Shell Model Description of $^{107,109,111}Sn$ *

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Motivation

Objectives:

- Describe the nuclei as a system of nucleons interacting via realistic interactions.
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Motivation

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$Z = 50$ Shell Gap near ^{100}Sn from Intermediate-Energy Coulomb Excitations in Even-Mass $^{106-112}$Sn Isotopes

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Rare isotope beams of neutron-deficient ^{106,108,110}Sn from the fragmentation of ^{124}Xe were employed in an intermediate-energy Coulomb excitation experiment. The measured $B(E2, 0_1^+ \rightarrow 2_1^+)$ values for ^{108}Sn and ^{110}Sn and the results obtained for the ^{106}Sn show that the transition strengths for these nuclei are larger than predicted by current state-of-the-art shell-model calculations. This discrepancy might be explained by contributions of the protons from within the $Z = 50$ shell to the structure of low-energy excited states in this region.

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Motivation

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THE EUROPEAN PHYSICAL JOURNAL A

Gamma-ray spectroscopy in ^{110}Sn and ^{111}Sn

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Abstract. Excited states in ^{110}Sn and ^{111}Sn nuclei have been investigated using in-beam γ-ray spectroscopic methods. An ^{16}O beam with an energy of 60–80 MeV was used to bombard a ^{98}Mo target. On the basis of the relative excitation functions, γ-ray angular distributions, γ-γ and γ-time distributions, γ-ray multiplicity and total energy data, the level schemes of ^{110}Sn and ^{111}Sn have been studied and extended up to $E_{\rm exc} \sim 11.5$ MeV, $I = 24\hbar$, and $E_{\rm exc} \sim 11.1$ MeV and $I = (51/2)\hbar$, respectively. An extension of the intruder, g.s. and negative-parity bands, as well as 5 new band-like structures are proposed in ^{110}Sn. The nature of newly introduced collective band 8 as well as 10^+ states fed in the decay of the collective band is discussed. In the ^{111}Sn nucleus an intruder band based on the $23/2^-$ state has been reinvestigated and the extension of the g.s. band and second negative-parity band is given. Evidence for neutron-core coupling in ^{111}Sn is found. The structure and systematics of excited states in light Sn isotopes is discussed.

Motivation

PHYSICAL REVIEW C, VOLUME 65, 044330

β decay studies of ^{109,107}Sb

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Low-spin, low energy-levels in ^{109,107}Sn have been studied following the β-decay of a 17-s ^{109}Sb and a 4-s ^{107}Sb, respectively. A number of new transitions and levels are established in ^{109}Sn with improved support for spin and parity assignments for previously known states. In addition, the presence of two pairs of levels separated by only 14 keV is confirmed. Four new levels are observed in ^{107}Sn, three of them are below 1 MeV excitation energy. The structure of these nuclides is discussed, focusing on three-quasiparticle cluster structures, movement of the Fermi level, and extrapolations for the single-neutron levels in ^{101}Sn.

DOI: 10.1103/PhysRevC.65.044330 PACS number(s): 23.40.−s, 23.20.Lv

I. INTRODUCTION

Excitation energies for the single-neutron $d_{5/2}, g_{7/2}, d_{3/2}$,

$Q=25$; nuclei with $A=108$ and $Q=25$ are produced with a higher cross section and form a tail under the $A=109$ recoil peak exiting the FMA. Mechanical slits were used on either

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Methods:

- Standard Shell Model (SSM) with Drexel University Shell Model (DUSM) code.
- A method based on group theory

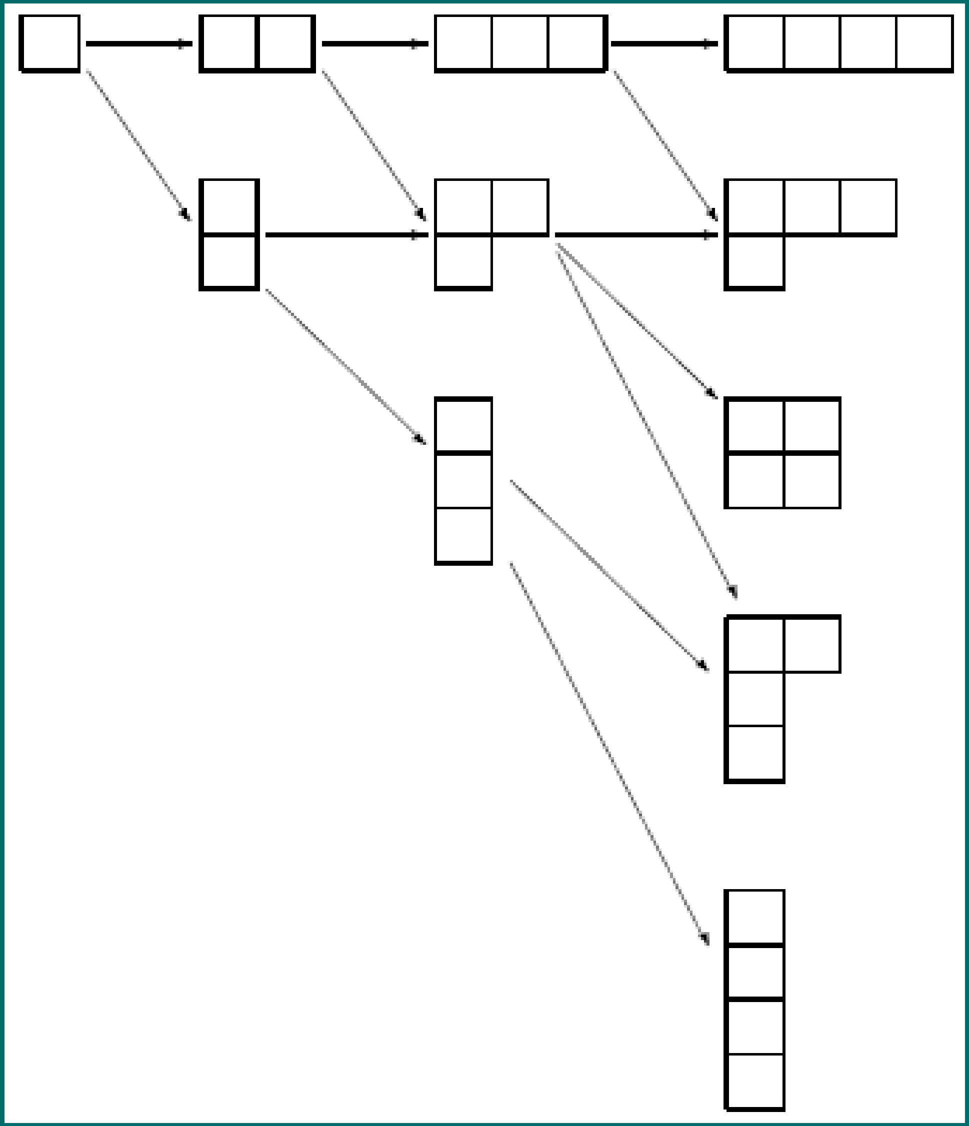
Drexel University Shell Model (DUSM) Code

