# Non-Exponential Tunneling Due to Mean-Field Induced Swallowtails

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Typically, energy levels change without bifurcating in response to a change of a control parameter. Bifurcations can lead to loops or swallowtails in the energy spectrum. The simplest quantum Hamiltonian that supports swallowtails is a non-linear $2\times2$ Hamiltonian with non-zero off-diagonal elements and diagonal elements that depend on the population difference of the two states. This work [1,2] implements such a Hamiltonian experimentally using ultracold atoms in a moving one-dimensional optical lattice. Self-trapping and non-exponential tunnelling probabilities, a hallmark signature of band structures that support swallowtails, are observed. The good agreement between theory and experiment validates the optical lattice system as a powerful platform to study, e.g., Josephson junction physics and superfluidity in ring-shaped geometries.

## References

[1] Q Guan, T M Bersano, S Mossman, P Engels and D Blume, Phys. Rev. A **101**, 063620 (2020)

[2] Q Guan, M K H Ome, T M Bersano, S Mossman, P Engels and D Blume, Phys. Rev. Lett. **125**, 213401 (2020)