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The first applications of the relativistic Second Tamm-Damncoff approximation in doubly-magic nuclei

Content

Understanding nuclear collective excitations and processes relevant to astrophysics requires theoretical frameworks that extend beyond the limitations of the Random Phase Approximation (RPA). The RPA, confined to a simple 1 particle - 1 hole (1p1h) configuration space, cannot fully capture the fragmentation and the spreading width of excitation spectra. To address this, we have developed a fully self-consistent Second Tamm-Dancoff Approximation (STDA) framework, incorporating complex 2 particle - 2 hole (2p2h) configurations. This approach, rooted in relativistic nuclear energy density functional theory, provides a comprehensive microscopic description of nuclear excitations. Our study focuses on isoscalar and isovector monopole and quadrupole, and isovector dipole transitions in \(^{16}\mathrm{O}\) and \(^{40}\mathrm{Ca}\). We have employed the subtraction method, thereby eliminating double-counting effects and ultraviolet divergence. Using the relativistic contact interaction with DD-PC1 parametrization in the particle-hole channel, we have analyzed the influence of energy cutoff for the 2p2h on the excitation spectra. We have calculated transition strength distribution of the giant resonances, the centroid energies and widths, and investigated the exhaustion of the summation rules. We performed a detailed analysis of the differences in the excitation spectrum arising from the application of the diagonal approximation compared to the full Second STDA. Furthermore, we investigated the impact of the subtraction method by comparing spectra obtained with and without its application. This dual comparison provides insight into the role of complex configurations and the elimination of double-counting effects in shaping the spectral characteristics.

Primary author: VALE, Deni (Istrian University of Applied Sciences, Preradovićeva 9D, 52100 Pula, Croatia)

Co-author: PAAR, Nils (University of Zagreb)

Presenter: VALE, Deni (Istrian University of Applied Sciences, Preradovićeva 9D, 52100 Pula, Croatia)

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