Nonlinear wave packets in deformed honeycomb lattices

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Abstract:

The spectrum of a Schrödinger operator with a perfect honeycomb lattice potential has special points, called Dirac points where the lowest two branches of the spectrum touch. Deformations can result in the merging and disappearance of the Dirac points and the originally intersecting dispersion relation branches separate. Corresponding to these deformations, nonlinear envelope equations are derived and their dynamics are studied. In the region where Dirac points exist a maximally balanced equation is derived which has limits to a nonlinear Schrödinger-Kadomtsev-Petviashvili type equation and its dispersionless reduction. When the Dirac points disappear and a gap opens a different maximally balanced equation is derived which has the nonlinear Schrödinger-Kadomtsev-Petviashvili type and a one dimensional nonlocal evolution equation as limits. When the gap is sufficiently wide a nonlinear Dirac equation with nonzero mass and a nonlinear Schrödinger focusing - defocusing system are found. The latter two equations admit nonlinear localized modes. Typical dynamical behaviors of the effective envelope equations are presented.