Magnetic interactions in the frustrated pentagonal compound $Bi_2Fe_4O_9$

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The Fe^{3+} ions in $Bi_2Fe_4O_9$ materialize the first analogue of a magnetic pentagonal lattice [1]. The unit cell contains two different sites of four iron atoms each, which have different connectivities with the other irons (three or four neighbours for Fe_1 and Fe_2 respectively), and that form a lattice of pentagons. Because of its odd number of bonds per elemental brick, this lattice is prone to geometric frustration. The compound magnetically orders around 240 K: the resulting spin configuration on the two sites is the same, i.e. two orthogonal pairs of antiferromagnetic spins in a plane, with a global rotation between the two sites Fe_1 and Fe_2. This peculiar magnetic structure, which is the result of the complex connectivity, has opened new perspectives in the field of magnetic frustration.

Here, we present the work in progress concerning the understanding and the consequences of the peculiar magnetic interactions in this original system. First, magnetization distribution maps have been measured at the Institut Laue Langevin (ILL) using polarized neutrons under an applied magnetic field. Remarkably, the magnetic moments of the Fe_1 sites, contrary to those of Fe_2, are extremely weakly (or even not) polarized by the field both in the paramagnetic phase and in the ordered one. This indicates a paramagnetic liquid of classical spin dimers that condensate into a long-range arrangement below the Néel temperature. These dimers are stabilized by a strong antiferromagnetic coupling between pairs of Fe_1 atoms combined with a high degree of frustration. In a second step, the magnetic excitations have been investigated by inelastic neutron scattering using triple axis spectrometers at the LLB and the ILL. The confrontation of the experimental results with spinwave calculations confirms the hierarchy of the interactions between the iron sites in the lattice, and therefore the validity of the classical spin dimer picture.

Our new experimental results on $Bi_2Fe_4O_9$ open interesting perspectives in the field of frustrated pentagonal lattices.

[1] E. Ressouche, V. Simonet, B. Canals, M. Gospodinov, V. Skumryev, Phys. Rev. Lett. 103, 267204 (2009).