DUSM algorithm:

- Permutational group concept
- JT Hilbert space separation
  - Multi-shell aspect : J-space
  - Single-shell aspect : T-space
- Recursive computation of wavefunctions of arbitrary permutational symmetry in each shell in both subspaces.
  - Preliminary step: construct all Young frames with up to N boxes

DUSM Algorithm

Branching diagram for the Young frames up to 4 particles:



DUSM Algorithm

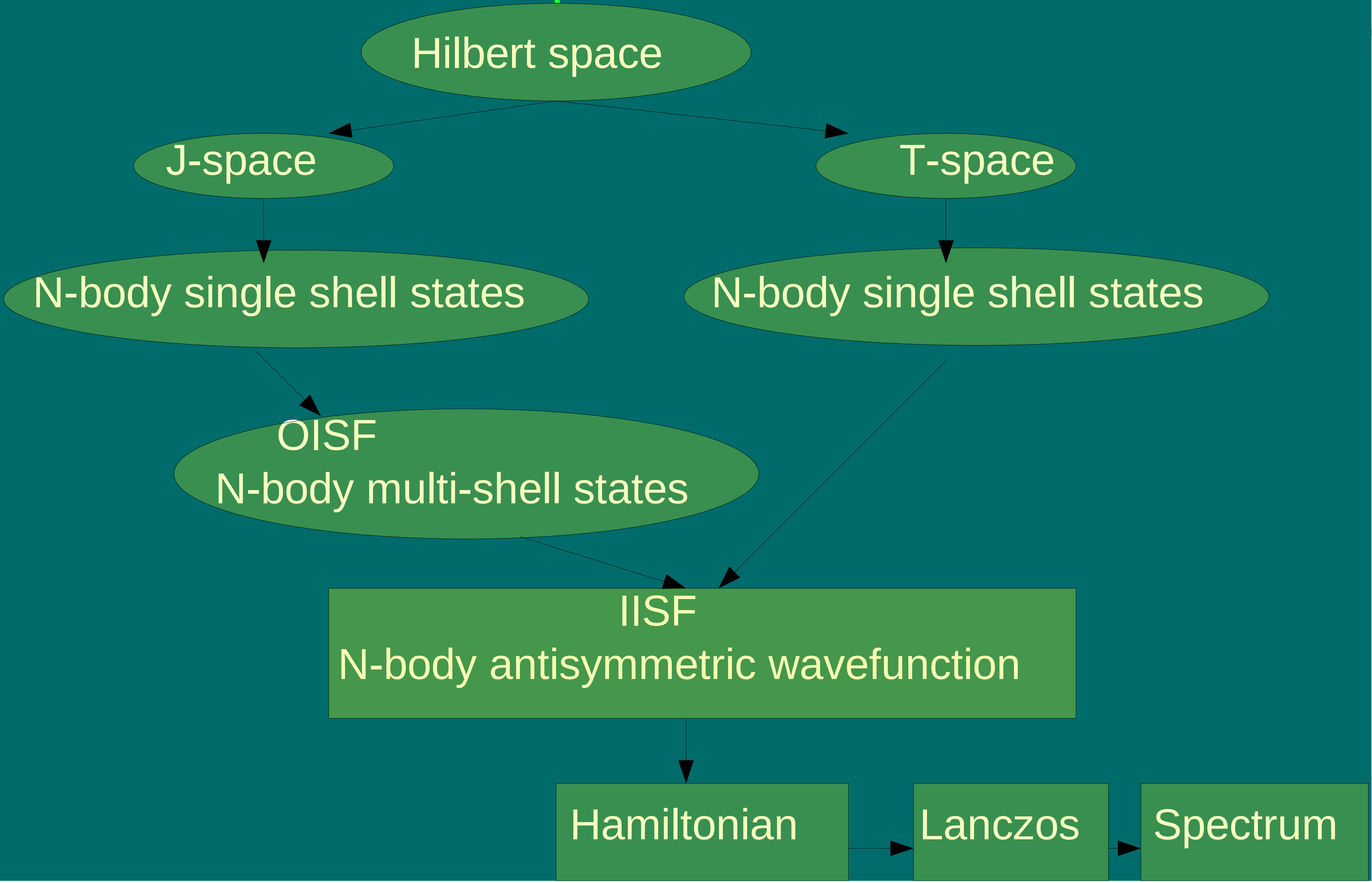
- Computation of matrix elements of a^+,a^+a, ..., a^+a^+aa within J and T subspaces
  - proportional to corresponding CFPs
  - CFP generated by diagonalization of SU(2j+1) Casimir operator
  - CFP labeled by permutation group labels and angular momentum labels
- Recursive computation of coupling coefficients for outer product of wavefunctions of arbitrary symmetry in different shells (OISF).
- Recursive computation of coupling coefficients for inner product of wavefunctions of arbitrary symmetry in different subspaces (IISF) to form a global antisymmetric wavefunction.

