High Field ESR Measurements of $S = 1/2$ Quasi One-Dimensional Antiferromagnet Cu$_3$Mo$_2$O$_9$

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Abstract $S = 1/2$ one-dimensional chain and dimer system Cu$_3$Mo$_2$O$_9$, in which the super-exchange network forms one-dimensional corner-sharing tetrahedron of Cu$^{2+}$ ion, has been investigated by high field ESR measurements using the powder sample and the pulsed magnetic field up to 40 T at 2.0 K. The high field ESR measurements with wide frequency range suggest the existence of the magnetic phase transition at 8 T. Three ESR modes appear above 18 T, which corresponds to the magnetization jump. The ground state of Cu$_3$Mo$_2$O$_9$ will be discuss.

Keywords ESR · Quasi one-dimensional · Antiferromagnet · High field
Since Haldane conjecture, quantum spin systems have attracted much attention due to their rich variety of magnetic properties. Especially, the field-induced quantum phenomena in quantum spin systems, such as a field-induced magnetic ordering and plateaus in the magnetization curve, have drawn much interests to quantum spin systems [1–8], and many unsolved problems still remain in their high field phases. In this work, we deal with Cu$_3$Mo$_2$O$_9$, which is a hybridized system of $S = 1/2$ one dimensional chain and dimer. The space group of Cu$_3$Mo$_2$O$_9$ is orthorhombic $Pnma$ and the lattice parameters are $a = 7.6793$ Å, $b = 6.8728$ Å, and $c = 14.6222$ Å [9]. Polyhedral representation of Cu$_3$Mo$_2$O$_9$ is shown in Fig. 1(a). There are three different Cu ion sites. Cu1 site, which is located at the center of CuO$_6$ octahedra, forms one dimensional chain along $b$-axis. Cu2 and Cu3 sites, which are located at offset center of CuO$_5$ pyramid shown in Fig. 1(b), form a pair Cu ion of tetrahedron [10]. The super-exchange network of Cu$_3$Mo$_2$O$_9$ consists of corner-sharing tetrahedron chain of Cu$^{2+}$ ions along the $b$-axis as shown in Fig. 1(c). From the crystallographic consideration, the super-exchange interactions of Cu1-Cu1 and Cu2-Cu3 are expected to be stronger than those of Cu1-Cu2 and Cu1-Cu3 [11]. The magnetic susceptibility shows a broad peak due to the low dimensionality at around 20 K and the anomaly at 7.9 K, which corresponds to a peak of the specific heat due to the antiferromagnetic ordering [10, 11]. Hamasaki proposed the $S = 1/2$ one-dimensional chain and $S = 1/2$ dimer model from fittings of the magnetic susceptibility and the specific heat results [11]. The sudden increases of magnetization due to the order of weak ferromagnetic moments were observed in the magnetization curves for $B//a$ and $B//c$. Moreover, the magnetization curve for $B//a$ and $B//c$ shows a magnetization jump at around 18 T. On the other hand, no major jump appears for $B//b$. The high field ESR measurements of Cu$_3$Mo$_2$O$_9$ powder have been performed to investigate the magnetism of the high field phase from the microscopic view point.

Fig. 1 The crystal structure of Cu$_3$Mo$_2$O$_9$. (a) Polyhedral representation along the $c$-axis. (b) Polyhedral representation in the $b$ plane. (c) The super-exchange path between Cu ions along the $c$-axis