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Superexchange Interactions in $MgFe_2O_4$

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$MgFe_2O_4$ has been studied using Mössbauer spectroscopy and X-ray diffraction. The crystal was found to have an inverse cubic spinel structure with the lattice constant $a_0 = 8.390 \pm 0.005$ Å. The Mössbauer spectra consisted of two sets of six lines, respectively, corresponding to Fe^{3+} at the tetrahedral (A) and the octahedral (B) sites. The isomer shifts indicated that the valence states of the irons at both A and B sites were in ferric high-spin states. The Néel temperature of $MgFe_2O_4$ was $T_N = 710 \pm 3$ K. The temperature dependences of the magnetic hyperfine fields at the ^{57}Fe nuclei at the tetrahedral (A) and the octahedral (B) sites were analyzed by using the theory of ferrimagnetism. The intrasublattice A-O-B and the intersublattice A-O-A superexchange interactions of $MgFe_2O_4$ were found to be antiferromagnetic with strengths of $J_{A-B} = -10.0 \pm 0.2\ k_B$ and $J_{A-A} = -0.7 \pm 0.2\ k_B$, respectively, while the intrasublattice B-O-B superexchange interaction was ferromagnetic with a strength of $J_{B-B} = 1.4 \pm 0.2\ k_B$. The Debye temperatures for the A and the B sites of $MgFe_2O_4$ were found to be $\theta_A = 417 \pm 5$ K and $\theta_B = 331 \pm 5$ K, respectively.

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