Neutron diffraction and Mössbauer studies of $CoAl_xFe_{2-x}O_4$[a)]

Sam Jin Kim, Bo Ra Myoung, and Chul Sung Kim[b)]
Department of Physics, Kookmin University, Seoul 136-702, Korea

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Al substituted $CoAl_xFe_{2-x}O_4$ powders were fabricated using the sol-gel method, and their magnetic and structural properties were studied with thermal analysis, x-ray, neutron diffraction, Mössbauer spectroscopy, and magnetization measurements. The crystals of the samples $x=0.1$ and 0.2 were found to have a cubic spinel structure with lattice constants $a_0=8.3864$ and 8.3784 Å, at room temperature, respectively. Neutron diffraction patterns on $CoAl_{0.1}Fe_{1.9}O_4$ were obtained at various temperature ranges from 10 to 816 K. Neutron diffraction at 10 K revealed a cubic spinel structure of ferrimagnetic ordering, with the effective magnetic moments of $Fe^{3+}(A)(-4.18\,\mu_B)$, $Fe^{3+}(B)(4.81\mu_B)$, and $Co^{2+}(B)(2.98\mu_B)$, respectively. The temperature dependence of the magnetic hyperfine field in ^{57}Fe nuclei at the tetrahedral (A) and octahedral (B) sites was analyzed based on the Néel theory of magnetism. For the sample $CoAl_{0.1}Fe_{1.9}O_4$, the intersublattice A–B interaction and intrasublattice A–A superexchange interaction were antiferromagnetic with strengths of $J_{A-B}=-23.3k_B$ and $J_{A-A}=-18.0k_B$, respectively, while the intrasublattice B–B superexchange interaction was found to be ferromagnetic with a strength of $J_{B-B}=5.6k_B$. It is interpreted that the unusual reduction of magnetic moment in $Fe^{3+}(A)$ and a noticeable strength of the A–A interaction are closely related to the covalency effects. [DOI: 10.1063/1.1557955]