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DECAY SCHEME OF E^{253}

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Lawrence Radiation Laboratory

University of California, Berkeley, California

The alpha and electron spectra of E^{253} were investigated with high resolution magnetic spectrographs. Previous measurements were confirmed[1-5] but in addition several new levels and transitions were observed leading to the identification of three rotational bands as shown in Fig. 1. α-γ, α-e-, and L Xray-γ coincidence measurements reinforced these assignments.

As seen from Fig. 1, the relative spacings of the assigned states in the 8.8-kev band are in excellent agreement with a spin of 3/2 for the base state. In addition the rotational constant for spin 3/2 is 6.1, in good agreement with the usual values for odd mass nuclides.

Although the parity of this band cannot be determined simply from the experimental data, inspection of a Nilsson diagram[6] readily shows the most probable state is 3/2 - [521]. These Nilsson quantum numbers[6] are partially defined in Fig. 1.

It will be shown later that the ground state spin of Bk^{249} is 7/2+. Thus an M2 transition might be expected between the 3/2- and 7/2+ states. α-e- delayed coincidence measurements showed a half-life of 0.3 milliseconds for about 2% of the E^{253} alpha transitions, in good agreement with the total alpha population to the 3/2- band. This lifetime is retarded by about a factor of 50 over the single proton M2 value.[7]

The ground state and 393-kev bands are discussed together as it will be shown that they are closely related. From the level spacing of this ground state band, the spin of the ground state is calculated t be 3.16 ± 0.01. This value is closer to 7/2 than any other spin, but the agreement is not very good. Also the rotational constant for this band has a value of 4.63-kev, which is unusually low. We have calculated the properties of this band, however, considering the Coriolis interaction[8] as modified by the pairing correlations[9] and will show that these quantities are both well explained provided the assignment 7/2 + [633]

