# Realistic Shell-Model Calculations for $^{110}$Sn

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Along with the experimental work of Ref. [1], where $^{110}$Sn has been studied via the $^{112}$Sn(p,t)$^{110}$Sn reaction, we have performed shell model calculations for $^{110}$Sn, assuming $^{100}$Sn as closed core and letting the 10 valence neutrons occupy the five single-particle (sp) orbits in the 50-82 shell. The calculations have been carried out within the framework of the broken pair approximation, including states up to two broken pairs.

As residual interaction between the valence neutrons we have employed a realistic effective interaction derived from the Bonn-A nucleon-nucleon potential by way of a $G$-matrix folded diagram method. Similarly to our previous calculations for $^{114}$Sn [2], we have found that the agreement between theory and experiment for $^{110}$Sn is substantially improved by weakening the matrix elements of the effective interaction. In particular, it turns out that all the calculated excitation energies go in the right direction when the $J^\pi = 0^+$ matrix elements are reduced by a factor of 0.85. Our adopted values for the sp energies are (in MeV): $\epsilon_{d5/2} = 0.0$, $\epsilon_{f7/2} = 0.05$, $\epsilon_{s1/2} = 2.30$, $\epsilon_{d3/2} = 2.45$, and $\epsilon_{h11/2} = 3.25$. They have been determined by reproducing the observed one-particle states in $^{111}$Sn.

The experimental [3] and theoretical spectra of $^{110}$Sn are compared in Table I, where all the calculated and experimental levels up to about 3.0 MeV are reported. We have only excluded the second and third $0^+$ excited states as well as the $3^-$ state observed at 2.46 MeV. The calculated energies for these states are, in fact, rather higher (about 800 keV) than the obverved ones. This is not surprising since configurations outside of our model space are likely to be important for the $3^-$ state, while for the description of excited $0^+$ states the two-broken pair approximation is, in general, not quite adequate. In the higher energy region only negative-parity states are reported as shown in Table II.

It should be noted that 8 out of the 18 excited states in the experimental spectrum of Table I have no , or no firm, spin-parity assignments. Up to about 3.0 MeV we predict the same number of states, but for some of them we cannot establish a safe correspondence with the observed levels owing to the ambiguities present in the experimental spectrum. However, we tentatively suggest the assignments $J^\pi = 3^+$ and $5^+$ to the two experimental levels at 2.80 and 2.82 MeV, and try to identify the three levels at 2.95, 2.96, and 2.98 MeV with our calculated $J^\pi = 4^+$, $3^+$ and $3^+$ states at 2.83, 2.98, and 3.10 MeV, respectively. As regards the (2), $(6)^+$, and $(2^+)$ experimental states at 2.12, 2.75, and 3.0 MeV, respectively, we identify them with the calculated states at 2.46, 2.60, and 3.17 MeV. With this correspondence the experimental and calculated excitation energies do not differ by more than 200 KeV, the only exceptions being the $2^+$ and (2) states at 1.21 and 2.12 MeV whose energies are overestimated by about 350 MeV. For most of the states reported in Table I, as well as for the negative-parity states of Table II, the discrepancy between theory and experiment is less than 150 keV.

Table 1: Experimental and calculated levels in $^{110}$Sn up to about 3.0 MeV excitation energy.

| $J^\pi$ | $E_{\rm expt}$(MeV) | $J^\pi$ | $E_{\rm calc}$(MeV) |
|---|---|---|---|
| $0^+$ | 0.0 | $0^+$ | 0.0 |
| $2^+$ | 1.21 | $2^+$ | 1.56 |
| (2) | 2.12 | $4^+$ | 2.23 |
| $4^+$ | 2.20 | $0^+$ | 2.34 |
| $0^+$ | 2.30 | $6^+$ | 2.36 |
| $4^+$ | 2.45 | $2^+$ | 2.46 |
| $6^+$ | 2.48 | $4^+$ | 2.58 |
| $2^+$ | 2.54 | $6^+$ | 2.60 |
| $4^+$ | 2.69 | $3^+$ | 2.61 |
| $(6)^+$ | 2.75 | $5^+$ | 2.62 |
| | 2.80 | $2^+$ | 2.65 |
| (2, 3, 4, 5) | 2.82 | $2^+$ | 2.70 |
| $2^+$ | 2.83 | $4^+$ | 2.76 |
| $2^+$ | 2.91 | $4^+$ | 2.83 |
| $(2^+, 3^+, 4^+, 5^+)$ | 2.95 | $3^+$ | 2.98 |
| | 2.96 | $4^+$ | 2.98 |
| | 2.98 | $2^+$ | 3.09 |
| $4^+$ | 2.98 | $3^+$ | 3.10 |
| $(2^+)$ | 3.00 | $2^+$ | 3.17 |

Table 2: Experimental and calculated excitation energy for negative-parity levels in $^{110}$Sn.

| $J^\pi$ | $E$(MeV) Expt. | Calc. |
|---|---|---|
| $5^-$ | 3.36 | 3.38 |
| $7^-$ | 3.69 | 3.53 |
| $8^-$ | 3.77 | 3.82 |
| $9^-$ | 3.93 | 3.86 |

## References

[1] P. Guazzoni *et al.*, this report **??**
[2] A. Covello *et al.*, in Proc. the 7th Int. Spring Seminar on Nucl. Phys., Maiori, 2001, ed. A. Covello, World Scientific, Singapore, 2002, p. 327.
[3] NNDC On-Line Data Service from the ENSDF database.