YU ISSN 0015—3206
FZKAAA 22 (1) 323 (1990)

THE STRUCTURE OF ^{98}Y FROM IBFFM CALCULATIONS

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Received 15 December 1989

UDC 539.142

Original scientific paper

The low lying levels of ^{98}Y have been investigated in the Interacting Boson-Fermion-Fermion Model. A U (5) core (^{96}Sr) has been used and the parameters for the calculations were deduced through studies of the neighbours ^{97}Y (odd proton), ^{97}Sr (odd neutron) and ^{96}Y (proton-neutron interaction). Thus, insight has been gained into the structure of the spherical states of the nucleus ^{98}Y which lies at the onset of nuclear deformations near $A = 100$ and which exhibits shape coexistence. It was found that this structure deviates remarkably from the zeroth order classification of multiplets which originate from a coupling of the relevant proton and neutron quasiparticles.

1. *Introduction*

The $A \approx 100$ neutron-rich nuclei provide a unique opportunity to study an extremely rapid onset of deformation$^{1)}$. This phase transition is particularly pronounced for the sequence of Y nuclei, where ^{96}Y $^{2)}$ and ^{97}Y $^{3-5)}$ exhibit the pattern

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* Alexander von Humboldt fellow, on leave of absence from University of Zagreb.

** Supported by Internationales Büro, Kernforschungsanlage Jülich, F. R. Germany.

associated with spherical shell-model states, while ^{99}Y[4,6–9] and ^{100}Y[10] have fully deformed structures with well developed rotational bands. Thus, the odd-odd isotope ^{98}Y is positioned in the center of the transitional region between spherical and deformed nuclei, and is therefore a particularly good candidate for shape coexistence of spherical and deformed structures. In fact, the first rotational band which was identified in a non-even-even nucleus of the $A \approx 100$ region, was the very regular band in ^{98}Y with the head at 496 keV[11–13]. Much effort has been recently devoted to the experimental investigations of ^{98}Y[1,14–16].

On the other hand, it is well known that the theoretical approach to nuclear structure in the framework of the Interacting Boson Model (IBM)[17], Interacting Boson-Fermion Model (IBFM)[18] and Interacting-Boson-Fermion-Fermion Model (IBFFM)[19–21] is capable of treating both spherical and deformed even-even, odd-A and odd-odd nuclei, respectively. In this framework, we have recently started to investigate the structure of nuclei in the $A \approx 100$ region[22–25]. The quantum chaos for the IBFM/IBFFM-energy spectra in that region has also been studied[26].

In this paper we report the application of the IBFFM approach to the low-lying levels in ^{98}Y which are of spherical character. Here we are in a particularly difficult situation since very little is known about the spins. A long-standing problem was the ground-state spin and parity for which values of 1^+ [1] and 1^- [14] have been proposed. Only recently, the 0^- assignment has been established[15,16]. In the light of such a situation, we have attempted to predict the properties of low-lying levels in ^{98}Y using the parameters from IBFM and IBFFM calculations for the neighbouring lighter nuclei ^{97}Y, ^{97}Sr and ^{96}Y.

2. *The calculational procedure*

In the first step we have performed IBFM calculations for the negative-parity states in the odd-even isotope ^{97}Y. Here, the same boson core of U (5) character (^{96}Sr) has been taken as in a previous IBFM calculation for the positive-parity states in ^{97}Y[22]. The BCS occupation probabilities for the proton quasiparticles $\tilde{p}^{1/2}$, $\tilde{p}_{3/2}$ and $\tilde{f}_{5/2}$ are taken the same as in the previous IBFFM calculation for ^{96}Y[23]. The proton quasiparticle positions $\varepsilon(\pi\tilde{p}_{3/2}) - \varepsilon(\pi\tilde{p}_{1/2}) = 0.78$ MeV, $\varepsilon(\pi\tilde{f}_{5/2}) - \varepsilon(\pi\tilde{p}_{1/2}) = 1.15$ MeV are fitted to ^{97}Y levels; these values are similar to those used for ^{96}Y. The boson-fermion interaction strengths Γ_0^π and χ are taken equal to those used in the calculation for positive-parity states in ^{97}Y[22]. The strengths $\Lambda_0^\pi = 0.4$ MeV and $A_0^\pi = -0.25$ MeV were adjusted to the low-lying negative-parity states in ^{97}Y. (For definition of the parameters see Ref. 27. For the IBFM and IBFFM computations we are using the computer codes PTQM and OTQM, respectively[28].)

