Magnetic ground states of oxyanion-based compounds with sawtooth-chain lattices

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The sawtooth spin-chain systems where magnetic ions form chains of corner-sharing triangles have drawn considerable attention from a theoretical standpoint as they can host flat-band magnons [1-3]. The sawtooth spin model is one of the prototype examples of frustrated lattices and can be seen as derived from a kagomé lattice by removing magnetic sites in a regular manner. In practice, such topology implies the presence of magnetic ions in at least two nonequivalent structural positions that creates an interplay between different magnetic order parameters and, consequently, a rich magnetic phase diagram.

To date, experimental realization of a magnetic sawtooth lattice has been limited to a handful of compounds. We recently undertook a systematic investigation of the magnetic properties of several sawtooth systems where magnetic chains are linked by nonmagnetic oxyanion groups such as AsO₄, MoO₄ or SeO₃. In this presentation, we will discuss the static and dynamic magnetic properties of three transition-metal sawtooth chain systems: Rb₂Fe₂O(AsO₄)₃ [4] CsCo₂(MoO₄)₂(OH) [5] and NaCo₂(SeO₃)₃(OH) [6]. The first two compounds display very similar magnetic behaviour, with the onset of a long-range magnetic order consisting of ferrimagnetic chains that are coupled antiferromagnetically with each other. Within each chain, the magnetic moments located at the tip of the sawtooth are aligned collinearly along the b-direction (the chain direction), while the moments on the spine sites are reversely canted by approximately 30°, forming a zigzag pattern in the plane of the triangular chain. The ordering transition occurs at T_N = 25 K for the Fe compound [4] and at 5 K for the Co one [5]. For both compounds, applied magnetic fields induce a transition to a ferrimagnetic state in which the coupling between adjacent sawtooth chains changed from antiferromagnetic to ferromagnetic. Hamiltonian models describing the main magnetic interactions are proposed based on the observed low-energy spin-wave excitations from inelastic neutron scattering data. The third system, NaCo₂(SeO₃)₃(OH), exhibits a more complicated phase diagram consisting of successive magnetic transitions: a ferrimagnetic order at 11 K, followed by a reconfiguration of the magnetic structure into an antiferromagnetic state at 3.8 K [6]. Neutron-powder diffraction measurements reveal that at 11 K only one Co site orders to form ferrimagnetic zigzag chains along the b-axis. Below 3.8 K, both sites order into a complex noncolinear antiferromagnetic structure. A field-induced spin flip transition has been observed at Hc = 1.3 kOe. The analysis of powder inelastic neutron spectrum suggests a complex exchange interaction pattern that goes beyond a Heisenberg Hamiltonian model with nearest neighbour couplings. Our results demonstrate the richness of the magnetic properties of sawtooth-type structures and will motivate further experimental studies of similar sawtooth oxyanions structures.


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