$Ba_3NbFe_3Si_2O_{14}$: a model system to study magnetic chirality

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The word “chiral”, introduced by Lord Kelvin in 1904, refers to an object whose image in a plane mirror does not coincide with itself [1]. One intuitive example is the left and right hands, which are mirror images of each other but are not superimposable. The two forms of a chiral object are called enantiomorphs or enantiomers for molecules. The chirality is a key property which is found in all branches of science, from biology to physics and at different scales, from microscopic to macroscopic objects. For instance, in biology, the notion of chirality is crucial for living organisms and plays a critical role in molecular recognition [2]. In parallel, in fundamental physics, the chirality is also an important property, as shown by the example of the weak interaction, not invariant under mirror symmetry [3], which only interacts with left-chiral fermions or right-chiral anti-fermions. The chirality can also be found in solid state physics, in crystallography where it refers to the concept of spatial inversion symmetry rather than mirror symmetry, or again in magnetism, where it refers to the sense of rotation of the spins on oriented loops [4].

In this talk, I will focus on the concept of chirality in magnetic ordered systems. I will present the archetype chiral magnetic compound, $Ba_3NbFe_3Si_2O_{14}$, which hosts three different types of chirality. This system belongs to the family of langasite materials providing interesting geometrically frustrated spin lattices. It crystallizes in the non-centrosymmetric P321 space group and displays a structural chirality. The magnetic Fe^{3+} ions form an original triangular network in the (*a*,*b*) planes, stacked along the *c*-axis (see **Figure 1**). Below $T_N \sim 27$ K, the system orders magnetically with a 120° spins structure within each triangle, in the (*a*,*b*) planes, and presents a helical modulation along the perpendicular direction, *i.e.* the *c*-axis, with a period of ~ 7 lattice parameters (see **Figure 1**) [5]. Surprisingly, this magnetic ground state displays a unique sense of rotation of the spins within the triangles (triangular chirality) as well as a unique sense of rotation of the spins along the helices (helical chirality). This multi-chiral magnetic ground state is correlated to the structural chirality through a twist of the inter-plane exchange interactions (see **Figure 1**) [5-7]. I will present the scientific arguments that led to the discovery of such complex multi-chiral magnetic structure and the consequences on its physical properties. I will conclude by presenting our last results focusing on the critical regime and the nature of the phase transition toward this peculiar multi-chiral magnetic order.

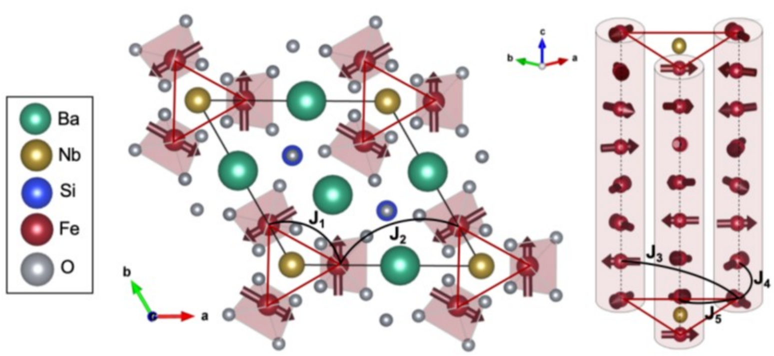

Figure 1: sketch of the crystal structure and long-range magnetic order of $Ba_3NbFe_3Si_2O_{14}$ projected in the *ab*-plane (left) and one Fe-triangle projected along the *c*-axis (right). The five magnetic exchange paths are shown.

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