Natural Exceptional Points Appearing in Semiconductor Microcavity Systems

M. Furman[1], A. Opala[1,2], M. Król[1], R. Mirek[1], K. Tyszka[1], B. Seredyński[1], W. Pacuski[1], J. Szczytko[1], M. Matuszewski[2], B. Piętka[1]

[1] *Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland*

[2] *Institute of Physics, Polish Academy of Sciences, Aleja Lotników 32/46, 02-668 Warsaw, Poland*

In quantum mechanics various systems can be represented within a Hermitian Hamiltonian description. In the case of a physical system in which gain and dissipation play a significant role, this description is no longer valid and the non-Hermitian character of the system must be taken into account.

An example of a phenomenon that can only occur in non-Hermitian systems is the appearance of the so-called exceptional points (EPs). These specific singularity points arise in parameter space, where at least two eigenvalues are degenerate (both the real and imaginary parts of the energies are equal). The EPs are characterized by an exotic topology of the eigenvalue surfaces near an exceptional point singularity [2], which can be demonstrated while encircling them in the parameter space in which they appear. Performing a full loop around the EP does not lead to the initial state, but results in switching to the second eigenstate. In this work, following the theoretical model, we observe such a behavior experimentally in a semiconductor microcavity.

In our work, we demonstrate the emergence of the exceptional points associated with the transition of the system from the strong to the weak light-matter coupling regime. We perform angle-resolved experiments in which we additionally vary the Rabi splitting by the power of the incident laser beam. Specifically, we encircle the EP in parameters space of a wave vector–coupling strength, as shown in the Figure. The presence of the EP is evidenced by the specific exchange between the eigenstates, which is in excellent agreement with the proposed theoretical model.

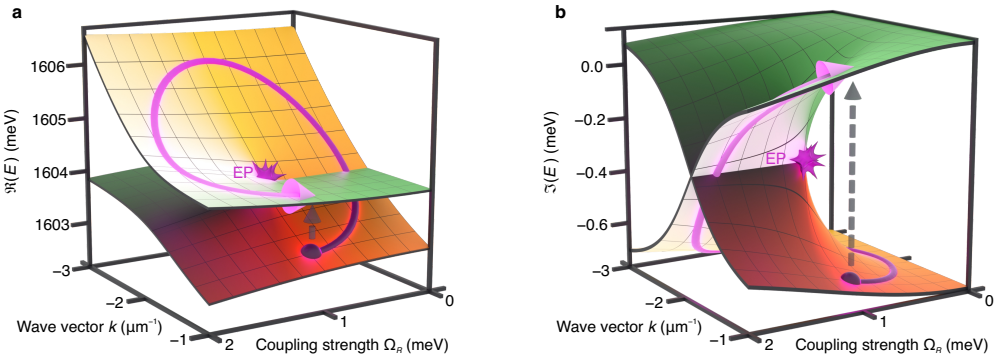

Figure: Encircling the exceptional point in a space of parameters: Rabi splitting and wave vector change, (a) real and (b) imaginary part of the energy.

[1] A. Opala, M. Furman, M. Król, R. Mirek, K. Tyszka, B. Seredyński, W. Pacuski, J. Szczytko, M. Matuszewski, B. Piętka, "Natural exceptional points in the collective excitation spectrum of a light-matter system", in review.

[2] M. Miri, A. Alù, "Exceptional points in optics and photonics", *Science* **363**, 6422, (2019).