Shell-Model Study of ^{110}Sn

A. Covello [a], A. Gargano [a], P. Guazzoni [b], L. Zetta [b], B.F. Bayman [c], G. Graw, R. Hertenberger, H.-F. Wirth, and M. Jaskóla [d]

[a] Dipartimento di Scienze Fisiche dell'Università and I.N.F.N, I-80126 Napoli, Italy
[b] Dipartimento di Fisica dell'Università and I.N.F.N, I-20133 Milano, Italy
[c] Physics and Astronomy Department, University of Minnesota, Minneapolis, USA
[d] Soltan Institute for Nuclear Studies, Warsaw, Poland

The present shell model study of ^{110}Sn complements the experimental work of Ref. [1] which concerns a new investigation of ^{112}Sn(p,t)^{110}Sn reaction.

Our calculation for ^{110}Sn has been performed assuming ^{100}Sn as a closed core, with the 10 valence neutrons occupying the five single-particle (SP) levels $0g_{7/2}$, $1d_{5/2}$, $1d_{3/2}$, $2s_{1/2}$, and $0h_{11/2}$ of the 50-82 shell. The two body effective interaction has been derived from the CD-Bonn nucleon-nucleon (NN) [2] potential. The difficulty posed by the strong short-range repulsion contained in the bare potential has been overcome by constructing a renormalized low-momentum potential, $V_{\mathrm{low-k}}$, that preserves the physics of the original NN potential up to a certain cutoff momentum Λ [3]. This is a smooth potential that can be used directly in the calculation of the shell-model effective interaction. We have used for Λ the value $2.1\,\mathrm{fm}^{-1}$ according to the criterion discussed in Ref.2.

Once the $V_{\mathrm{low-k}}$ is obtained, the calculation of the effective interaction is carried out within the framework of the $\hat{Q}$-box plus folded diagram method, as described in Ref. [3]. In our calculation of the $\hat{Q}$ box we include all diagrams up to second order and compute these diagrams by inserting intermediate states composed of particle and hole states restricted to the two major shells above and below the $N = Z = 50$ Fermi surface. A description of our derivation of the effective interaction can be found in Ref.4. Note that the effective interaction represents the interaction between two-valence neutrons outside the doubly closed ^{100}Sn and may be not completely adequate for systems with several valence particles, as is the case of ^{110}Sn. However, we have not attempted in the present study to modify the effective interaction derived as described above. As regards the neutron SP energies, they are the same as those used in the DWBA microscopic calculations [6]. The shell-model calculations have been performed by using the ANTOINE shell-model code [7].

We now compare our shell-model results with the experimental ones of Ref. [8]. In Table 1 all the experimental and calculated levels of ^{110}Sn up to about 3.0 MeV are reported. We have only excluded the 3^- state, whose calculated energy is rather higher ($\sim$ 1 MeV) than the observed one (2.45 MeV). This is not surprising since configurations outside our model space are likely to be important for this state. In the higher energy region only negative-parity states are reported. As may be seen in the table, some ambiguities are present in the experimental spectrum. In fact, 8 out of the 20 excited states have no, or no firm spin-parity assignment.

NDS J^π	NDS E_{exc}	Shell Model J^π	Shell Model E_{exc}	NDS J^π	NDS E_{exc}	Shell Model J^π	Shell Model E_{exc}
Positive Parity States							
0^+	0.00	0^+	0.00	$(6)^+$	2.75	5^+	2.61
2^+	1.21	2^+	1.73		2.80	2^+	2.79
(2)	2.12	4^+	2.20	(2,3,4,5)	2.82	4^+	2.89
4^+	2.20	6^+	2.32	2^+	2.83	2^+	2.91
0^+	2.30	0^+	2.36	2^+	2.91	3^+	2.98
4^+	2.45	6^+	2.41	(2^+ to 5^+)	2.95	0^+	3.11
6^+	2.48	6^+	2.51		2.96	3^+	3.13
2^+	2.54	2^+	2.51		2.98	4^+	3.22
0^+	2.58	4^+	2.55	4^+	2.98	0^+	3.23
4^+	2.69	1^+	2.56	(2^+)	3.00	5^+	3.28
0^+	2.74	3^+	2.60			2^+	3.29
Negative Parity States							
5-	3.36	5-	3.58	8-	3.77	9-	3.77
7-	3.69	7-	3.70	9-	3.93	8-	3.78

Table 1: ^{110}Sn Energy Spectrum

Here, we do not try to establish a one-to-one correspondence between theory and experiment, but make only some general remarks. First, we note that the number of calculated 0^+, 2^+, 4^+, and 6^+ states compares well with the observed one, being just the same for $J^\pi = 0^+$ and 4^+ and differing by one for $J^\pi = 2^+$ and 6^+ (five and three calculated states versus the six and two observed ones). This is so with our assignment $J^\pi = 2^+, 6^+$, and 2^+ to the observed states at 2.12, 2.75 and 3.00 MeV with $J^\pi = (2)$, $(6)^+$, and (2^+), respectively. Furthermore, from 2.6 to 3.3 MeV excitation energy we predict one 1^+ state, two 5^+ and three 3^+ states. In this energy range three states without spin and parity assignment have been observed at 2.80, 2.96, and 2.98 MeV and two states with $J^\pi = (2,3,4,5)$, and $(2^+, 3^+, 4^+, 5^+)$ at 2.82 and 2.95 MeV, respectively.

References

[1] P. Guazzoni *et al.*, this report, p.13
[2] R. Machleidt, Phys. Rev. **C63** (2001) 024001
[3] Scott Bogner, T.T.S. Kuo, L. Coraggio, A. Covello, and N. Itaco, Phys. Rev. **C65** (2002) 051301(R)
[4] T.T.S. Kuo, S.Y. Lee, and K.F. Ratcliff, Nucl. Phys. **A176** (1971) 62
[5] M.F. Jiang, R. Machleidt, D.B. Stout, and T.T.S. Kuo, Phys. Rev. **C46** (1992) 910
[6] B.F. Bayman *et al.*, this report, p.11
[7] E. Caurier, shell-model code ANTOINE, IRES, Strasbourg 1989-2002
[8] D. De Frenne and E. Jacobs, Nuclear Data Sheets **89** (2000) 481