THE GENERATOR COORDINATE FORMALISM FOR COLLISIONS OF ^3H WITH ^4He AND ^4He WITH ^6Li

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A variational calculation of the K-matrix, performed within the framework of the generator coordinate method (GCM), is discussed for collisions of alpha particles with ^6Li and tritons with ^4He. Using the Kohn-Kato variational principle [1] we obtain the following expression for the elements of the K-matrix:

$$K_{ji} = -\left\{(\Delta_{\mathcal{F}\mathcal{F}})_{ij}/w - \left[(\Delta_{\mathcal{G}\mathcal{F}})^T(\Delta_{\mathcal{G}\mathcal{G}})^{-1}(\Delta_{\mathcal{F}\mathcal{G}})\right]_{ij}\right\}.$$

Here i and j are channel indices and w is a constant [1]. A typical element $(\Delta_{\mathcal{F}\mathcal{G}})_{ij}$ is of the form

$$(\Delta_{\mathcal{F}\mathcal{G}})_{ij} = \int d^3\underset{\sim}{S}'\int d^3\underset{\sim}{S}\, f_{i,F}(\underset{\sim}{S}')\,\Delta_{ij}(\underset{\sim}{S}',\underset{\sim}{S})\, f_{j,G}(\underset{\sim}{S})$$

where $f_{i,F}$ and $f_{j,G}$ are the GCM amplitudes for Coulomb scattering, associated with the regular and irregular Coulomb function, respectively [2]. The form factor Δ_{ij} is given by

$$\Delta_{ij}(\underset{\sim}{S}',\underset{\sim}{S}) = \langle\phi_i(\underset{\sim}{S}')|H-E|\phi_j(\underset{\sim}{S})\rangle - \sum_{k',k}\sum_{p',p}\sum_n \langle\phi_i(\underset{\sim}{S}')|H-E|\phi_{k'}(\underset{\sim}{S}_{p'})\rangle \cdot \frac{b_{nk'p'}\,b_{nkp}}{E_n - E}\langle\phi_k(\underset{\sim}{S}_p)|H-E|\phi_j(\underset{\sim}{S})\rangle$$

where $\phi_i(\underset{\sim}{S})$ is a two-centre shell model function [1] projected onto the eigenspace of the operators for the total angular momentum of th system $\underset{\sim}{J}^2$ and J_z [3]. The generator parameter $\underset{\sim}{S}$ is the separation of the two shell model potentials. The coefficients b_{nkp} and the energies E_n are obtained by diagonalization of the Hamiltonian H in the basis of the functions $\phi_k(\underset{\sim}{S}_p)$ where the distance of the points $\underset{\sim}{S}_p$ from the origin is not greater than the sum of the radii of the two colliding nuclei.

For ^3H and ^4He in the incoming channel we calculate the cross section for the elastic scattering and for the reaction $^4He(t,n)^6Li$. In the case of collision of ^4He with ^6Li the elastic and the inelastic channel ($^6Li^*$, $J = 3^+$) are coupled. For pseudo-channels [3] in both cases the same fragmentation as in the corresponding elastic channels is assumed.

The form factors $\Delta_{ij}(\underset{\sim}{S}',\underset{\sim}{S})$ are calculated by the programming system for symbolic evaluation of algebraic expressions [4]. They are expanded in terms of partial waves of the relative motion in the channel i and j of the two shell model wells. These expressions contain a rather large number of terms ($\sim 10^{11}$ terms for $^4He + {}^6Li$).

Numerical evaluation of the cross sections is in progress.

References

1)M.V.Mihailović,L.J.B.Goldfarb,M.A.Nagarajan, Nucl.Phys. in press.
2)H.Friedrich,H.Hüsken and A.Weiguny, Nucl.Phys. A220(1974)125.
R.Beck,J.Borysovicz,D.Brink,M.V.Mihailović,Nucl.Phys.A244(1975)45.
3)M.V.Mihailović,M.Poljšak,another contribution to these Proceedings.
4)H.Strubbe, Comp. Phys. Comm. 8(1974)1.

COMPENSATION FOR NEGLECTING OPEN CHANNELS IN THE K-MATRIX APPROACH

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In collisions of nuclei the number of open reaction channels is usually large. In measurements and theoretical calculations one limits oneself only to few open channels. The effect of the neglected channels is usually compensated by introducing a phenomenological complex optical potential.

A new method for compensating for neglected open channels is proposed, which consists in introducing one (or few) additional "pseudo" channels defined by an average energy and a suitable description of channel fragments without modifying the Hamiltonian. When the K-matrix approach is used this method provides a unitary S-matrix. Another advantage of this approach is that one can perform the numerical calculation with real quantities only.

Let us consider a collision of two fragments with N_c open channels, $A_i + B_i \longrightarrow A_j + B_j$, $i,j = 1,\ldots,N_c$. Consider for the sake of simplicity the calculation of the cross section for elastic scattering. Let us call $\tilde{K}$ and $\tilde{S}$ the corresponding reactance and scattering matrix for a model system consisting of the elastic and a pseudochannel. The pseudochannel is then defined by

$$|\tilde{S}_{11} - 1| = |S_{11} - 1| \qquad (1)$$

so that the model two-channel system will produce the same elastic cross section as the true system. By using the relation $S = (1 + iK)/(1 - iK)$, eq. (1) reduces to the following condition for $\tilde{K}_{11}$, $\tilde{K}_{12}$ and $\tilde{K}_{22}$:

$$\tilde{K}_{11}^2 + \tilde{K}_{12}^2 (\tilde{K}_{12}^2 - 2\alpha^2) + \tilde{K}_{11} \tilde{K}_{12} (\tilde{K}_{11} \tilde{K}_{22} - 2\tilde{K}_{12}^2) - \alpha^2 \tilde{K}_{22}^2 = \alpha^2$$

where α^2 is a positive constant depending on S. This equation represents a surface which lies partly in the octant $\tilde{K}_{11}^2, \tilde{K}_{12}^2, \tilde{K}_{22}^2 \geqslant 0$ and therefore a real K-matrix exists. The existence of the K-matrix for more complicated situations can be proved similarly.

Some experience in choosing the parameters of the pseudochannel has been obtained from the calculations on soluble models for multichannel reactions [1]). The application to the microscopic theory of reactions of light composite nuclei is in progress.

References

1) W. Tobocman, Phys. Rev. 166(1968)1063.
H. Weidenmüller, Ann. Phys. 28(1964)60.
B.H.J. McKeller, J. Phys. G 1(1975)180.