Annihilation of exceptional points from different Dirac valleys in a microcavity filled with liquid crystal

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Exceptional points (EPs) are characteristic for non-Hermitian systems singularities at which eigenvalues and eigenvectors coalesce. They carry a topological charge and are of special interest due to such phenomena as unidirectional transport, single mode lasing and enhanced sensitivity to perturbations. EPs often originate from Hermitian singularities like Dirac or Weyl points from which two EPs of opposite charge can emerge upon increasing non-Hermicity. Conversely, when the non-Hermicity is removed, EPs annihilate.

In this work, we investigate an optical cavity filled with birefringent liquid crystal (LC) (Fig. 1a). Profiting from the sensitivity of the LC to external electric bias and TE-TM spin-orbit coupling in planar microcavities within the Hermitian limit, we construct 2D photonic bands exhibiting four Dirac points (DP) in the momentum space (Fig. 1b,c). By changing the voltage applied to the LC cell, we can control splitting of the real part, which for fixed polarization dependent losses in the cavity gives us access to steer the non-Hermicity degree. It allows us to create eight EPs—four pairs from each DP—and to change their position in the reciprocal space (Fig. 1d). In particular, for sufficiently high non-Hermicity degree, we observe that EPs of opposite charge issued from different DPs annihilate (Fig. 1e), which constitutes a first demonstration of a non-Hermitian phase transition where upon increasing non-Hermicity all band singularities originating from separate valleys in momentum space are removed from the system.

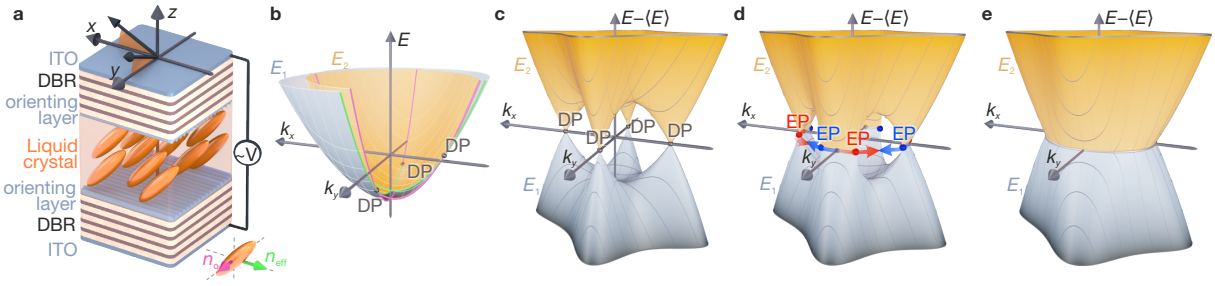

Fig. 1: **a** Cavity filled with liquid crystal. **a** Dispersion relation of photonic modes in LC cavity in the Hermitian limit. **b** Energy of the modes subtracted by their mean value $\langle E \rangle$. **c** Dispersion with nonzero polarization dependent losses exhibiting 8 exceptional points (EPs). **d** At high non-Hermicity degree EPs associated with different DPs annihilate.

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