Properties of exceptional points in open quantum systems

Savannah Garmon
Department of Physical Science, Osaka Prefecture University
sgarmon@p.s.osakafu-u.ac.jp

We demonstrate some general properties of open quantum systems in the vicinity of an exceptional point, at which two or more eigenstates coalesce and the usual diagonalization scheme of the Hamiltonian fails. In the literature this scenario is often treated by relying on a heuristic effective Hamiltonian; however, here we treat the problem analytically relying on a generalized perturbative method using simple models as examples. We show that the exceptional points are mathematically equivalent to branch points in the parameter space of the Hamiltonian, which is illustrated in the non-analytic properties of the eigenvalues in the vicinity of the exceptional points. As a direct result of these eigenvalue properties, the norm of the associated eigenstates diverges at the exceptional point. Using our analytic approach, we show that the Hamiltonian can only be reduced to Jordan block form at the exceptional point [1]. Finally we briefly discuss the influence of an exceptional point on the evolution of an initially prepared state, emphasizing that continuum threshold effects [2] may play a significant role.

[1] G. Bhamathi and E. C. G. Sudarshan, Int. J. Mod. Phys. B **10**, 1531 (1996).
[2] S. Garmon, T. Petrosky, L. Simine, and D. Segal, Fortschr. Phys. **61**, 261 (2013).
[3] S. Garmon, I. Rotter, N. Hatano, and D. Segal, Int. J. Theor. Phys. **51**, 3536 (2012).
[4] S. Garmon, M. Gianfreda, and N. Hatano, Phys. Rev. A **92**, 022125 (2015).
[5] N. Hatano and G. Ordonez, J. Math. Phys. **55**, 122106 (2014).