Magnetocaloric-effect study on a Pd(dmit)$_2$-based spin-liquid material

Takayuki Isono$^1$, Shiori Sugiura$^2$ Taichi Terashima$^2$, Shinya Uji$^2$, and Reizo Kato$^1$

$^1$RIKEN
$^2$National Institute for Materials Science (NIMS)
Email: takayuki.isono@riken.jp

A quantum spin liquid (QSL) is an exotic new state of matter in condensed-matter systems, where the strongly interacting electron spins continue to fluctuate without any magnetic long-range ordering even at zero temperature [1]. The most remarkable feature of the QSL is the presence of anomalous magnetic excitations carrying spin-$1/2$ quantum number, called spinons. The nature of low-energy excitations was experimentally studied in several candidate materials for the QSL. In case of an organic spin-$1/2$ triangular-lattice insulator, EtMe$_3$Sb[Pd(dmit)$_2$]$_2$, metallic-like thermodynamic and heat-transport properties were reported by the specific-heat [2], thermal-conductivity [3], and magnetic-torque studies [4]. On the other hand, the nuclear-magnetic-resonance (NMR) study suggested the presence of some instability in the QSL state [5].

In the present study, we have measured the magnetocaloric effect (MCE) on EtMe$_3$Sb[Pd(dmit)$_2$]$_2$, in order to simultaneously investigate the thermal relaxation from electron spins to lattices, and the magnetic-entropy change in the QSL state. Figure 1 shows the temperature variation in the thermal relaxation time between the electron spins and lattices, $\tau$, at $\mu_0H = 5$ T. Below $T \sim 1$ K, $\tau$ rapidly increases by more than two orders of magnitude, showing that the electron spin-lattice coupling is significantly reduced. Moreover, at very low temperatures, $\tau$ shows the power-law behavior with the exponent about -2, which approximately agrees with the power law of the nuclear relaxation rate $T_1$ [5]. Here, considering that $T_1$ probes the electron spin excitations through hyperfine coupling, the agreement between $T_1$ and $\tau$ implies that long $\tau$ observed here comes from a change in the spin-excitation spectrum. On the other hand, we observe no prominent change in the magnetic entropy near $T \sim 1$ K; the $\tau$ increase could not be a phase transition such as a field-induced magnetic order and a paring transition, but be a crossover phenomenon in the QSL state.

![Figure 1. Temperature variation in the thermal relaxation time of MCE at $\mu_0H = 5$ T in EtMe$_3$Sb[Pd(dmit)$_2$]$_2$.](image)

References