DUSM Algorithm

- Calculation of Hamiltonian matrix using :
  - Matrix elements of elementary operators,
  - Coupling coefficients; OISF and IISF
  - Given single particle and potential matrix elements

- Exact diagonalization or Lanczos diagonalization of Hamiltonian matrix

Schematic Representation of DUSM



DUSM Improvement

Sn isotopes $T_z = T_{max}$ ----> one column with n boxes

- For a nucleus in *sdgh* shell ---> include all the single shell states of $h_{11/2}$ which belong to 90 two column irreps (24 valence nucleons with maximum 12 rows)

- To model Sn isotopes, it is enough to consider only 12/90 irreps:
  - 12 one column irreps : [1] [11],.......,[11111111]

- This truncation is exact. This saves great memory for the single shell states (especially for higher j value of the single shell).

DUSM Improvement

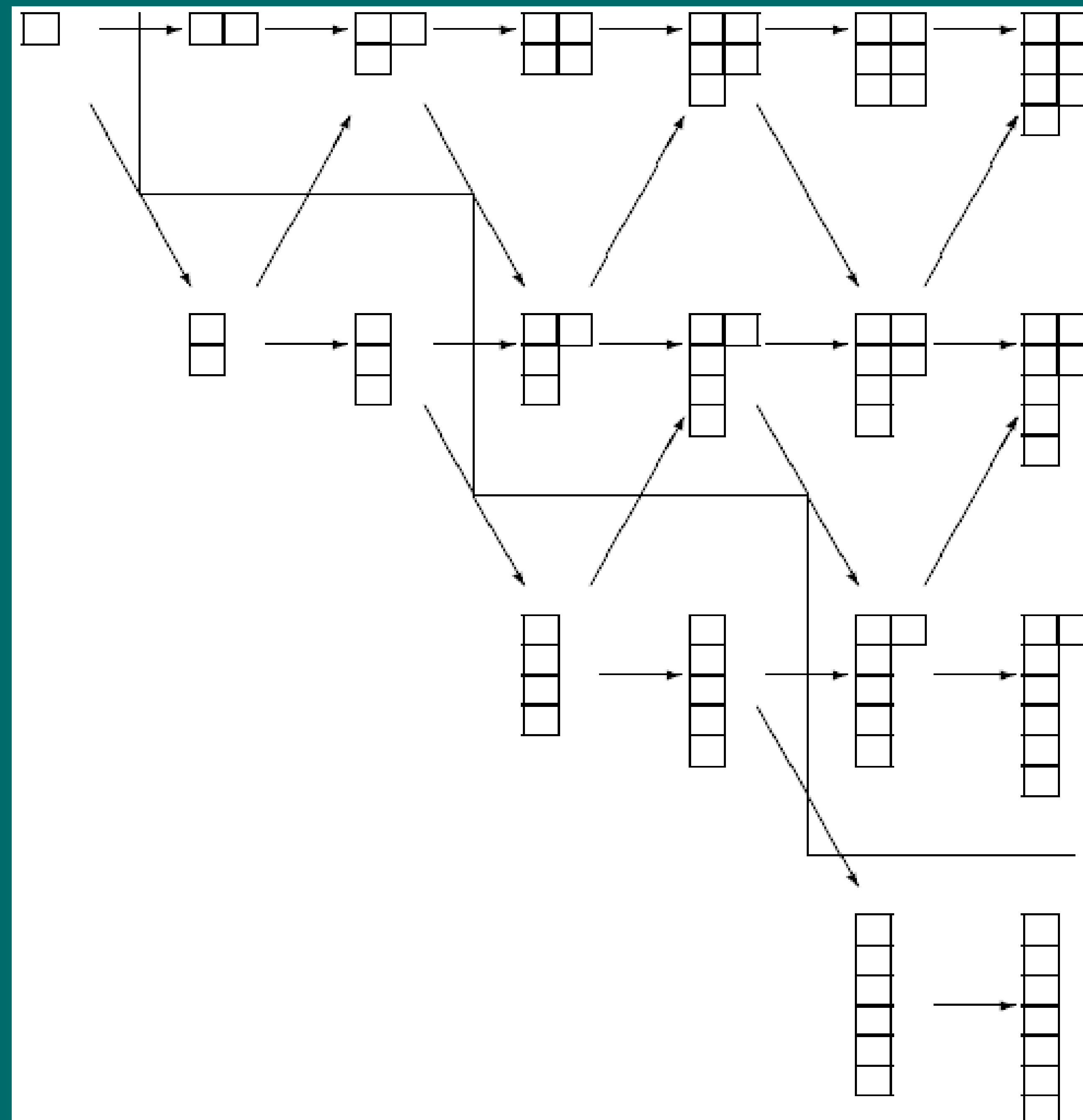
Two column irreps

for 1-7 particles:

19

For Sn isotopes:

only 7 irreps



Effective Interactions and s.p.e.

