LOCAL AND GLOBAL NUCLEON OPTICAL MODELS FROM 1 keV TO 200 MeV

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The phenomenological, OMP for nucleon–nucleus scattering, U, is defined as

$$\begin{aligned} U(r,E) &= -V_V(r,E) - iW_V(r,E) + \\ &+ iW_D(r,E) + \left(V_{SO}(r,E) + iW_{SO}(r,E)\right)(\vec{l}\cdot\vec{\sigma}) + V_C(r), \end{aligned} \tag{1.1}$$

where $V_{V,SO}$ and $W_{V,D,SO}$ are the real and imaginary components of the volume-central (V), surface-central (D) and spin-orbit (SO) potentials, respectively. E is the laboratory energy of the incident particle in MeV. All components are separated in E-dependent well depths, V_V, W_V, W_D, V_{SO}, and W_{SO}, and energy-independent radial parts f, namely

$$\begin{aligned} V_V(r,E) &= V_V(E) f(r,R_V,a_V), \\ W_V(r,E) &= W_V(E) f(r,R_V,a_V), \\ W_D(r,E) &= -4a_D W_D(E)\frac{d}{dr} f(r,R_D,a_D), \\ V_{SO}(r,E) &= V_{SO}(E)\left(\frac{\hbar}{m_\pi c}\right)^2 \frac{1}{r}\frac{d}{dr} f(r,R_{SO},a_{SO}), \\ W_{SO}(r,E) &= W_{SO}(E)\left(\frac{\hbar}{m_\pi c}\right)^2 \frac{1}{r}\frac{d}{dr} f(r,R_{SO},a_{SO}). \end{aligned} \tag{1.2}$$

As usual, the form factor $f(r,R_i,a_i)$ is a Woods–Saxon shape

$$f(r,R,a) = \left(1+\exp\left[(r-R_i)/a_i\right]\right)^{-1}, \tag{1.3}$$

where, with A being the atomic mass number, the geometry parameters are the radius $R_i = r_i A^{1/3}$ and the diffuseness parameters a_i. For charged projectiles, the Coulomb term V_C, as usual, is given by that of a uniformly charged sphere

$$V_C(r) = \begin{cases} \dfrac{Zze^2}{2R_C}\left(3-\dfrac{r^2}{R_C^2}\right), & \text{for } r \le R_C, \\ \dfrac{Zze^2}{r}, & \text{for } r > R_C, \end{cases} \tag{1.4}$$

with $Z(z)$ the charge of the target (projectile), and $R_C = r_C A^{1/3}$ the Coulomb radius.

Proton OMP parameterization

The global proton OMP parameters for $0.001 \le E \le 200$ MeV and $24 \le A \le 209$ are given by

$$
\begin{aligned}
V_V(E) &= v_1\left[1 - v_2(E-E_f) + v_3(E-E_f)^2 - v_4(E-E_f)^3\right] + \\
&\quad + \overline{V}_C v_1\left[v_2 - 2v_3(E-E_f) + 3v_4(E-E_f)^2\right], \\
W_V(E) &= w_1\frac{(E-E_f)^2}{(E-E_f)^2 + w_2^2}, \\
r_V &= 1.3039 - 0.4054A^{-1/3}, \\
a_V &= 0.6778 - 1.487\times10^{-4}A, \\
W_D(E) &= d_1\frac{(E-E_f)^2}{(E-E_f)^2 + d_3^2}\exp\left[-d_2(E-E_f)\right], \\
r_D &= 1.3424 - 0.01585A^{1/3}, \\
a_D &= 0.5187 + 5.205\times10^{-4}A, \\
V_{SO}(E) &= v_{so1}\exp\left[-v_{so2}(E-E_f)\right], \\
W_{SO}(E) &= w_{so1}\frac{(E-E_f)^2}{(E-E_f)^2 + w_{so2}^2}, \\
r_{SO} &= 1.1854 - 0.647A^{-1/3}, \\
a_{SO} &= 0.59, \\
r_C &= 1.198 + 0.697A^{-2/3} + 12.994A^{-5/3}
\end{aligned}
\tag{1.5}
$$

where the units are in fm and MeV, and the parameters for the potential depths and E_f are the following

$$
\begin{aligned}
v_1 &= 59.3 + 21.0(N-Z)/A - 0.024A \quad (MeV) \\
v_2 &= 0.007067 + 4.23\times10^{-6}A \quad (MeV^{-1}) \\
v_3 &= 1.729\times10^{-5} + 1.136\times10^{-8}A \quad (MeV^{-2}) \\
v_4 &= 7\times10^{-9} \quad (MeV^{-3}) \\
w_1 &= 14.667 + 0.009629A \quad (MeV) \\
w_2 &= 73.55 + 0.0795A \quad (MeV) \\
d_1 &= 16.0 + 16.0(N-Z)/A \quad (MeV) \\
d_2 &= 0.0180 + 0.003802\big/\left(1 + \exp\left[\left(A-156\right)/8\right]\right) \quad (MeV^{-1}) \\
d_3 &= 11.5 \quad (MeV) \\
v_{\text{so1}} &= 5.922\text{+}0.003\text{A} \quad (MeV) \\
v_{\text{so2}} &= 0.004 \quad (MeV^{-1}) \\
w_{\text{so1}} &= -3.1 \quad (MeV) \\
w_{\text{so2}} &= 160 \quad (MeV) \\
E_f &= -8.4075 + 0.01378A \quad (MeV) \\
\overline{V}_C &= 1.73Z/R_C \quad (MeV)
\end{aligned}
$$