Low-lying 2qp structures in ^{244}Bk

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The identification of ^{244}Bk nuclide was first reported by Wolf and Unik in 1972 [1]. The latest Nuclear Data Sheets (NDS) for ^{244}Bk [2] lists 4 excited states with one of them identified as an isomeric state with $t_{1/2}$ = 820 ns. However, except for a tentative assignment to the ground state (g.s), none of the levels have been characterized yet. In the present work, we attempt to characterize these levels by employing a simple phenomenological model [3] to evaluate low-lying bandheads ($E_x \leq 500$) keV in ^{244}Bk and assign spin-parities. The formula used in the model is given as:

$$E(K{:}\,\Omega_p,\Omega_n) = E_K^0 + E_p(\Omega_p) + E_n(\Omega_n) + E_{rot}\text{-}\left(\tfrac{1}{2}\text{-}\delta_{(\Sigma,0)}\right)\Delta E_{GM} + \delta_{K,0}(\text{-})^I E_N \qquad (1)$$

The single particle proton and neutron energies in eq. (1) are taken from the respective neighboring odd-particle nuclei $^{241-247}$Bk (Z = 97) and ^{243}Cm (N = 147). Using the data presented in Table 1, we determine the low-lying bandhead energies in ^{244}Bk. The evaluated bandhead energies thus presented in Fig. 1.

As a first step, we note that the present evaluation is in agreement with a 4^- assignment to the g.s in ^{244}Bk arising from the AZ combination of Table 1. The 1^- singlet GM member of this combination lies at least 50 keV above. We next consider the 170 keV level in ^{244}Bk which is described by the NDS evaluators has having an identical structure to the g.s of the parent ^{248}Es from which a very low hindrance factor (HF) α-decay (HF = 7) proceeds to the 170 keV level in ^{244}Bk. The structure of the parent ^{248}Es g.s is mentioned by the NDS evaluators [4] as possibly arising from a combination of π3/2[521] or π7/2[633] for the Z = 99 proton and ν7/2[624] for the 149th neutron. From Table 1 and going by the GM coupling rule, this would assign the triplet members from either AX or BX combination for the g.s in ^{248}Es – i.e. 2^- or 0^+ respectively. From Fig. 1, if 2^- were to be the assignment to the 170 keV level in ^{244}Bk, then low multipole gamma transitions to at least some of the lower levels, notably an E2 transition to the g.s, should have been observed. On the other hand, if the assignment were to be 0^+ triplet from the BX combination, then while most of the decaying transitions would be highly converted due to their low energies, a high multipole transition to the 4- g.s would be improbable in comparison to the E2 transition. Since no decaying gamma has been observed thus far, the most probable assignment to the 170 keV level and consequently to the g.s of parent ^{248}Es, is the triplet 0^+ from BX combination.

The observation of an α-decay from the parent ^{248}Es to the 140 keV level in ^{244}Bk with a low HF of 22 suggests that the 140 keV level could have at most one configuration change from the parent level. The g.s of ^{248}Es is most probably assigned BX. Hence the 140 keV level could arise from BZ combination since all other possible combinations (AX and BY) give levels that are higher than the 170 keV BX triplet. The absence of any decaying gamma from the 140 keV level and also from the higher lying 170 keV (0^+) to the 140 keV level suggests a 6^+ triplet assignment from the BZ combination to the 140 keV level.

Finally, the low HF (38) α-decay from ^{248}Es to the 200 keV level in ^{244}Bk allows at most a single configuration change between the two levels. This gives probable assignments of singlet (7^+) of BX combination or the GM pairs (3^+,4^+) of BY combination to this level. Once again, the assignment of any of the BY combination to the 200 keV level would enable the possibility of observing at least a few low multipole transitions decaying to the lower levels in ^{244}Bk. However, since none was observed, we assign the 200 keV as the singlet 7^+ from the BX combination.

Table 1: Low-lying ($E_x \leq 500$) 2qp bands expected to occur in ^{244}Bk. Since no data is available for the GM splitting energy or the Newby shift, we assume ΔE_{GM} = 80 keV and E_N = 25 keV averaged from the values usually occurring in this region [5].

	(Z)	**(Y)**	**(X)**
n_j → / p_j ↓	n_0 = 0.0 keV 5/2[622]	n_1 = 87 keV 5/2[622]	n_2 = 130 keV 7/2[624]
p_0 = 0.0 keV 3/2[521] (A)	4^- 1^-	1^- 2^-	2^- 5^-
p_1 = 46 keV 7/2[633] (B)	6^+ 1^+	3^+ 4^+	0^+ 7^+

Based on the above arguments the spin-parity assignments for the observed levels in ^{244}Bk are summarized in Table 2.

Table 2: Spin-parity assignment to the observed levels in ^{244}Bk based on the 2qp configurations given in Table 1.

Level	J^π	**Characterizations**
0 keV	4^-	Triplet AZ
140 keV	6^+	Triplet BZ
170 keV	0^+	Triplet BX
200 keV	7^+	Singlet BX

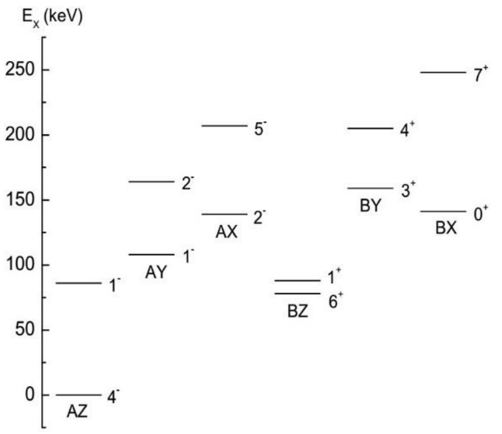

Fig. 1 Expected low-lying levels in ^{244}Bk

References

[1] K.L. Wolf, K.P. Unik, Phys. Lett. **B38** (1972), 405
[2] Y.A. Akovali; Nuclear Data Sheets **99** (2003) 197
[3] P.C. Sood, D.M. Headly, R.K. Sheline & R.W. Hoff; At. Data. Nucl. Data Tables **58** (1994) 107.
[4] Y.A. Akovali; Nuclear Data Sheets **87** (1999) 249.
[5] R.W. Hoff, A.K. Jain, J. Kvasil, P.C. Sood, R.K. Sheline, in *Exotic Nuclear Spectroscopy*, edited by W.C. Harris (Plenum, New York, 1990) p.413.

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