Collective character of $K^{\pi}=4^{+}$ band in ^{188,190}Os

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The algebraic sd boson Interacting Boson Model (IBM-1) is based on the assumption of the conservation of the bosons in the boson-boson interaction. Each valence nucleon pair of neutrons and protons (particle or hole) is represented by an L=0 s-boson or L=2 d-boson [1]. It has three dynamical symmetries called the U(5), SU(3) and O(6), corresponding to the three classical limits in the Bohr-Mottelson (BM) model: spherical vibrator, deformed rotor and γ-unstable rotor. These may be represented by the three corners of a symmetry triangle. The SU(5) to SU(3) transition is called Transition class-A, the U(5) to O(6) the class C and SU(3) to O(6) the class B. The recently identified critical symmetry points E(5) and X(5) lie on class C and class A respectively, which yield analytical solutions [2], if one uses special shape potential for the β- and γ-variables.

The Os nuclei in the third quadrant of major shell Z=50-82, N=82-126, lie on the Class B branch. Iachello and Arima [1] cited energy level structure and E2 transitions in the lower levels of $^{186-192}$Os as illustration of IBM capability for this class. Earlier, Casten et al. [3] studied Os nuclei as illustration of the perturbed O(6) symmetry.

With the advances in nuclear detector techniques, the absolute B(E2) values for the lower levels were studied through Coulomb excitation and RDM life time measurements. Wu et al. [4, 5] studied $^{188-190}$Os by both methods. Recently, the interest in Os is focused on the collective character of the K=4 states which lies low in Os [4-6]. The very low-lying K=2 γ-band indicates that these Os nuclei are γ-soft. This gives rise to the possibility of the γγ K=4 band to lie at low energy. However an opposite view is also possible, that these are λ=4 hexadecapole vibrations mixed with quasi-particle excitations [6]. Here we have used the PHINT program of IBM-1 for the study of the character of these K=4 bands in $^{188-190}$Os We used the 4-parameter Hamiltonian [1]

$$H_{IBM} = \varepsilon\, n_d + kQ.Q + k'L.L + k''P.P \qquad (1)$$

This program attempts to trace the appropriate parameters for the IBM Hamiltonian by the least square fit method. But secondary minima are often obtained, which may provide apparent deceptive fit. We have carried out a careful search for the reasonable fit to level energies, and obtained reasonable values in agreement with experiment (Table 1).

Table 1 The level energies in keV.

Isotope	^{188}Os		^{190}Os	
Iπ	EX	IBM	EX	IBM
2+	155	142	187	191
4+	478	470	547	581
6+	940	977	1050	1160
K=2				
2’	633	570	557	488
3	790	734	756	773
4’	965	926	955	938
5	1181	1186	1203	1333
6’	1424	1455	1474	1559
0”	1086	744	911	633
2	1076	958	1060	993
K=4				
4”	1279	1226	1163	1220
5”	1424	1546	1466	1705
6”	1836	1808	1836	1904

Table 2. Parameters used in IBM-1 for Os in keV.

A	EPS	PAIR	ELL	QQ
188	195.6	120.1	32.5	-19.7
190	401.4	123,1	31.4	-12.8

However, the calculated 0_2^+ lies low compared to experiment by almost 300 keV. This seems to be an in-built feature [1, 3]. The increase of K" in the P.P term does not improve this aspect, which should raise this energy. The input parameter values are listed in Table 2. The quadrupole operator of Eq. (1) is given by

$$Q = \alpha\ [s+d + d+s]^{(2)} + \beta\ [d+d]^{(2)} \qquad (2)$$

The ratio β/α is ≅1.32 for the SU(3) limit and is equal to zero in the O(6) limit. Here in view of the γ-soft character of the Os isotopes we have taken its value ~0.9 only. This gave a better mixing of the O(6) symmetry with the SU(3),

The calculated B(E2) values are listed in Table 3. Here we present the values for those transitions for which the absolute values are available from recent measurements [4, 5]. The charge parameter of the E2 transition operator is chosen to approximately reproduce the 2-0 strength. The ratio B(E2 2_2- 0/2) is a good measure of the degree of deformation and the γ-soft character of the nucleus. Our calculated values for absolute B(E2) are in fair agreement with experiment. Same is true for the E2 transitions from the K=2, I=4 state.

Next, the character of the K=4 I=4 is tested with its preferential decay to the members of the k=2 band, which may partially indicate its two phonon character. Our calculated values are in good agreement with the experiment in this respect. Thus our attempt to properly reproduce the structure of the $^{188\text{-}190}$Os seems to be fairly successful.

Table 3. Absolute B(E2) values in $e^2.b^2$ in Os from experiment [4, 5] versus IBM.

Transition		^{188}Os			^{190}Os		
I_i	I_f	Coul.	τ (RDM)	IBM	Coul.	τ(RDM)	IBM
2-	0	0.50 1	0.54 8	0.55	0.47 1	0.47 3	0.45
4-	2	0.77 5	0.85 5	0.78	0.62 4	0.69 4	0.64
6	4	0.84 2	0.89 5	0.83	0.61 3	0.84 4	0.69
2'-	0	0.047 2	0.033 4	0.031	0.039 2	0.038 4	0.020
	2	0.150 4	0.104 11	0.073	0.23 2	0.22 3	0.22
4'-	2	0.009 1	0.009 1	0.008	0.005 3	0.004 4	0.001
	4	0.134 7	0.140 14	0.078	0.23 2	0.20 2	0.15
	2'	0.35 3	0.37 4	0.30	0.39 2	0.35 3	0.32
4" -	2	0.0017 6	0.0014 6	0.0001	0.0003 2	0.0002 2	0.0001
	2'	0.077 7	0.065 15	0.065	0.066 9	0.048 11	0.010
	3	0.15 4	0.129 47	0.095	0.27 9	0.19 7	0.27
	4'	0.30 3	0.25 6	0-10	0.28 4	0.20 5	0.27

+ Associated.

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