Most popular effective interactions in *sdgh* shell are:

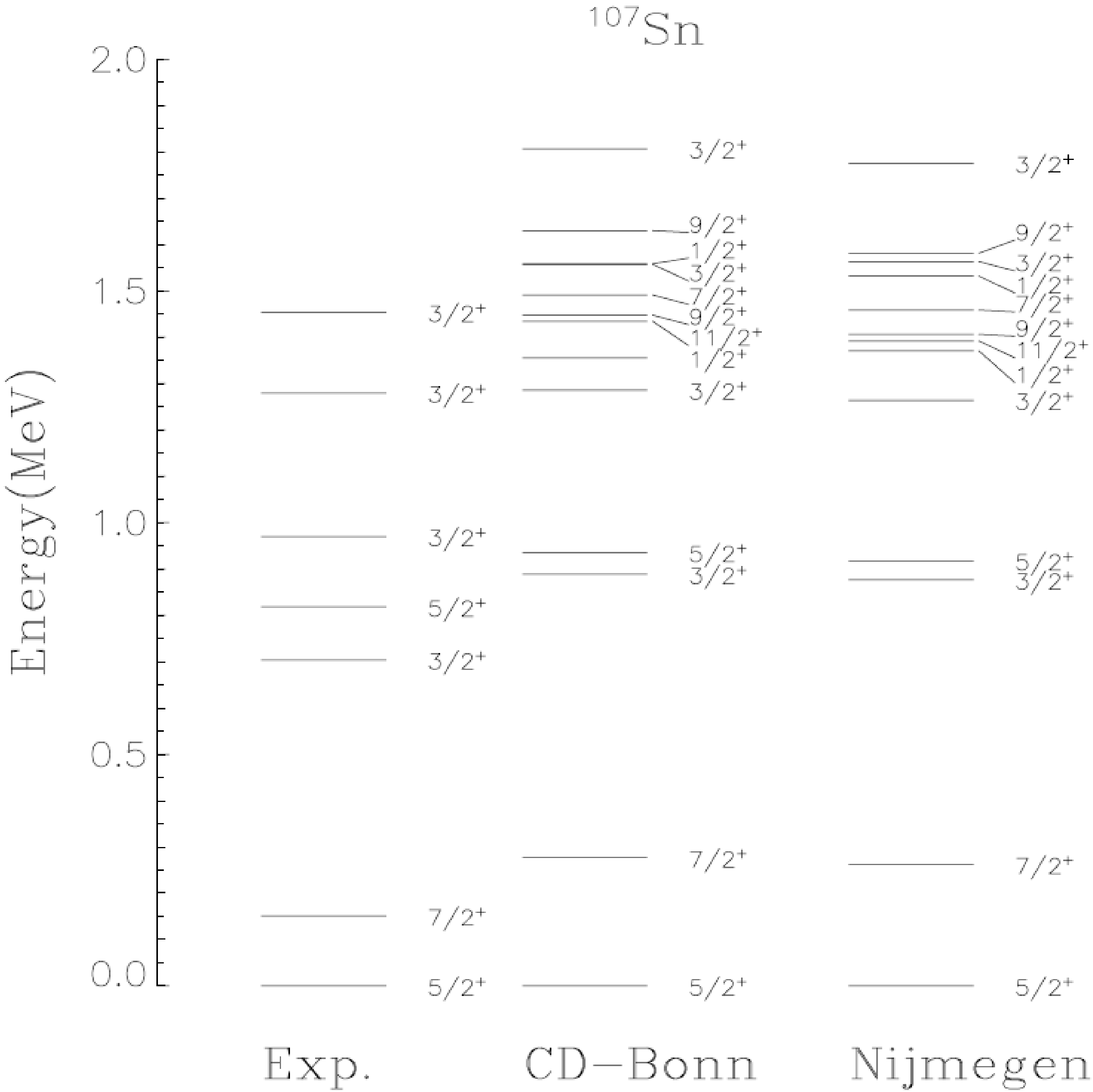
- CD-Bonn ----> Momentum space
- Nijmegen1 ----> Coordinate space

obtained from Oslo Group

Single particle energies (s.p.e):

$0h_{11/2}$	3.20 MeV
$1d_{3/2}$	2.55 MeV
$2s_{1/2}$	2.45 MeV
$0g_{7/2}$	0.08 MeV
$1d_{5/2}$	0.00 MeV

Shell model states of ^{107}Sn



Shell model states of ^{107}Sn

The ground state configuration:

- coupling of s.p. $1d_{5/2}$ neutron and ^{106}Sn core

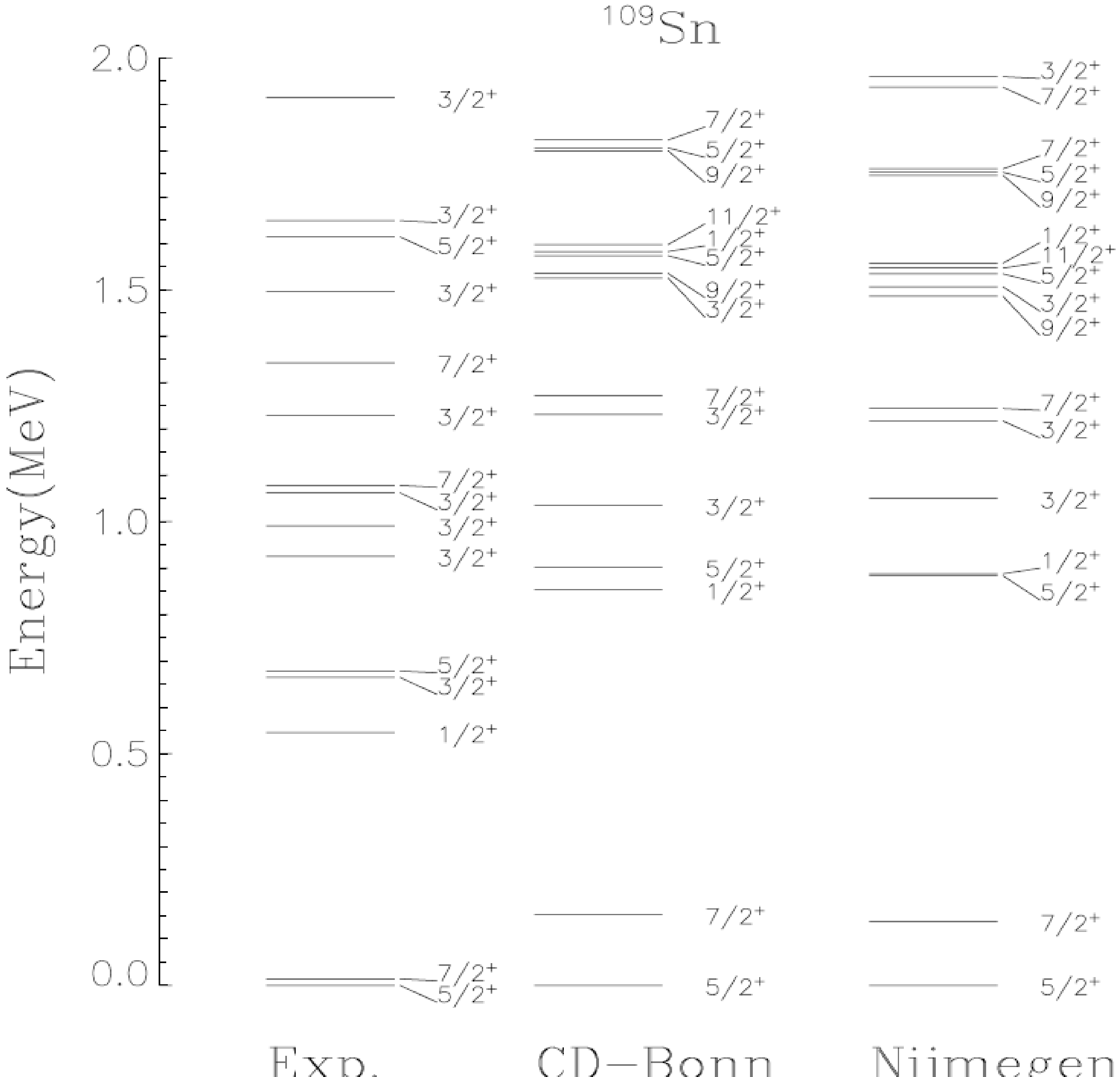
$$\nu d_{5/2} \otimes \{^{106}\mathrm{Sn}\}_{0^+}$$

