LETTERS TO THE EDITOR

THE SHELL MODEL CALCULATIONS OF ^{42}Ca AND ^{42}Sc STATES WITH INCLUSION OF $1g_{9/2}$ ORBIT

By A. Jasielska and S. Wiktor*

Holy Cross Technological University of Kielce

Institute of Nuclear Physics, Cracow*

(*Received February 8, 1979*)

The shell model calculations with MSDI for ^{42}Ca and ^{42}Sc nuclei are extended by including the $1g_{9/2}$ orbit. The adjustable parameters A_T are treated either as state independent or as state dependent. Inclusion of the $1g_{9/2}$ orbit produces no substantial changes in the density and the sequence of the states.

In our previous work [1] the shell model calculations for nuclei having two nucleons outside the ^{40}Ca core were presented. The two active nucleons were located in the $1f_{7/2}$, $2p_{3/2}$, $1f_{5/2}$ and $2p_{1/2}$ orbits and a modified surface delta interaction (MSDI), acting between them, was used. Because the density of observed states is much larger than the calculated one, it, therefore, seems interesting to extend the configuration basis by including the $1g_{9/2}$ orbit. Such large basis shell model calculations, as is known from many investigations (see references given in our previous work [1]), can account simultaneously for the observed single particle and collective phenomena. Some evidence of occupation of the $1f_{9/2}$ orbit in nuclei with $20 \leqslant A \leqslant 50$ have been found recently in studies of stripping reactions [2–5].

The two body matrix elements, used by us, were taken from the tables [6, 7] and the single particle energies $E(j)$ were taken from Ref. [8]. The state independent parameters A_T were the same as in Ref. [1].

In order to account for the possible state dependence of the two body interaction, the parameters A_T were allowed to vary in a similar way as was done in Ref. [1]. That is the integrals of radial overlaps have been evaluated, then five groups of their values,

* Address: Instytut Fizyki Jądrowej, Radzikowskiego 152, 31-342 Kraków, Poland.

TABLE I

Parameters of the MSDI calculations

Without $1g_{9/2}$ shell				With the $1g_{9/2}$ shell			
A_T = const		A_T variable		A_T = const		A_T variable	
parameter	value	parameter	value	parameter	value	parameter	value
A_1	0.55	$A_1(0.30)$	0.65	A_1	0.50	$A_1(0.40)$	0.90
		$A_1(0.20)$	0.55			$A_1(0.30)$	0.65
		$A_1(0.18)$	0.45			$A_1(0.20)$	0.55
						$A_1(0.18)$	0.45
						$A_1(0.14)$	0.25
A_0	0.30	$A_0(0.30)$	0.70	A_0	0.30	$A_0(0.40)$	0.80
		$A_0(0.20)$	0.60			$A_0(0.30)$	0.70
		$A_0(0.18)$	0.40			$A_0(0.20)$	0.60
						$A_0(0.18)$	0.40
						$A_0(0.14)$	0.20
B	0.168	B	0.20	B	0.30	B	0.30

Single particle energies: $E(1g_{9/2})$ = 5.9 MeV, $E(1f_{5/2})$ = 6.5 MeV, $E(2p_{1/2})$ = 3.9 MeV, $E(2p_{3/2})$ = 2.1 MeV.

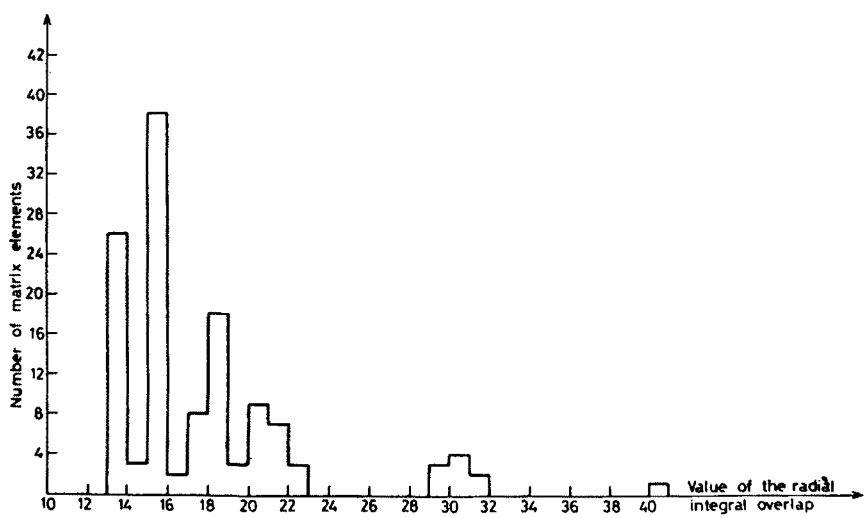

Fig. 1. Distribution of the integrals of radial overlaps

(concentrated at 0.14, 0.18, 0.20, 0.30 and 0.40 (Fig. 1)) have been identified and consequently five different parameters A_T have been adjusted. All the parameters used are listed in Table I.

