Emergent electromagnetic phenomena in spin chiral matter

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Temporal modulation of the Berry phase in a condensed matter can produce the emergent electric field acting on conduction electrons. For example, conducting multiferroic, such as semi-magnetic topological insulators and polar ferromagnetic Weyl semimetals, in which the electronic polarity (P) and the ferromagnetic order (M) coexist, can generate the emergent electric field as a consequence of the temporal drive of the toroidal moment ($T \sim P \times M$). One other example for the emergent electric field generation is the temporal drive of the emergent magnetic field (Berry curvature) as typically observed in the current drive of the magnetic skyrmion lattice. For more general example, the spin chiral matter in the real space can be always driven by ac electric current to generate the emergent electric field. All these can be termed *emergent electromagnetic induction* as an extension of Faraday's law in classic electromagnetism. Such emergent electromagnetic induction based on the spin chiral matter is applied to the design of nanometric inductor or sensor element.

Here, several mechanisms in the real-space and momentum space spin topology are discussed together with the experimental observations for the large emergent electric field generation in topological magnets.