The first excited state configuration:

- coupling of s.p. $0g_{7/2}$ neutron and ^{106}Sn core

$$\nu g_{7/2} \otimes \{^{106}\mathrm{Sn}\}_{0^+}$$

Shell model states of ^{109}Sn



Shell model states of ^{109}Sn

The ground state configuration:

- coupling of s.p. $1d_{5/2}$ neutron and ^{108}Sn core

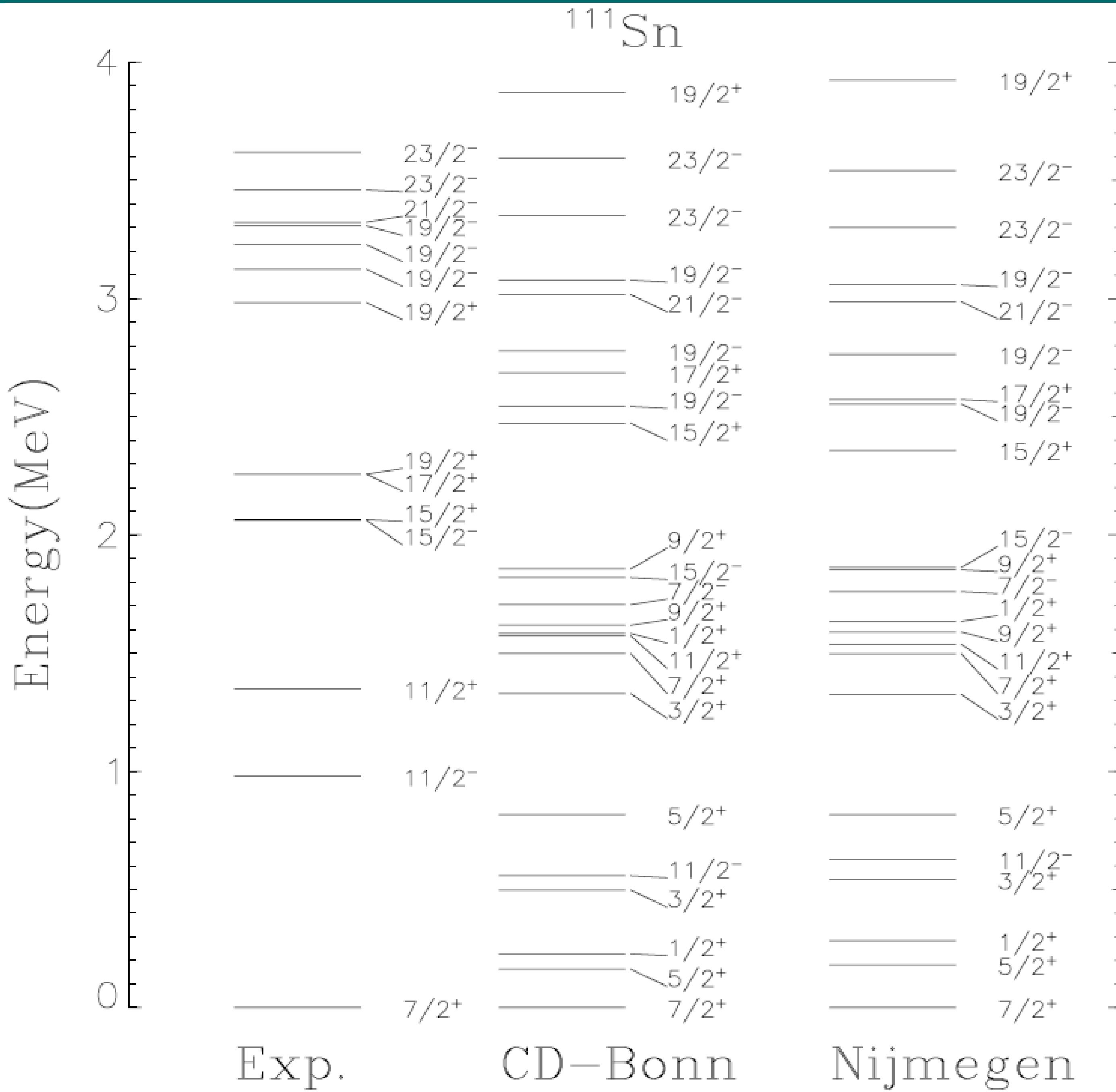
$$\nu d_{5/2} \otimes \{^{108}\mathrm{Sn}\}_{0^+}$$

1st excited state configuration: $$\nu g_{7/2} \otimes \{^{108}\mathrm{Sn}\}_{0^+}$$

2nd excited state configuration: $$\nu s_{1/2} \otimes \{^{108}\mathrm{Sn}\}_{0^+}$$

3rd and 4th excited state configuration: → similar discussion!

