Uniaxial-stress-control of domain growth kinetics in isosceles-triangular lattice Ising magnet CoNb2O6

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The isosceles triangular lattice (ITL) Ising antiferromagnet is characterized by the ratio of exchange interactions defined as $\gamma = J_1$ (along the base direction) $/J_2$ (along the equilateral direction), and its magnetic property dramatically changes, depending on whether γ is larger than 1.0 or not. As one of the model materials, we have studied an Ising magnet $CoNb_2O_6$, where the quasi-1D ferromagnetic zigzag chains along the c axis form a frustrated antiferromagnetic ITL with $\gamma \simeq 1.33$ in the a-b plane. If the exchange ratio γ can be controlled in $CoNb_2O_6$ via anisotropic deformation of ITL by uniaxial pressure, variety of interesting magnetic features intrinsic to γ would be observed.

Actually along this context, we succeeded in crossing the Wannier point ($\gamma = 1$) and providing access to the region of $\gamma < 1$ by applying uniaxial pressure p up to 1.1GPa along the c axis, where entirely different $H_{\|c}$-T magnetic phase diagram with ground-state AF-I magnetic ordering appears, as is in the experimental reports of No.1802 and No.1841. Note that in those experiments we used a good single crystal of $CoNb_2O_6$ prepared by the floating zone(FZ) technique, instead of the sample prepared by flux method, which is accompanied by extrinsic magnetic ordering due to crystal imperfection.

As a continuation of the proposal, we performed the neutron-diffraction measurements at the two-axis diffractometer E4 installed at the Berlin Neutron Scattering Center in the Helmholtz Centre Berlin for Materials and Energy, using transverse- as well as longitudinal- uniaxial pressure device so that we can provide access to the ($HK0$) scattering zone under applied vertical magnetic field to the c axis.

As is in the experimental reports of No. 1683, the uniaxial pressure dependence of the ratio γ along both the a- and b-axes were already measured but using the flux-sample with crystal imperfection. Therefore, in present experiment, changing the original plan of " uniaxial-stress control of magnetic domain-growth kinetics characteristic to ITL ", we re-measured these up to 0.6 GPa using FZ-sample. Results shown in Fig.1 are qualitatively agree with these of flux-sample, but are quantitatively different, which are crucial to estimate the uniaxial pressure dependence of coupling constants J_1 and J_2 in combination with magnetic phase transition fields obtained by dc- and ac-susceptibility.

As shown in Fig.2(a1-a3), we also investigated temperature variation in the magnetic correlations at $\gamma \sim 1.3$ ($p_{\|c}$ = 0 MPa), $\gamma \sim 1.$ ($p_{\|c}$ = 0.8 GPa) and $\gamma \sim 0.9$ ($p_{\|c}$ = 1.1 GPa) in detail. Because of unavoidable inhomogeneity of uniaxial pressure, at $p_{\|c} \sim 0.8$ GPa ($\gamma \sim 1$), AF-I and AF-II magnetic LRO coexist so that unfortunately we were not able to investigate magnetic correlations specific to Wannier point ($\gamma = 1$) at the lowest temperature. As shown in Fig.2(b), however, the temperature dependence of propagation wavenumber q of sinusoidally-amplitude- modulated incommensurate (IC) state at specific γ is qualitatively consistent with Stephenson 's exact calculation for 2D isosceles triangular lattice Ising antiferromagnet.

In contrast to that both AF-I and AF-II magnetic orderings coexist at $p_{\|c} \sim 0.8$ GPa ($\gamma \sim 1$) as is seen in Fig.3(a), almost flat diffraction profile can be seen at $p_{\|b} \sim$ 0.6GPa ($\gamma \sim 1$) as shown in Fig.3(b), suggesting good " spot " to investigate field-induced magnetic states specific to Wannier point ($\gamma = 1$) . Further beam experiments are desired.

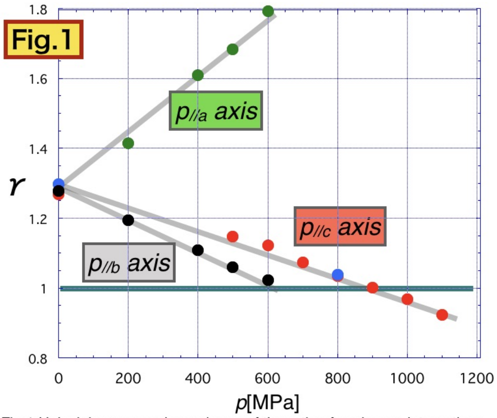

Fig.1 Uniaxial-pressure dependence of the ratio of exchange interactions γ along the a-, b- and c- axes.

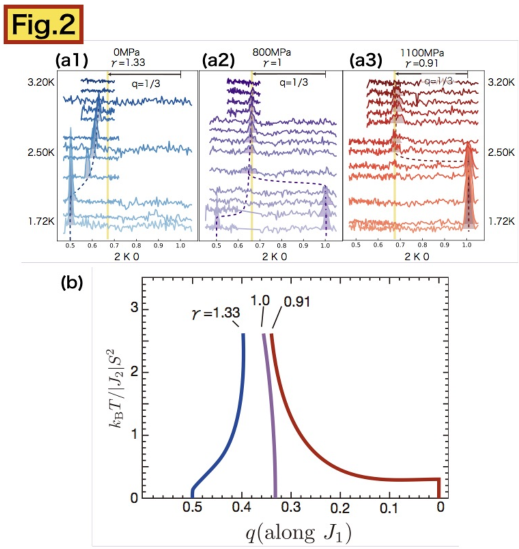

Fig.2 Temperature dependence of (2 k 0) scan profiles in zero magnetic field at (a1) γ~1.33 ($p_{//c}$=0GPa), (a2) γ~1.0 ($p_{//c}$=0.8GPa) and (a3) γ~0.9 ($p_{//c}$= 1.1GPa), respectively. (b) Temperature variation of propagation wavenumber q of short range magnetic correlation at specific γ, which is obtained from Stephenson's exact calculation for 2D isosceles triangular lattice Ising antiferromagnet.

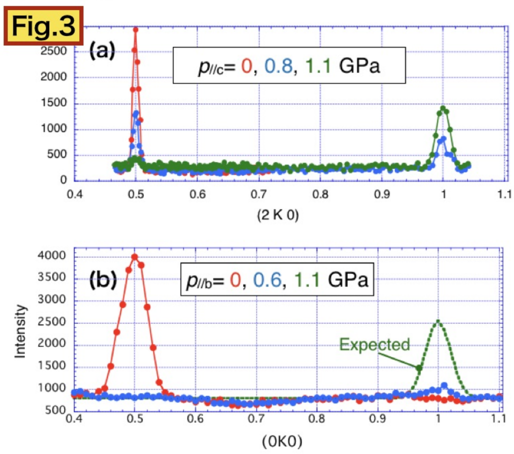

Fig.3 (a) (2 k 0) scan profiles in zero magnetic field at T=1.7K and $p_{//c}$= 0, 0.8 and 1.1GP , (b) (0 k 0) scan profiles in zero magnetic field at T=1.7K and $p_{//b}$= 0, 0.6 and 1.1 GP.

Fig. 1.