Chiral-symmetry protection of the zeroth Landau level on a two-dimensional lattice.

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We addresses the challenge of preserving the chiral-symmetry protection of the zeroth Landau level on a two-dimensional lattice [1], particularly in the context of topological insulators. The study focuses on the behavior of massless Dirac fermions in a perpendicular magnetic field, where the zeroth Landau level remains independent of the magnetic field strength due to chiral symmetry. By developing a nonlocal discretization scheme [2], we successfully avoid the broadening of the zeroth Landau level caused by spatial fluctuations in the magnetic field when using the conventional method of Wilson fermions. This work not only simulates the quantum Hall effect in a 3D topological insulator on a 2D lattice but also provides a gauge-invariant approach to discretizing the Dirac equation on a lattice without breaking chiral symmetry, ensuring the topological protection of the zeroth Landau level in a magnetic field.

[1] A. Donís Vela, G. Lemut, **J. Tworzydło**, C. W. J. Beenakker, *Annals of Physics* **456**, 169208 (2023).
[2] C.W.J. Beenakker, A. Donís Vela, G. Lemut, M.J. Pacholski, **J. Tworzydło**, *Annalen der Physik* **535**, 2300081 (2023).