Shell model states of ^{111}Sn



Shell model states of ^{111}Sn

The ground state configuration:

- coupling of s.p. $0g_{7/2}$ neutron and ^{110}Sn core

$$\nu g_{7/2} \otimes \{^{110}\mathrm{Sn}\}_{0+}$$

The first exp. excited state configuration:

- coupling of s.p. $0h_{11/2}$ neutron and ^{110}Sn core

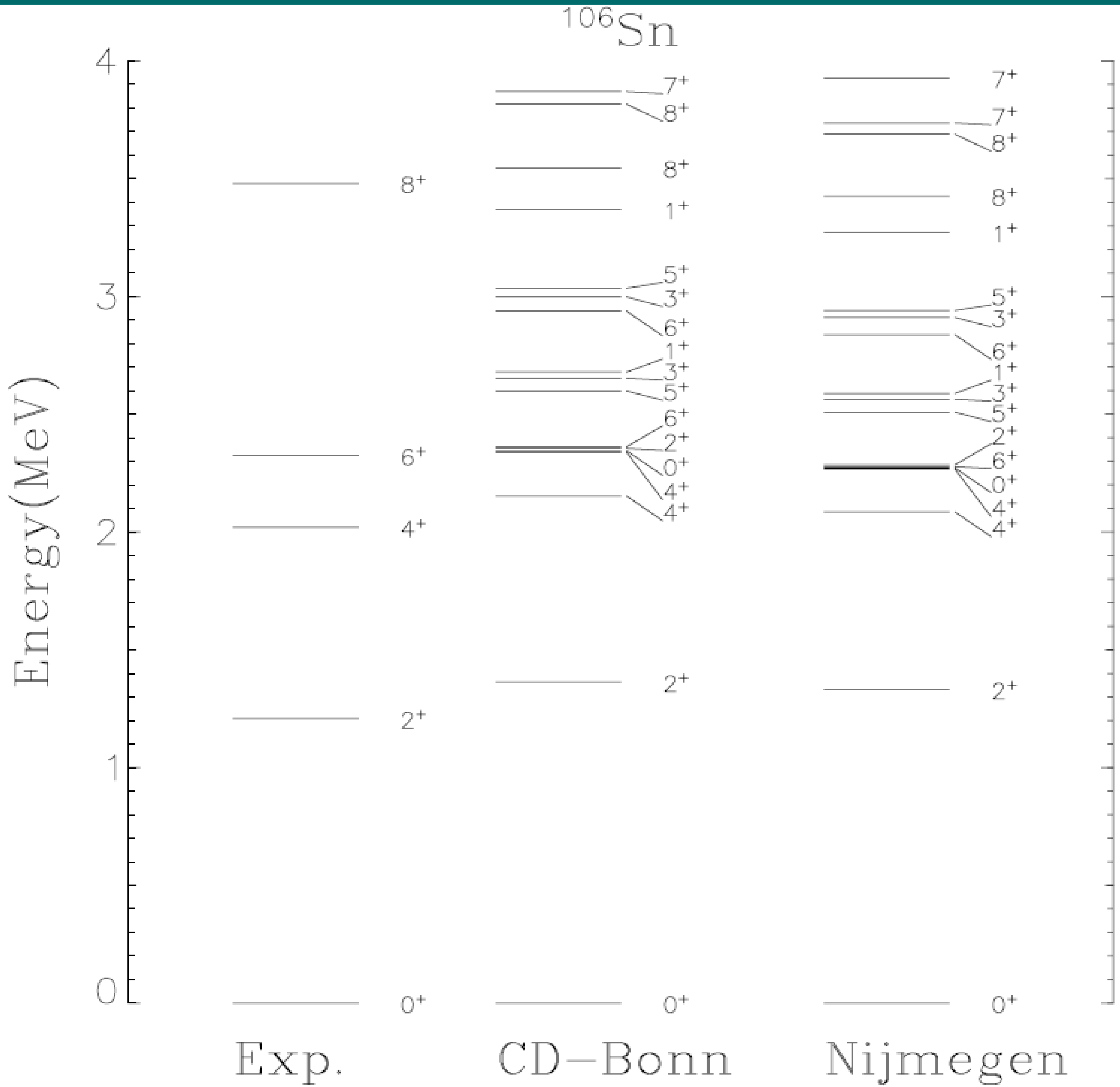
$$\nu h_{11/2} \otimes \{^{110}\mathrm{Sn}\}_{0+}$$

The other theoretical excited states: → similar discussion!

