Mean-Field and RPA Approaches to Stable and Unstable Nuclei with Semi-Realistic Interactions*

H. Nakada
Department of Physics, Graduate School of Science,
Chiba University, Chiba 263-8522, Japan

We have developed semi-realistic NN interactions [1, 2] by modifying the M3Y interaction [3] that was derived from the G-matrix. The modification has been made so that the saturation and the spin-orbit splittings could be reproduced. The new interactions contain finite-range LS and tensor channels, as well as Yukawa-form central channels having reasonable spin and spin-isospin properties. In order to handle such interactions in practical calculations, we have also developed new numerical methods [4–6], in which the Gaussian expansion method [7] is applied. It is noted that these methods have the following advantages: (i) we can efficiently describe the energy-dependent asymptotics of single-particle wave functions at large r, as is typified in arguments on the deformed neutron halo in ^{40}Mg [6], (ii) we can handle various effective interactions, including those having non-locality, and (iii) a single-set of bases is applicable to wide mass range of nuclei and therefore is suitable to systematic calculations. Thereby we can implement Hartree-Fock, Hartree-Fock-Bogolyubov and RPA calculations for stable and unstable nuclei with the semi-realistic interactions.

It will be shown first that the new interactions have desired characters for the nuclear matter and for the single- and double-closed nuclei. We shall particularly focus on roles of specific channels of the effective interaction, by studying (a) 'shell evolution' and role of the spin-isospin and the tensor channels [8] in stable and unstable nuclei, and (b) the magnetic response in a fully self-consistent RPA calculation with the tensor force [9]. All these properties seem to be simultaneously and naturally reproduced by the semi-realistic interactions. Thus the semi-realistic interactions are promising in describing various aspects of nuclear structure from stable to drip-line nuclei, in a self-consistent and unified manner. Since they have microscopic origin with minimal modification, we can expect high predictability for unstable nuclei by applying these interactions. Prediction will be given for the neutron drip line for some isotopes and on excited states of several unstable nuclei.

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