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Investigation of the Magnetic Properties of $Ni_{0.7}Fe_{0.3}Ga_2S_4$

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We have studied the magnetic properties of $Ni_{0.7}Fe_{0.3}Ga_2S_4$ with Fe substituted at the Ni sites by using an X-ray diffractometer (XRD), a superconducting quantum interference device (SQUID) magnetometer, and a Mössbauer spectrometer. The polycrystalline sample of $Ni_{0.7}Fe_{0.3}Ga_2S_4$ is found to be a single phase of the trigonal structure with a space group of P-3m1. The structural parameters of the sample are obtained by using a Reitveld refinement with lattice constants of $a_0 = 3.640$ Å and $c_0 = 12.020$ Å. The bond length between Fe and S ions is about 2.420 Å, which suggests a short-range ordering with the frustration effect. From the Mössbauer spectra, the magnetic hyperfine field and the electric quadrupole interaction are estimated to be $H_{\rm hf} = 124.2$ kOe, and $\Delta E_Q = 2.10$ mm/s, respectively, at 4.2 K. The charge state of the Fe ions is ferrous (Fe^{2+}) from the value of the isomer shift, $\delta = 0.66$ mm/s, at room temperature. The spin quantum number of $Ni_{0.7}Fe_{0.3}Ga_2S_4$ is determined to be $S = 3/2$, while it is $S = 1$ for $NiGa_2S_4$ and $S = 2$ for $FeGa_2S_4$. This indicates an increase an spin-orbital interactions with increasing Fe.

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