PHYSICAL REVIEW C VOLUME 14, NUMBER 2 AUGUST 1976

Level structure of ^{85,87}Y

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(Received 3 May 1976)

The odd-A Y isotopes ^{85}Y and ^{87}Y are studied in a semimicroscopic model which couples the proton quasiparticle motion to the quadrupole vibrations of the neighboring even core. The calculated results are in good agreement with recent (^{3}He, d) data.

[NUCLEAR STRUCTURE ^{85,87}Y; calculated levels, J, π, S, $B(E2)$, $B(M1)$. Quasiparticle-phonon coupling.]

The yttrium nuclei ^{85}Y and ^{87}Y have recently been studied experimentally with the (^{3}He, d) reaction[1,2] to investigate the nature of proton strength distributions in the presence of neutron holes in the $N = 50$ shell. The observed splittings of the $l = 1, 3, 4$ proton strengths in these nuclei (Figs. 1 and 2) indicate the presence of significant coupling between the single proton and collective motion of the core. We have recently shown[3] that a quasiparticle-phonon coupling calculation can successfully explain similar features observed in the odd-A Rb isotopes. The purpose of the present note is to see how far the quasiparticle-phonon coupling model calculation can reproduce the available (^{3}He, d) results in the yttrium nuclei. As the technique of the quasiparticle-phonon coupling model calculation is well known[4] and the mathematical formalisms used in the present work have already been discussed in earlier publications,[3,5] we shall discuss only the results.

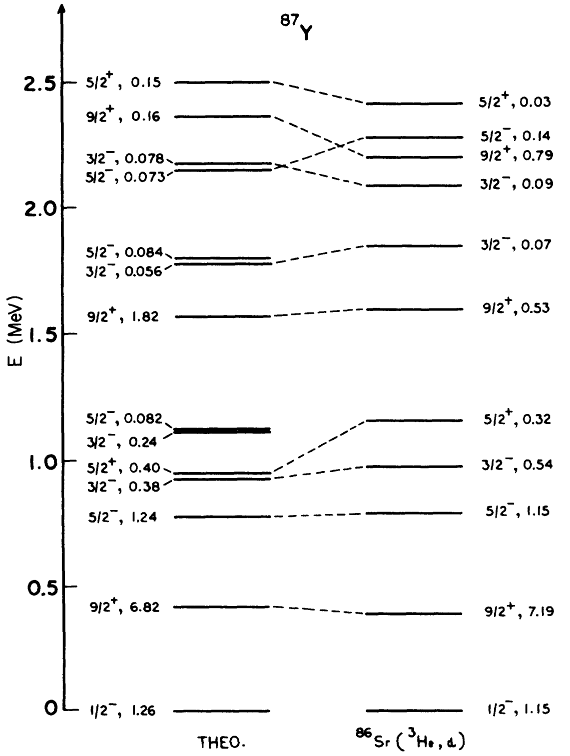

FIG. 1. Calculated and experimental level schemes of ^{87}Y. The excitation energies, spin-parities, and spectroscopic factors of the levels are shown. The ^{86}Sr(^{3}He, d) data are taken from Ref. 2.

We have considered the $1f_{5/2}$, $2p_{3/2}$, $2p_{1/2}$, $1g_{9/2}$, and $2d_{5/2}$ single-particle orbitals and core states up to two quadrupole phonons. The phonon energies are taken from the excitation spectra of the neighboring even Sr nuclei,[6] and the phonon matrix elements have been calculated following the method of Ford and Levinson.[7] There are several param-

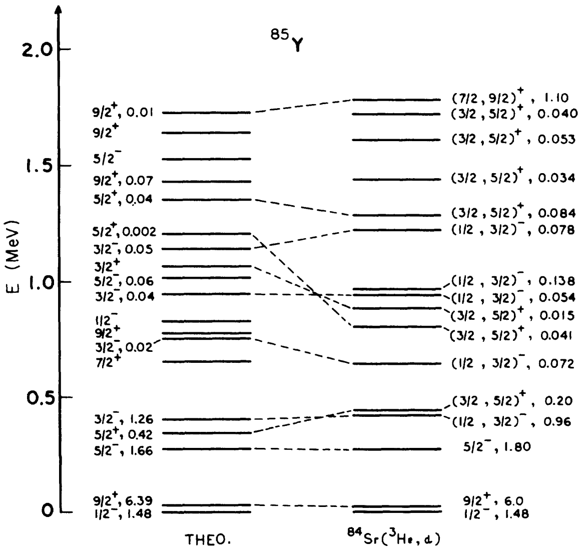

FIG. 2. Calculated and experimental level schemes of ^{85}Y. The excitation energies and spin-parities of the levels are shown. The spectroscopic factors are given provided $(2J + 1)S \geq 0.001$. The ^{84}Sr(^{3}He, d) data are taken from Ref. 1.

TABLE I. Parameter values used in this calculation.