In the second step, we have performed IBFM calculations for the positive parity states in the even-odd isotone ^{97}Sr. This nucleus in which shape isomerism has been observed recently[29], has 9 neutrons in the valence shell and thus the $\nu\tilde{d}_{5/2}$ quasiparticle lies above the $\nu\tilde{g}_{7/2}$, $\nu\tilde{d}_{3/2}$ and $\nu\tilde{s}_{1/2}$ quasiparticles. Therefore, we have assumed that the $\nu\tilde{d}_{5/2}$ configuration is completely occupied and it was thus omitted from the calculations. The neutron quasiparticle parameters were adjusted to the levels in ^{97}Sr: $\varepsilon(\tilde{g}_{7/2}) - \varepsilon(\tilde{s}_{1/2}) = 0.9$ MeV, $\varepsilon(\tilde{d}_{3/2}) - \varepsilon(\tilde{s}_{1/2}) = 1.2$ MeV, $v^2(\tilde{s}_{1/2}) = 0.5$, $v^2(\tilde{g}_{7/2}) = 0.2$, $v^2(\tilde{d}_{3/2}) = 0.15$. We note that $\nu\tilde{d}_{3/2}$ was included above $\nu\tilde{g}_{7/2}$ in accordance with the investigation of ^{96}Y [23]. Thus, it is assumed that the $3/2_1^+$ state at 167.1 keV in ^{97}Sr is not of quasiparticle but of more complex nature as associated with the $I = j - 1, j - 2$ anomaly[30], or the analogous effect in IBFM. The boson-fermion interaction strengths $A_0^\nu = 0.18$ MeV, $\Gamma_0^\nu = 0.5$ MeV, $\Lambda_0^\nu = 0.4$ MeV were adjusted to the levels of ^{97}Sr. The IBFM energy spectrum of the positive-parity spherical states in ^{97}Sr are presented in Fig. 1, in comparison to the available experimental data. For completeness, the available experimental levels of rotational character are also presented.

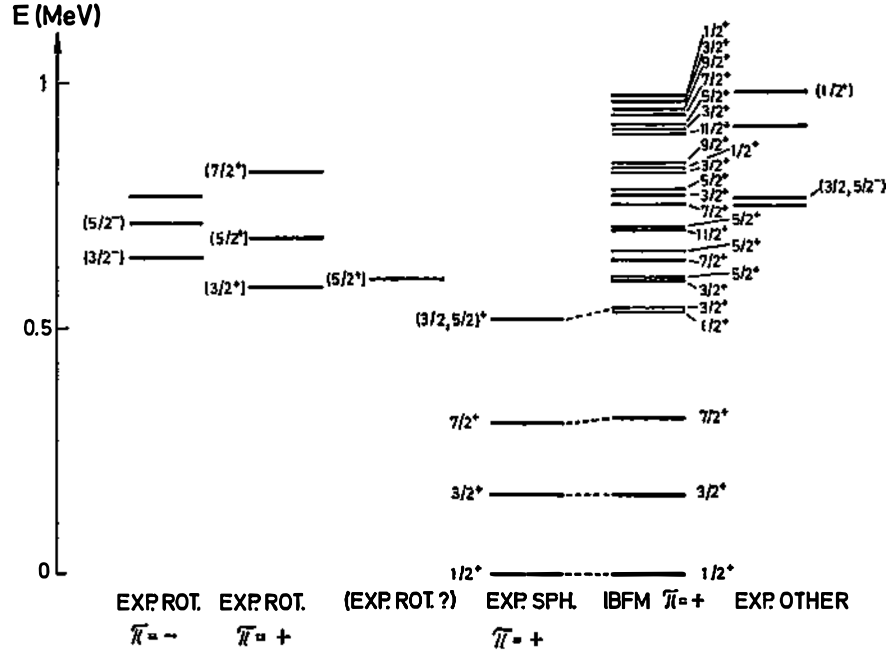

Fig. 1. Low-lying spherical states of ^{97}Sr calculated in IBFM and comparison to data.

