STUDY OF THE ELECTROMAGNETIC CONSTANT S OF ROTATIONAL BANDS $\frac{7}{2}^+$[404] AND $\frac{5}{2}^-$[512]

A.K. KARAKHODZHAEV

National University of Uzbekistan
(Tashkent, Uzbekistan; e-mail: ashrafhon@yandex.ru)

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The values of the electromagnetic constant S of rotational bands $\frac{7}{2}^+$[404] and $\frac{5}{2}^-$[512] have been determined. It has been shown that the weighted mean values of S for rotational bands with identical asymptotic quantum numbers remain intact for various mass numbers of the nuclei.

The studies of the electromagnetic constant S of the rotational band and of the multipole mixing parameter δ of electromagnetic transitions provide important information concerning the probability of electromagnetic interactions in nuclei. In this work, the values of the electromagnetic constant S of rotational bands $\frac{7}{2}^+$[404] and $\frac{5}{2}^-$[512] for odd nuclei with the mass numbers $A = 165 \div 173$ were determined for the first time. The electromagnetic constant S is a ratio of the matrix elements of the gamma-transition with a $(M1+E2)$-multipolarity within a rotational band. This value is positive or negative depending on the sign of the multipole mixing parameter δ. Here, we evaluated the absolute values of S.

The value of S is known to remain constant within a rotational band within the limits of experimental errors. It is of interest to reveal its behavior along with the variation of the nucleus mass number for rotational bands with identical asymptotic quantum numbers $K^\pi[\mathrm{N}n_z\Lambda]$ [1].

In the generalized model of deformed nuclei, the probabilities of the gamma-transitions with multipolarities $E2$ and $M1$ between the levels of a rotational band are expressed by the formulae [2]

$$\lambda_\gamma(E2) = 1.22 \cdot 10^{-3} E^5 Q_0^2 \langle I_i K 20 | I_f K\rangle^2, \quad \mathrm{s}^{-1}, \tag{1}$$

$$\lambda_\gamma(M1) = 4.18 \cdot 10^3 E^3 (g_K - g_R)^2 \times$$
$$\times [1 + b_0(-)^{I-1/2}\delta_{K,1/2}]^2 K^2 \langle I_i K 10 | I_f K\rangle^2, \quad \mathrm{s}^{-1}, \tag{2}$$

where E is the energy of gamma-transition measured in keV, Q_0 is the intrinsic quadrupole moment, g_k and g_R are the one-particle and collective gyromagnetic ratios, respectively, b_0 is a magnetic decoupling parameter, $\delta_{K,1/2}$ is the delta-function, K is a projection of the total angular momentum onto the nucleus symmetry axis, and $\langle \ldots \rangle$ denotes the Clebsch—Gordan coefficient. Using those relations, the connection between the rotational band parameter S^2 and the mixing coefficient δ^2 is [3]:

$$S^2 = \frac{(g_K - g_R)^2}{Q_0^2}[1 + (-)^{I-1/2} b_0 \delta_{K,1/2}]^2 =$$
$$= \frac{8.76 \cdot 10^{-7} E^2}{\delta^2 (I^2 - 1)} \left(\frac{\text{nucl.magn.}}{e \cdot \text{b}}\right)^2, \tag{3}$$

where I is the spin of the initial state and $\delta^2 = \lambda_\gamma(E2)/\lambda_\gamma(M1)$.

The experimental values of the energy, intensity, and mixing parameter were taken from [4–9]. For nuclei ^{167}Er, ^{169}Yb, and ^{169}Lu, the mixing parameter δ^2 was calculated through the ratio r of the gamma-quantum intensities I_γ's of intrinsic rotational transitions [3]:

$$\delta^2 = \frac{r}{F - r}, \quad r = \frac{I_{\gamma 1}(I \to I-2)}{I_{\gamma 2}(I \to I-1)},$$

$$F = \frac{\lambda_{\gamma 1}(E2)(I \to I-2)}{\lambda_{\gamma 2}(E2)(I \to I-1)}. \tag{4}$$

The experimental data on the characteristics of gamma-transitions within rotational bands $\frac{7}{2}^+$[404] and $\frac{5}{2}^-$[512] are quoted in the table, together with the relevant values of δ and S.

Experimental data on the gamma-transition parameters of rotational bands $\frac{7}{2}^+$[404] and $\frac{5}{2}^-$[512] and the calculated values of the electromagnetic constant S

Transition energy E_γ, keV	Intensity I_γ	Spin Init. $2I_i$	Spin Final $2I_f$	Mixing parameter δ	$\lvert S(\Delta S)\rvert$ nucl.magn./(e·b)
1	2	3	4	5	6
^{165}Lu 7/2$^+$[404] [4]					
184.2	367	11	9	0.47 (7)	0.068 (7)
207.8	153	13	11	0.57(10)	0.053(6)
247.1	89	17	15	0.38(13)	0.072(17)
276.7	116	21	19	0.26(7)	0.095(18)
292.4	56	27	25	0.44(12)	0.046(8)
295.0	65	25	23	0.40(12)	0.055(11)
Weighted mean value $\lvert S(\Delta S)\rvert = 0.058(4)$					