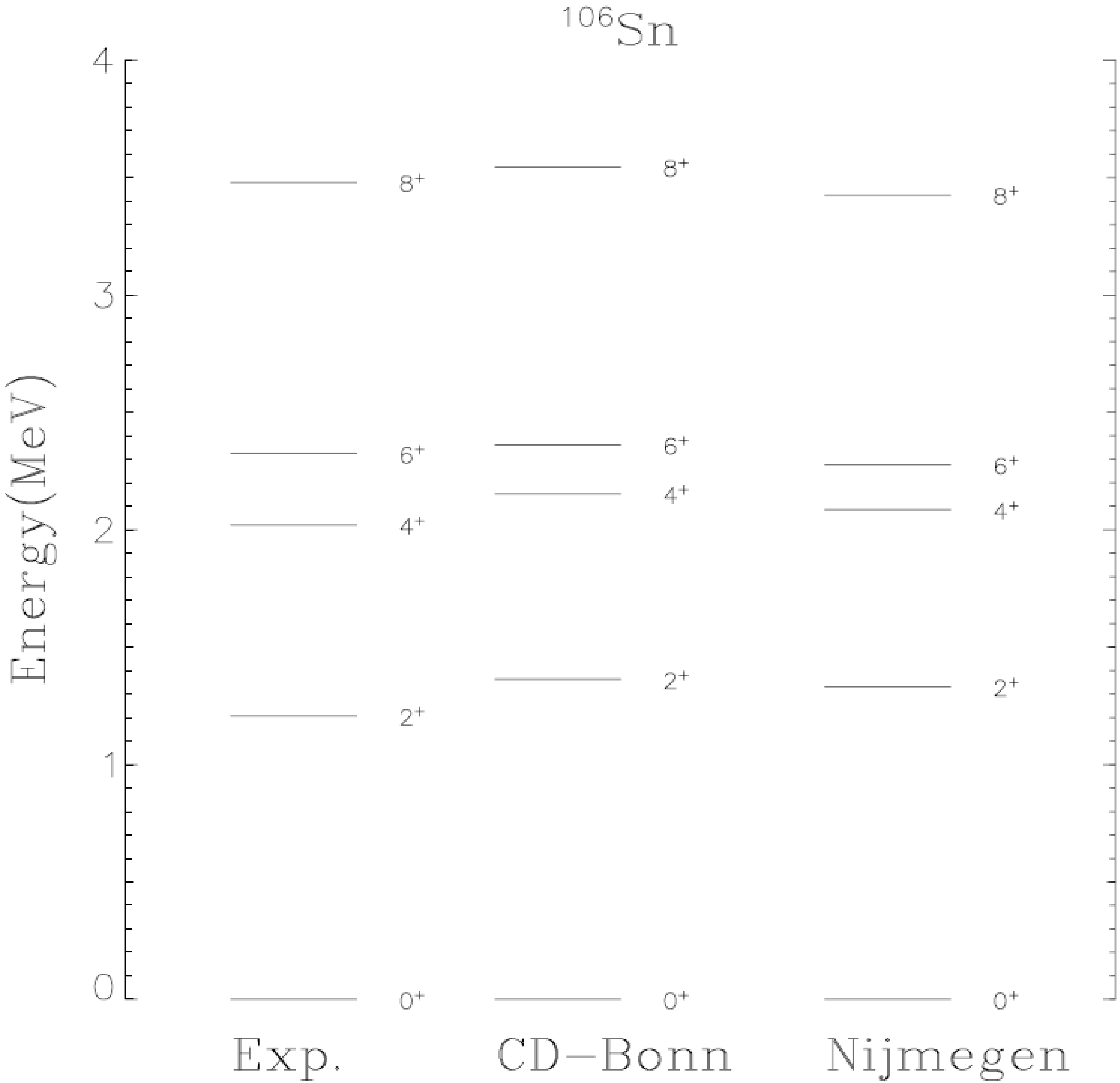
Conclusion

- Low-lying shell model states of ^{107,109,111}Sn are presented with the new experimental data.
- DUSM code has been used for the calculation and found to be very efficient in *sdgh* shell calculations.
- We have used two different interactions in our calculations: CD-Bonn and Nijmegen1.
- Spectrum from CD-Bonn and Nijmegen1 are similar, but Nijmegen1 gives better agreement with experimental data.
- We will expand the shell model calculations in this region for:
  - All mid-heavy Sn isotopes
  - Tellurium (Te) and Iodine (I) isotopes

