Quantum Physics

Analysis technique for exceptional points in open quantum systems and QPT analogy for the appearance of irreversibility

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We propose an analysis technique for the exceptional points (EPs) occurring in the discrete spectrum of open quantum systems (OQS), using a semi-infinite chain coupled to an endpoint impurity as a prototype. We outline our method to locate the EPs in OQS, further obtaining an eigenvalue expansion in the vicinity of the EPs that gives rise to characteristic exponents. We also report the precise number of EPs occurring in an OQS with a continuum described by a quadratic dispersion curve. In particular, the number of EPs occurring in a bare discrete Hamiltonian of dimension $n_\textrm{D}$ is given by $n_\textrm{D} (n_\textrm{D} - 1)$; if this discrete Hamiltonian is then coupled to continuum (or continua) to form an OQS, the interaction with the continuum generally produces an enlarged discrete solution space that includes a greater number of EPs, specifically $2^{n_\textrm{C}} (n_\textrm{C} + n_\textrm{D}) [2^{n_\textrm{C}} (n_\textrm{C} + n_\textrm{D}) - 1] $, in which $n_\textrm{C}$ is the number of (non-degenerate) continua to which the discrete sector is attached. Finally, we offer a heuristic quantum phase transition analogy for the emergence of the resonance (giving rise to irreversibility via exponential decay) in which the decay width plays the role of the order parameter; the associated critical exponent is then determined by the above eigenvalue expansion.

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