A novel method for determining the effect of short range correlations on single particle density: Application to the charge density difference between the isotones ^{206}Pb – ^{205}Tl

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The relation between shell model wave functions and the real nuclear ones is rather complicated. Important information about it may be gleaned from the measurement of the charge distribution of the proton $3s_{1/2}$ orbit. This is given by the measured charge density difference, $\Delta\rho_c(r)$, between charge density distributions of the isotones ^{206}Pb – ^{205}Tl. The experimental data of the charge density shows a clear maximum at the center of ^{206}Pb with two additional maxima. This seems to be the shape obtained from a $3s_{1/2}$ single proton wave-function, in agreement with the simple shell model. It was pointed out in the literature that commonly used central potentials, such as the Wood-Saxon potential, lead to a $3s_{1/2}$ charge density in disagreement with experimental data. In particular, the central density obtained from the Woods-Saxon potential is too large by 40%. This difference between data and the Woods-Saxon results was considered earlier in the literature resulting with the statement that it is accounted for by the effect of two-body short range correlations (SRC) on the shell model wave functions. In this work [1] we take a closer look at the effect of SRC on the nuclear density.

Using the Jastrow many-body correlated wave function, with a two-body correlation factor, and employing the single pair approximation we derive a simple and accurate method (within few percent) for calculating the effect of (SRC) on the single particle density. Adopting the harmonic oscillator single particle wave functions we determined the effect of (SRC) on the charge densities of ^{206}Pb and ^{205}Tl. In Fig. 1 we show the results for the $3s_{1/2}$ single proton wave-function and compare with experiment. We have thus demonstrated that although the effect of SRC is to reduce the $3s_{1/2}$ single proton charge density at r = 0 by 30%, the calculated density disagrees with the experimental data by more than a factor of 2, particularly in the region of r = 2 – 4 fm.

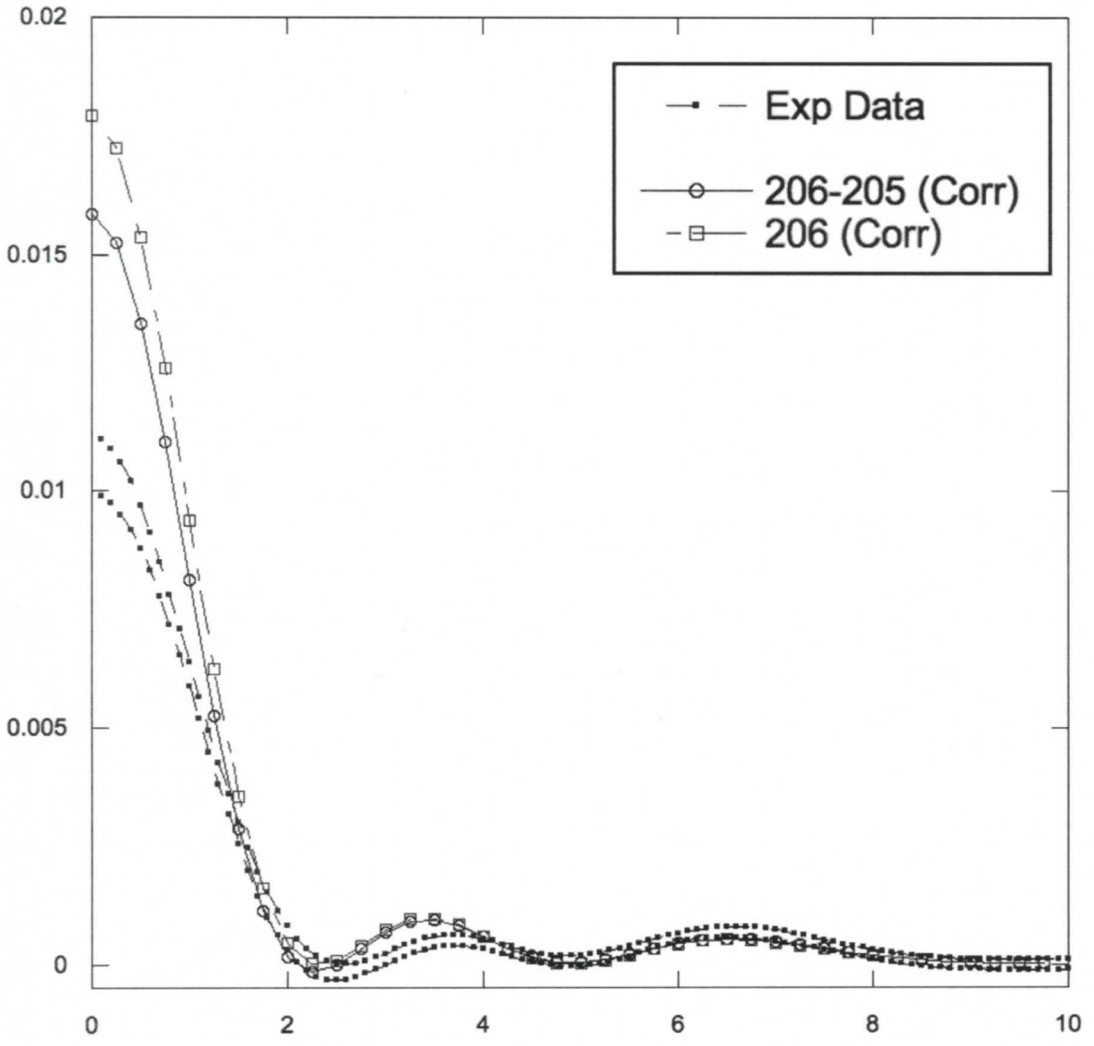

FIG. 1. Calculated (solid line) and experimental (dotted lines) difference, $\Delta\rho_c(r)$ between ^{206}Pb and ^{205}Tl charge distributions. The dashed dotted line is for the $3s_{1/2}$ proton orbit in ^{206}Pb.

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