CROSS TOKAI **Experimental Report** J-PARC

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実験装置名／BL番号 Name of Instrument/BL

4SEASONS/BL01

実験装置責任者 Name of the person responsible for the instrument:

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1．研究成果概要 （a）装置グループ内の成果、（b）ユーザー課題実装時における特筆すべきサポート、（c）ユーザー課題の執行状況について、まとめてください。A4 サイズ用紙使用のこと。

Outline of your activities. Following results at your instrument should be reported in A4 size papers: (a) results of your instrument group, (b) significant user support works, and (c) statistical summary of user experiments.

(a) Results of the instrument group

First, we performed position calibration of the ^{3}He detectors and phase calibration of the choppers. These are regular calibrations of the instrument performed after long-term shutdowns.

We had a trouble with the T0 chopper, and had to perform experiments without the T0 chopper in November and December. Then, we performed several test measurements using standard samples and a user's sample to estimate how the increased background affects the data. Fortunately, we found that the increase in the background was acceptable for the experiments allocated in this period.

Secondly, we performed performance evaluation measurements of the oscillating radial collimator (ORC) and the Fermi chopper. Here we describe the result of the former in detail. Although we had already measured the transmission of the ORC using the aluminum sample, the overlap of scattering from the aluminum in the sample environment made it difficult to extract the scattering intensity from the sample. Then, this time we used Al_2O_3 samples and succeeded in correctly evaluating the transmission. Figure 1 shows the observed transmission of the ORC as a function of the radius of the sample. The observed transmission is independent of E_i and scattering angle, and has enough high value (even higher than the calculated value based on the Copley's model [1]). This result should be a good measure for users to decide the appropriate sample sizes for measurements with the ORC.

We made a progress in the aspect of software. Recently, the MLF Computing Environment Group developed a new measurement and analysis system, which enables the 4D mapping of the reciprocal and energy space by *continuously* rotating a single crystal. We introduced this new measurement system on 4SEASONS this year and performed test measurements using single crystals of copper and $CuGeO_3$. Figure 2 shows the phonon spectra of a single crystal of copper measured by continuously rotating the crystal using the new system. By rotating the crystal at a reasonably fast speed (160°/h), we obtained the rough picture at an early measurement stage [Figs. 2(a) and 2(b)]. The statistics improved with time by repeating the rotation [Fig. 2(c)]. With this new system, we do not need to determine the rotation step size in advance and can visualize the data in real time, which gives us high

flexibility in the 4D mapping measurements.

In addition to the above maintenance and developing works, we used several days for users to perform preliminary and supplementary measurements such as sample check and background measurements, and to compensate for beamtime lost by an instrument trouble. In addition, we performed measurements of spin dynamics in $Ba_{0.75}K_{0.25}Fe_2As_2$, $Li_2Cr_3SbO_8$, $CaCu_3(OD)_6Cl_2{\cdot}0.6D_2O$, and lattice dynamics in $Sr_{0.95}La_{0.05}Ti_{0.98}Mn_{0.02}O_3$ for our own scientific interests. Here we briefly describe the results for $Li_2Cr_3SbO_8$ and $Ba_{0.75}K_{0.25}Fe_2As_2$.

$Li_2Cr_3SbO_8$ has a kagome lattice with a classical S = 3/2 spins and undergoes $\sqrt{3} \times \sqrt{3}$ long-range ordered state below T_N = 4 K. Due to the frustrated lattice, unique magnetic properties are expected. Accordingly, we studied the magnetic excitations in a powder sample of this compound. Figure 3(a) shows the Q-E map of the excitation spectrum measured at 40 K. This data shows that the classical spin liquid behavior centered at the wave vector for the long-range order q_M (= 1.5 Å^{-1}) exists above T_N.

$Ba_{1-x}K_xFe_2As_2$ is a hole-doped iron-based superconductor. We studied the low-energy spin dynamics in a single crystal of underdoped $Ba_{0.75}K_{0.25}Fe_2As_2$. Figure 3(b) shows the Q-E map of the excitation spectrum at 5 K < T_c. We found presence of two distinct resonance modes at energies of E_{r1} = 8.0 meV and E_{r2} = 4.0 meV. This feature should be characteristic of the underdoped iron-based superconductor which locates at the boundary between the antiferromagnetically ordered phase and the superconducting phase. We consider it can be understood in terms of the multiple superconducting gap structure of iron-based superconductors.

(b) User support works

User programs were performed with technical and scientific supports by the instrument group staff of 4SEASONS, R. Kajimoto (JAEA, J), M. Nakamura (J), K. Kamazawa (CROSS, C), K. Ikeuchi (C), and K. Iida (C). Y. Inamura (J) played a key role in supporting the data acquisition and analysis. One dedicated technical staff, M. Ishikado (C), provided technical support. In addition, many other technical staff in MLF such as R. Takahashi (J), N. Kubo (J), W. Kambara (J), and K. Aoyama (J) supported the operation of sample environments, electric work and machine design related to the user programs.

