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Spiral order in $Ba_2CuGe_2O_7$.

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The quasi 2-dimensional square-lattice antiferromagnet $Ba_2CuGe_2O_7$ was studied by neutron scattering and bulk magnetic techniques. An incommensurate magnetic spiral structure with the propagation vector $(1+\xi,1+\xi,0)$ (ξ=0.027) was observed below T_N=3.26 K. The spin dynamics can be adequately described by conventional spin-wave theory with two exchange constants: nearest-neighbor in-plane antiferromagnetic coupling $J_1\approx0.48$ meV and interplane ferromagnetic interaction $J_3\approx0.013$ meV. This set of exchange parameters apparently fails to explain the spiral order. The non-centrosymmetric crystal structure suggests that the incommensurate phase may be the result of a Dzyaloshinskii-Moriya instability of the Neel ground state.

Keywords: Antiferromagnetism, Spin waves, Chiral systems

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AF arrangement) by an angle $\phi=9.7°$ in spin space ($\phi=0$ would corresponds to Neel order). ξ is given by $\xi=\phi/(2\pi)$.

As a rule, spiral order is caused by competing exchange interactions [4]. To verify the applicability of this hypothesis to $Ba_2CuGe_2O_7$ we performed inelastic neutron scattering measurements of the spin wave dispersion relation, that was measured in constant-Q scans along the *(1,0,0)*, *(1,1,0)* and *(0,0,1)* directions. We have worked out the classical spin-wave dispersion law assuming the relevant Heisenberg exchange parameter are 1-nn and 2-nn in-plane AF coupling constants J_1 and J_2, as well as the 1-nn interplane FM exchange J_3. The model produces good fits to our data with J_1=0.482 (0.003) meV, J_2/J_1=0.01 (0.04) and J_3=0.013 (0.001) meV. Two immediate conclusions can be drawn: i) the system is indeed strongly 2-dimensional with J_1/ J_3=37 and ii) 2-nn interactions in the Cu-planes are negligible. The Neel ground state for a 2-D square-lattice AF is known to be stable in a wide range of J_2/J_1 [5] and thus *competing interactions can not explain the spiral order* in $Ba_2CuGe_2O_7$.

So, what causes the spiral phase? We believe the answer lies in the non-centric nature of the crystal structure, as is the case for MnSi [6,7] and FeGe [7], for example. The absence of inversion center allows Dzyaloshinskii- Moriya (DM) terms [8] in the Hamiltonian. These are proportional to the *vector* product of nearest-neighbor spins. A symmetry analysis by S. Maslov and P. Bak shows that it is exactly the observed type of spiral structure that must be stabilized by DM interactions in the particular symmetry of $Ba_2CuGe_2O_7$. Additional valuable information on the DM transition was obtained in high-field experiments, that are beyond the scope of this paper.

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Figure captions:

Fig. 1 Square-lattice arrangement of the magnetic Cu-sites in the *(a,b)* plane of $Ba_2CuGe_2O_7$ and a schematic view of the spiral magnetic structure.