Supplementary Materials for "Magnetic field effects on the quantum spin liquid behaviors of $NaYbS_2$

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We present here:
1. Magnetization data of $NaYbS_2$ under magnetic fields.
2. Inelastic neutron scattering results of $NaYbS_2$.

MAGNETIZATION UNDER MAGNETIC FIELDS

The magnetic field-dependence of AC magnetic susceptibility was measured at 0.09 K and the derivative dM/dH presented a series of phase transitions at 3.6 T, 6.3 T, 12.2 T and 16.2 T, respectively. Moreover, the isothermal magnetization was measured from 0.5 K to 1.5 K for $NaYbS_2$ up to 7 T, Fig.1(b), and was sensitive to the magnetic phase transition induced by the magnetic field. Although any transition could not be observed at 1.5 K, the derivation of isothermal magnetization clearly displayed one transition at the around 3.9 T below 1.0 K. As the temperature decreased, the transition field dropped to 3.5 K and the moment increased to S = 0.15 which is close to 1/3 of theoretical $S(Yb^{3+})$ = 1/2 in $NaYbS_2$.

INELASTIC NEUTRON SCATTERING

The INS spectra were obtained with E_i =4.83 Å from 1.5 to 30 K, Fig. 2, and there is no sign for LRO or structural distortion down to 0.05 K. The magnetic dynamic signal begins to appear around T = 20 K, and the magnetic spectra becomes more clear as the temperature decreased. Although the INS spectra did not change below T = 1.5 K and the spin-wave is not well formed even at 0.05 K.

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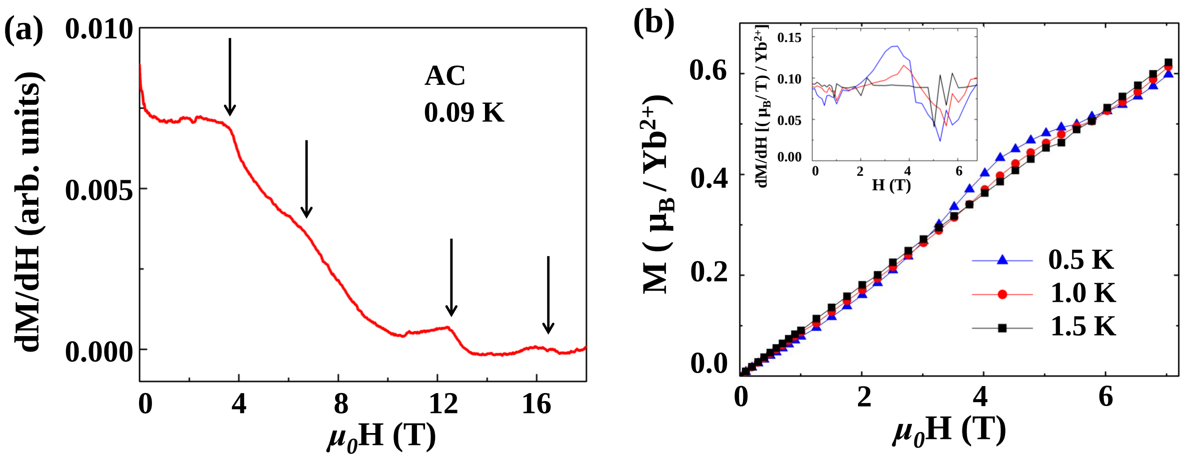

FIG. 1. **The magnetization with H//ab-plane of $NaYbS_2$.** (a)The derivative AC magnetic susceptibility dM/dH versus magnetic field (H) at 0.09 K. The anomaly fields (black arrows) are 3.6 T, 6.3 T, 12.2 T and 16.2 T, respectively. (b) Isothermal magnetization up to 7 T at 0.5 K, 1.0 K, and 1.5 K at H||ab. Inset: Derivation of isothermal magnetization from 0 T to 7 T.

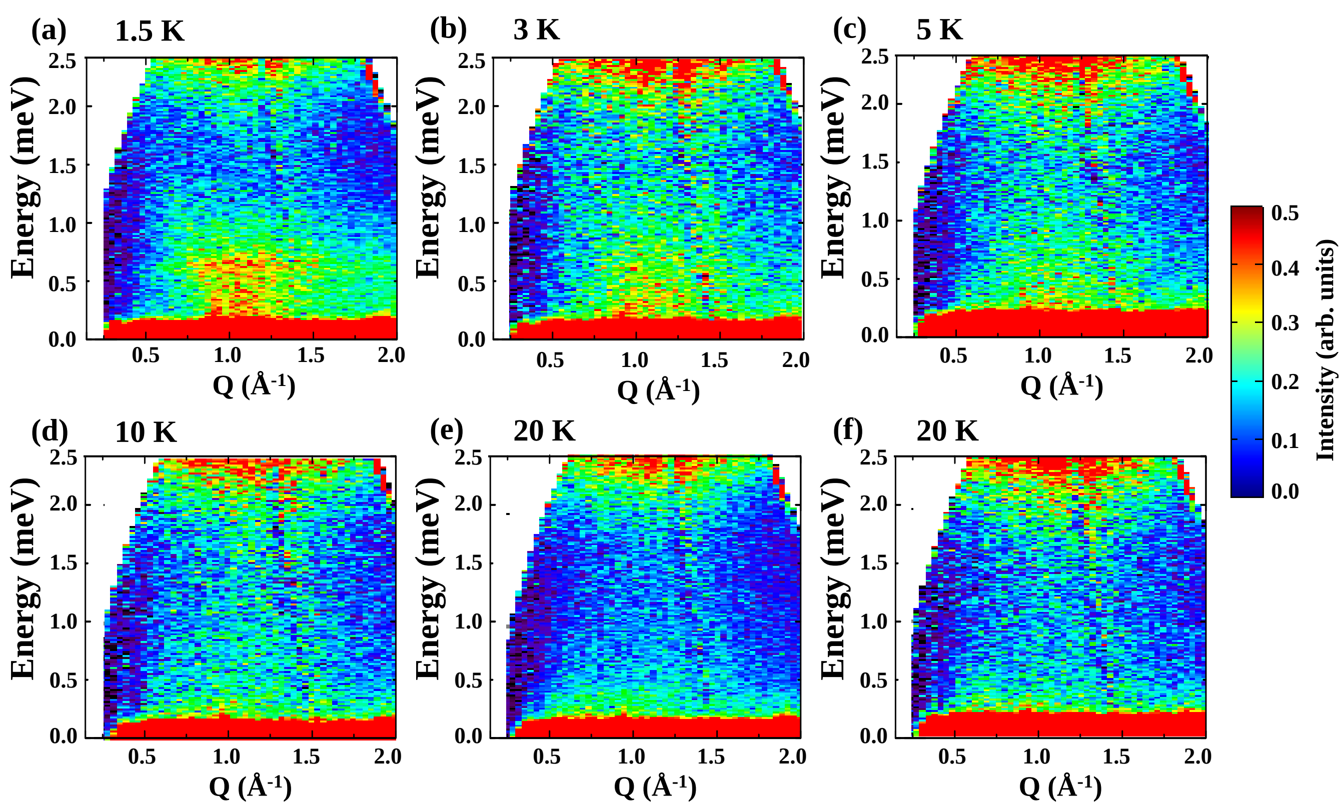

FIG. 2. The temperature dependence of INS spectra for $NaYbS_2$.

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