Continuation

1	2	3	4	5	6
		^{167}Tm 7/2$^+$[404] [5]			
139.83(1)	100(5)	11	9	0.46(3)	0.052(2)
161.40(1)	62.2(25)	13	11	0.40(3)	0.059(1)
181.50(2)	—	15	13	0.45(11)	0.051(9)
199.56(2)	243(13)	17	15	0.46(9)	0.048(5)
216.29(4)	15.2(10)	19	17	0.461(22)	0.047
415.79(2)	100(2)	19	15	—	—
229.85(4)	28(1)	21	19	0.276(98)	0.07
446.11(5)	100(50)	21	17	—	—
		Weighted mean value $\lvert S(\Delta S)\rvert = 0.057(1)$			
		^{169}Lu 7/2$^+$[404] [6]			
147.2(2)	42.8	11	9	0.195	0.057
270.5(2)	31.0	11	7	—	
169.1(1)	23.1	13	11	0.236	0.051
316.2(2)	46.3	13	9		
189.2(2)	100.0	15	13	0.020	0.168
358.3(2)	34.9	15	11		
207.4(2)	9.2	17	15	0.369	0.038
396.7(2)	30.2	17	13		
224.0(2)	14.9	19	17	0.064	0.088
431.(3)	33.8	19	15		
238.3(3)	4.2	21	19	0.214	0.046
462.0(2)	37.1	21	17		
250.8(3)	7.1	23	21	0.062	0.082
488.9(2)	26.5	23	19		
261.0(3)	4.2	25	23	0,787	0,022
512.0(5)	148.0	25	21		
270.5(2)	31.0	27	25	0.005	0.266
531.6(3)	14.2	27	23		
		Weighted mean value $\lvert S(\Delta S)\rvert = 0.060(6)$			
		^{167}Er 5/2$^-$[512] [7]			
105.75(10)	100(16)	9	7	0.056(15)	0.096(13)
189.3(3)	32(3)	9	5		
		^{169}Yb 5/2$^-$[512] [8]			
110.93	96(12)	9	7	0.045 (24)	0.111 (30)
198.31	25 (9)	9	5		
133.54	12 (4)	11	9	0.26 (9)	0.091 (22)
244.47	11 (4)	11	7		
154.2	2.9	13	11	0.274	0.082
287.6	5.5	13	9		
174.5	2.4	15	13	0.279	0.079
328.4	7.2	15	11		
191.0	28.5	17	15	0.050	0.424
365.5	4.3	17	13		
207.4	2.2	19	17	0.141	0.146
399.4	3.5	19	15		
		Weighted mean value $\lvert S(\Delta S)\rvert = 0.098(18)$			
		^{173}Yb 5/2$^-$[512] [9]			
100.8(1)	58.4(11)	9	7	0.205(20)	0.105(7)
122.4(1)	22.7(4)	11	9	0.22(6)	0.096(19)
144.0(1)	11.3(2)	13	11	0.207(4)	0.139(26)
164.9(1)	5.30(11)	15	13	0.199(4)	0.17(4)
185.6(1)	1.78(3)	17	15	0.15(4)	0.137(26)
205.7(1)	0.77(3)	19	17	0.20(4)	0.102(14)
225.2(1)	0.238(11)	21	19	0.18(7)	0.112(31)
244.6(1)	0.108(16)	23	21	0.18(18)	0.11(8)
		Weighted mean value $\lvert S(\Delta S)\rvert = 0.113(9)$			

The weighted mean absolute values of the electromagnetic constant S for rotational band $\frac{7}{2}^+[404]$ are seen from the table to be 0.058 ± 0.004, 0.057 ± 0.001, and 0.060 ± 0.006 in nuclei with mass numbers $A = 165$, 167, and 169, respectively. For rotational band $\frac{5}{2}^-[512]$, the relevant values are 0.096 ± 0.013, 0.098 ± 0.018, and 0.113 ± 0.009 in nuclei with $A = 167$, 169, and 173, respectively. If the mass number A changes, the electromagnetic constant S keeps its value within the limits of experimental errors. The variations of the value obtained for the same band may be due to the influence of other rotational bands and vibration types of motion.

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ДОСЛІДЖЕННЯ ЕЛЕКТРОМАГНІТНОЇ СТАЛОЇ S ОБЕРТАЛЬНИХ СМУГ $\frac{7}{2}^+[404]$ ТА $\frac{5}{2}^-[512]$

А.К. Караходжаєв

Р е з ю м е

Знайдено значення електромагнітної сталої обертальних смуг $\frac{7}{2}^+[404]$ та $\frac{5}{2}^-[512]$. Середні зважені значення електромагнітної сталої S обертальних смуг з такими самими асимптотичними квантовими числами зберігаються при зміні масового числа ядра.