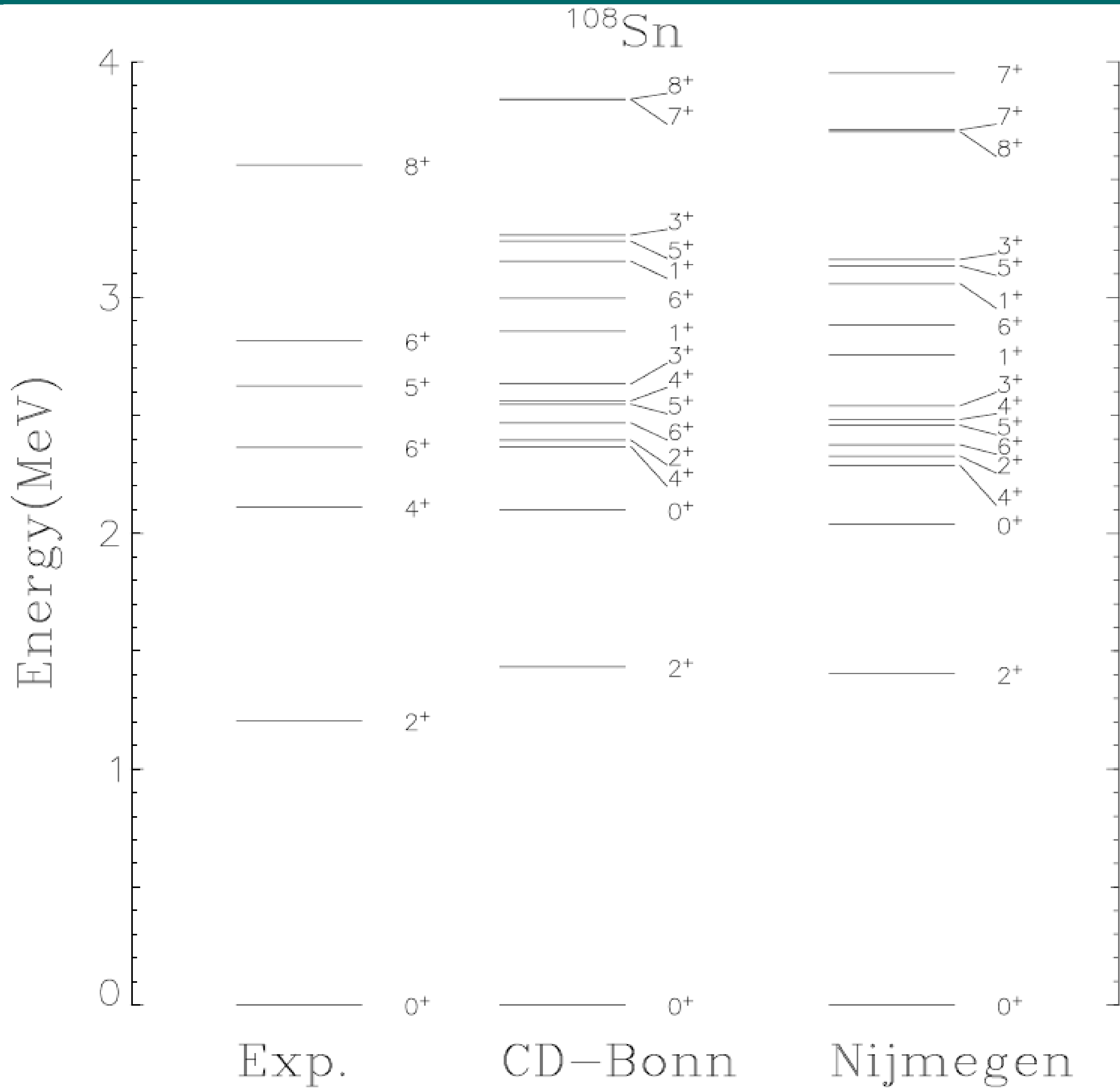
Shell model states of ^{106}Sn



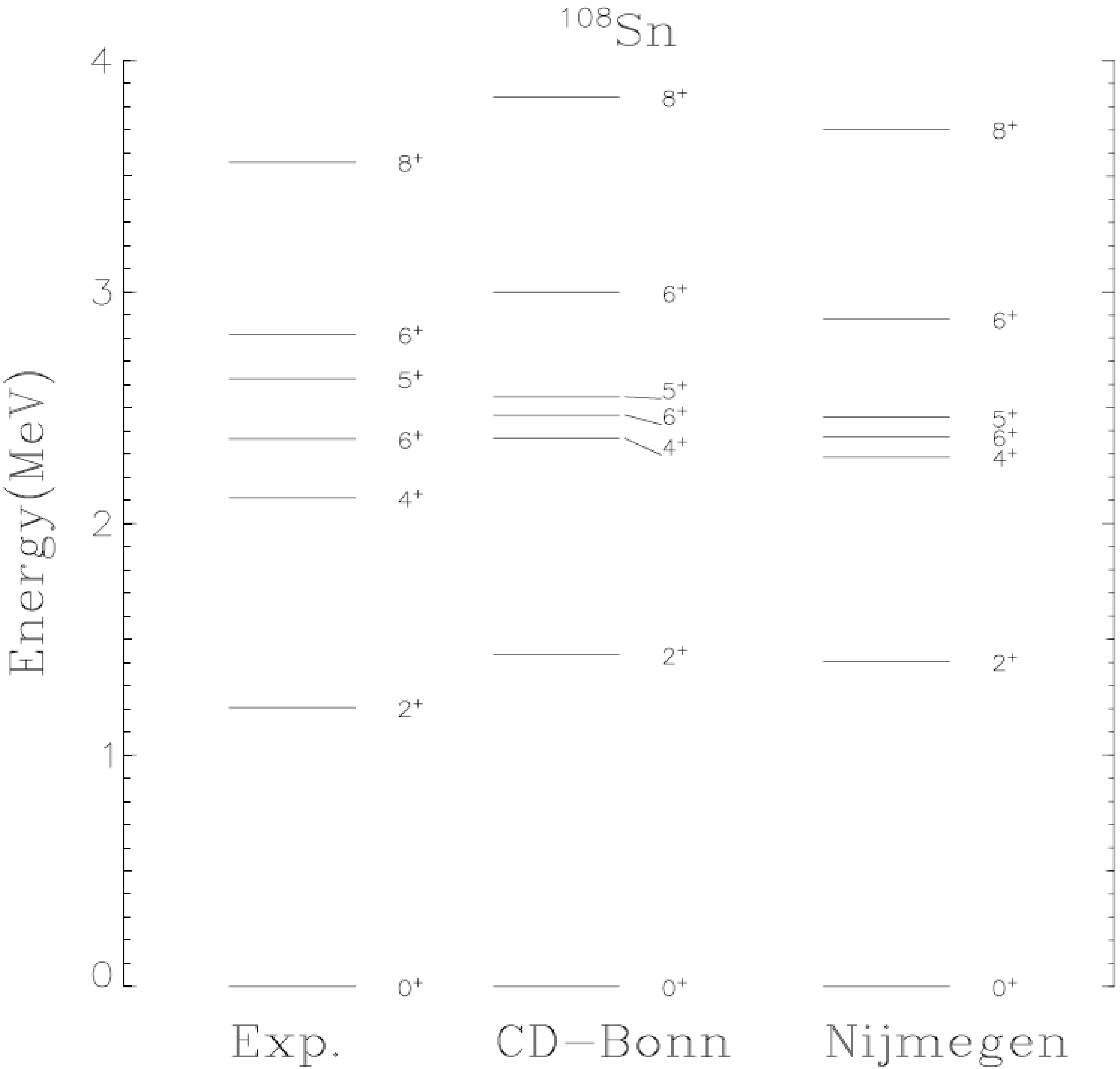
Shell model states of ^{106}Sn



Shell model states of ^{108}Sn



Shell model states of ^{108}Sn



Shell model states of ^{110}Sn