measurement. The measurement time was quite short and was 1.5 days. Figure 2 shows the inelastic scattering spectrum measured at 5 K with E_i = 35.9 meV. A dispersion curve of spin wave excitations is clearly observed around K = 0, which is consistent with a previous study with a triple-axis spectrometer at a reactor source [2]. We also observed the dispersion relations up to ~60 meV using E_i = 100 meV.

The above results become good examples for users to estimate the sample size and measurement time for their measurements.

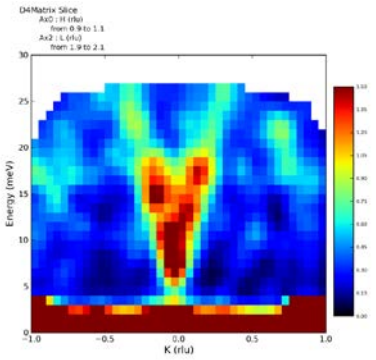

Fig. 2. Spin wave excitations in of $Nd_{0.25}Sr_{0.75}MnO_3$ along the [010] direction measured with E_i = 35.9 meV. The size of the crystal was ϕ12 mm × 15 mm, and the measurement time was ~ 1.5 days when the power of the accelerator was ~300 kW.

2. Single-E_i measurement

Simultaneous utilization of multiple E_i's (multi-E_i measurement) is the default measurement condition and one of the most significant characteristics of 4SEASONS [3]. However, it is important to know whether the overlaps of scattering process of different E_i's cause increase in background. Accordingly, we performed a test measurement with a single E_i which was defined by tuning the phases of the disk choppers. We measured magnetic excitations in a single crystal of $La_{1.5}Sr_{0.5}NiO_4$. This compound has a layered perovskite crystal structure, and Ni spins form antiferromagnetic ordering below ~80 K with a wave vector (ε, 0, 0) and ε ~ 0.44 (in the orthorhombic notation). Figure 3 shows a comparison of the magnetic excitation spectra at 5 K with the multi-E_i mode and with the single-E_i mode. The both spectra show clear excitation peaks at H = 1 ± ε, consistent with a previous study [4]. Both the spectra show very little spectra, indicating practically no increase in background in the multi-E_i measurement.

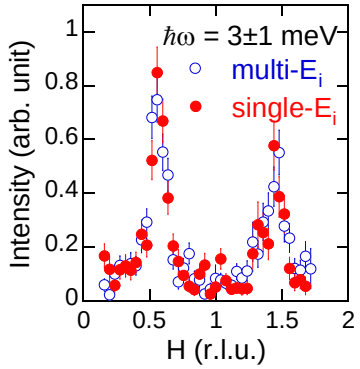

Fig. 3. Magnetic excitation spectra of $La_{1.5}Sr_{0.5}NiO_4$ at 5 K measured with the multi-E_i mode (open symbols) and with the single-E_i mode (closed symbols). The utilized E_i is 15.3 meV, and the data are cut along the [1 0] direction at $\hbar\omega$ = 3±1 meV.

References

[1] M. Fujita *et al.*, in preparation.

[2] R. Kajimoto *et al.*, J. Phys. Soc. Jpn. **74**, 502 (2005).

[3] M. Nakamura *et al.*, J. Phys. Soc. Jpn. **78**, 093002 (2009).

[4] P. G. Freeman *et al.*, Phys. Rev. B **71**, 174412 (2005)

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