Ferromagnetism and unconventional impurity effects in Rh- and Ga-doped LaCoO$_3$ SHINICHIRO ASAI, RYUJI OKAZAKI, ICHIRO TERASAKI, Department of Physics, Nagoya University, YUKIO YASUI, Department of Physics, Meiji University — The perovskite oxide LaCoO$_3$ has been long investigated because of a dramatic change of its spin state for Co$^{3+}$ ions with temperature variation. The Co$^{3+}$ ions (3$d^6$) in LaCoO$_3$ takes the non-magnetic low-spin state of $t^6_{2g}$ at low temperature. The spin state of the Co$^{3+}$ ions in this system is sensitive to the chemical substitutions; we have found a weak ferromagnetism in a solid solution of LaCoO$_3$ and LaRhO$_3$ [S. Asai et al., JPSJ 80, 104705 (2011)]. Since the two oxides are non-magnetic at low temperature, our finding is an example of “order by disorder,” where a non-magnetic impurity makes a non-magnetic oxide ferromagnetic. We have further investigated the magnetization and x-ray diffraction of LaCo$_{0.8-y}$Rh$_{0.2}M_y$O$_3$ (M = Rh, Ga) [S. Asai et al., PRB 86, 014421 (2012)]. The magnetization decreases by the Ga$^{3+}$ substitution much more drastically than by the Rh$^{3+}$ substitution. It indicates that at least two kinds of Co$^{3+}$ ions exist in LaCo$_{0.8}$Rh$_{0.2}$O$_3$; one is nonmagnetic, and the other is magnetic. In this talk, we will also discuss the change of the lattice volume with the Rh$^{3+}$ and Ga$^{3+}$ substitution [S. Asai et al., JPSJ 82, 114606 (2013)].