E^{253} decay scheme

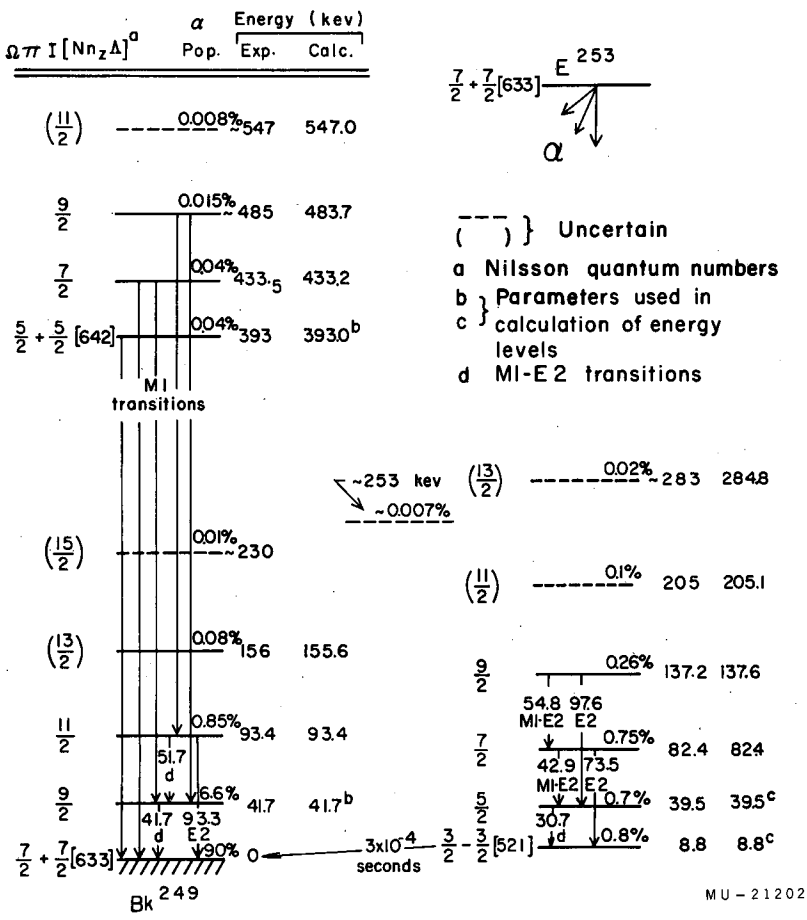

Fig. 1

is made for this band. This is consistent with what one would expect from the Nilsson diagram. The decay characteristics and spacing of the 393-kev band are also well accounted for if the 5/2 + [642] assignment is made, which, again is not unexpected considering the Nilsson diagram. This case is a particularly favorable one for detailed Coriolis calculations because (1) within the entire 82-126 proton shell the only positive parity levels (a requirement for the interaction is no change of parity) are those originating from the $i_{13/2}$ shell-model level and these can all be taken into account explicitly. (2) The Coriolis matrix elements are large and do not depend on details of the Nilsson wave functions, and (3) the positions and moments of inertia of two bands from the $i_{13/2}$ orbital are known. We have used two parameters in the calculation, which seem to fix the positions of the 393 and 41.7 kev levels. The other calculated energies are given in Fig. 1, and agree well with the experimental values. It is interesting to note that the mixing causes positive deviations from the I(I+1) formula in the ground (K=7/2) band and irregular deviations from the I(I+1) formula in the 393-kev (K=5/2) band. The experimental data confirm the former trend but are not sufficiently accurate to test the latter. The transitions between the two bands are M1 as would be expected from calculations using the mixed Nilsson wave functions.

The theoretical alpha populations to various members in a rotational band are readily calculated for an alpha wave of a given angular momentum.[9] In addition if the parent and daughter states have the same configuration, the alpha transition to the base state of the band is essentially unhindered, and the relative alpha populations to the various band members are explicitly determined. As seen from Table I, the above conditions are well met by the ground state band, resulting in the same assignment for the E^{253} ground state, 7/2 + [633], as found for Bk^{249}.

In the hindered alpha decays to the other bands, the relative alpha populations are also in good agreement with the calculated values, consistent with the spin and parity assignments.

TABLE I

Alpha Decay of E^{253} to the 7/2+ band in Bk^{249}.

Excited state Energy (kev)	I	Calculated Abundances[a] (%) L=0	L=2	L=4	$\sum_L$	Experimental values (%)	Hindrance factors[b]
0	7/2	79.6	10.0	0.1	89.7	90	1.9
41.7	9/2	---	5.9	0.3	6.2	6.6	17
93.4	11/2	---	0.9	0.3	1.2	0.85	7.7
156	13/2	---	---	0.11	0.11	0.08	430
230	15/2	---	---	0.009	0.009	0.01	~1500

[a]The abundances are calculated from the expression

$$P_E = P_{OE} \sum_L C_L \begin{pmatrix} I_i & L & I_f \\ C_{K_i} & K_f-K_i & K_f \end{pmatrix}; \quad \sum_E P_E$$ is the total population to the rotational band, P_{OE} is the unhindered population to a state E calculated from simple spin independent alpha decay theory, C_L is the reciprocal of the hindrance factors for the vari us L waves in the adjacent even-even nuclides ($C_0:C_2:C_4$ = 1:0.27:0.023 from Fm^{254} and Cf^{252}),[10] and the last factor is a Clebsch Gordan coefficient.

[b]The hindrance factors as used here are the ratio of the experimental partial half life of a given α group to the value calculated from spin independent alpha decay theory[11] using the radii of adjacent even-even nuclides.

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FIGURE CAPTIONS

Fig. 1. Decay Scheme of E^{253} --all dashed levels or quantities in parentheses are uncertain.

a. The Nilsson quantum numbers, $\Omega\pi[Nn_z\Lambda]$.

b. These energies were arbitrary parameters in the calculation of the level energies for the 5/2+ and 7/2+ bands.

c. These energies were arbitrary parameters in the calculation of the level energies for the 3/2- band.