In the third step, we have performed the IBFFM calculations for the lowest-lying states in ^{98}Y which are associated with a spherical shape[1,14]. For the boson core we used the same $U(5)$ parameters as in the IBFM calculations for ^{97}Y and ^{97}Sr. For the quasiparticle parameters and boson-fermion interaction strengths we used the values from the IBFM calculations for the normal-parity states in ^{97}Y and ^{97}Sr. The value of Γ_0^ν is the same as the one used in the IBFFM calculation for ^{96}Y. For the spin-spin residual interaction strength we employ the estimate $V_{\sigma\sigma} = 20/A = 0.2$ MeV. The strength of the surface delta interaction is taken as $V_8 = -0.22$ MeV, which is close to the value obtained from the strength used in the ^{96}Y calculation[23], by requiring that the diagonal matrix element for the $(\pi\tilde{g}_{9/2}, \nu\tilde{g}_{7/2})$ configuration for ^{98}Y is the same as for ^{96}Y.

3. Results

In this way, we obtained the IBFFM states for ^{98}Y without adjusting any parameter. The resulting low-lying negative-parity spectrum is presented in Fig. 2. The calculated states are tentatively attributed to the experimental levels in the ordering of increasing energies. As will be shown below, such an attribution is supported by the electromagnetic properties of the low-lying states.

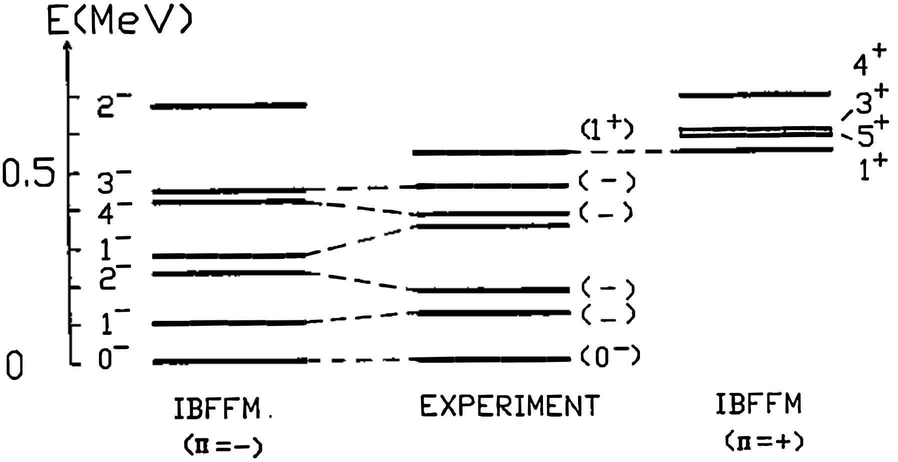

Fig. 2. Low-lying spherical states of ^{98}Y (below 0.7 MeV) calculated in IBFFM and comparison to data (level energies and parities from Refs. 1 and 14 and g. s. spin from Ref. 16). The experimental level at 496 keV is of deformed nature and therefore is omitted from the experimental spectrum of spherical states. The calculated 1_1^+ state is assigned to the experimental (1$^+$) level at 548 keV which is assumed to be spherical (see text for details). The tentative assignment of the calculated states to the low-lying negative parity levels is supported by the electromagnetic data (see Table 2) and the observed conversion coefficients$^{1)}$.

In Table 1 we present the IBFFM wave functions of the low-lying states. The two lowest-lying IBFFM levels are 0$^-$ and 1$^-$, in agreement with the prediction of the parabolic rule$^{31)}$. In the zeroth order classification these states arise from the $(\pi\tilde{p}_{1/2}, \nu\tilde{s}_{1/2})\, J^\pi = 0^-, 1^-$ multiplet; the corresponding Nordheim number is $\mathcal{N}=0$ and therefore the leading-order approximation predicts $E(0^-) < E(1^-)$. As seen from Table 1, the IBFFM wave functions of 0_1^- and 1_1^- states, although mixed, are dominated by the corresponding components $(\pi\tilde{p}_{1/2}, \nu\tilde{s}_{1/2})\, 0^-$ and $(\pi\tilde{p}_{1/2}, \nu\tilde{s}_{1/2})\, 1^-$.

On the other hand, there is not a single dominant component in the IBFFM wave functions of the 2_1^- and 1_2^- states. In each of these states there are two large components with comparable magnitudes

$$|2_1^-> \, = 0.57\, |(\pi\tilde{p}_{1/2}, \nu\tilde{d}_{3/2})\, 2, 00; 2> + \, 0.49\, |(\pi\tilde{p}_{1/2}, \nu\tilde{g}_{7/2})\, 4, 12; 2> + \ldots$$

$$|1_2^-> \, = 0.56\, |(\pi\tilde{p}_{1/2}, \nu\tilde{d}_{3/2})\, 1, 00; 1> + \, 0.51\, |(\pi\tilde{p}_{1/2}, \nu\tilde{g}_{7/2})\, 3, 12; 1> + \ldots.$$

TABLE 1.

