

THE TWO-PARTICLE CORE COUPLING MODEL APPLIED TO THE  
N = 84 NUCLEI

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Recently, great interest has been shown in the determination of the properties of the energy levels of the doubly-even  $N = 84$  nuclei. The spectra of these nuclei have been investigated by  $\beta$ - and  $\gamma$ -spectroscopic measurements [1-3]. A one-particle transfer reaction,  $^{143}\text{Nd}(d,p)$ , yields strengths for the various two-neutron components of the excited state wave functions in  $^{144}\text{Nd}$  [4]. Measurements of electric quadrupole and magnetic dipole moments of the first excited  $2^+$  state have been performed [5,6]. A  $(p,t)$  reaction study reports information about some  $I^\pi = 0^+$  levels [7].

Heyde and Brussaard [8] have treated some  $N = 84$  nuclei in an intermediate coupling scheme. They assumed that the two extra-neutrons were moving in the  $2f_{7/2}$  single-particle orbit. Although the low-lying energy part of the level scheme was well reproduced, they obtained the wrong sign for the quadrupole moment of the first excited  $2^+$  state. We have investigated the doubly-even  $N = 84$  nuclei in the two-particle core coupling model [9]. The available single-particle shell-model states in the region  $82 \leq N \leq 126$  are  $3p_{1/2}$ ,  $3p_{3/2}$ ,  $2f_{5/2}$ ,  $2f_{7/2}$ ,  $1h_{9/2}$  and  $1i_{13/2}$ . To reduce the size of the configuration space, we have taken into account up to three-phonon states of the core and we have neglected several highest-lying two-particle states, since their contribution, estimated by a perturbation calculation seems to be small. As a typical example we compare in fig. 1 the theoretical and experimental level scheme of  $^{144}\text{Nd}$  up to 2.5 MeV. Levels with a

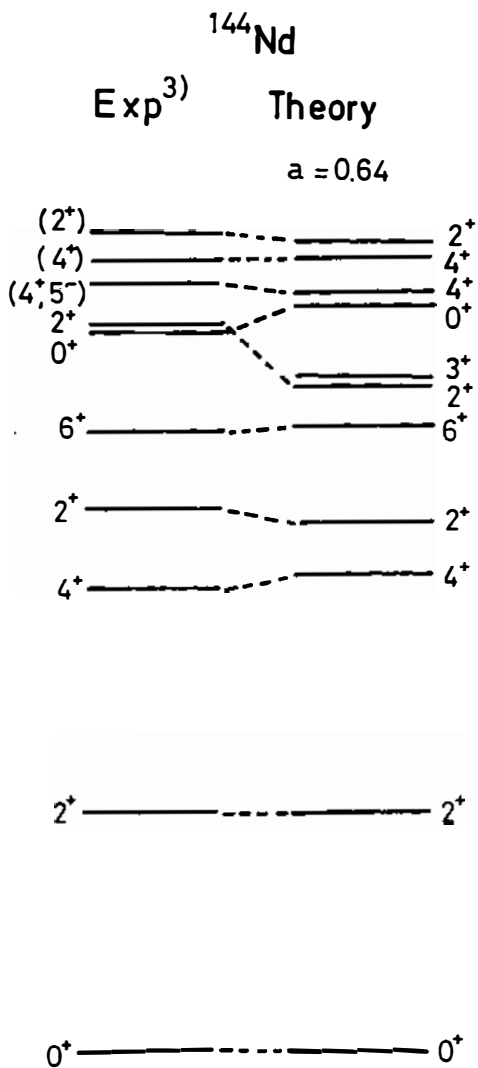


fig. 1

definite negative spin have not been plotted. A good agreement has been obtained. The spectroscopic factors for a transfer reaction of the type  $^{143}\text{Nd}(d,p)$  are given in table 1. The theoretical results reproduce the experimental data within the experimental error (30 à 40%).

The magnetic moment of the first excited  $2^+$  state in  $^{144}\text{Nd}$  has been calculated for  $g_R = Z/A$ ,  $g_l = 0$  and  $g_s = -2.686$ . The obtained value of 0.37 n.m. makes the most recent experimental value of  $(0.26 \pm 0.04)$  n.m. more believable than the earlier one of  $(0.62 \pm 0.16)$  n.m. [6]. In table 2 the calculated  $B(E2)$  values between the lowest-lying positive-parity states are given. The calculations

were performed with  $e_n^{\text{eff}} = e$ . Comparison with experiment is only possible for the value  $B(E2; 2_1^+ \rightarrow 0_1^+) = (0.090 \pm 0.002)e^2 b^2$  [5]. The calculated electric quadrupole moments are listed in table 3. The only experimental data  $Q_{2^+} = (-0.39 \pm 0.21)eb$  [5] is well reproduced. An interesting feature can be noted

TABLE 1

$I^\pi$	$\ell$	$^{143}\text{Nd}(d,p)$	$^{144}\text{Nd}$
		$S^{\text{exp}}  4 $	$S^{\text{theory}}$
$0_1^+$	3	0.72	0.95
$2_1^+$	1	0.14	0.10
	3	0.37	0.42
$4_1^+$	1	0.10	0.15
	3	0.59	0.59
$2_2^+$	1	0.10	0.14
	3	0.29	0.40
$6_1^+$	3	0.84	1.19

TABLE 2

$I^\pi \rightarrow I^\pi$	$B(E2) (e^2 b^2)$
$2_1^+ \rightarrow 0_1^+$	0.0855
$2_2^+ \rightarrow 0_1^+$	0.0005
$2_3^+ \rightarrow 0_1^+$	0.0014
$4_1^+ \rightarrow 2_1^+$	0.1301
$2_2^+ \rightarrow 2_1^+$	0.1218
$2_3^+ \rightarrow 2_1^+$	0.0230
$6_1^+ \rightarrow 4_1^+$	0.1057

TABLE 3

$I^\pi$	$Q(e \cdot b)$
$2_1^+$	-0.32
$2_2^+$	0.36
$2_3^+$	0.13
$4_1^+$	-0.51
$4_2^+$	-0.15
$4_3^+$	-0.25
$6_1^+$	-0.77

in the obtained results. A set of levels (i.e. the levels with spin  $0_1^+$ ,  $2_1^+$ ,  $4_1^+$  and  $6_1^+$ ) with particular properties can be extracted. The last three states have a large negative quadrupole moment. The transitions between these states are

considerably larger than those to the other states. An analogous situation was found in the Te |9| and Hg |10| isotopes..

The sign and the amplitude of the quadrupole moment of the  $2_1^+$  state, whose main wave function component is of the type  $|(2f_{7/2})^2 0;12,2\rangle$ , can also be understood in terms of a rearranged perturbation expansion theory |9,11|. The main competing cluster contributions are  $Q|(f_{7/2}^2 2) > 0$  and  $Q|(p_{3/2}, f_{7/2}) 2| < 0$ . The quadrupole moment (sign and amplitude) is extremely sensitive to the  $3p_{3/2}$  single-particle position. This explains also the fact that the result for that quadrupole moment, as obtained in a previous calculation |8|, where the  $3p_{3/2}$  single-particle state was omitted, had the wrong sign.

Several low-lying negative-parity states have been observed in the  $N = 84$  nuclei:

- a)  $I^\pi = 3^-$  state in the vicinity of 1.5 MeV
- b)  $I^\pi = 1^-$ ,  $5^-$  and  $(4^-)$  states between 2.0 and 2.5 MeV.

These levels can also be explained in the framework of the proposed model, if next to the quadrupole also octupole vibrations of the core would be taken into account. Such work is now in progress.

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