New ^{166}Er Nuclear States Populated in the ^{166m}Ho Decay*

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The structure of the strongly deformed ^{166}Er nucleus has been studied over the past years using different nuclear reactions. Single nucleon transfer reactions, such as ^{167}Er(d, t) [1], ^{165}Ho(^{3}He, d) and ^{165}Ho(α, t) [2], gave evidence of quasiparticle structure, while inelastic scattering ^{166}Er (d, d′) [3] was more appropriate to observe collective excitations.

The electromagnetic deexcitation of some low-lying energy levels fed in the β decay of ^{166}Ho ($T_{1/2}$ = 26.80 h) was studied by Allab *et al.* [4]. Our actual knowledge of the high-spin levels of ^{166}Er is due to the study of the ^{166m}Ho ($T_{1/2}$ = 1200 years) decay [5]. We decided to reinvestigate the decay of this nuclide in order to precisely determine the K quantum number of some negative parity levels.

Experimental

Spectrometers

The detectors used in this work were mainly a 17% relative efficiency intrinsic germanium detector having an energy resolution F.W.H.M. (Full Width at Half-Maximum) of 1.9 keV on the 1.33 MeV γ-line (^{60}Co), and a 2 cm^3 planar HPGe detector having an F.W.H.M. of 190 eV at the K X-line. The pulses were amplified with a spectroscopy amplifier (572 EG & G Ortec) and analysed through a 8192 channel 918 ADCAM multichannel buffer system (EG & G Ortec) coupled with a PDP11/23 (350 DEC) disk based microcomputer.

Radiochemical Procedure

The $^{166m}HoCl_3$ source was provided by the L.M.R.I. (Laboratoire de Métrologie des Radiations Ionisantes) as a standard source of 48.5 kBq. From this 8 month old source, the only holmium nuclide remaining at the date of measurements was ^{166m}Ho. However, preliminary measurements exhibited small contaminations (~0.1%) from long-lived rare-earth isotopes such as ^{152}Eu and ^{154}Eu. Thus, a radiochemical separation was needed to attribute the presence of very weak lines to the ^{166m}Ho decay. The following classical procedure [6] was applied: the holmium solution was put on the top of a Dowex 50 WX-8 cation exchange column of 15 cm length and 0.05 cm^2 area preliminarily conditioned with the elutant; holmium was eluted with a 0.51 M ammonium 2-hydroxy-2-methylpropanoate solution, adjusted to pH = 3.3 with NH_4OH. At room temperature [6], holmium passed between 1.5 and 3 column volumes (CV), whereas europium isotopes needed more than 8 CV.

The spectrometers were calibrated in energy and efficiency by counting runs with standard sources such as ^{152}Eu, ^{137}Cs and ^{207}Bi; the method of calibration has been described elsewhere [7].

Results and Discussion

The energy and intensity of 54 γ-lines were accurately measured in this work, of which 11 are reported for the first time. Their values are in very good agreement with Reich and Cline's values [5] as well as that of other authors [8–10]. Table I lists the energies (column 1) of the new γ-lines observed here, together with their relative intensities (column 2) normalized to 100 photons of the 184.414 keV γ-ray.

The interpretation of these lines was made possible using the Ritz combination principle with our improved energy values and the γ–γ coincidence data.

The new 785.79 keV state in ^{166}Er is deduced here, because of the presence of new γ-rays of 785.81, 705.09 and 520.85 keV interpreted as deexciting respectively the 0^+, 2^+ and 4^+ members of the ground state band. This level is the band-head of the so-called 'γ-band' (K = 2) which is populated up to spin I = 8 in the ^{166m}Ho decay, and was observed until now in the ^{166}Yb decay and in the ^{166g}Ho decay [4].

A 1527.12 keV level is suggested to be fed for the first time in the ^{166m}Ho decay as the result of its deexcitation by the new 1261.98 and 1446.72 γ-lines to the respective $KI^\pi = 04^+$ and 02^+ levels in the ground state band. This level is identified to the $I^\pi = 2^+$ state found in the ^{166}Yb decay and in the ^{166g}Ho decay [4]. The reduced probability ratio $B(E2)$ of the assumed $E2$ transitions to the respective 2^+ and 4^+ levels is equal to ~0.5, which compares well to the squared Clebsch–Gordan ratio, *i.e.*, 0.55 for K = 0. Hence, this level belongs to the $K^\pi = 0^+$ band whose band-head energy 1460.0 keV was measured in the ^{166m}Ho decay [4].

A 1572.07 keV level with $I^\pi = 4^-$ is also newly reported in the ^{166m}Ho decay; it feeds the $KI^\pi = 25^+$

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TABLE I. New Photons Lines Observed in the ^{166m}Ho Decay

E_γ (keV)	I_γ [c]	Initial level				Final level			
		E (keV)	K	I	π	E (keV)	K	I	π
305.03(5)	0.023(3)	1376.00	2	7	+	1075.25	2	5	+
476.38(6)	0.052(6)	1692.24		5	–	1215.97	2	6	+
496.86(4)	0.17(1)	1572.07[b]	2	4	–	1075.25	2	5	+
520.85(5)[a]	0.21(1)	1596.12	2	4	–	1075.25	2	5	+
		785.79[b]	2	2	+	264.991	0	4	+
615.84(5)	0.044(13)	1572.07[b]	2	4	–	956.24	2	4	+
705.09(7)	0.011(2)	785.79[b]	2	2	+	80.577	0	2	+
785.81(7)	0.019(4)	785.79[b]	2	2	+	0.000	0	0	+
1261.98(12)	0.010(2)	1527.12	0	2	+	264.991	0	4	+
1306.60(15)	0.010(2)	1572.07[b]	4	4	–	264.991	0	4	+
1331.04(13)	0.010(2)	1596.12	2	4	–	264.991	0	4	+
1446.72(13)	<0.01	1527.12[b]	0	2	+	80.577	0	2	+

[a]This line can be placed twice. [b]New level in ^{166}Er. [c]The relative intensities are normalized to $I_\gamma = 100$ for the 184.407 keV γ-ray. Uncertainties (in parentheses) on energies and intensities are given on the last digits.

and 24$^+$ members of the γ-band, resulting in new lines of 496.80 and 615.84 keV respectively. We also observe a ΔK hindered transition of 1306.60 keV to the $KI^\pi = 04^+$ state. The reduced probability ratio $B(E1)$ of the γ-lines feeding the γ-band favors a quantum number $K = 4$, but the mixing with higher K values is not excluded.

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