0_1^-	
$(\pi p_{1/2}, \nu s_{1/2})$ 0,00	0.91
$(\pi p_{1/2}, \nu d_{3/2})$ 2,12	0.26
$(\pi p_{3/2}, \nu s_{1/2})$ 2,12	0.17
$(\pi f_{5/2}, \nu s_{1/2})$ 2,12	−0.17
1_1^-	
$(\pi p_{1/2}, \nu s_{1/2})$ 1,00	0.88
$(\pi p_{3/2}, \nu s_{1/2})$ 1,00	0.19
$(\pi p_{1/2}, \nu d_{3/2})$ 1,12	−0.20
$(\pi p_{1/2}, \nu d_{3/2})$ 2,12	0.19
$(\pi p_{3/2}, \nu s_{1/2})$ 2,12	−0.15
2_1^-	
$(\pi p_{1/2}, \nu s_{1/2})$ 0,12	0.17
$(\pi p_{1/2}, \nu s_{1/2})$ 1,12	−0.19
$(\pi p_{1/2}, \nu d_{3/2})$ 1,12	0.16
$(\pi p_{1/2}, \nu d_{3/2})$ 2,00	0.57
$(\pi p_{1/2}, \nu d_{3/2})$ 2,12	−0.23
$(\pi p_{1/2}, \nu d_{3/2})$ 2,20	−0.19
$(\pi p_{1/2}, \nu g_{7/2})$ 3,12	−0.16
$(\pi p_{1/2}, \nu g_{7/2})$ 4,12	0.49
$(\pi p_{1/2}, \nu g_{7/2})$ 4,22	−0.20
2_2^-	
$(\pi p_{1/2}, \nu s_{1/2})$ 0,12	0.25
$(\pi p_{1/2}, \nu s_{1/2})$ 1,12	0.24
$(\pi p_{3/2}, \nu s_{1/2})$ 2,00	0.80
$(\pi p_{3/2}, \nu d_{3/2})$ 2,00	−0.16
$(\pi p_{3/2}, \nu s_{1/2})$ 2,12	0.23
$(\pi p_{3/2}, \nu d_{3/2})$ 2,12	−0.15
$(\pi p_{3/2}, \nu d_{3/2})$ 3,12	0.17
1_2^-	
$(\pi p_{1/2}, \nu d_{3/2})$ 1,00	0.56
$(\pi p_{1/2}, \nu s_{1/2})$ 1,12	−0.25
$(\pi p_{1/2}, \nu d_{3/2})$ 1,12	−0.19
$(\pi p_{1/2}, \nu d_{3/2})$ 1,20	−0.19
$(\pi p_{1/2}, \nu d_{3/2})$ 2,12	−0.23
$(\pi p_{1/2}, \nu g_{7/2})$ 3,12	0.51
$(\pi p_{1/2}, \nu g_{7/2})$ 3,22	−0.21
4_1^-	
$(\pi p_{1/2}, \nu d_{3/2})$ 2,12	0.42
$(\pi p_{1/2}, \nu d_{3/2})$ 2,22	−0.16
$(\pi p_{1/2}, \nu g_{7/2})$ 4,00	0.66
$(\pi p_{1/2}, \nu g_{7/2})$ 4,12	−0.37
$(\pi p_{1/2}, \nu g_{7/2})$ 4,20	−0.18
3_1^-	
$(\pi p_{1/2}, \nu d_{3/2})$ 1,12	0.36
$(\pi p_{1/2}, \nu d_{3/2})$ 1,22	−0.15
$(\pi p_{1/2}, \nu d_{3/2})$ 2,12	0.17
$(\pi p_{1/2}, \nu g_{7/2})$ 3,00	0.65
$(\pi p_{3/2}, \nu g_{7/2})$ 3,00	−0.18
$(\pi p_{1/2}, \nu g_{7/2})$ 3,12	−0.36
$(\pi p_{1/2}, \nu g_{7/2})$ 3,20	−0.17
$(\pi p_{1/2}, \nu g_{7/2})$ 4,12	−0.16
1_1^+	
$(\pi g_{9/2}, \nu g_{7/2})$ 1,00	0.77
$(\pi g_{9/2}, \nu g_{7/2})$ 1,12	−0.17
$(\pi g_{9/2}, \nu g_{7/2})$ 2,12	0.28
$(\pi g_{9/2}, \nu g_{7/2})$ 3,12	−0.30
$(\pi g_{9/2}, \nu d_{3/2})$ 3,12	0.36
$(\pi g_{9/2}, \nu d_{3/2})$ 3,22	−0.15

