Jordan block of the total Hamiltonian in the extended Hilbert space for open quantum systems

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We show that the Hamiltonian for an open quantum system at an exceptional point is represented by a Jordan block in a subspace spanned with basis vectors which are outside of the Hilbert space.[1] We describe how to obtain a Jordan basis which consists of dual eigenvectors and associated dual pseudoeigenvectors on the basis of the Feshbach projection method. In this method the complex eigenvalue problem of the total Hamiltonian is reduced to that of the effective Hamiltonian which depends on the eigenvalue itself. Because of the eigenvalue dependence, the effective Hamiltonian cannot be represented as a matrix having a Jordan block, in contrast to the case of a phenomenological effective Hamiltonian.

Actually the Jordan block form is not restricted to exceptional points, but even away from exceptional points an operator can be represented by a matrix having a Jordan block.[2] We give a Jordan block away from an exceptional point by making a Jordan basis in a subspace spanned by two eigenstates which coalesce at an exceptional point, and show that this generalized Jordan block connects continuously to the Jordan block just at the exceptional point.

[1] T. Petrosky, I. Prigogine, and S. Tasaki, Physica A **173**, 175 (1991).
[2] K. Hashimoto, K. Kanki, H. Hayakawa, and T. Petrosky, Prog. Theor. Exp. Phys. **2015**, 023A02 (2015).