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Spectral density for a discretized continuum

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Different approaches which employ discretization of continuum, for example, by projecting the operators and wave functions into some finite L_2 basis, are widely used nowadays as efficient techniques to solve the scattering problems. Here we discuss how to extract information about scattering from the discretized spectra of unperturbed and total Hamiltonians. It is shown that if the discrete eigenvalues E_j lie on some smooth curve $\lambda(x)$ (i.e. $E_j = \lambda(x = j)$) then one can construct a smooth integrated spectral density (ISD) for the corresponding Hamiltonian by using the inverse function. The difference of ISDs for the total and unperturbed Hamiltonians gives the spectral shift function which is proportional to the scattering phase shift. Also, one can define separate spectral densities for the Hamiltonians as derivatives of the above ISDs. Although each spectral density doesn't correspond to the initial continuous spectrum and depends on the way of the discretization, the difference of these densities for the total and unperturbed Hamiltonians does define a proper continuum level density (CLD) for the initial problem in question. In particular, this CLD can be used to find resonances in the system. Thus, a rather simple treatment of discretized spectra of unperturbed and total Hamiltonians allows to find scattering observables in a wide energy region without solving scattering theory equations.
The approach represents a generalization of the discrete spectral shift method [1,2] developed by the authors previously. As illustrations, we consider several examples from atomic and nuclear physics, including p-^{12}C scattering, by using the Gaussian basis representation. Also, relations between the suggested method and the known approaches, such as the SS-HORSE [3] and the R-matrix, are discussed.

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