Magnetic excitations near the pressure-induced quantum critical point in the spin gap system $KCuCl_3$

N. Kurita[A], H. Tanaka[A], H. Kikuchi[B], S. Asai[B], T. Masuda[B]

[A]*School of Science, Tokyo Institute of Technology,* [B]*ISSP-NSL, Univ. of Tokyo*

A gapped S=1/2 spin dimer magnet $KCuCl_3$ undergoes a pressure-induced quantum phase transition (QPT) to the antiferromagnetically ordered phase [1,2]. In the vicinity of a pressure-induced quantum critical point (QCP), the magnetic moment shrinks by significant quantum fluctuations. Thus, it is expected to observe intriguing quantum phenomena at around pressure-induced QCP such as a Higgs mode which is a collective mode of amplitude oscillations of order parameters [3]. In fact, the Higgs mode was confirmed experimentally in an isostructural system $TlCuCl_3$ via inelastic neutron scattering (INS) measurements [4,5]. This can be explained by reconstruction of the triply degenerate singlet-to-triplet excitation into one Higgs mode and two NG modes at the pressure-induced QCP [3].

Previous studies on $KCuCl_3$ showed that the spin gap of 2.67 meV closes at the critical pressure of $P_c \sim 0.8$ GPa [1]. Although softening of the excitation mode was unambiguously confirmed at pressures below P_c [2], very little was known about excitation spectra at $P \sim P_c$. At higher pressures above P_c, Bragg reflections indicative of magnetic ordering were observed at Q = (0, 0, 1) where the lowest excitation occurs [2]. Thus, it is of interest to unveil dispersion relations in $KCuCl_3$ at around P_c via INS experiments.

In this study, we measured magnetic excitations of $KCuCl_3$ using the triple-axis spectrometer HER (C1-1) installed at JRR-3 in JAEA, Tokai. The INS measurement was performed with E_f = 3.6 meV at 0.7 K under hydrostatic pressure at 0.8 GPa ($\sim P_c$). A $KCuCl_3$ single crystal was set in the Teflon cell, which was installed in the piston cylinder pressure apparatus. Deuterated glycerin was used as a pressure medium. The constant-$\boldsymbol{Q}$ energy scan profiles were collected in the a^*–c^* plane.

Figure 1 shows the obtained constant-Q scan for (h, 0, 1) in $KCuCl_3$ at 0.8 GPa ($\sim P_c$). One can find continuum-like excitation ranging from 0.5 to 1.5 meV for h = 0 probably because the system locates near pressure-induced QCP. It was systematically suppressed by increasing h and, instead, a broad excitation emerged at 1.5 meV for h = 0.05. For h = 0.1, neither peak nor continuum was observed in the experimental range. This might indicate the fractionalized excitation, though complete set of scans is required for this pressure.

[1] A. Oosawa *et al.*, Phys. Rev. B. **66**, 104405 (2002).
[2] K. Goto *et al.*, J. Phys. Soc. Jpn. **75**, 064703 (2006); **76**, 053704 (2007).
[3] M. Matsumoto *et al.*, J. Phys. Soc. Jpn. **76**, 073709 (2007).
[4] C. Rüegg *et al.*, Phys. Rev. Lett. **100**, 205701 (2008).
[5] P. Merchant et al., Nat. Phys. (2014)]

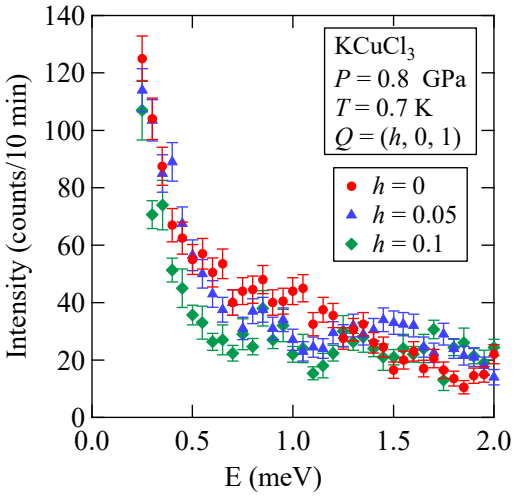

Fig. 1 Constant-Q scan profiles for (h, 0, 1) in $KCuCl_3$ measured at 0.7 K and 0.8 GPa.