Effects of long range correlations on nuclear charge radii in fully self-consistent Hartree-Fock RPA method

Tapas Sil,[1] and Shalom Shlomo
[1]*Department of Physics, VIT University, Vellore 632 014, TN, India*

Mean field model is very successful in describing various nuclear ground state properties. But there are many observed phenomena, such as the parabolic shape of isotopic shifts in the calcium chain (^{40}Ca to ^{48}Ca), for which one needs to consider correlation effects beyond the mean field. Systematic study of nuclear charge radii sheds light on nuclear structure and forces between nucleons. Highly accurate experimental data of nuclear charge radii are presently available which demand very accurate theoretical calculations. Random phase approximation (RPA) is one of the commonly used ways to take into account the ground state long range correlations (LRC) which are interpreted as zero point oscillations of collective vibrations.

We have employed highly accurate and fully self consistent Hartree-Fock (HF) based RPA calculations [1] to evaluate the corrections to the charge root mean square (rms) radii due to the LRC for several spherical nuclei (^{16}O, ^{40}Ca, ^{48}Ca, ^{56}Ni, ^{90}Zr and ^{208}Pb). We plot in the left panel of the figure,

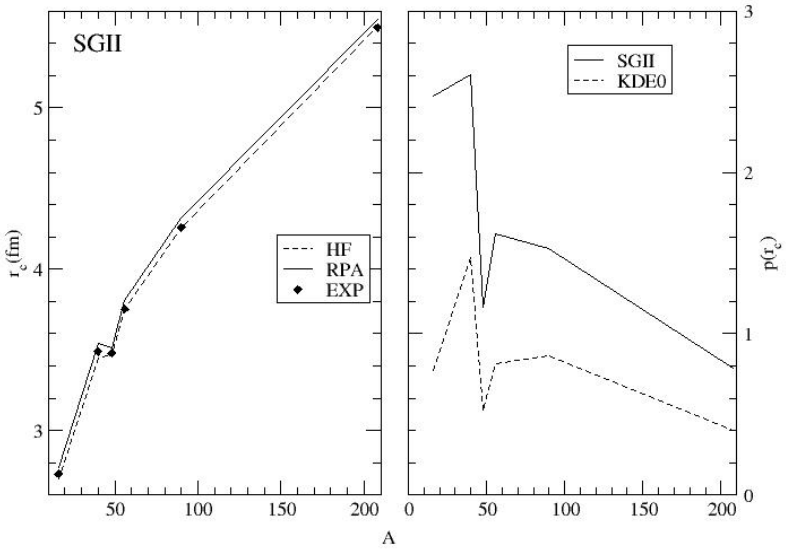

Figure 1. Long range correlation effects in charge radii

the charge rms radii calculated from HF ground state and compare them with those considering the LRC corrections. HF calculations in, over all, better agreement with the experimental values whereas those obtained from HF-RPA calculations overestimate the experimental data. This is because of that in the

fitting process for the interaction parameter sets within HF, these experimental values are used. But the qualitative trend of experimental data (r_c of ^{48}Ca is slightly smaller than that of ^{40}Ca) is better reproduced by the HF-RPA calculations. The percentage of the change of charge rms radii {$p(r_c)$ =100[r_c(RPA) - r_c(HF)]/ r_c(HF)} for the same nuclei are plotted in the right panel for the SGII and KDE0 forces. Qualitative trends are similar for both of the forces but the quantitative values of the corrections are somewhat different for different force [2].

[1] T. Sil, S. Shlomo, B. K. Agrawal and P.-G. Reinhard, Phys. Rev. C **73**, 034316 (2006).
[2] T. Sil, and S. Shlomo, (submitted).