Main components in the IBFFM wave functions of the low-lying spherical states in ^{98}Y. The wave functions are expressed in the basis $|(j_\pi j_\nu)\, J_{\pi\nu}, n_d I; J\rangle$ where the proton-neutron angular momentum $J_{\pi\nu}$ and the angular momentum I of the boson state with n_d d-bosons are coupled to the total angular momentum J. For simplicity, the label of the total angular momentum is omitted in the Table from the notation for basis vectors. Only the components with amplitudes which exceed 2% are listed.

This structure differs basically from the zeroth-order classification, according to which the 2_1^- and 1_2^- states are predicted to based on $(\pi\tilde{p}_{3/2}, \nu\tilde{s}_{1/2})\,1^-$ and $(\pi\tilde{p}_{3/2}, \nu\tilde{s}_{1/2})\,2^-$ configurations, respectively.

The structure of the next two levels, 4_1^- and 3_1^-, is similarly complex. In fact, it is in its main part boson-symmetrical to the 2^- and 1^- states: the main components are

$$|4_1^-\rangle = 0.42\,|(\pi\tilde{p}_{1/2}, \nu\tilde{d}_{3/2})\,2, 12; 4\rangle + 0.66\,|(\pi\tilde{p}_{1/2}, \nu\tilde{g}_{7/2})\,4, 00; 4\rangle + \ldots$$

$$|3_1^-\rangle = 0.36\,|(\pi\tilde{p}_{1/2}, \nu\tilde{d}_{3/2})\,1, 12; 3\rangle + 0.65\,|(\pi\tilde{p}_{1/2}, \nu\tilde{g}_{7/2})\,3, 00; 3\rangle + \ldots.$$

Only the next higher state, 2_2^- is based on the $(\pi\tilde{p}_{3/2}, \nu\tilde{s}_{1/2})$ configuration. Thus, this state, due to its structure, approximately corresponds to the 2_1^- state at 652 keV in ^{96}Y [23].

Thus the situation in ^{98}Y differs from the one in ^{96}Y, where the observed levels are close to zeroth-order classification. The main cause of this change of structure of low-lying negative-parity states going from ^{96}Y to ^{98}Y is a change in the pattern of the quasiparticle levels with the addition of a pair of neutrons.

In order to test the tentative level assignments in Fig. 2, based until here solely on energy ordering of IBFFM and experimental states, we have also investigated the branching ratios and half-lives of these states. They were obtained from the $E2$ and $M1$ transition moments, which were calculated employing proton and neutron effective charges and gyromagnetic ratios used previously in the IBFFM calculation for ^{96}Y [23].

For protons, the main role in the structure of the low-lying levels is played by the spin-flip quasiparticle partners $\pi\tilde{p}_{1/2}$ and $\pi\tilde{p}_{3/2}$, and thus the tensor term in the $M1$ operator plays a minor role; therefore we set $g_T^\pi = 0$. The two remaining parameters in the electromagnetic operators, e^{VIB} and g_T^ν are, in the first step, fitted in IBFM[32] to the 167 and 141 keV transitions in ^{97}Sr with $B(M1: 3/2_1^+ \rightarrow \rightarrow 1/2_1^+) = 0.005\,\mu_N^2$ and $B(E2: 7/2_1^+ \rightarrow 3/2_1^+) = 0.006\,e^2b^2$, respectively. In this way we get $e^{VIB} = 0.35$, $g_T = \frac{1}{50}\, g_s^{free} \langle r^2 \rangle$. In the calculation for ^{98}Y we have somewhat modified these parameter values to 0.25 and $\frac{1}{90}\, g_s^{free} \langle r^2 \rangle = -0.78$, which were adjusted to reproduce the values of $t_{1/2}$ for the assumed 4^- state at 374 keV and of $I_\gamma(2_1^- \rightarrow 1_1^-)/I_\gamma(2_1^- \rightarrow 0_1^-)$ to the experimental data. In Table 2 we present the calculated results for the branching ratios and the level half-lives in comparison to the available data. The agreement is rather good, except for $I_\gamma(1_2^- \rightarrow 0_1^-)$, which is predicted to be more than an order of magnitude stronger

TABLE 2.

