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Quasiparticle Spectrum of 2-d Dirac Vortices in Optical Lattices[1]

LAITH HADDAD, Colorado School of Mines — Bose-Einstein condensates in a honeycomb optical lattice are described by a nonlinear Dirac equaton (NLDE) in the long wavelength, mean field limit [1]. The upper and lower two-spinor equations decouple and superficially resemble the equations of previously studied NLDE's such as the Soler model for extended fermions. Although much work has been done on NLDE's, the bulk of the literature deals with models with Poincare invariant nonlinearites. In contrast our equations break Poincare symmetry providing an opportunity to study phenomenological models in cosmology and particle physics where this symmetry is not manifest. We obtain and classify localized solutions to our equations for both repulsive and attractive contact interactions. We also derive analogs of the Bogoliubov-de Gennes equations for the lattice and use these to study the stability and low energy spectrum of our solutions showing the existence of stable exotic structures such as vortices with fractional statistics.

[1] L. H. Haddad and L. D. Carr, "The Nonlinear Dirac Equation in Bose-Einstein Condensates: Foundation and Symmetries," Physica D: Nonlinear Phenomena, v. 238, p. 1413 (2009). http://arxiv.org/pdf/0803.3039v1

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