Nuclear Density

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Nonlocal nuclear density is derived from the no-core shell model (NCSM) one-body densities by generalizing the local density operator to a nonlocal form. The translational invariance (*trinv*) is generated by exactly removing the spurious center of mass (c.m.) component from the NCSM eigenstates expanded in the harmonic oscillator (HO) basis. This enables the *ab initio* NCSM nuclear structure to be used in intermediate energy nuclear reactions. The ground state local and nonlocal density of ^{4}He, ^{6}He, ^{8}He, ^{12}C, and ^{16}O are calculated to display the effects of c.m. removal on predicted nuclear structure. From these nonlocal densities, we can now construct more physically accurate optical potentials.

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I. WRITTEN

Hello there, my name is Michael Gennari and I am an undergraduate co-op working with Petr Navrátil in the theory group here at TRIUMF. There have been substantial advancements in developments of *ab initio* approaches to nuclear physics from which we can extract crucial quantities like nuclear densities.

Typically, two issues are not addressed. Often local densities are used as an approximation when generally we require a nonlocal density - nonlocal being in the sense of quantum nonlocality. The second issue is the contribution of a spurious centre of mass (c.m.) component from the single particle basis we use. My work has been to address these two issues and to explore the impact of their correction.

Looking to the figure in the top left, we have the translationally invariant (trinv) and c.m. contaminated (wiCOM) local density of ^{4}He. We can easily see how drastic the effect of c.m. removal is in light nuclei. We expect a huge impact on observables as a result.

Looking to the figure in the bottom left, we have the kinetic density for ^{4}He, a DFT quantity dependent on gradients of the nonlocal density. The translationally invariant density profile is very different from the c.m. contaminated one. By integrating the translationally invariant one we can reproduce the exact kinetic energy of the nucleus, which the c.m. contaminated density cannot do.

Finally, looking to the figure on the right we have some plots of the differential cross section for proton scattering off of ^{4}He. In the top plot, we have comparisons between the translationally invariant local and nonlocal density. We can pretty clearly see how much better the nonlocal density is at reproducing the data up to around 120 degrees. Now in the bottom plot we have the comparison between the c.m. contaminated and translationally invariant nonlocal density. Now we see the importance of translational invariance in our density as the trinv density more accurately reproduces the data.

Hopefully I have convinced you about how important having accurate nuclear densities.