Emergent Phenomena and Functionality in Topological Magnets

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Since the discovery of quantum Hall effect in a two-dimensional electronic system, [1] the concept of topology has been appreciated in the classification of quantum states, leading to the identification of topological states and the emergent electromagnetism in condensed matters. With combinations of well-established physics of strongly-correlated systems, magnetism, superconductivity and so on, topology in the quantum system has been offering a platform of versatile electronic and spintronic phenomena. [2] For example, topological spin textures, such as skyrmions and hedgehogs, and topological electronic states of topological insulators and Weyl fermion systems can realize low-dissipative drive of magnetic domains or non-dissipative electron and spin currents. Also, Majorana fermions with non-Abelian statistics at an interface of superconductor and topological insulator are one of the promising candidates for robust bits in quantum computation technology. Nowadays, when a huge amount of electricity is consumed for information processing, it is expected to create power-saving electronic technology that utilizes these topological states, namely ‘topological electronics’. And control of topological states by external stimuli is an essential factor to realize such energy-saving technology.

In this talk, we introduce how topological states in electronic and spin structures are coupled with multiple degrees of freedom of electrons and provide unique electromagnetic responses. We illustrate that the effective electromagnetic fields, so-called emergent electromagnetic fields, have critical influence on quantum properties, and also overview the real-space topological spin textures of skyrmions and momentum-space topological electronic structures in magnetic topological insulators (Fig. 1).

Reference
1) K. v. Klitizng, G. Dorda, and M. Pepper, Phys. Rev. Lett., **45** (1980) 494.
2) Y. Tokura, M. Kawasaki, and N. Nagaosa, Nature Phys., **13** (2017) 1056.

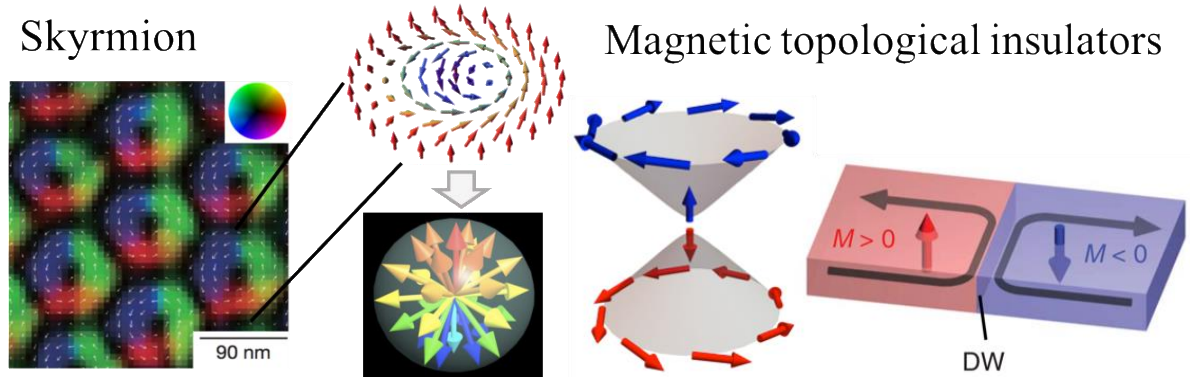

Fig.1 Skyrmions and magnetic topological insulators as representative examples of topological spin and electronic states in condensed matters.