Shell-model study of nuclear structure around ^{100}Sn

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The nuclear structure around the doubly-magic N=Z nucleus ^{100}Sn has been of great interest from various viewpoints such as the development of shell-structure and the proton-neutron correlations. For a reliable prediction of unknown targets by the shell model, one of our strategies is to minimally modify so-called G-matrix interactions$^{1)}$ by fitting the shell-model results to available experimental energy data. In the previous work$^{2)}$, we have determined an effective interaction called JUN45 in the model space covering nuclei with $28 \leq N, Z \leq 50$. Also, we have tried the shell-model fits to describe Sn isotopes with N=$50 \sim 82$ and obtained an effective interaction SNBG1$^{3)}$. Since the ^{100}Sn is located at the end of the model space in both studies, it was impossible to discuss the excitation across the N and/or Z=50 shell closure. In this report, we present another approach along this line, aiming at the description of nuclei including ^{100}Sn.

We take four single-particle orbits $1p_{1/2}$, $0g_{9/2}$, $1d_{5/2}$ and $0g_{7/2}$ for both protons and neutrons assuming a hypothetical "core" $^{76}_{38}$Sr$_{38}$. This choice is motivated by the excellent success of the $(p_{1/2}, g_{9/2})$ model space near the $N \sim 50$ lines due to the approximate degeneracy of these orbits around there, as suggested in Fig.1(a). Also, since the $7/2^+$ state comes down rapidly as the proton number is increased towards $Z = 50$ (see Fig.1(b)), the last two orbits $(d_{5/2}, g_{7/2})$ are essential. Based on the information about the dominant configurations obtained with the JUN45 and the SNBG1 interactions, we have selected the experimental data in the range of $47 \leq N \leq 58$ for the fit. In order to reduce the amount of computation for the fitting, we take the t=4 truncated model space, where t stands for the maximum number of nucleons that can excite from the $(p_{1/2}, g_{9/2})$ orbits to the $(d_{5/2}, g_{7/2})$ orbits relative to the naive lowest configuration. Starting from the G-matrix interaction derived from the N^{3}LO interaction$^{4)}$, we have carried out a series of iterative fits. We assume the isospin symmetry, and adopt the $A^{-0.3}$ mass-dependence of the two-body matrix element (TBME). In the latest fit, 197 TBMEs and 4 single-particle energies have been determined with a rms error of 231keV for 528 data.

As examples of the fitted results, the energy levels of low-lying states are shown in Fig.1 for odd-mass isotones with $N = 50$ and 51. It can be seen that the overall trends are reasonably described by the present shell-model calculations. As for ^{100}Sn, using this interaction at the $t = 6$ truncation level, the excitation energy of the 2^+_1 state is predicted to be 4.8MeV, and the 0p-0h component in the ground-state wavefunction is 71%. The calculated $B(\mathrm{E2};\, 0^+ \to 2^+)$=0.13 e^{2}b^2 with the effective charges e_p=1.5, e_n=0.5 is almost consistent with the shell-model result in a different model space$^{7)}$.

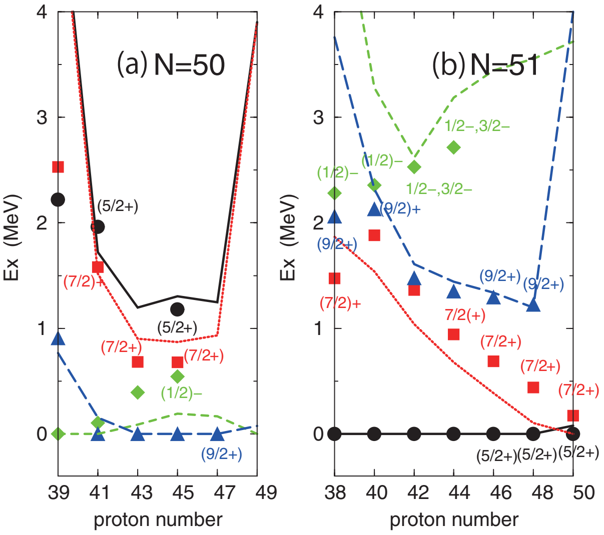

Fig. 1. Energy levels of low-lying states for (a) N=50 isotones with odd-number of protons and (b) N=51 isotones with even-number of protons. Calculated $1/2^-$, $9/2^+$, $5/2^+$ and $7/2^+$ states are shown with dashed, long-dashed, solid and dotted lines, respectively, which are compared with the experimental data denoted by diamonds, triangles, circles and squares, respectively. Experimental data are taken from Ref.$^{5)}$, where uncertain spin assignments are explicitly shown. The shell-model results are obtained by using the efficient code MSHELL64$^{6)}$.

References

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