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Emergent momentum-space topological pseudospin defects in non-Hermitian systems

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Point defects in spinor fields protected by topological invariants, the winding of the spinor configuration around the centre of the defect, have attracted a great amount of interests as they present a potential platform for spintronics and quantum communication. In this work, we present the generation of momentum-space pseudospin (polarization) defects in non-Hermitian exciton-polariton systems. Exciton-polaritons are hybrid light-matter systems arising from the strong coupling between the electron-hole pairs (excitons) in semiconductors and the cavity photons. The exciton polaritons have momentum-dependent dissipation inherited from their photonic components, and therefore, they can be described by effective non-Hermitian Hamiltonians, which give rise to complex-valued eigenenergies. Hence, exciton polaritons feature new types of complex energy structures, such as the bulk (imaginary) Fermi arcs, where the real (imaginary) parts of the eigenenergy cross, and degeneracies, where both the real and imaginary parts of the eigenenergies cross, such as the exceptional points and hybrid points. Therefore, exciton polaritons present an experimentally accessible platform to study the non-Hermitian physics where the exceptional points and the pseudospin textures have been directly measured.

In this work, we consider two non-Hermitian two-band two-dimensional models, and describe the emergence and dynamics of topological pseudospin defects that spontaneously appear on the vicinity of the imaginary Fermi arcs in momentum space. We also show that while in the fully gapped phase, the defects annihilated each other, in the gapless phases, the non-Hermitian degeneracies protect the defects from annihilation. We also show that the qualitative change of the defect dynamics from the gapped to gapless phases can potentially be experimentally measured using the skyrmion number. Our work shows the rich new physics in non-Hermitian systems and our theory can be realized using a liquid-crystal based exciton polariton system.

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