

## Topological Vortex Domains in Quantum Materials

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Engineering of domains and domain boundaries is quintessential for technological exploitation of numerous functional materials. However, it has only recently realized that the configuration of these domains/domain boundaries can have non-trivial topology. We will discuss a new topological classification scheme of domain/domain boundary configurations with Ising-type or two-dimensional order parameters:  $Z_m \times Z_n$  domains ( $m$  directional variants and  $n$  translational antiphases) and  $Z_l$  vortices (where  $l$  number of domains and that of domain boundaries merge). This classification, with the concept of topological protection and topological charge conservation, has been applied to a wide range of materials such as improper ferroelectric  $R(\text{Mn,Fe})\text{O}_3$ , antipolar  $\text{In}(\text{Mn,Ga})\text{O}_3$ , hybrid improper ferroelectric  $(\text{Ca,Sr})_3\text{Ti}_2\text{O}_7$ , chiral (and ferromagnetic)  $\text{Fe}_{1/3}\text{TaS}_2$ , and magnetic-superconducting  $\text{Sr}_2\text{VO}_3\text{FeAs}$ . We will also discuss the emergent physical properties of domain boundaries, distinct from those of domains. The presented topological consideration provides a basis in understanding the formation, kinetics, manipulation and property optimization of domains/domain boundaries in quantum materials.