Mössbauer and neutron diffraction studies on Co-Al ferrite

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Al substituted CoAlₓFe₁₋ₓO₄ (x=0.1, 0.2, 0.3, and 0.5) have been studied with x-ray and neutron diffraction, Mössbauer spectroscopy and magnetization measurements. Neutron diffraction at 10 K for CoAl₀.₅Fe₀.₅O₄ revealed a cubic spinel structure of ferrimagnetic long range ordering, with magnetic moments of Fe³⁺(A)(-4.18 μₜ), Fe³⁺(B)(4.81 μₜ), Co²⁺(B)(2.99 μₜ), respectively. Mössbauer data were collected in the temperature range of 14-850 K. The temperature dependence of the magnetic hyperfine field in ⁵⁷Fe nuclei at the tetrahedral (A) and octahedral (B) sites was analyzed based on the Néel theory of magnetism. For the sample CoAl₀.₅Fe₀.₅O₄, the intersublattice A-B interaction and intrasublattice A-A superexchange interaction were antiferromagnetic with strengths of J_A-B = -23.3 k_B and J_A-A = -17.6 k_B, respectively, while the intrasublattice B-B superexchange interaction was found to be ferromagnetic with a strength of J_B-B = 5.5 k_B. With increasing Al substitution the A-B and B-B interaction decreased but the A-A interaction increased.

It is interpreted that the reduction of magnetic moment in Fe³⁺(A) and a noticeable strength of the A-A interaction are closely related to the covalency effects.