Nucleus	Core	U_j [b]					Quasiparticle energies [a] (MeV)			
		$2p_{1/2}$	$2p_{3/2}$	$1f_{5/2}$	$1g_{9/2}$	$2d_{5/2}$	$2p_{3/2}$	$1f_{5/2}$	$1g_{9/2}$	$2d_{5/2}$
^{85}Y	^{84}Sr	0.860	0.583	0.547	0.842	1.0	0.450	0.320	0.150	2.5
^{87}Y	^{86}Sr	0.793	0.436	0.489	0.954	1.0	1.15	0.900	0.780	4.13

[a] These energies are relative to the $2p_{1/2}$ orbital.
[b] These values are taken from Refs. 1 and 8.

eters in this calculation, viz., quasiparticle energies, U_j factors, the dipole-dipole (η), and the quadrupole-quadrupole interaction strength (ξ) parameters. The U_j factors are taken from the work of Comfort, Duray, and Braithwaite[8] and that of Medsker *et al.*[1] in the cases of ^{87}Y and ^{85}Y, respectively. The parameter value η is taken to be the same as used in the cases of Rb nuclei.[3] To fix up the value of the parameter ξ, the positive parity spectrum of ^{87}Y is first calculated. Since this calculation involves only two single-particle orbitals $1g_{9/2}$ and $2d_{5/2}$, there are two adjustable parameters ξ and the $2d_{5/2}$-$1g_{9/2}$ quasiparticle energy spacing.

It is found that a good agreement with the experimental spectrum can be achieved with $\xi = 2.5$ and $2d_{5/2}$ quasiparticle energy $= 3.35$ MeV with respect to the $1g_{9/2}$ orbital. However, the agreement between the experimental and calculated single-particle strengths for the $\frac{9}{2}_2$ and $\frac{9}{2}_3$ states is not satisfactory. Negative parity levels of ^{87}Y are then calculated with this ξ value and the $2p_{3/2}$ and $1f_{5/2}$ quasiparticle energies are adjusted to get a good fit to the experimental spectrum. The parameter values used in the present work are listed in Table I. It is interesting to note that all the levels below 2.5 MeV excitation energy observed in the (^{3}He, d) reaction can be accounted for in this coupling scheme and the overall agreement between the calculated and experimental energy spectra as well as the spectroscopic factors are quite good (Fig. 1). In view of the restricted model space used, other higher energy levels observed in the (^{3}He, d) reaction are not expected to be reproduced correctly in the present calculation.

The levels of ^{85}Y are calculated exactly in the similar manner with the same value of ξ as used in the case of ^{87}Y. However, the agreement between the calculated and the experimental energy spectra and spectroscopic factors in this case (Fig. 2) is worse than that observed in the case of ^{87}Y. In ^{85}Y, several levels below 2 MeV excitation energy have been observed in the stripping reaction corresponding to the $l = 2$ transition. The present calculation cannot reproduce all these levels and it seems necessary to include the $2d_{3/2}$ orbital in the model space to explain them.

To summarize, it may be said that the quasiparticle-phonon coupling calculation can reproduce correctly the properties of the low-lying levels of ^{87}Y populated by the single-proton stripping reaction. In ^{85}Y, although the qualitative features ob-

TABLE II. Calculated electric quadrupole and magnetic dipole moments.

Isotope	E (keV)	J^π	Quadrupole moment (eb)	Magnetic moment (μ_N)
^{85}Y	0	$\frac{1}{2}^-$	0	0.062
	28	$\frac{9}{2}^+$	−0.348	5.711
	267	$\frac{5}{2}^-$	0.247	1.540
	401	$\frac{3}{2}^-$	0.135	2.591
	336	$\frac{5}{2}^+$	−0.226	4.645
^{87}Y	0	$\frac{1}{2}^-$	0	0.0615
	415	$\frac{9}{2}^+$	−0.607	5.622
	773	$\frac{5}{2}^-$	0.295	1.410
	886	$\frac{3}{2}^-$	0.153	1.879
	917	$\frac{5}{2}^+$	−0.347	4.612

served in the single-proton stripping reaction can be reproduced in this coupling scheme, the quantitative agreement is not good. This fact implies that removal of neutrons from the $N = 50$ shell introduces complexity in the level structure of the yttrium isotopes. The electromagnetic properties of some of the levels of these nuclei, calculated with the same effective charge and g_s factor as used in the case of Rb nuclei[3] are listed in Tables II and III. The validity of the model can be tested more rigorously only when experimental data on the electromagnetic properties of these nuclei will be available.

TABLE III. Calculated $B(E2)$ and $B(M1)$ values.

Isotope	E_γ (keV)	J_i^π	J_f^π	$B(E2)$ ($e^2 b^2$)	$B(M1)$ (μ_N^2)
^{85}Y	267	$\frac{1}{2}^-_1$	$\frac{5}{2}^-_1$	0.000 29	0
	401	$\frac{1}{2}^-_1$	$\frac{3}{2}^-_1$	0.002 59	0.823
	308	$\frac{9}{2}^+_1$	$\frac{5}{2}^+_1$	0.0228	0
^{87}Y	773	$\frac{1}{2}^-_1$	$\frac{5}{2}^-_1$	0.009	0
	886	$\frac{1}{2}^-_1$	$\frac{3}{2}^-_1$	0.0459	0.503
	502	$\frac{9}{2}^+_1$	$\frac{5}{2}^+_1$	0.0242	0

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