Semions, Skyrmions, and a Zoo of Nonlinear Waves in the Nonlinear Dirac equation

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Abstract: A Bose-Einstein condensate in a honeycomb optical lattice gives rise to long-wavelength excitations described by a nonlinear Dirac equation (NLDE). Having previously established this equation and its symmetries [1], we proceed to solve the NLDE. The four components of the Dirac spinor allow for a large class of localized nonlinear excitations. In order to evaluate the experimental viability of these solutions, we have developed a complete linear perturbation theory, a relativistic generalization of the Boguliubov-de-Gennes equation; we call this new equation the Relativistic Linear Stability Equation (RLSE). We present various soliton, vortex, semion (vortices with fractional statistics), and skyrmion solutions of the NLDE, and their associated stability properties according to the RLSE.

References:

1. L. H. Haddad and L. D. Carr, "The Nonlinear Dirac Equation in Bose-Einstein Condensates: Foundation and Symmetries," Physica D: Nonlinear Phenomena, **238**, p. 1413 (2009).