Spin/Orbital Order and Randomness Effect in Perovskite RVO$_3$

R. Fukuta[A], K. Henmi[A], S. Miyasaka[A], S. Tajima[A], D. Kawana[B], K. Ikeuchi[B], Y. Yamasaki[B], A. Nakao[B], H. Nakao[B], Y. Murakami[B], and K. Iwasa[C]
Dept. of Physics, Osaka University[A], CMRC/KEK[B], Tohoku University[C]

Perovskite RVO$_3$ (R : rare earth or Y) has orbital degrees of freedom between d_{yz} and d_{zx} orbitals in V^{3+} ions, and shows two types of spin and orbital ordering : G-type orbital ordering (G-OO) accompanied with C-type spin ordering (C-SO), and C-OO with G-SO. The transition temperature of each spin/orbital ordering show the systematic dependence on the R(rare earth)-site ionic radius [1]. The experimental results in the R-sites solid solution systems such as $Y_{1-x}La_xVO_3$, indicate the stabilization of C-OO with G-SO by increasing the randomness on the R-site [2].

We synthesized $Eu_{1-x}(La_{0.2542}Y_{0.7458})_xVO_3$ and measured magnetization and heat capacity in order to clarify the randomness effect in t_{2g} orbital ordering system. In $Eu_{1-x}(La_{0.2542}Y_{0.7458})_xVO_3$, the average ionic radius of $(La_{0.2542}Y_{0.7458})^{3+}$ is the same as that of Eu^{3+}. The randomness of this system increases with $(La_{0.2542}Y_{0.7458})$ content x. Spin/orbital phase diagram of $Eu_{1-x}(La_{0.2542}Y_{0.7458})_xVO_3$ is shown in Fig. 1. With increasing the randomness, transition temperatures to the G-OO (T_{OO1}) and C-SO with G-OO (T_{SO1}) decrease. In contrast, other new transition to the C-OO with G-SO, which was clarified as described below, appears above $x \sim 0.35$ and this transition temperature ($T_{SO2} = T_{OO2}$) increases. The decrease of T_{OO1} and T_{SO1} can be understood as suppression of long range spin/orbital ordering by the randomness, while the increase of $T_{SO2} = T_{OO2}$ can not by same manner.

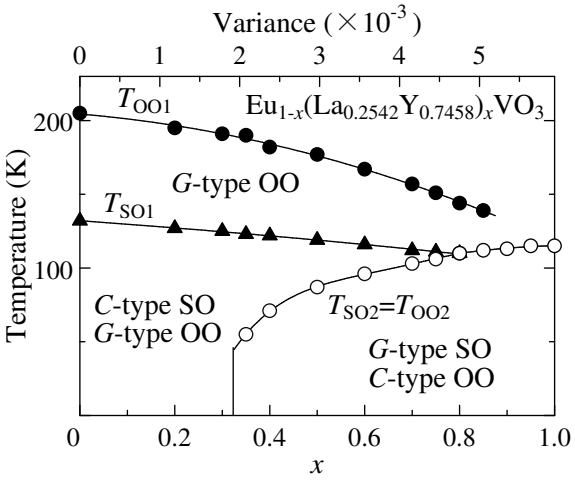

Fig. 1: Spin/orbital phase diagram of $Eu_{1-x}(La_{0.2542}Y_{0.7458})_xVO_3$

Additionally we measured the temperature dependence of lattice constants by using synchrotron powder X-ray diffraction at beam line 8A of the Photon Factory (PF), KEK. The change of lattice constants corresponding to orbital ordering was observed. To determine the spin/orbital ordering of $x = 1.0$ sample, we performed the resonant X-ray scattering measurements at beam line 4C of PF KEK and the neutron diffraction measurements at the triple-axis thermal neutron spectrometer TOPAN installed at JRR-3 research reactor in Japan Atomic Energy Agency. As a result, we have concluded that the low-temperature spin-orbital ordering above $x \sim 0.35$ is C-OO with G-SO.

Reference
[1] S. Miyasaka *et al.*, Phys. Rev. B, **68**, 100406(R) (2003).
[2] J. -Q. Yan *et al.*, Phys. Rev. Lett, **99**, 197201 (2007).