Chiral interface states in pn junctions in graphene

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We present a theoretical study of unidirectional interface states which form near pn junctions in a graphene monolayer subject to a homogeneous magnetic field. The semiclassical limit of these states corresponds to trajectories propagating along the pn interface by a combined skipping-snaking motion. Studying the two-dimensional Dirac equation with a magnetic field and an electrostatic potential step, we provide and discuss the exact and essentially analytical solution of the quantum-mechanical eigenproblem for both a straight and a circularly shaped junction. The spectrum consists of localized Landau-like and unidirectional snaking-skipping interface states, where we always find at least one chiral interface state. For a straight junction and at energies near the Dirac point, when increasing the potential step height, the group velocity of this state interpolates in an oscillatory manner between the classical drift velocity in a crossed electromagnetic field and the semiclassical value expected for a purely snaking motion. Away from the Dirac point, chiral interface states instead resemble the conventional skipping (edge-type) motion found also in the corresponding Schrödinger case. We also investigate the circular geometry, where chiral interface states are predicted to induce sizeable equilibrium ring currents.