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Mössbauer studies of superexchange interactions in Ni$_{0.5}$Cu$_{0.5}$Fe$_2$O$_4$

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Ni$_{0.5}$Cu$_{0.5}$Fe$_2$O$_4$ has been studied by Mössbauer spectroscopy and x-ray diffraction. The crystal is found to have a cubic spinel structure with the lattice constants $a_0 = 8.370 \pm 0.005$ Å. Mössbauer spectra of Ni$_{0.5}$Cu$_{0.5}$Fe$_2$O$_4$ were obtained at various absorber temperatures from 13 to 820 K. The iron ions at both A (tetrahedral) and B (octahedral) sites are found to be in ferric high-spin states. Its Néel temperature $T_N$ is found to be 820 ± 3 K. The Debye temperatures for the A and B sites are found to be $\Theta_A = 417 \pm 5$ K and $\Theta_B = 331 \pm 5$ K, respectively. The temperature dependence of the magnetic hyperfine fields at $^{57}$Fe nuclei at the tetrahedral (A) and octahedral (B) sites is analyzed by the Néel theory of ferrimagnetism. The intersublattice A-O-B and intrasublattice A-O-A superexchange interactions are found to be antiferromagnetic with their strength of $J_{A-B} = -25.8$ $k_B$ and $J_{A-A} = -10.5$ $k_B$, respectively, while intrasublattice B-O-B superexchange interaction is ferromagnetic with its strength $J_{B-B} = 12.5$ $k_B$.

![Hyperfine Field vs Reduced Temperature](image)

**Figure 1.** The reduced hyperfine field as a function of the reduced temperature $T/T_N$. (Solid circle and square represent reduced hyperfine fields of A and B site, respectively. Solid line represents theoretical value.)

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