Restoration of Heavy-Ion Potentials at Intermediate Energies

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Contrary to the usual phenomenological optical potentials the following forms are constructed:

\[ U^{A;B;C}_{\text{opt}}(r) = N^A_r V^H + i N^A_{im} W^H; \quad N^B_r V^{DF} + i N^B_{im} W^{DF}; \quad N^C_r V^{DF} + i N^C_{im} V^{DF}. \]

The suggested potentials are based on the microscopically calculated patterns for the real \( V^H \) and imaginary \( W^H \) parts of the potential obtained in [1], which reproduce the high-energy amplitude of scattering [2]. Another used template \( V^{DF} \) is calculated within the standard double-folding (DF) model with the exchange term included [3]. They are as follows

\[ U^H_{\text{opt}}(r) = V^H + i W^H = -\frac{2E}{k(2\pi)^2} \frac{d^2}{dq^2} j_0(qr) \tilde{\rho}_p(q) \tilde{\rho}_t(q) \tilde{f}_N(q), \]

\[ V^{DF}(r) = \int d^3 r_p d^3 r_t \rho^o_p(r_p) \rho^o_t(r_t) v^{D}_{NN}(r_{pt} = r + r_t - r_p) + \]

\[ + \int d^3 r_p d^3 r_t \rho^o_p(r_p, r_p + r_{pt}) \rho^o_t(r_t, r_t - r_p) v^{EX}_{NN}(r_{pt}) \exp \left[ -i K(r) r_{pt} \right]. \]

Here \( \tilde{\rho}_{p(t)}(q) \) are form factors of the point densities \( \rho_{p(t)}^o(r) \) of the projectile and target nuclei, \( \tilde{f}_N(q) \) is expressed through the form factor of the NN-scattering amplitude, \( \tilde{\sigma}_{NN} \) is the total cross section while \( \tilde{\sigma}_{NN} \) is the ratio of the real-to-imaginary part of the forward NN-scattering amplitude. The ”bar” means averaging on isotopic spins of colliding nuclei; \( K(r) \) is the local relative momentum motion of nuclei; \( Mm = A_p A_t m/(A_p + A_t) \) is the reduced mass; \( v_{NN} \) is the effective NN-potential given in [3].

Thus, we do not introduce free parameters except the \( N_r \) and \( N_{im} \) factors, the weights of contributions of the microscopic real and imaginary heavy-ion potentials of scattering. Doing so, we calculated within the high-energy approximation (HEA) (see, e.g. [4]) the differential cross-sections for scattering of the \(^{16,17}\text{O} \) heavy-ions on different target-nuclei at about hundred Mev/nucleon [1], [5], [6] and compare them with the experimental data from [7]. As an example the Fig. 1 shows that the potential \( U^A_{\text{opt}} = 1.13V^H + iW^H \) (dashed lines in (a),(b)) behaves in a peripheral region in coincidence with the phenomenological 4-parameter WS-potential [7], and results in the corresponding cross-section (dashed curve in (c)) closed to that calculated for the WS-potential.

Main conclusion is that the presented idea proves itself to utilize the microscopic models as patterns for further fit with the experimental data. Moreover, at high energy
interactions, one can be confident to claim that the results of the calculations done by using the microscopic potentials show that in the outer region of the interactions a true prediction and behavior of these potentials can be gained in the very sensitive domain of the heavy-ion scattering.

References