# Shell-model fits for $N = 82$ isotones

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Owing to the well-established shell gap at $Z = 50$ and 82, the shell model has been successfully applied for describing the structure of the $N = 82$ isotones with $50 < Z < 82$ by taking the valence single-particle orbits $0g_{7/2}$, $1d_{5/2}$, $0h_{11/2}$, $2s_{1/2}$ and $1d_{3/2}$ on top of an inert $^{132}$Sn core. The $N = 82$ isotones show various interesting features. For example, the excitation energy of the first $2^+$ state increases as a function of $Z$ and shows a prominent maximum at $Z = 64$, suggesting the development of a subshell gap. The lighter isotones with $Z < 64$ are dominated by mixed configurations of the lower two orbits ($g_{7/2}$ and $d_{5/2}$) with excitations to the upper orbits, while for the heavier ones the unique-parity high-$j$ orbit $h_{11/2}$ plays a crucial role. The systematics of yrast spectra and the property of some isomers are successfully explained by the seniority scheme. In addition, the development of the octupole collectivity has been observed in the low-lying states connected by strong $E3$ transitions.

It is interesting to investigate to what extent such variety of nuclear structures can be described within the shell-model framework. The effective interaction is a key ingredient to address this problem, which can be either determined purely empirically[1] or derived microscopically from the realistic nucleon-nucleon potential. The latter attempt has been extensively developed,[2,3] and the importance of the three-body force has been suggested to account for the deviation of the shell-model results from the experimental observations. Another possible approach for a better description of the experimental data is to modify such a microscopically determined effective interaction[4] by fitting the calculated energies to the experimental data. In this report, we present such fitting calculations for the $N = 82$ isotones. The similar analysis for Sn isotopes was reported previously.[5]

The single-particle energies of the $d_{5/2}$, $d_{3/2}$, and $h_{11/2}$ orbits relative to the $g_{7/2}$ are taken from the experimental energy spectra of $^{133}$Sb,[7] and only that of the $s_{1/2}$ orbit is determined by the fit. Starting from the microscopically derived effective interaction based on the N3LO potential,[6] we have carried out iterative fitting calculations. In the latest fit, 26 linear combinations of the fit parameters (*i.e.* 160 two-body matrix elements with $A^{-0.3}$ mass dependence and the single-particle energy of the $s_{1/2}$ orbit) have been modified, and we have attained a rms error of 142 keV for 338 energy data of 22 isotones.

Figure 1 illustrates the quality of the fit. It can be seen that the overall agreement between the shell-model results and the experimental data is quite good including the "magic"-like feature at $Z$=64. The fit is successful also for odd-$Z$ cases. The semi-empirical approach presented here would be useful not only for the analysis of experimental data but also as a reference for clarifying various effects such as the three-body forces that are not included in the present microscopic approach. It is also interesting to extend the scope of this interaction beyond the semi-magic nuclei by combining it with a suitable proton-neutron interaction.

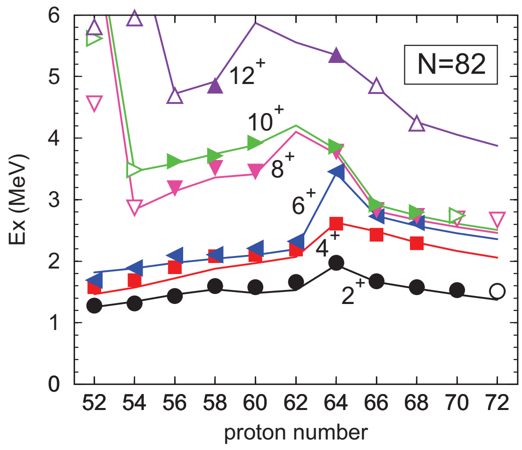

Fig. 1. Comparison of excitation energies of even-spin yrast states between the experimental data (symbols) and the shell-model results (lines). Experimental data are taken from Ref.[8] Open symbols indicate that the spin or parity assignment is uncertain. The shell-model results are obtained by using the efficient shell-model code MSHELL64[9].

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