Nuclear Shell Structure in Semi-Realistic Mean-Field Approach

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As typically manifested in magic numbers, the shell structure is one of the fundamental concepts in the nuclear structure physics. The experimental data in unstable nuclei have clarified [1] that the shell structure may depend on Z or N more strongly than expected from most conventional theories, and this discovery has stimulated to reexamine and refine theories relevant to the nuclear shell structure. As the new experimental facilities [2] are expected to access heavier unstable nuclei in coming years, it is desired to give predictions on the shell structure from the refined theories, which could be a good guidance to new experiments and will eventually be tested by them.

Concerning the Z or N dependence of the shell structure, two mechanisms have been argued: the absent or low centrifugal barrier in low-ℓ orbits near the drip lines, and influence of specific ingredients of the NN interaction; *e.g.* the tensor force. For full understanding of the shell structure in unstable nuclei, we should take both possibilities into account.

The mean-field (MF) theories are a good tool to study the nuclear shell structure from the nucleonic degrees of freedom. The author has recently developed semi-realistic NN interactions [3], and numerical methods for the MF and RPA calculations [4]. The semi-realistic interacions are obtained by modifying the M3Y interaction [5] so as to describe basic observed properties such as the saturation and the ℓs splitting. The numerical methods are applicable to finite-range interactions including the semi-realistic ones, and well take account of spatial extension of wave functions in drip-line nuclei. By applying the MF calculations with the newly developed methods and interactions, shell structure of the neutron-rich Ca and Ni nuclei has been investigated [6], with paying special attention to the magicity of $N = 32$, 34, 40 and 58. After surveying the results for these nuclei, I plan to present extensive investigation in other unstable medium-mass nuclei in this paper, particularly focusing on the (possible) magic numbers; *e.g.* $N = 28$ and $Z = 40$.

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