Treatment of the continuum states in the Woods-Saxon Strutinsky method

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Strutinsky shell correction methods with finite height potentials have a well known problem [1] in applying to unstable nuclei: The level density around zero energy leads to an artificial increase. Kruppa et al. [2] have proposed a prescription with which one can get rid of the unwanted contribution of the particle gas to the level density by utilizing the Green function approach. Namely, a new level density is defined as the difference between two kinds of discrete level densities: $g_M(\epsilon) = \sum_{i=1}^{M} 2\delta(\epsilon - e_i) - \sum_{i=1}^{M} 2\delta(\epsilon - e_i^0)$, where e_i is a single particle level of the total Hamiltonian and e_i^0 is that of the free Hamiltonian in the same truncated subspace. The positive energy part of this modified level density does not diverge as the number of basis M is increased. However, this procedure does not guarantee the fulfillment of the plateau condition for the smoothed single-particle energy [3].

Recently, it has been shown [4] that the plateau condition can be satisfied by transforming the single-particle spectrum in such a way that its average level density coincides with some simple function. We employ this method, expecting that it works for the Woods-Saxon potential, too.

We have noticed that it is also necessary to modify the BCS gap equation in a similar manner as the Kruppa-Strutinsky method.

With these prescriptions, we have applied the Woods-Saxon Strutinsky method to unstable nuclei. We met another problem, however, that existing parameter sets of the Woods-Saxon potential are not suitable for dripline nuclei. We have calculated the driplines for several Woods-Saxon parameter sets and found that all of them have a tendency to retract inward the driplines compared with those predicted by empirical mass formulae. Therefore, it is necessary to find a new parameter set applicable not only to near stable nuclei but also to the driplines.

We are also applying the method to investigate the origin of the prolate dominance [5] by changing the potential parameters. In this case, increasing the diffuseness parameter of potential tends to unbound the nucleus. So it is necessary to adjust the potential depth as a function of the diffuseness. We determine the potential depth so that the Fermi level in the Thomas-Fermi approximation agrees with that calculated with a mass formula.

In summary, with several modifications, the Strutinsky shell correction method is now capable of treating neutron-rich nuclei because of the proper treatment of the continuum level density. It becomes possible to perform more accurate and reliable calculations of the nuclear masses to produce a new mass formula based on the Woods-Saxon Strutinsky method.

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