The energy levels calculated according to both procedures, mentioned above, are presented in Figs 2 and 3. Inclusion of the $1g_{9/2}$ orbit involves the negative parity excitations. However, they are situated at higher energies and are not shown in the figures.

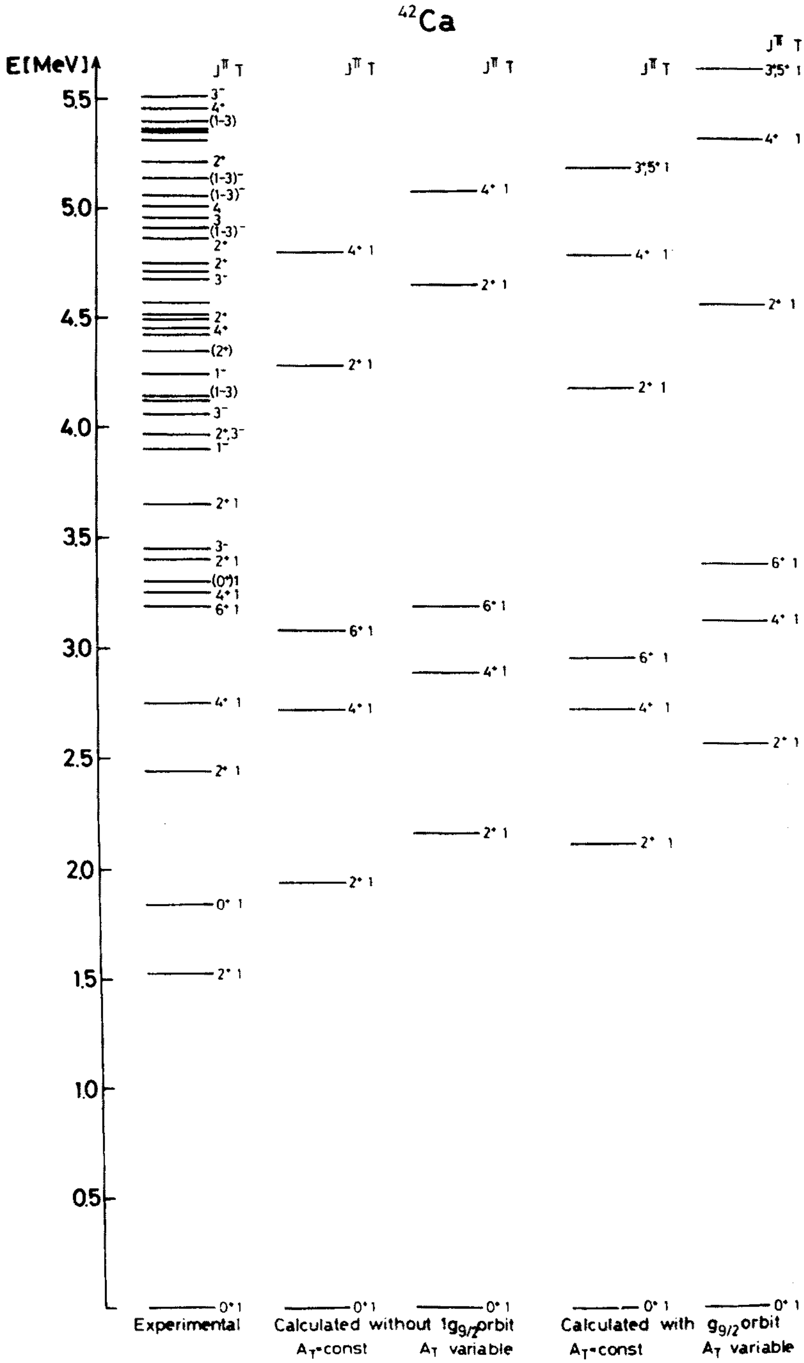

Fig. 2. Comparison of the observed and calculated levels of ^{42}Ca as indicated below each column