	$I_\gamma(I_i \rightarrow I_f)$		$T_{1/2}(I_i)$	
$I_i \rightarrow I_f$	IBFFM	EXP[1]	IBFFM	EXP[1,13]
$1_1^- \rightarrow 0_1^-$	1	1	0.12 ns	0.14 ns
$2_1^- \rightarrow 0_1^-$	1	1	0.4 μs	0.62 μs
$\rightarrow 1_1^-$	0.22	0.19		
$1_2^- \rightarrow 0_1^-$	3.9	0.11	0.03 ns	
$\rightarrow 1_1^-$	1	1		
$\rightarrow 2_1^-$	0.96	0.32		
$4_1^- \rightarrow 2_1^-$	1	1	34.6 ns	36 ns
$3_1^- \rightarrow 1_1^-$	0.0000	—	0.05 ns	
$\rightarrow 2_1^-$	1	1		
$\rightarrow 1_2^-$	0.0000	—		
$\rightarrow 4_1^-$	0.02	0.07		

Electromagnetic properties (branching ratios and halflives) calculated in IBFFM for the low-lying states in ^{98}Y. Comparison to data is given under the assumption of the spin assignment from Fig. 2. The branching ratios are normalized to unity for the strongest observed depopulation of each level.

than the measured value. An interesting additional experimental information for transitions between the low-lying states is the conclusion from the measured conversion coefficients that the $2_1^- \rightarrow 1_1^-$ transition is of $M1$ type with a possible small $E2$ admixture[1]. The IBFFM calculation predicts $M1 + 2\% \ E2$ for this transition, in good agreement with the experiment.

Employing the parametrization deduced from neighbouring lighter nuclei, we have also calculated the positive-parity levels. We obtain 1^+ as the lowest positive-parity state in IBFFM. A few calculated low-lying positive-parity levels are also presented in Fig. 2, where the 1_1^+-IBFFM level was assigned to the experimental 1^+ level at 548 keV. The wave function of this state, presented in Table 1, has the largest component $(\pi g_{9/2}, \nu g_{7/2})\ 1^+$. This is in agreement with the parabolic rule since the parabola $(\pi g_{9/2}\ \nu g_{7/2})$ has $\mathcal{O} = 1$ and therefore is open downwards. The next higher calculated positive-parity states are 5_1^+ and 3_1^+. Their relative position is rather sensitive to the strengths of the residual interaction and can be reversed by a modification of the interaction strengths. Further experimental information is needed in order to obtain firm assignemnts for the positive parity states in ^{98}Y. Here it should be mentioned that the 1^+ state at 548 keV might also belong to a deformed configuration since it is strongly populated through the β^- decay of the deformed ground state of ^{98}Sr. If so, then the spherical 1^+ state resulting from the calculation may lie higher in energy.

Finally, let us comment on the coexisting deformed states in ^{98}Y. The band head at 496 keV has no reliable spin/parity assignment. As most probable, 2^+ or 2^- assignments have been proposed[14,15]. Calculations of the excitation energies of the band heads of odd-odd nuclei in the $A \approx 100$ region[34] offer candidates for both parities, namely $\{\pi\,[422\ 5/2], \nu\,[404\ 9/2]\}2^+$ and $\{\pi\,[303\ 5/2], \nu\,[404\ 9/2]\}\ 2^-$ which have the same neutron configuration. Also the state $\{\pi\,[301\ 3/2], \nu\,[404\ 9/2]\}\ 3^-$ could be a possible candidate for the band head; it would, however, involve an unexpectedly large moment of inertia of the band. We note that the band structure, similar to the results of the Nilsson model calculations, can be obtained in IBFFM employing an SU(3) boson core[35]. Such a treatment of the deformed states in ^{98}Y would require large computations involving the full valence oscillator shells for protons and neutrons and is not available at this stage.

