

Compact topological edge localization in flux-dressed graphene photonic ribbons: interplay of Aharonov–Bohm caging, flat bands, and topology

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In lattices with synthetic gauge fields, destructive interference, band geometry, and topology can cooperate to produce unusual localization phenomena. We study a graphene-like photonic ribbon in which an effective magnetic flux controls the transition between trivial and topological regimes [1]. In the linear system, tuning the flux opens and closes central spectral gaps and induces zero-energy edge states, while the special value π generates full Aharonov–Bohm caging and a flat-band structure. At this point, topology and interference act simultaneously, yielding perfectly compact edge states that are strongly protected against transport into the bulk. Their topological character is identified through the mean chiral displacement, complemented by Zak-phase and winding-based analyses. Experimentally, these states are realized in femtosecond-laser-written photonic graphene ribbons with engineered 0 and π flux configurations, and their robustness is observed against wavelength variation, input-phase mismatch, and fabrication imperfections. Beyond the reported linear regime, this platform also suggests a natural nonlinear extension, in which Kerr-type or effective interaction-induced terms may compete with compactification and topological confinement, opening the possibility of nonlinear compact edge modes, bifurcating localized states, and interaction-modified transport.

Reference:

[1] G. Cáceres-Aravena et al., Phys. Rev. Lett. 133, 116304 (2024).