Shell Model Calculations of ^{88}Zr

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The structure of ^{88}Zr has been studied in the framework of the shell model, using the OXBASH code [1].

For the calculations, the shell model Hamiltonian can be written as

$$H = \sum_i \epsilon_i a_i^\dagger a_i + \sum_{ijkl} V_{ijkl}\ a_i^\dagger a_j^\dagger a_k a_l\ .$$

For calculating the two body matrix elements V_{ijkl}, the PMM90 interaction [1], which was introduced by B.A.Brown, is used, while the model space has been constructed from the $1f_{5/2}, 2p_{3/2}, 2p_{1/2}$ and $1g_{9/2}$ orbitals for both neutrons and protons.

The allowed occupation numbers, in square brackets, for each orbital and the corresponding total single particle energies ϵ_i (MeV) used to generate both positive (PPS) and negative (NPS) parity states are given in the following:

PPS: $1f_{5/2}$ [10-12] 2.30 MeV, $2p_{3/2}$ [6-8] 3.40 MeV, $2p_{1/2}$ [2-4] 5.13 MeV, $1g_{9/2}$ [8-10] 2.75 MeV;
NPS:$1f_{5/2}$ [12] 2.30 MeV, $2p_{3/2}$ [7-8] 3.40 MeV, $2p_{1/2}$ [2-4] 5.13 MeV, $1g_{9/2}$ [9-11] 2.75 MeV.

For positive parity states the number of predicted states is correct and the calculated energies are in acceptable agreement with the experiment, even if the 2^+ states are predicted systematically at higher energies and the 4^+ and 6^+ at energies lower than the experimental ones. A similar agreement is found for the negative parity states, with the exception of the first 5^- state, predicted at 1.497 MeV of excitation energy, but experimentally unobserved.

The main components of the positive and negative parity states are given in tables 1 and 2. Note that, for the lowest 0^+, 2^+, 4^+ and 6^+, the main component always corresponds to having a full shell closure at Z, N=40 and the remaining 8 neutrons in the $g_{9/2}$ shell. Nevertheless, the part of wave functions corresponding to two particle core excitation across the N=40 subclosure is rather large and amounts to about 41%, 53%, 44% and 41%, respectively.

References

[1] B. A. Brown *et al.*, MSU-NSCL Report No. 524 (1985)

E(th), J$^\pi$	0.000 , 0^+	1.492 , 2^+	1.934 , 4^+	2.110 , 6^+	Orbit partition order			
[NO]	p%	p%	p%	p%	$f_{5/2}$	$p_{3/2}$	$p_{1/2}$	$g_{9/2}$
[2]	1.50	1.66	1.88	1.82	11	7	4	10
[0]	16.90	14.94	13.93	13.46	10	8	4	10
[2]	2.05	3.98	2.68	2.44	11	8	3	10
[2]	1.94	4.09	3.00	2.72	12	7	3	10
[0]	7.36	8.35	7.71	7.37	12	6	4	10
[0]	11.92	19.58	15.45	13.19	12	8	2	10
[0]	58.32	47.41	55.34	59.01	12	8	4	8

Table 1: The wave functions of the first 0^+, 2^+, 4^+ and 6^+ states of ^{88}Zr. Each line corresponds to a state belonging to the basis with the partition order reported in the last four columns. [NO] is the number of unpaired nucleons; p% is the percentage occupation contributing by more than 0.5 %.

E(th), J$^\pi$	2.298, 3^-	1.479, 5^-	Orbit partition order			
[NO]	p%	p%	$f_{5/2}$	$p_{3/2}$	$p_{1/2}$	$g_{9/2}$
[2]	13.74	2.27	12	7	2	11
[2]	27.85	3.93	12	7	4	9
[2]	58.41	93.80	12	8	3	9

Table 2: The wave functions of the first 3^- and 5^- states of ^{88}Zr