In conclusion, the IBFFM calculations reproduce satisfactorily the known properties of the low-lying levels of ^{98}Y and thus strengthen the assumption that they are of spherical nature. It is remarkable that this good description is obtained through an extrapolation of the parameters from the lighter neighbours although the levels of ^{98}Y seem to be more complex than those of ^{96}Y. Of course, a measurement of the spins and parities of the levels of ^{98}Y is necessary to confirm the IBFFM results. An open problem is the nature of the β-decaying isomer in this nucleus with $I \sim 5\hbar$ [36] at an excitation energy of about 1 MeV[37]. It is difficult to describe this level as a proton-neutron coupled state as in the case of ^{96}Y where the corresponding isomer probably is the 8^+ member of the $(\pi g_{9/2}, \nu g_{7/2})$ multiplet. The present results may help to gain better understanding of ^{98}Y and to serve as a possible guideline in identification of low-lying levels in this nucleus, which presents a challenge to the understanding of coexistence of spherical and deformed phases at the point of rapid onset of deformation.

References

1) G. Lhersonneau, R. A. Meyer, K. Sistemich, H. P. Kohl, H. Lawin, G. Menzen, H. Ohm, T. Seo and D. Weiler, In: *Recent Advances in the Study of Nuclei off the Line of Stability*, Chicago, 1985, D. S. Brenner, R. A. Meyer (eds.), p. 202, ACS Symposium Series 324 (1985);

2) G. Jung, B. Pfeiffer, P. Hungerford, S. M. Scott, F. Schussler, E. Monnand J. A. Pinston L. J. Alquist, H. Wollnik and W. D. Hamilton, Nucl. Phys. **A352** (1981) 1;

3) E. Monnand, J. Blachot, F. Schussler, J. P. Bocquet, B. Pfeiffer, G. Sadler, H. A. Selic, T. A. Khan, W. D. Lauppe, H. Lawin and K. Sistemich, In: *Proceedings of* 3^{rd} *International Conference on Nuclei far from Stability*, Cargese, 1976, Report CERN 73-13 (1977) 477;

4) B. Pfeiffer, E. Monnand, J. A. Pinston, F. Schussler, G. Jung, Münzel J. and H. Wollnik, In: Proceedings of 4th International Conferencc on Nuclei far from Stability, Helsingor, 1981. Report CERN 81-09 (1981) 423;

5) G. Lhersonneau, D. Weiler, P. Kohl, H. Ohm, K. Sistemich and R. A. Meyer, Z. Phys. A-Atomic Nuclei **323** (1986) 59;

6) E. Monnand, J. A. Pinston, F. Schussler, B. Pfeiffer, H. Lawin, G. Battistuzzi, K. Shizuma and K. Sistemich, Z. Phys. A-Atoms and Nuclei **306** (1982) 183;

7) R. F. Petry, H. Dejbakhsh, J. C. Hill, F. K. Wohn, M. Schmid and R. L. Gill, Phys. Rev. **C31** (1985) 621;

8) F. K. Wohn, J. C. Hill, R. F. Petry, Phys. Rev. **C31** (1985) 634;

9) R. A. Meyer, E. Monnand, J. A. Pinston, F. Schussler, I. Ragnarsson, B. Pfeiffer, H. Lawin, G. Lhersonneau, T. Seo and K. Sistemich, Nucl. Phys. **A439** (1985) 510;

10) F. K. Wohn, J. C. Hill, J. A. Winger, R. F. Petry, J. D. Goulden, R. L. Gill, A. Piotrowski and H. Mach, Phys. Rev. **C36** (1987) 1118;

11) J. W. Grütter, Thesis, Universität zu Koln, 1972, Report Jül-879-NP;

12) J. W. Grüter, K. Sistemich, P. Armbruster, J. Eidens, K. Hübenthal and H. Lawin, In: Proc. colloque sur les noyaux de transition, Orsay, 1971, Report IN2P3;

13) K. Sistemich, R. Fabbri, J. W. Grüter, T. A. Khan, W. D. Lauppe, H. Lawin, G. Sadler, H. A. Selic, M. Shaanan and P. Armbruster, Nucl. Instr. Meth. **130** (1975) 491;

14) H. Mach and R. L. Gill, Phys. Rev. **C36** (1987) 2721;

15) K. Sistemich et al., to be published;

16) H. Mach, E. K. Warburton, R. L. Gill, R. F. Casten, A. Wolf, Z. Berant, J. A. Winger, K. Sistemich, G. Molnar and S. W. Yates, In: *Nuclear Strcuture of the Zyrconium Region*, Bad Honnef 1988, Research Reports in Physics, J. Eberth, R. A. Meyer and K. Sistemich (eds.), p 391 (1988);

