

Curved domain-wall fermion and its applications

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The Witten effect predicts that a magnetic monopole acquires a fractional electric charge inside topological insulators. In this work, we give a microscopic description of this phenomenon as well as an analogous two-dimensional system with a vortex. We solve the Dirac equation of electron field both analytically in a continuum and numerically on a lattice by adding the Wilson term and smearing the gauge field within a finite range to regularize the short-distance behavior of the system. Our results reveal that the Wilson term induces a strong positive mass shift, creating a domain-wall around the monopole or vortex. This small yet finite-sized domain wall localizes the chiral zero modes and ensures their stability through the Atiyah-Singer index theorem, whose cobordism invariance is crucial in explaining why the electric charge is fractional.

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