Shell-model fits for Sn isotopes

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The Sn isotopes provide us with an ideal test for conventional shell-model calculations on the basis of the microscopic effective interaction theory and also the knowledge of nuclear forces. Because of the Z=50 semi-magic structure, the deformation is not significant, and the the shell-model description within a limited one-major shell is expected be reasonable. In fact, shell-model calculations using an effective interaction derived microscopically from a realistic nucleon-nucleon potential have been successfully applied for the analysis of new experimental data and also the prediction for unobserved properties[1].

However, such a microscopic approach is not necessarily successful in the middle of the neutron shell as shown in Ref.[2] for example, where the excitation energy of the 2_1^+ state is predicted to be too high by 0.4MeV for ^{118}Sn. On the other hand, it has been shown that the microscopic effective interaction can be improved for a practical use by fitting to the experimental data. Therefore, it is interesting to investigate how accurate the structure of Sn isotopes can be described by using such a fitted effective interaction. We report the results of such an attempt.

The adopted model space consists of five single-particle orbits $1d_{5/2}$, $0g_{7/2}$, $0h_{11/2}$, $2s_{1/2}$ and $1d_{3/2}$ in which the Sn isotopes are described by valence neutrons, and the $T = 1$ part of the two-body interactions is relevant. We start with an effective interaction obtained in a microscopic way as described in Ref.[3] using the N^{3}LO interaction[4]. A series of fitting calculations was carried out by taking 313 experimental energy data including 29 binding energies. We utilized the Linear-Combination (LC) method as in our previous approach[5]. We found that only a small modification was necessary to improve the microscopic interaction. In fact a reasonable convergence was obtained by varying only 22 LC's of 165 Hamiltonian parameters (5 single-particle energies and 160 two-body matrix elements). In the final fit, the rms deviation of 147 keV was obtained.

As an example of the results, the excitation energies of the yrast states of even-N isotopes are shown in Fig.1. One can find a reasonable agreement between the experimental data and the shell-model results throughout the isotope chain. The quality of the fit is similar for odd-N isotopes. The predicted ground-state spin of ^{101}Sn is $7/2^+$ rather than $5/2^+$, in good agreement with recent experimental observation.[6] The fit of the binding energy is basically successful for heavier isotopes, but the shell-model result begins to show underbinding as approaching ^{100}Sn. This result suggests the development of collectivity which can not be described by the present model space. Such a picture is consistent with the large B(E2) values below $N = 64$ observed in recent extensive measurements[7].

This fitted interaction can be a good starting point for extending the model space so as to describe the ^{100}Sn core excitations and also for the study of more neutron-rich isotopes.

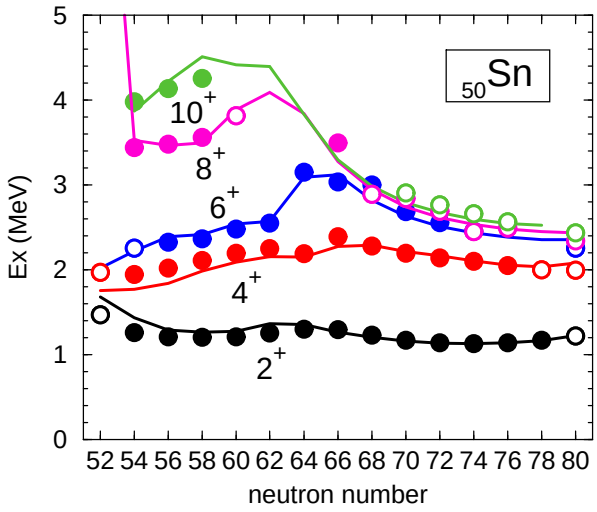

Fig. 1. Comparison of excitation energies of even-spin yrast states between the experimental data (symbols) and the shell-model results (lines). Experimental data are taken from Ref.[8] Open symbols indicate that the spin assignment is uncertain. The shell-model results are obtained by using the efficient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

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