


実験報告書様式(一般利用課題・成果公開利用)

(※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。)

 <b>MLF Experimental Report</b>	提出日 Date of Report
課題番号 Project No. 2016B0176 実験課題名 Title of experiment HYDROGEN DYNAMICS IN KAGOME HYDROXYL SALTS MGCO <sub>3</sub> (OD) <sub>4</sub> CL <sub>2</sub> AND MGCO <sub>3</sub> (OD) <sub>4</sub> CL <sub>2</sub> 実験責任者名 Name of principal investigator Xu-Guang Zheng 所属 Affiliation Saga University	装置責任者 Name of responsible person Y. Miyake 装置名 Name of Instrument/(BL No.) D1 実施日 Date of Experiment 2017. 2.4-2.6

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。(適宜、図表添付のこと)  
 Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.
<p>CO<sub>2</sub>(OD)<sub>3</sub>CL AND CO<sub>2</sub>(OD)<sub>3</sub>BR in powder</p>

2. 実験方法及び結果 (実験がうまくいかなかった場合、その理由を記述してください。)
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.
<p>Similar compounds but with slightly different chemical formula were used for this experiment, to accomplish previous experiment 2015A0201, which had been insufficient.</p> <p>Polycrystalline Co<sub>2</sub>(OD)<sub>3</sub>Cl and Co<sub>2</sub>(OH)<sub>3</sub>Cl, as synthesized from hydrothermal reaction of NaOD/NaOH and CoCl<sub>2</sub>, was used for the <math>\mu</math>SR experiments. The powder samples of Co<sub>2</sub>(OD)<sub>3</sub>Cl and Co<sub>2</sub>(OH)<sub>3</sub>Cl, respectively, were pressed into a pellet 3 cm in diameter and 1 mm thick, and then tightly covered with a 25-<math>\mu</math>m thick high-purity silver foil and mounted to a silver sample-holder. A double-pulsed positive surface muon beam was used with the temperature controlled by a standard He-4 gas flow cryostat.</p>

## 2. 実験方法及び結果(つづき) Experimental method and results (continued)

Examples of  $\mu$ SR spectra at two typical temperatures for  $\text{Co}_2(\text{OD})_3\text{Cl}$  under zero-field (ZF) and longitudinal-field (LF), are given in Fig. 1. Although  $\text{Co}_2(\text{OD})_3\text{Cl}$  showed magnetic transition at  $T_C = 10.5$  K, the  $\mu$ SR experiments revealed the existence of magnetic couplings at much higher temperatures.

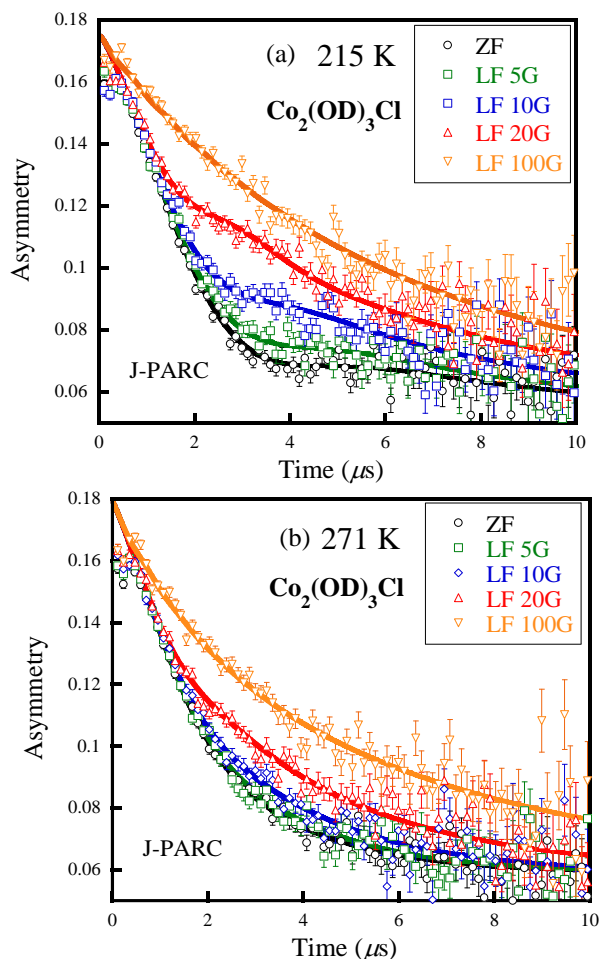


Fig. 1. An example of the  $\mu$ SR spectra under zero-field and longitudinal fields for  $\text{Co}_2(\text{OD})_3\text{Cl}$  at 215 K and 271 K, respectively, showing the change in the dynamics of nuclei. The solid lines are fitted lines according to Eq. (1).

The ZF- $\mu$ SR spectrum consists of Kubo-Toyabe relaxation or dynamic Kubo-Toyabe relaxation due to the nuclear field of D and Cl nuclei, and exponential relaxations due to the magnetic spins of  $\text{Co}^{2+}$ . For example, for  $\text{Co}_2(\text{OD})_3\text{Cl}$  at 215 K, the depolarization due to the nuclear fields was almost decoupled under a small longitudinal field of 100 G (Fig. 1a). Meanwhile, the dynamics of the nuclear field at 271 K are apparently different from those at 215 K (Fig. 1b). Therefore, by analyzing the ZF- $\mu$ SR and LF- $\mu$ SR spectra, the distribution of the nuclear fields and their evolution with temperature, i.e., the dynamics of the deuteriums on the lattice of  $\text{Co}_2(\text{OD})_3\text{Cl}$  at various temperatures, can be estimated.

In summary, the present study has revealed that the newly-identified ferroelectric response in the geometrically frustrated magnet  $\text{Co}_2(\text{OD})_3\text{Cl}$  occurs with a drastic change in the dynamics of the deuterium atoms.