

and theoretical studies revealed that noncollinear spiral spin structures breaking the spatial inversion symmetry often make the system ferroelectric. A  $120^\circ$  structure which is the classical ground state in a Heisenberg triangular lattice antiferromagnet (TLA) also breaks the inversion symmetry, being another candidate for inducing ferroelectricity. To test this prediction, we investigated magnetic and dielectric properties of a typical TLA  $\text{CuCrO}_2$  showing the  $120^\circ$  structure with easy axis anisotropy [1]. Single crystals of  $\text{CuCrO}_2$  were successfully grown by a flux method. Temperature profile of the magnetic susceptibility shows an anomaly at  $T_N \approx 24.5\text{K}$ , due to the ordering into the  $120^\circ$  structure. Dielectric constant perpendicular to the  $c$  axis shows a sharp peak near  $T_N$ . In addition, spontaneous polarization perpendicular to the  $c$  axis emerges below  $T_N$ . The sign reversal of spontaneous polarization by applying electric field is also observed below  $T_N$ . These results ensure the emergence of ferroelectricity induced by  $120^\circ$  structure in  $\text{CuCrO}_2$ . Furthermore, the ferroelectric property is affected by an application of magnetic fields. In the presentation, we show detailed experimental results, and discuss the coupling between the magnetic and dielectric properties in the TLA  $\text{CuCrO}_2$ .

[1] H. Kadowaki, H. Kikuchi and Y. Ajiro, *J. Phys.: Condens. Matter* 2, 4485 (1990)

Keywords: strongly correlated systems, magnetoelectricity, magnetic frustration

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### Location of proton in proton conducting perovskite oxides $\text{Ba}_3\text{Ca}_{1.18}\text{Nb}_{1.82}\text{O}_{8.73}$ and $\text{BaZr}_{0.8}\text{Sc}_{0.2}\text{O}_{2.9}$

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Some oxides with perovskite structure have high proton conductivity of  $10^{-2}$  -  $10^{-3}$   $\text{Scm}^{-1}$ . However, the locations of proton, the proton conduction path, and the thermodynamic properties have not been clarified yet. In the present study, the location of proton and the lattice vibrations have been studied by neutron diffraction and heat capacity measurements. The samples of a proton conducting mixed perovskite oxide  $\text{Ba}_3\text{Ca}_{1.18}\text{Nb}_{1.82}\text{O}_{8.73}$  and a simple perovskite oxide  $\text{BaZr}_{0.8}\text{Sc}_{0.2}\text{O}_{2.9}$  were synthesized by a method of solid-state reaction. The neutron diffraction experiments were performed using HRPD at JAEA for the deuterated and dried samples. All the neutron diffraction peaks of the deuterated samples are shifted to lower angles comparing with the dried samples. This attributes to the expansion of the lattice due to the introduction of oxide and deuterium ions into the dry samples. The location of deuterium was analyzed by Rietveld method and maximum entropy method (MEM). The MEM shows that deuterium exists at 96j site in  $\text{Ba}_3\text{Ca}_{1.18}\text{Nb}_{1.82}\text{O}_{8.73}$ , which leans to the Ca/Nb mixed site, and 12h site in  $\text{Zr}_{0.8}\text{Sc}_{0.2}\text{O}_{2.9}$ , which is similar to that of the other simple perovskite-type proton conductors. The shift of OD groups slightly toward the opposite side of deuterium was observed in both compounds. The location of proton was discussed comparing with the results of *ab-initio* structure calculations. The results of heat capacity measurements are also discussed in terms of the change of the lattice vibrations due to the introduction of oxide and hydrogen ions.

Keywords: neutron diffraction, proton conductivity, *ab-initio* calculations

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### Solution SAXS and NMR on the domain orientation and binding of the components of human BCKD complex

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The mammalian mitochondrial branched-chain- $\alpha$ -ketoacid dehydrogenase (BCKD) complex, containing E1, E2, and E3 subunits, catalyzes the oxidative decarboxylation of branched-chain- $\alpha$ -ketoacids derived from leucine, isoleucine, and valine, hence, gives rise to branched-chain acyl-CoAs. The transacylase subunit (E2) of BCKD complex carries three independently folded domains linked together by flexible loops: the hbLBD (a.a. 1-84), hbSBD (a.a. 104-152), and C-terminal inner-core domain hbICD (aa.168-395). Both hbLBD and hbSBD domains play central roles in substrate channeling and substrate recognition, which functions relate closely to their structures and relative orientations in the BCKD complex. With solution NMR, we have extracted the individual structures of hbLBD and hbSBD domains, respectively. Whereas the tertiary structure of the full di-domain hbDD (aa. 1-168), consisting of hbLBD, hbSBD, and the linker region, in a linear-like arrangement, is resolved for the first time by solution small angle X-ray scattering (SAXS) with the rigid body refinement, based on the two structures of hbLBD and hbSBD individually determined by NMR. Furthermore, SAXS profiles measured for the E1 component before and after its binding to the hbDD, imply that hbLBD is less confined than hbSBD, in the binding. The result helps in differentiating the two interaction modes of hbDD-E1 and hbDD-E3 in the BCKD complex.

Keywords: SAXS, protein complex structure, NMR

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### Crystal and local structural studies of superionic conductor cubic CuI

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Crystalline superionic conductor of copper iodide (CuI) with cubic symmetry has been studied by time-of-flight (TOF) neutron powder diffraction in  $\gamma$ -phase (300 K) and  $\alpha$ -phase (773 K). Crystal structure of the both phases were examined by the Rietveld method combined with maximum entropy method (MEM) technique using single-atom and split-atom structural models with the F-43m ( $\gamma$ -phase) and Fm-3m ( $\alpha$ -phase) symmetry, respectively. Local structure analyses were also carried out by employing pair distribution function (PDF) and the reverse Monte Carlo (RMC) techniques to model the disorder of the mobile copper ions. The crystal structure analysis revealed