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Anisotropic scaling for 3D topological models

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A proposal to study topological models beyond the standard topological classification and that exhibit breakdown of Lorentz invariance is presented. The focus of the investigation relies on their anisotropic quantum critical behavior. We study anisotropic effects on three-dimensional (3D) topological models, computing their anisotropic correlation length critical exponent ν obtained from numerical calculations of the penetration length of the zero-energy surface states as a function of the distance to the topological quantum critical point. A generalized Weyl semimetal model with broken time-reversal symmetry is introduced and studied using a modified Dirac equation. An approach to characterize topological surface states in topological insulators when applied to Fermi arcs allows to capture the anisotropic critical exponent $\theta = \nu_x/\nu_z$. We also consider the Hopf insulator model, for which the study of the topological surface states yields unusual values for ν and for the dynamic critical exponent z. From an analysis of the energy dispersions, we propose a scaling relation $\nu_{\bar{\alpha}} z_{\bar{\alpha}} = 2q$ and $\theta = \nu_x/\nu_z = z_z/z_x$ for ν and z that only depends on the Hopf insulator Hamiltonian parameters p and q and the axis direction $\bar{\alpha}$. An anisotropic quantum hyperscaling relation is also obtained.

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