Complex normalization constant of eigenstates for a non-Hermitian Hamiltonian and Fano profile in the intra-atomic photo absorption spectrum

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The intra-atomic photo absorption spectrum of an impurity atom embedded in a semi-infinite quantum wire is investigated in terms of the complex eigenvalue problem for an effective non-Hermitian Hamiltonian describing an open quantum system[1,2]. The effective Hamiltonian for the impurity state is constructed from the original Hermitian Hamiltonian following the Brillouin-Wigner-Feshbach projection method. Bi-orthonormal and bi-complete eigenstates with complex eigenvalues of the total Hamiltonian are obtained in the dual space, which is a complex extension of the usual Hilbert space. In the dual space, the normalization constant of the eigenstate is in general a complex number. The imaginary part of the normalization constant manifests itself as a non-symmetric profile (the so-called Fano profile) appearing in the photo absorption spectrum, as it leads to a principal-part-type contribution. Our treatment of the Fano profile in terms of the complex spectral representation reveals a new aspect of the Fano resonance, which may also appear in other optical spectra, such as resonance Raman spectrum, emission spectrum, and so on.

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