(c) Statistical Summary of user experiments

Unfortunately, the number of the approved proposals for the 2016A and 2016B terms was limited, because the facility decided to decrease the beamtime for these terms to accept the proposals postponed due to the facility troubles in 2014 and 2015. Only 8 General Use proposals, 1 Urgent Use proposal, 1 New User Promotion proposal, were approved for BL01 in JFY2016 in addition to 2 Element Strategy Initiative Use proposals and 1 Project Use proposals. Instead, 3 2014A General Use proposals and 7 2015A General Use proposals were performed in the 2016A term. In addition, we were able to give beamtimes to 3 reserved proposals.

1．研究成果概要（つづき） Outline of experimental results (continued).

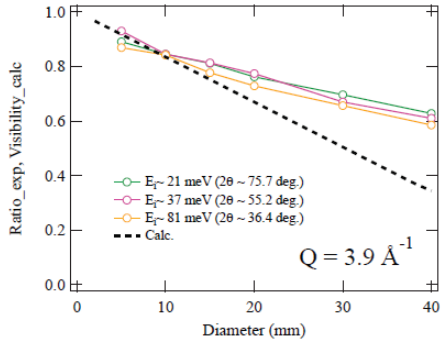


Fig. 1. The ratio of a Bragg peak intensity with to that without the ORC as a function of the diameter of the sample. Solid line is the calculated result based on Copley's model. (Cited from Ref. 2.)

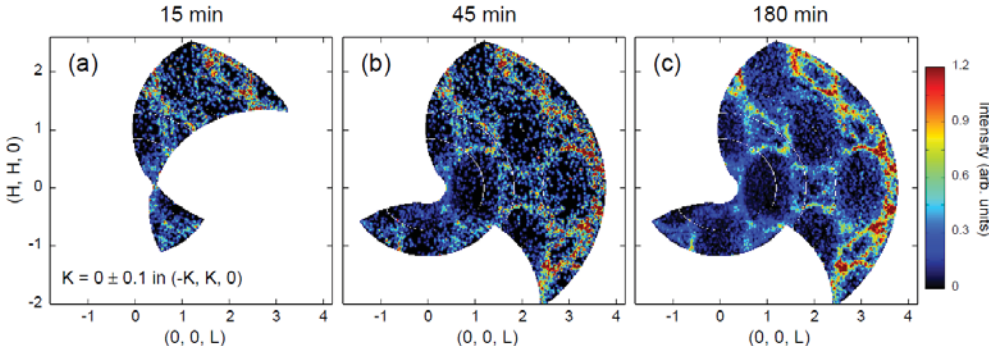
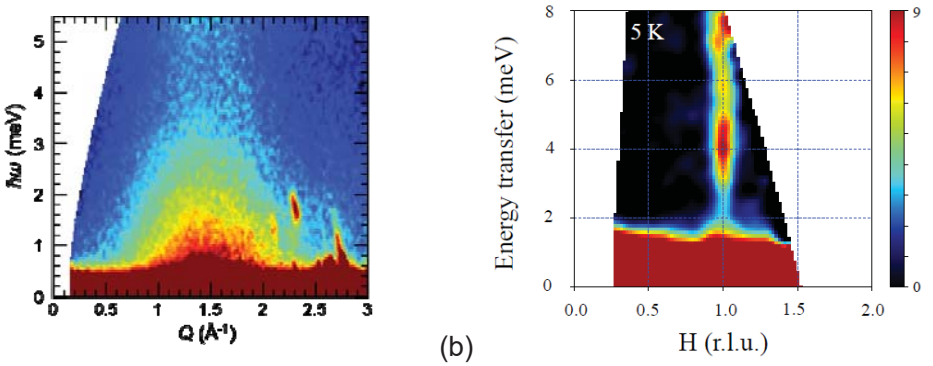


Fig. 2. Phonon spectra of a single crystalline copper obtained by continuously rotating the crystal. (a), (b), and (c) show the constant *E* slices at *E* =13±1 meV, 15, 45, and 180 min after the start of the measurement, respectively. (Cited from Ref. 3.)



(a) (b)

Fig. 3. (a) Excitation spectrum of $Li_2Cr_3SbO_8$ at 40 K as functions of *Q* and *E*. (b) Excitation spectrum of $Ba_{0.75}K_{0.25}Fe_2As_2$ at 5 K as functions of (*H*, 0) and *E*.

References

[1] J. R. D. Copley and J. C. Cook, Nucl. Instrum. Methods Phys. Res., Sect. A **345**, 313 (1994).

[2] M. Nakamura *et al.*, submitted to Physica B.

[3] R. Kajimoto *et al.*, J. Phys.: Conf. Ser., to be published.

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