Mössbauer Studies on Superexchange Interactions in Fe_3O_4

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Fe_3O_4 has been studied by using Mössbauer spectroscopy and X-ray diffraction. The crystal is found to have a cubic spinel structure with the lattice constant $a_0 = 8.3970 \pm 0.0005$ Å. The temperature dependence of the magnetic hyperfine fields at ^{57}Fe nuclei at the tetrahedral (A) and the octahedral (B) sites is analyzed by using the Néel theory of ferrimagnetism. The dominant superexchange interaction is found to be the antiferromagnetic intersublattice $A-O-B$ superexchange interaction and its strength is $J_{A-B} = -23.4\ k_B$. The intrasublattice $A-O-A$ superexchange interaction is also antiferromagnetic with a strength of $J_{A-A} = -14.6$ kB. The weakest superexchange interaction is the ferromagnetic $B-O-B$ interaction: $J_{B-B} = 1.23\ k_B$. The Debye temperatures of the tetrahedral and the octahedral sites are found to be $\Theta_A = 351 \pm 5$ K and $\Theta_B = 322 \pm 5$ K, respectively.

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