

## Natural boundary condition methods for nuclear reactions

Syed Saeed Ahmad

The Barrett and Delsanto and iterative  $R$ -matrix methods for calculating cross sections are discussed. Both methods are characterized by their use of natural boundary conditions at the surfaces separating internal and external regions of configuration space and the employment of energy-dependent basis states. An energy correction which greatly improves the rate of convergence of the Barrett and Delsanto method is also given.

The methods are compared with both standard and generalized  $R$ -matrix calculations with energy-independent basis states for the reaction  $^{12}\text{C}(n, n)^{12}\text{C}$  at incident energies below the inelastic threshold using a weak vibrational model. The convergence of the natural boundary condition methods was found to be substantially better than for the other cases. Moreover, the methods are used to calculate both the elastic and inelastic scattering cross sections for an exactly soluble model comprising two square well potentials coupled by a square well interaction. The methods are investigated for weak, intermediate, and strong coupling interactions and the results are compared where possible with those of other related methods. It is concluded that for the practical calculation of reaction cross sections from a basic physical model, the natural boundary condition methods offer the most tractable approach particularly for problems involving strong channel coupling.

The iterative  $R$ -matrix method is also applied to the  $^{12}\text{C}(p, p)^{12}\text{C}$  reaction below 8 MeV using a collective rotational model for the target nucleus. The predictions of the method are again substantially better than

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the standard  $R$ -matrix method and are in good agreement with the equivalent coupled-channels calculations.