Coulomb distorted T-matrix Elements in Momentum Space

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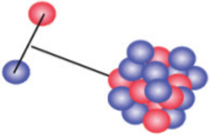
Motivation



(d, p) reactions

$\Downarrow$

Effective Three-Body problem

$\Downarrow$

Faddeev-AGS equations with Coulomb interaction without screening

$\Downarrow$

Interactions in two-body subsystems in separable form

- Faddeev-AGS equations $\Rightarrow$ preferrably solved in momentum space.
- No screening of Coulomb interaction $\Rightarrow$ Coulomb basis.

$\Downarrow$

Separable representation of optical $N + A$ potentials in Coulomb basis.

$n + A$ scattering

Generalized Ernst-Shakin-Thaler (EST) procedure
for non-Hermitian complex optical potentials

Two-body potential u.

$$\Downarrow$$

$$\text{Separable representation } \mathbf{U} = \sum_{ij} u|f_i\rangle\lambda_{ij}\langle f_j^*|u.$$

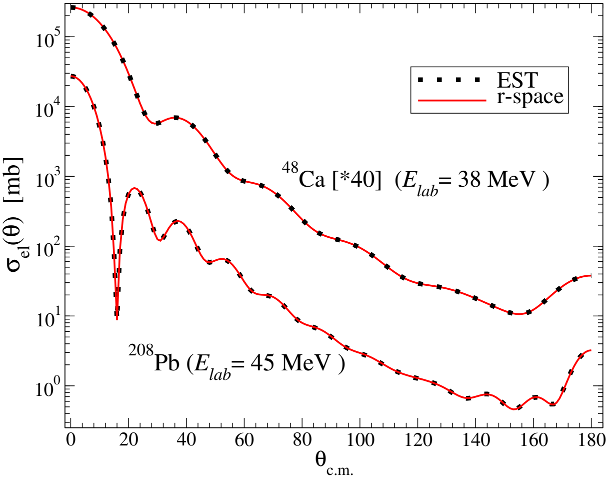
- Reproduces the scattering wave functions (half-shell t-matrices) at a given set of the energy points.
- Incoming and outgoing states are required to fulfill the reciprocity.

$$\Downarrow$$

$$\text{Two-body transition } t\text{-matrix } t = \sum_{ij} u|f_i\rangle\tau_{ij}(E)\langle f_j^*|u.$$

It works!
PRC **90**, 014615.

$n + A$ cross-section is reproduced by using rank 5 separable representation (^{12}C … ^{208}Pb)



$p + A$ scattering

Generalized Ernst-Shakin-Thaler (EST) procedure for charged particles

Two-body potential: $w = v^c + u^s$.

u^s = nuclear + short-range Coulomb.

$$\Downarrow$$

Scattering amplitude $f = f^C + M^{CN}$. (Two-potential formula)

$$\Downarrow$$

Coulomb distorted short-range scattering amplitude

$$M^{CN} \sim \langle \Phi_p^c | \tau^{CN} | \Phi_{p0}^c \rangle.$$

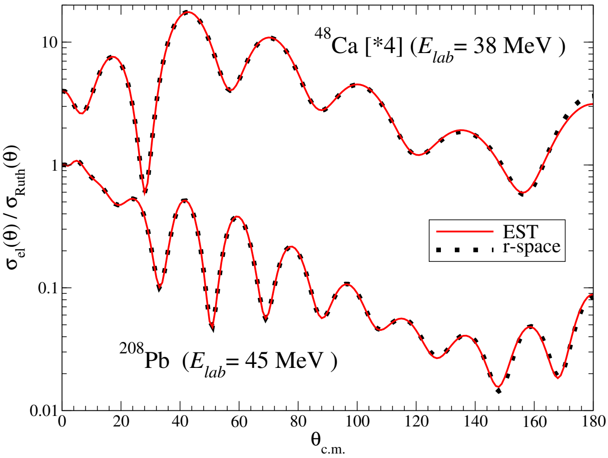
$$\Downarrow$$

$$\langle \Phi_p^c | \tau^{CN} | \Phi_{p0}^c \rangle = \langle \Phi_p^c | u^s | \Phi_{p0}^c \rangle + \int \frac{\langle \Phi_p^c | u^s | \Phi_q^c \rangle \langle \Phi_q^c | \tau^{CN} | \Phi_{p0}^c \rangle q^2 dq}{E_{p0} - E_q + i\varepsilon}.$$

$$\Downarrow$$

Separable t-matrix in Coulomb basis $\tau^{CN} = \sum_{ij} u^s | f_i^c \rangle \tau_{ij}^c \langle f_j^{c*} | u^s$.

$p + A$ cross-section is reproduced by using rank 5 separable representation (^{12}C … ^{208}Pb)



$n + A$ in Coulomb basis

From configuration space

$$\langle \psi^c_{lp} | u | f_{lk_E} \rangle = \langle \psi^c_{lp} | u | lk_E \rangle + \int \frac{\langle \psi^c_{lp} | u | lq \rangle \langle lq | u | f_{lk_E} \rangle}{E - E_q + i\varepsilon} q^2 dq,$$

$$\langle \psi^c_{lp} | u | lq \rangle = \int \frac{2r'^2 dr' \, r^2 dr}{\pi p r'} F_l(\eta', pr') \langle r' | u | r \rangle j_l(qr).$$

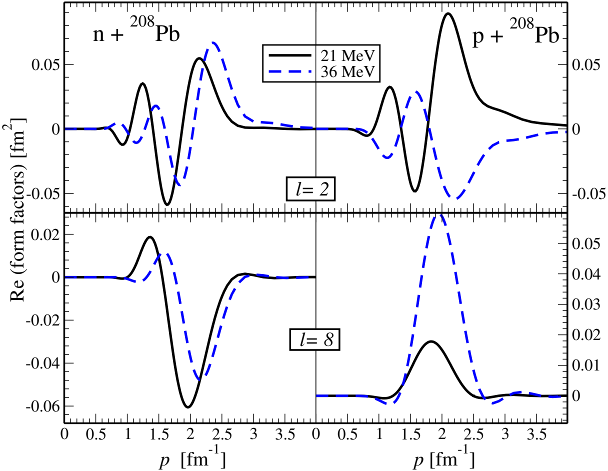
From momentum space

$$\langle \psi^c_{lp} | u | f_{lk_E} \rangle = \int \frac{dq \, q^2}{2\pi^2} u_l(q) \psi^c_{lp}(q)^*.$$

Gel'fand-Shilov regularization to deal with oscillatory singularity.
PRC **90**, 014615 and references therein.

Both ways lead to the same results.

Example: nucleon-^{208}Pb form factors in Coulomb basis



$n + A$ form factors differ from $p + A$.

Summary

- We can reliably represent optical potentials in separable form.
- We are providing reliable Coulomb distorted form factors for $p + A$ and $n + A$.

Near Future

Implementation of Faddeev-AGS equations in Coulomb basis for (d, p) reactions.