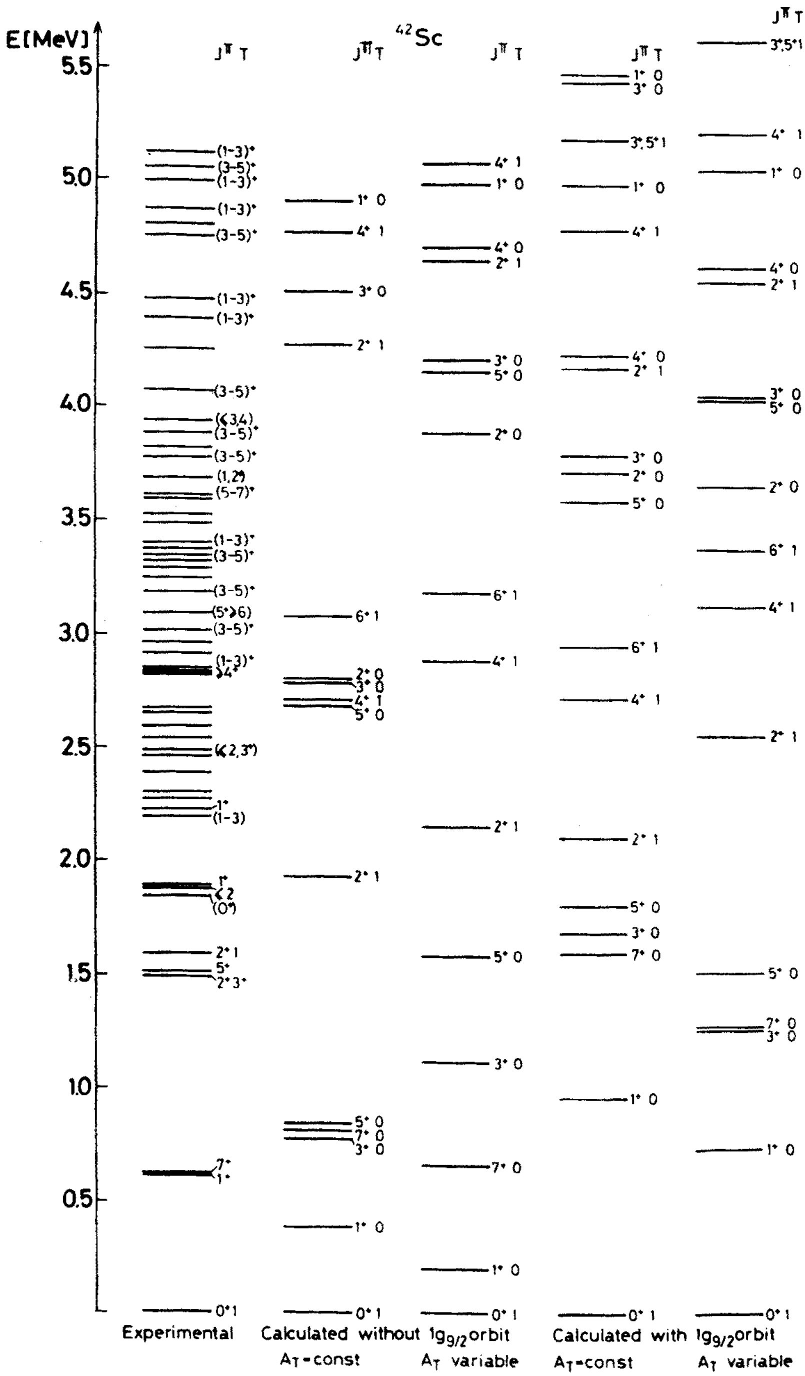

Fig. 3. Comparison of the observed and calculated levels of ^{42}Sc as indicated below each column

As it is seen from these figures, the introduction of the $1g_{9/2}$ orbit produces no substantial charge in the density and sequence of the calculated states. The sequence of the states in ^{42}Ca is neither affected by choosing the variable instead of constant A_T parameters nor by extending the model space by inclusion of the $1g_{9/2}$ orbit. Our calculation does not reproduce the experimental 0^+ (1.84 MeV) and 2^+ (2.42 MeV) excited states. These states are commonly interpreted as core excited states and, therefore, they cannot be described by the model used here.

In the case of the ^{42}Sc nucleus the right sequence of low lying states is produced alternatively either by taking the variable parameters A_T or by including the $1g_{9/2}$ orbit (columns 3 and 4 in Fig. 3). It appears from our calculations that trying to characterize the states in ^{42}Ca and ^{42}Sc nuclei according to a simple two particle structure outside the doubly closed ^{40}Ca core is likely an oversimplification.

REFERENCES

[1] A. Jasielska, S. Wiktor, *Acta Phys. Pol.* **B7**, 133 (1976).
[2] S. Gales et al., *Phys. Lett.* **B56**, 449 (1975).
[3] S. Gales et al., *Nucl. Phys.* **A259**, 189 (1976).
[4] T. Suzuki et al., *Nucl. Phys.* **A288**, 493 (1977).
[5] H. Nann et al., *Nucl. Phys.* **A292**, 205 (1977).
[6] A. Jasielska, S. Wiktor, P. W. M. Glaudemans, Rep. IFJ No 907/PL, 1976.
[7] A. Jasielska, S. Wiktor, Rep. IFJ No 973/PL, 1977.
[8] T. T. S. Kuo, *Nucl. Phys.* **114**, 241 (1968).