Chiral Soliton Lattice in a Monoaxial Chiral Magnet

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ABSTRACT: The concept of chirality, meaning left or right handedness, plays an essential role in symmetry properties of nature at all length scales from elementary particles to biological systems. In materials science, chiral materials are found in molecules or crystals with helical structures, which break mirror and inversion symmetries but combine rotational and translational symmetries. Chiral materials frequently exhibit intriguing functionality because electrons distribute themselves along chiral framework of atomic configurations and their rotational and translational motions couple to give specific physical processes.

In magnetic crystals belonging to chiral space group, orbital motions of localized electrons with spin magnetic moments take helical paths in the chiral framework of atoms and mediate coupling of the neighboring spins of electrons via the relativistic spin-orbit interaction called Dzyaloshinskii-Moriya (DM) interaction. This antisymmetric DM exchange competes with ferromagnetic (FM) exchange interaction, which will result in an emergence of chiral magnetic orders and various interesting functions unique to chiral magnets.

In this talk, I will present that chiral soliton lattice (CSL) emerges in a monoaxial chiral magnet CrNb3S6 in small magnetic fields by means of low-temperature Lorenz transmission electron microscopy (TEM) and small-angle electron scattering (SAES) method [1]. Based on detailed analyses in both real and reciprocal space, we clearly demonstrate that CSL develops from chiral helimagnetic structure (CHM) with increasing the spatial period from 48 nm toward infinity (sample size) in rising magnetic fields perpendicular to the helical axis. Chiral magnetic orders of CSL and CHM do not exhibit any structural dislocation, indicating their high stability and robustness. This is because chiral magnetic orders are macroscopically induced by the uniaxial Dzyaloshinkii-Moriya (DM) exchange interaction that is allowed in CrNb3S6 hexagonal crystals belonging to noncentrosymmetric chiral space group. Magnetization and interlayer magneto-resistance data in CrNb3S6 crystals will be discussed in terms of CSL formation [2]. In theoretical viewpoints, CSL would exhibit a variety of interesting functions including spin current induction, nontrivial soliton transport, anomalous topological magneto resistance, current-driven collective CSL transport and so on. Present observations of a new state of matter will be the first step to explore novel type of functionalities of CSL for spin electronic device applications using chiral magnetic crystals.

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References
[1] Y. Togawa, T. Koyama, S. Mori, Y. Kousaka, J. Akimitsu, S. Nishihara, K. Inoue, A. S. Ovchinnikov and J. Kishine, Phys. Rev. Lett. 108, 107202 (2012).
[2] Y. Togawa, Y. Kousaka, S. Nishihara, K. Inoue, J. Akimitsu, A. S. Ovchinnikov and J. Kishine, Phys. Rev. Lett., in press.

ALL ARE WELCOME!!!