

## Materials Science and Technology Division

# “New multiferroic material Ba<sub>2</sub>CoGe<sub>2</sub>O<sub>7</sub>: Ferroelectricity induced by spin-dependent metal-ligand hybridization”

**Professor Nobuo Furukawa**  
Aoyama Gakuin University  
Sagamihara, Kanagawa, Japan

Friday, August 6, 2010  
11:00 a.m.  
HTML/4515, Room 265

### Abstract

We have investigated multiferroic properties in a quasi two-dimensional antiferromagnet Ba<sub>2</sub>CoGe<sub>2</sub>O<sub>7</sub>. Below T<sub>N</sub> = 6.7 K, the Co magnetic moments (S = 3/2) show a collinear antiferromagnetic structure [1]. Recently, the magnetic field induced ferroelectric polarization has been discovered [2,3], which cannot be explained by the exchange striction mechanism and spin current mechanism, which are well accepted as the origin of the spin-driven ferroelectricity in most multiferroics materials. Instead, we consider the spin-dependent hybridization mechanism as the origin of the polarization in this compound [3]. The mechanism, where the metal-ligand hybridization is modified by local spin configurations through spin-orbit coupling, has first been proposed to explain multiferroicity in delafossite compounds Cu(Fe,Al)O<sub>2</sub> [4]. Ba<sub>2</sub>CoGe<sub>2</sub>O<sub>7</sub>, Co ions are placed in tetrahedra of O ions. In this case, the spin dependent hybridization mechanism gives us

$$p_i^z \propto (S_i^x)^2 - (S_i^y)^2.$$

Using an S = 3/2 Heisenberg model on a square lattice with an easy-plane anisotropy, we clarify that the multiferroic behaviors of Ba<sub>2</sub>CoGe<sub>2</sub>O<sub>7</sub> can well be explained by the spin-dependent hybridization mechanism. Our results indicates that a classical spin picture can well explain the ferroelectric properties in high magnetic fields, but the effects of quantum fluctuation play an important role in a small magnetic field region. We also discuss electromagnon spectra in these compounds.

References:

- [1] A. Zheludev et al., Phys. Rev. B 68 024428 (2003).
- [2] H.T. Yi et al., Appl. Phys. Lett 92 212904 (2008).
- [3] H. Murakawa et al., arXiv:1005.4986.
- [4] T. Arima, J. Phys. Soc. Jpn. 76 073702 (2007).

Host: Satoshi Okamoto (576-1317, okapon@ornl.gov)