

MICROSCOPIC THEORIES FOR THE DESCRIPTION OF NUCLEAR COLLISIONS

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Microscopic theories for the description of nuclear collisions are compared first and then a new theory which uses the two-centre generator coordinate basis is presented. Two centre generator coordinate (GC) basis offers the possibility to develop a microscopic theory in which Pauli principle is properly taken into account, the spurious c.m. motion is eliminated for collisions of similar mass nuclei, the angular momentum is projected and the calculation is tractable at least for light nuclei. The GC basis is spanned by the set $\{\phi_{AB}^{JM}(\underline{x}, \underline{S})\}$, $\phi_{AB}^{JM}(\underline{x}, \underline{S}) = P_M^J[\phi_{AB}(\underline{x}, \underline{S})]$, $\underline{x} = (\underline{x}_1, \dots, \underline{x}_{A+B})$, where $\phi_{AB}(\underline{x}, \underline{S} = \underline{S}_1 - \underline{S}_2) = \int \phi_A(\underline{x}_1, \dots, \underline{x}_A, \underline{S}_1) \cdot \phi_B(\underline{x}_{A+1}, \dots, \underline{x}_{A+B}, \underline{S}_2)$, ϕ_A and ϕ_B being superpositions of Slater determinants of harmonic oscillator single particle functions in the wells at \underline{S}_1 and \underline{S}_2 , respectively. The K-matrix is derived⁽¹⁾ from the Kato extremal principle by using the Kohn trial functions for the channel c of the form

$$\psi_c^{JM}(\underline{x}) = \sum_{p=1}^{N_D} f_{c,p}^{JM} \phi_{A_c B_c}^{JM}(\underline{x}, \underline{S}_p) + \int d^3S (f_{R,c}^{JM}(\underline{S}) + \sum_{c'} K_{c,c'}^t f_{I,c'}^{JM}(\underline{S})) \phi_{A_c B_c}^{JM}(\underline{x}, \underline{S}) .$$

The partial wave amplitudes $f_{R,c,L}^{JM}$ and $f_{I,c,L}^{JM}$ are related⁽¹⁾ to the Coulomb functions $F_L(kr)$ and $G_L(kr)$ by

$$\int \begin{Bmatrix} f_{C,R,L}(\underline{S}) \\ f_{C,I,L}(\underline{S}) \end{Bmatrix} = - \frac{1}{2}(r^2 + S^2) i_L(\sqrt{rS}) S^2 dS = \begin{Bmatrix} F_L(kr) \\ G_L(kr) \end{Bmatrix}$$

Kato's formula is applicable if channels are orthogonal. To achieve this one has to solve eq. (1) in a rather large internal ($0 < r \ll$ (sum of radii of fragments)).

The coefficients $f_{c,p}^{JM}$ describing the system when the fragments overlap are calculated from an integral equations of the Hill-Wheeler type. A method is developed for projecting⁽²⁾ two-centre functions onto the eigen space of angular momentum.

The microscopic Hamiltonian contains the Coulomb interactions and the nuclear interaction expressed in terms of a sum of Gaussian functions. The parameters of the nuclear two-body force are the only parameters in the theory.

Basic matrix elements $\langle \phi_{AB}(\underline{x}, \underline{s}') | H - E \cdot I | \phi_{AB}(\underline{x}, \underline{s}) \rangle$ are calculated analytically by using programs for symbolic algebra on computers (REDUCE 2, SCOONSCHIP).

A pseudo-channel (instead of an optical potential) is introduced in order to compensate neglected open channels.

The method is applied⁽³⁾ to reactions ${}^4\text{He} + {}^4\text{He}$, ${}^4\text{He} + {}^3\text{H} \rightarrow {}^4\text{He} + {}^3\text{H}$, ${}^6\text{Li} + n$ and ${}^4\text{He} + {}^6\text{Li} \rightarrow {}^4\text{He} + {}^6\text{Li}$, ${}^4\text{He} + {}^6\text{Li}^*$. The results of the calculation of the elastic scattering of ${}^4\text{He} + {}^4\text{He}$ and ${}^4\text{He} + {}^6\text{Li}$.

- 1) M.V.Mihailović, L.J.B.Goldfarb and M.A.Nagarajan, Nucl. Phys. A273 (1976) 207.
- 2) M.V.Mihailović and M.Poljšak, submitted to Phys. Letts.
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