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A Bosonic Analogue of a Topological Dirac Semi-Metal[1]
MATTHEW LAPA, University of Illinois at Urbana-Champaign, GIL YOUNG CHO, Korea Advanced Institute of Science and Technology, TAYLOR HUGHES, University of Illinois at Urbana-Champaign — We construct a bosonic analogue of a two-dimensional topological Dirac Semi-Metal (DSM). The low-energy description of the most basic 2D DSM model consists of two Dirac cones at positions $\pm\mathbf{k_0}$ in momentum space. The local stability of the Dirac cones is guaranteed by a composite symmetry $Z_2^{\mathcal{TI}}$, where $\mathcal{T}$ is time-reversal and $\mathcal{I}$ is inversion. This model also exhibits interesting time-reversal and inversion symmetry breaking electromagnetic responses. In this work we construct a bosonic analogue of a DSM by replacing each Dirac cone with a copy of the $O(4)$ Nonlinear Sigma Model (NLSM) with topological theta term and theta angle $\theta = \pm\pi$. One copy of this NLSM also describes the gapless surface termination of the 3D Bosonic Topological Insulator (BTI). We compute the time-reversal and inversion symmetry breaking electromagnetic responses for our model and show that they are twice the value one gets in the DSM case. We also investigate the local stability of the individual $O(4)$ NLSM's in the BSM model. Along the way we clarify many aspects of the surface theory of the BTI including the electromagnetic response, the charges of vortex excitations, and the stability to symmetry-allowed perturbations.

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Matthew Lapa
University of Illinois at Urbana-Champaign

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