Spin-Disorder and Non-Degenerate Energy States in Geometrically Frustrated Materials

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We have studied chalcogenide $Ni_{1-x}Fe_xGa_2S_4$, showing geometrical frustration effect. M-H curves at 4.2 K reveal that the disordered spins cannot be rotated completely along the direction of high external field of 5 T, since these spins are strongly constrained in the triangular lattice. H_C increases with increasing Fe concentration, being consistent with the enhanced antiferromagnetic (AFM) spin-spin interactions and the suppressed spin-fluctuation due to the increase in freezing temperature T_f. The specific heat (C_p/T) measurement do not show any phase transformation between 2 and 160 K and there is no clear indication of gap in the temperature dependent C_p curve between 0 and 7 T, because the atomic short-range ordering of the strained spin in the geometrically frustrated triangular lattice exists at low temperature. Though typical geometrically frustrated magnet shows degeneracy, Mössbauer analysis at 4.2 K shows that 5D of 3d orbit in the samples studied here is splitted into $^5T_{2g}$ and $^5E_{2g}$, and $^5T_{2g}$ is further splitted into singlet and doublet by large electric quadrupole splitting. This suggests that Fe^{2+} ionic state has no absolute degenerate energy states in all samples due to Jahn-Teller effect.

Index Terms—**Geometrically frustrated magnet, Mössbauer spectroscopy, non-degenerated energy, spin-disorder.**