Uniaxial pressure effect on magnetic ordering in a frustrated isosceles triangular lattice Ising antiferromagnet CoNb2O6

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The isosceles triangular lattice 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 isosceles-triangular lattice (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 have succeed in controlling the exchange ratio γ from 1.33 to 1.13 by applying uniaxial pressure p up to 400 MPa along the b axis (J_1 direction), as in the previous experimental reports 21 (N0 1683).

In present experiment, to cross the Wannier point ($\gamma = 1$) and access the region of $\gamma < 1$ by further applying uniaxial pressure p up to 1GPa along the c axis, 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. Note that we applied uniaxial pressure along the c axis instead of the b axis, because it turned out in preliminary experiments up to 400 MPa that uniaxial pressure along the c axis have the same effect as one along the b axis.

As shown in the fig.1(a), the exchange ratio γ, which are obtained from the propagation wave number q of sinusoidally-amplitude-modulated incommensurate (IC) state at the phase transition temperature T_1 (from IC to paramagnetic state), shows monotonic decreasing with increasing the applied pressure and crosses 1.0 (Wannier point) at around $p \simeq 700$ MPa. Correspondingly, it can be clearly seen that as the magnetic ground state AF-II magnetic ordering with q=1/ 2 is switched to AF-I magnetic ordering with q=0 at this critical pressure, as shown in fig.1(b). The AF-I magnetic ordering appearing in the region of $\gamma < 1$ is exactly one suggested by Stephenson's exact calculation for 2D ITL. We cursorily investigated $H_{//c} - T$ magnetic phase diagram at p=1 GPa, which should be entirely different from the well-studied phase diagram with AF-II magnetic ordering as a ground state at p=0 Pa. To investigate entire 1 GPa-magnetic phase diagram having newly appearing magnetic state with 1/5 magnetic propagation wave number, further beam-experiment is indispensable.

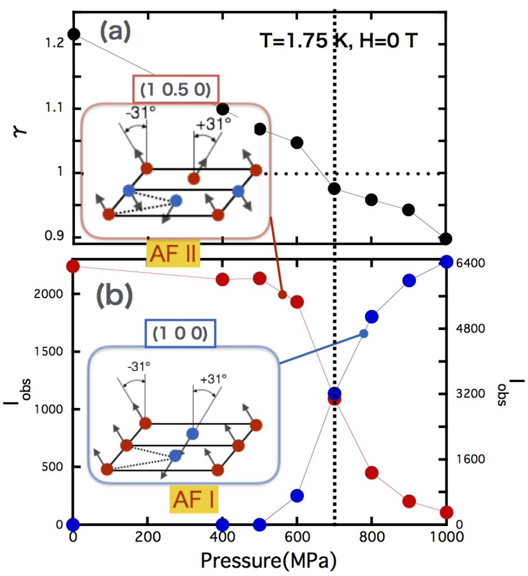

Fig. 1. Uniaxial-pressure p dependence of (a) the exchange ratio γ and (b) integrated intensities of (1 0.5 0) and (1 0 0) magnetic reflections.