17) A. Arima and F. Iachello, Phys. Rev. Lett. **35** (1975) 157;

18) F. Iachello and O. Scholten, Phys. Rev. Lett. **43** (1979) 679;

19) S. Brant, V. Paar and D. Vretenar, Z. Phys. A-Atoms and Nuclei **319** (1984) 355;

20) V. Paar, In: *Capture Gamma-Ray Spectroscopy and Related Topis*, S. Raman, (ed.) New York, American Institute of Physics, p. 70 (1985);

21) V. Lopac, S. Brant, V. Paar, O. W. B. Schult, H. Seyfarth and A. B. Balantekin, Z. Phys. A-Atomic Nuclei **323** (1986) 491;

22) S. Brant, K. Sistemich, V. Paar and G. Lhersonneau, Z. Phys. A-Atomic Nuclei **330** (1988) 365;

23) S. Brant, G. Lhersonneau M. L. Stolzenwald, K. Sistemich and V. Paar, Z. Phys. A-Atomic Nuclei **329** (1988) 301;

24) K. Sistemich, K. Kawade, H. Lawin, G. Lhersonneau, H. Ohm, U. Paffrath, V. Lopac, S. Brant and V. Paar, Z. Phys. A-Atomic Nuclei **325** (1986) 139;

25) S. Brant, K. Sistemich, H. Seyfarth, H. Ohm, M. L. Stolzenwald, V. Paar, D. Vretenar, D. Vorkapić, V. Lopac, R. A. Meyer, G. Lhersonneau, K.-L. Kratz and B. Pfeiffer, In: *Nuclear Structure of the Zirconium Region*, J. Eberth,, R. A. Meyer and K. Sistemich (eds.), p. 391 (1988);

26) V. Paar, D. Vorkapić, S. Brant, H. Seyfarth and V. Lopac, In: *Nuclear Strcuture of the Zirconium Region*, J. Eberth, R. A. Meyer and K. Sistemich (eds.), p. 184 (1988);

27) Y. Tokunaga, H. Seyfarth, R. A. Meyer, O. W. B. Schult, H. G. Börner, G. Barreau, H. R. Faust, K. Schreckenbach, S. Brant, V. Paar, M. Vouk and D. Vretenar, Nucl. Phys. **A439** (1985) 427;

28) S. Brant, V. Paar and D. Vretenar, *Computer codes PTQM and OTQM*, Jülich 1985 (unpublished);

29) G. Lhersonneau, K.-L. Kratz, H. Ohm, B. Pfeiffer and K. Sistemich, In: *Nuclear Structure of the Zirconimu Region*, Bad Honnef 1988, *Research Reports in Physics*, J. Eberth, R. A. Meyer, K. Sistemich (eds.), p. 58 (1988);

30) V. Paar, Nucl. Phys. **A211** (1973) 29;

31) V. Paar, Nucl. Phys. **A331** (1979) 16;

32) G. Lhersonneau et al.: to be published;

33) H. Ohm, G. Lhersonneau, K. Sistemich, B. Pfeiffer and K.-L. Kratz, Z. Phys. A-Atomic Nuclei **327** (1987) 483;

34) R. A. Meyer and K. Sistemich, In: *Atomic Masses and Fundamental Constants* **7**, O. Klepper (ed.), Technische Hochschule Darmstadt, p. 523 (1984);

35) S. Brant and V. Paar, Z. Phys. A-Atomic Nuclei **329** (1988) 151;
S. Brant, V. Paar, D. K. Sunko and D. Vretenar: Phys. Rev. **C37** (1988) 830;

36) M. L. Stolzenwald, Thesis, Univ. Köln, 1989;

37) R. Stippler, F. Münnich, H. Schrader, J. P. Bocquet, M. Ashgar, G. Siegert, R. Decker, B. Pfeiffer, H. Wollnik, E. Monnand and F. Schussler: Z. Phys. A-Atoms and Nuclei **284** (1978) 95.

STRUKTURA ^{98}Y POMOĆU IBFFM RAČUNA

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UDK 539.142

Originalni znanstveni rad

Istraživana su niskoležeća stanja ^{98}Y u IBFF modelu. Korištena je U (5) sredica (^{96}Sr), a parametri su određeni iz proučavanja susjednih jezgri. Dobiven je uvid u strukturu sferičnih stanja jezgre ^{98}Y.