MLF Experimental Report

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課題番号 Project No. 2010A0005	装置責任者 Name of responsible person 梶本亮一
実験課題名 Title of experiment Magnetic fluctuations in Sr2RuO4	装置名 Name of Instrument/（BL No.） BL-01
実験責任者名 Name of principal investigator Seunghun Lee	実施日 Date of Experiment 2010/12/01-2010/12/03
所属 Affiliation University of Virginia	

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.

Ruthenate (Sr_2RuO_4)

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.

Five single crystals of Sr_2RuO_4 with a total mass of 29.15 g were prepared by a floating-zone method. They were coaligned for our neutron scattering measurements performed at 4SEASONS. The crystals were mounted in a way that the crystallographic c-axis was along the incident neutron beam, which allows one to probe the scattering in the (HK0) plane for this quasi-two-dimensional system. The crystals were put into an aluminum sample can that was then attached to a closed-cycle displex refrigerator, and the measurements were done at 5 and 300 K. We selected a setup that collected the following set of incident energies: E_i=12.6, 21.6, 45.5, and 151.2 meV.

To study the $\hbar\omega$ dependence of the ICmagnetic fluctuations at 5K, we obtained constant-$\hbar\omega$ cuts at several different energy transfers as a function of H or K. Figure 1 shows the results. Figures 1(a) and 1(b) showthe low-energy IC peaks. Figures 1(c)–1(h) show the IC peaks at high energies where phonons are weak and the magnetic scattering can be extracted from the data. Our data clearly show that IC magnetic fluctuations in Sr2RuO4 survive all the way up to ~80 meV. The magnetic scattering intensity is related to the imaginary part of the dynamic susceptibility, $\chi''(\mathbf{Q},\hbar\omega)$, using the fluctuation dissipation theorem,

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

$S(\mathbf{Q},\hbar\omega) = |F(Q)|2\ \chi''(\mathbf{Q}\hbar\omega) / (1-\exp(-\hbar\omega/k_B T))$. (1)

For a quantitative analysis, we fit the data to the general form of the phenomenological response function used to describe a Fermi liquid system:

$\chi''(\mathbf{Q},\hbar\omega) = \Sigma\chi_\delta(\kappa_0)4\ (\hbar\omega/\hbar\omega_{SF})/[\{(\kappa_0)^2+ (\mathbf{Q} - \mathbf{Q}_c)^2\}^2 + (\hbar\omega/\hbar\omega_{SF})^2(\kappa_0)^4]$, (2)

where χ_δ, κ_0, $\hbar\omega_{SF}$, and **Q**c are parameters for the peak intensity, the sharpness of the peak, the characteristic energy of the spin fluctuations, and the IC peak position, respectively, which are all independent of $\hbar\omega$. We fitted the H and K dependences at each $\hbar\omega$ position simultaneously to Eqs. (1) and (2) with a linear background. **Q**c was obtained as **Q**c = **(**0.301(3),0.303(4)**)** from fitting the 3meV data [Figs. 1(a) and 1(b)] and was fixed for all other energies. As shown by the solid lines in Fig. 1, Eq. (2) describes our data well over the entire energy range. The optimum parameters obtained from the best fit are χ_δ = 10.6(3), κ_0 = 0.053(2) r.l.u. [=0.086(4) °A−1], and $\hbar\omega_{SF}$ = 5.0(2) meV. The fact that $\hbar\omega_{SF}/k_B$ =58(3) K is close to T_{FL} may indicate that the two-dimensional IC spin fluctuations may be responsible for the Fermi liquid behavior.

Our inelastic neutron scattering measurements on Sr_2RuO_4 over a very wide range of the **Q**−$\hbar\omega$ phase space revealed the three components of the magnetic fluctuations: the strong IC spin fluctuations at 5 K centered at **Q**c = **(**0.301(3),0.303(4)**)** that extend up to at least 80 meV with a characteristic energy of $\hbar\omega_{SF}$ = 5.0(2) meV

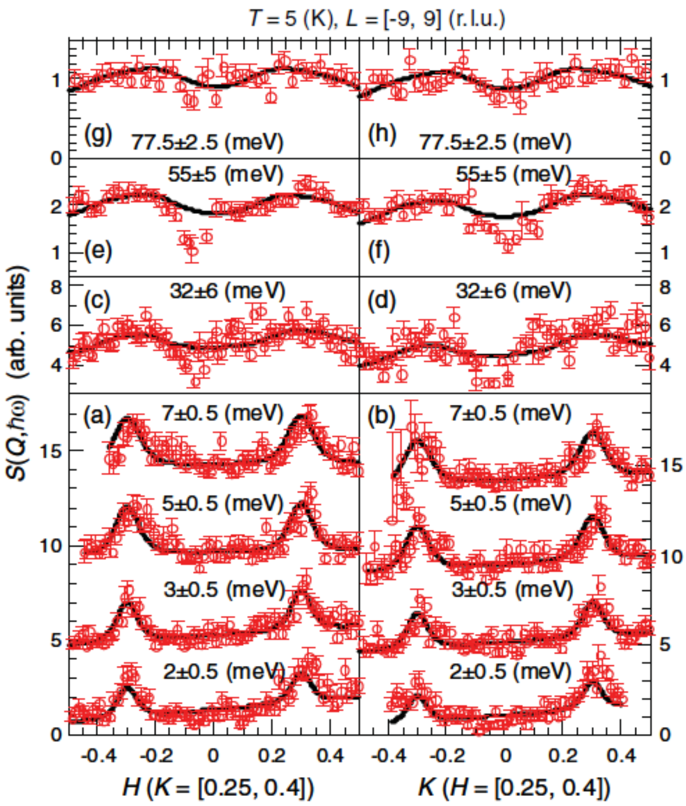

Fig. 1. H and K dependences of the neutron scattering intensity in the normal state at (a), (b) $\hbar\omega$ = 2, 3, 5, and 7; (c), (d) 32; (e), (f) 55; and (g), (h) 77.5 meV. H and K were integrated from 0.25 to 0.4, respectively, and L was integrated from −9 to 9. The incident neutron energies are (a), (b) E_i = 12.6, (c), (d) 101.6, and (e) –(h) 151.2 meV. Fitting results using Eqs. (1) and (2) with a linear background at each $\hbar\omega$ are also described by solid lines.