Investigation of hydrogen dynamics in hydroxyl salts Co$_2$(OD)$_3$Cl

X.L. Xu,*† X.G. Zheng,*† H.J. Guo,*‡ and I. Watanabe*‡

Hydroxyl salts of the type $M_2$(OH)$_3$X (X = Cl, Br, or I) have been known for a long time. These compounds containing magnetic ions are magnetic materials. However, only in recent years their magnetic properties have been clarified as a result of our research 1,2) and they are known as “frustrated magnets”. Our latest finding is universal strong magnetic--dielectric--lattice coupling in all such compounds. Measurements of dielectric constants and lattice parameters revealed simultaneous changes at the respective $T_N$ for all hydroxyl salts, which indicate strong magnetic--dielectric--lattice coupling. Moreover, we found that for Co$_2$(OH)$_3$Cl and Co$_2$(OH)$_3$Br, which have the highest crystal symmetry in the hydroxyl salt series shown in Fig. 1, the corresponding deuterated compounds Co$_2$(OD)$_3$Cl [Br] clearly exhibited a ferroelectric response at exceptionally high temperatures. Sharp peaks were observed at 229 K in both dielectric constants measured at 100 kHz for Co$_2$(OD)$_3$Cl. Similar behaviors were observed in Co$_2$(OD)$_3$Br ($T_N = 224$ K at 100 kHz).

The dynamic Kubo-Toyabe function represents the contribution from the nuclear dipolar field of D atoms, and the exponential one accounts for magnetic relaxation.

Fig. 2. Muon-spin-relaxation spectra indicating a change in the dynamics of D atoms in Co$_2$(OD)$_3$Cl.

Fig. 3. The analyzed fluctuation rate of the nuclear dipolar field of the D atoms in Co$_2$(OD)$_3$Cl.

The analyzed fluctuation rate of the nuclear dipolar field of the D atoms in Co$_2$(OD)$_3$Cl shows an abrupt change around the ferroelectric transition temperature $T_N = 230$ K (Fig. 3), suggesting that the hydrogen (D) dynamics plays a critical role in the ferroelectric response of Co$_2$(OD)$_3$Cl.

References

*† Department of Physics, Saga University
*‡ RIKEN Nishina Center