Self-Acceleration of Non-Hermitian Exciton-Polariton Wave Packets

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Open dissipative systems described by non-Hermitian Hamiltonians have recently attracted a lot of interests as they lead to a wide range of effects such as coherent-perfect absorption and lasing [1], directional emission [1], novel topological invariants [2] and edge states [3]. One of such systems is the exciton polaritons in an optical microcavity which arise from the strong coupling of excitons in a semiconductor and cavity photon modes. The inherent loss and gain in this system have already enabled measurements of non-Hermitian degeneracies [4] and topological invariants [2]. Inspired by recent studies [3, 5] showing the self-acceleration of non-Hermitian wave packets, we theoretically investigate the time-evolution of wave packets in a non-Hermitian exciton-polariton system.

In particular, we numerically study wavepacket dynamics in momentum space and observe self-acceleration. The wave packets tend to self-organise into the eigenstate with the smaller decay rate or the larger imaginary part of the eigenenergy, then propagate towards the minima of the decay rate or the maxima of the imaginary part of the corresponding eigenenergies in momentum space. We also observe the generation of pseudospin defects (half skyrmions) in momentum space along the imaginary Fermi arc, where the decay rates of the two eigenenergies coincide. All of these effects do not require an external potential and can be measured in an exciton-polariton system with optical anisotropy, e.g., perovskite [2], organics [6], or ZnO-based microcavities [7]. Our results highlight the excellent potential of exciton polaritons as a platform to study non-Hermitian dynamics.

[1] Ş. K. Özdemir, *et al.*, *Natural Materials* **18**, 783-798 (2019).

[2] R. Su, *et al.*, *Science Advances* **7**, eabi8905 (2021).

[3] S. Longhi, *Phys. Rev. B* **105**, 245143 (2022).

[4] T. Gao, *et al.*, *Nature* **526**, 554–558 (2015).

[5] D. D. Solnyshkov, *et al.*, *Phys. Rev. B* **103**, 125302 (2021).

[6] Q. Liao, *et al.*, *Phys. Rev. Lett.* **127**, 107402 (2021).

[7] S. Richter, *et al.*, *Phys. Rev. Lett.* **123**, 227401 (2019).