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Nuclear Physics With a Separable Monopole Interaction

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A new separable interaction was recently published[1] which described correlated ground states of spherical nuclei using many-body perturbation theory based on a zeroth order Hartree-Fock state. We summarize the philosophy behind the approach and the results obtained so far.

The separable monopole interaction consists of a sum of terms of the form $V(r_1, r_2) = \sum_i g_i(r_1)g_i(r_2)$. It is in the spirit of the separable multipole interactions (e.g. Quadrupole-Quadrupole[2]) with the difference that each function g carries no angular momentum and the interaction may be used to calculate bulk properties of nuclei and is not (just) a residual interaction. Like other separable interactions previously used[3] our interaction is weak enough with which to perform standard perturbation theory using the Hartree-Fock as a starting point. Unlike them, the new interaction is a density-dependent effective interaction, which means that the HF state can be a good starting point, giving already a reasonable description of data, on which to build correlations.

In a previous paper[1], calculations of the ground state masses of some spherical closed-shell nuclei both stable and far from stability were calculated including correlation up to third order. The results from this work were that the binding energies were reproduced reasonably throughout the periodic table, and that the corrections from perturbation theory were small and convergent, but not insignificant. It was argued that quantitative agreement could be further improved by completion of the force to include multipole forces and by use of a more sophisticated surface term and spin-orbit term in the effective monopole interaction. While work is underway in this regard, we are attempting to understand the physical properties of the interaction by application to further systems and observables.

Calculations of nuclear matter have been performed[4], both of Symmetric Nuclear Matter (SNM) in which the number of protons is equal to the number of neutrons, and Pure Neutron Matter (PNM), which consists of neutrons alone. The results from the parameterisation used in [1] proved to be of very good quality for SNM, as seen in the left-hand panel of Figure 1, where it (SMO1) is compared to a leading Skyrme parameterisation for the nuclear matter regime (SLy230a) and to a calculation made with the realistic Argonne + Urbana potentials (A18+δv+UIX). In PNM the results of SMO1 are perfectly respectable (see right panel of Figure 1), but a further parameterisation has been developed which is similar to SMO1 for finite nuclei and symmetric matter, but better in PNM. Using our nuclear matter equation of state (EoS) for n-p-e-μ in equilibrium and matching to other EoS's at appropriate boundaries of density, nonrotating neutron stars have also been calculated. We are preparing the results of neutron matter and neutron stars for publication.

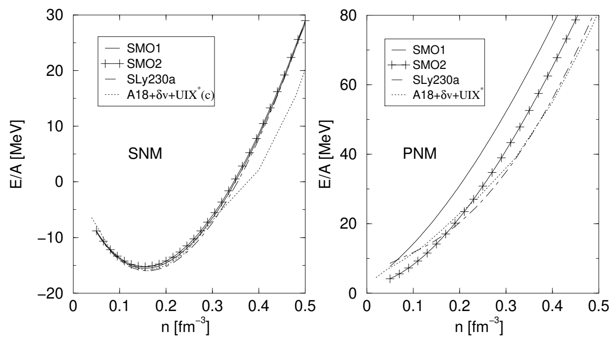

Fig. 1. Energy per particle for Symmetric Nuclear Matter (SNM) and Pure Neutron Matter (PNM)

References

1. P. Stevenson, M. R. Strayer and J. Rikovska Stone, *Phys. Rev.* **C 63** 054309 (2001).
2. Michel Baranger and Krishna Kumar, *Nucl. Phys.* **62** 113 (1965).
3. see A. Kerman, Cargése Lectures in Physics, Vol.3 p.396 (1969) for a summary.
4. J. Rikovska Stone, P. D. Stevenson, J. C. Miller and M. R. Strayer, to be published