Ab initio Nonlocal NCSM One-Body Densities as Input to Folding Potentials for Proton-Nucleus Scattering*

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Constructing effective interactions ('optical potentials') between a proton or neutron and a nucleus for computing elastic scattering observables has a long tradition. Based on a multiple scattering expansion for the nucleon-nucleus scattering problem, the first order term in this expansion requires a folding integral over a nonlocal one-body density and a nonlocal nucleon-nucleon (NN) scattering amplitudes, which may be represented as Wolfenstein amplitudes.

Thus, translationally invariant nonlocal densities are needed. Though it is standard to extract translationally invariant local one-body densities from the no-core shell model (NCSM) to calculate local nuclear observables like radii and transition amplitudes, the corresponding nonlocal one-body densities have raised several challenges. We developed the formalism to calculate these nonlocal one-body densities in momentum space using NCSM matrix elements and remove the center-of-mass contribution. In general one obtains a scalar as well as vector one-body density if one takes into account the spin of the nucleus. However, in traditional calculations of first order folding potentials only the scalar part is taking into consideration, assuming spin-saturated nuclei.

In this talk proton-nucleus elastic scattering observables calculated with *ab initio* first order folding effective interaction based on the scalar density will be shown for ^{4}He, ^{6}He, ^{12}C, and ^{16}O in the energy regime between 100 and 200 MeV laboratory kinetic energy. In addition, the expectation value of the spin-orbit contribution of the struck nucleon with respect to the rest of the nucleus will be discussed. This piece is constructed from the non-local spin density and in principle should contribute in an *ab initio* first order folding potential.

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