Experimental report

13/02/2019

Proposal:	**5-31-2566**		**Council:**	4/2017

Title: Magnetic field dependence of the spin structure of $CdMn_7O_{12}$

Research area: Physics

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Samples: $CdMn_7O_{12}$

Instrument	Requested days	Allocated days	From	To
D20	3	2	22/06/2018	24/06/2018

Abstract:

$(AA)_4B_4O_{12}$ type perovskite $CdMn_7O_{12}$ has been synthesized by high pressure method. This compound shows two successive magnetic transitions at TN1 = 88 K and TN2 = 33 K, respectively, in zero external magnetic field condition. The transition at TN1 is very robust against the magnetic field while the TN2 transition is gradually suppressed. Additional magnetic transition also appears between TN1 and TN2 with magnetic field of 9 T. Moreover, dielectric constant shows no anomaly in zero external magnetic field, whereas a sharp increase at TN1 is observed when a field is larger than 3 T, suggesting a magnetic field induced ferroelectricity. However, the relationship between the magnetic structure and ferroelectricity is no clear due to the lack of information about the magnetic structure, which is partially due to the strong neutron aborption effect by the Cd atoms. In order to uncover the relationship between the magnetic transition and dielectric anomaly, we propose to perform powder neutron diffraction with a special method on $CdMn_7O_{12}$ as a function of magnetic fields using the D20 diffractometer.

Magnetic field dependence of the spin structure of $CdMn_7O_{12}$

$(AA'_3)B_4O_{12}$ type perovskites have been investigated intensively due to their diverse properties such as metal-insulator transition, non-collinear magnetic ordering and ferroelectricity. These compounds can be synthesized only under high pressure and high temperature conditions except for $CaMn_7O_{12}$ [1-4]. On the other hand, $CdMn_7O_{12}$ is much less studied compared to $CaMn_7O_{12}$ which is partially because of the requirement of high pressure during the crystal growth and maybe also because of the strong neutron absorption effect for the Cd atoms. $CdMn_7O_{12}$ shows a structural transition from cubic to hexagonal below T_s ~ 490 K, and a commensurate structural modulation below ~254 K. Specific heat and magnetic susceptibility measurements indicate two magnetic transitions below T_{N1} = 88 K and T_{N2} = 33 K in zero magnetic field [5]. The transition temperature T_{N2} is gradually suppressed by magnetic fields, while T_{N1} is very robust against the fields. Moreover, an additional phase transition below T_{N1} is observed in a magnetic field of 9 T. Temperature dependence of the dielectric constant at various magnetic fields shows no anomaly in zero external field, whereas a sharp increase appears for magnetic fields larger than 3 T.

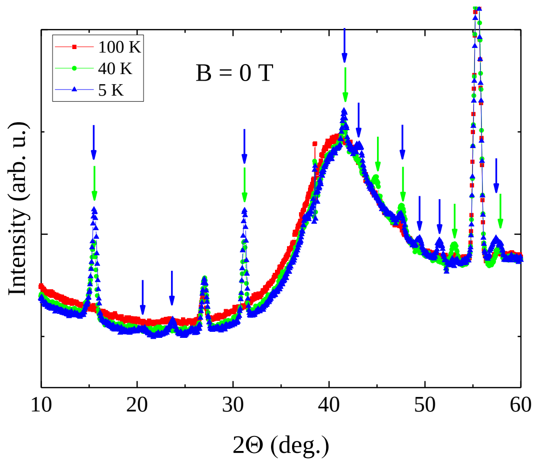

Fig. 1 Neutron diffraction patterns measured at characteristic temperatures in zero field. The arrows indicate the magnetic peak positions appear at low temperatures. The bump at 2Θ ~ 40° originate from the isopropanol used to fix the sample under magnetic field.

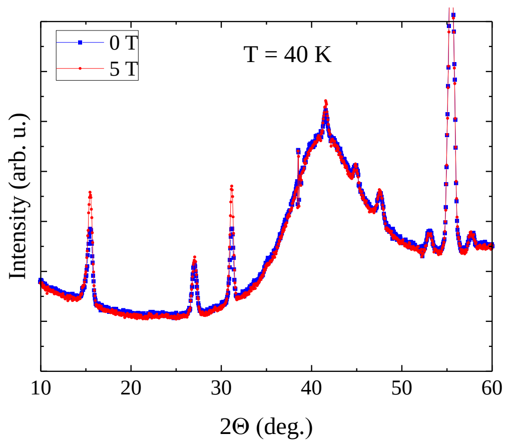

Fig. 2 Comparison of the neutron diffraction pattern measured at 40 K at 0 T and 5 T.

We have successfully solved the magnetic structure of $CdMn_7O_{12}$ between T_{N1} and T_{N2} in zero field condition [6]. We now extend our study to the magnetic structure in magnetic fields in order to understand the interplay of magnetic and dielectric properties under applied fields. The experiment has been performed on the D20 diffractometer equipped with vertical magnet and neutron wavelength of 2.41 Å. The sample was mixed with liquid isopropanol at room temperature and quenched to nitrogen temperature in order to fix the sample and avoid the movement of the sample with the application of magnetic fields.

Fig. 1 shows the neutron diffraction patterns measured at characteristic temperatures in zero magnetic field. The results are consistent with our previous measurement (except of the bump appearing at ~40°, which originates from the isopropanol).

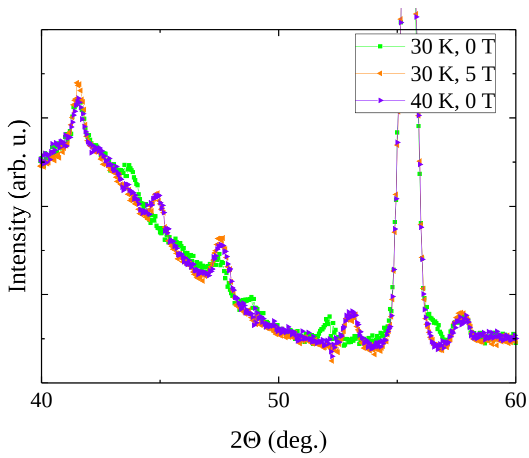

Fig. 3 Comparison of the neutron diffraction pattern measured at 30 K and 40 K with different magnetic fields.

Next, we investigated the influence of magnetic fields on the magnetic structure at different temperatures. Above T_{N2}, the magnetic fields enhance the magnetic peak intensities with no signature of peak shifting or peak splitting, as shown in Fig. 2. On the other hand, the magnetic field has a significant effect below T_{N2}. As shown in Fig. 3 for the neutron pattern measured at 30 K, certain magnetic peaks shift under the application of a magnetic field.

Interestingly, it is observed that the pattern measured at 30 K with 5 T overlaps with that measured at 40 K with 0 T, thus, the application of magnetic fields stabilizes the magnetic structure observed above T_{N2}.

References:

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