Momentum Space Coulomb Distorted Matrix Elements for Heavy Nuclei

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Single particle transfer reactions (d,p) involving rare isotopes are an important tool to study nuclear structure. In addition, one can connect the (d,p) process with the neutron capture process, a topic of great relevance to astrophysics and the questions around the synthesis of heavy elements. The (d,p) reaction may be viewed as a three-body $n+p+A$ problem, in which the deuteron and the nucleus A act as participants in the reaction. Currently, the most advanced momentum space Faddeev-type reaction calculations use a screening procedure for the Coulomb interaction, which is adequate only for light and medium mass nuclei [1]. Recently, a Faddeev-AGS formalism for (d,p) reactions with explicit inclusion of the unscreened Coulomb interaction was proposed [2]. A crucial difference here is the use of a Coulomb basis instead of the plane wave basis.

A first step in the practical implementation of this new formulation is the computation of vertex functions: these are matrix elements of Coulomb wavefunctions, $\psi^C_{q,l}(p)$, integrated with the nuclear form factor in momentum space [3]. Here the nuclear interactions are taken in separable form. Onshell $\psi^C_{q,l}(p)$ has as leading singularity $S(x) = x^{-1-i\eta}$, with $x = p - q$ and η being the Coulomb parameter. To regularize this singularity, one has to go beyond the 'principal value regularization' (Fig. 1), and apply the Gel'fand-Shilov regularization to estimate the contribution of the singular region. The integration, as well as the computation of $\psi^C_{q,l}(p)$ itself, require algorithmic care in order to obtain results with controllable accuracy. The calculation of these Coulomb distorted nuclear matrix elements will be shown.

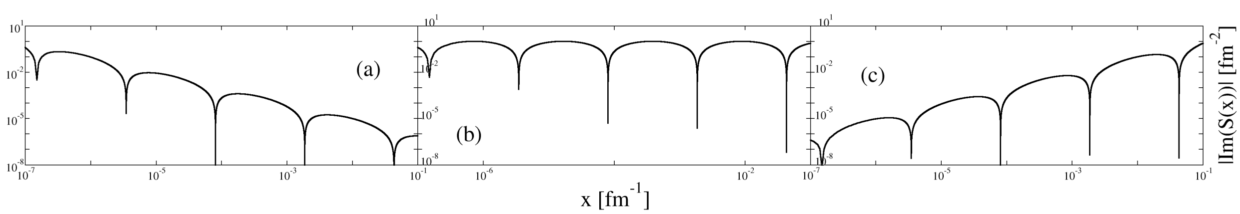

Figure 1: The singularity $|\Im m[S(x)]|$ near the on-shell point $x = 0$: (a) un-regularized, (b) with principal value regularization, and (c) with Gel'fand-Shilov regularization.

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[3] E. I. Dolinskii and A. M. Mukhamedzhanov. Sov. J. of Nucl. Phys. V. 3, 180 (1966).

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