The Hindrance Factors For Some Transitions In ^{165}Er

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^{165}Er'un 20 geçişi için multipol karışımları bulunmuştu. Bu izotobun bazı state'leri için Nilsson dalga fonksiyonları da bilinmektedir. Böylece Hindrans faktörleri hesaplanıp aynı multipol için daha önce diğer izotopların geçişlerine bulunan değerlerle karşılaştırılabilir. Aynı multipollar için bu şekilde bulunan değerlerin çok iyi uyuştukları tesbit edilmiştir.

The multipole mixing ratios for 20 transitions were determined for ^{165}Er. The Nilsson wave functions for some of these states are also known. Thus the hindrance factors may be determined and a comparision of the results with the previous values for the same multipolarities in other nuclei can be plotted. It is found that there is a good agrement omongst the hindrance factors for the same multipolarities.

INTRODUCTION :

The ratio of the theoretical and the experimental transition probabilities are known as hindrance factors F. The theoretical transition propabilities may be given by the Weisskopf estimate, and the hindrance factors (F_W) with respect to this are:

$$F_W = T_{(\frac{1}{2})}(\pi L)_{experiment} / T_{(\frac{1}{2})\gamma}(\pi L)_{Weisskopf}$$

The partial gamma-ray halflives $T_{(\frac{1}{2})\gamma}(\pi L)$ with respect to the Weisskopf estimate are listed in table 1 (Löbner, 1974), and the experimental values may be calculated from

$$T_{(\frac{1}{2})\gamma exp}(\pi L) = T_{(\frac{1}{2})}(\text{level}) \left[\sum_d N_d / N_8(\pi L) \right]$$

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where $N_\gamma(\pi L)$ is the intensity of the gamma-ray with multipolarity L and $\Sigma_d N_d$ is the sum of the intensities of all transitions depopulating the level of interest.

Table 1. Partial gamma-ray half-lives according to the Weisskopf estimate for different multipole transitions. (A = mass number, E = transition energy in MeV).

$T_{(\frac{1}{2})\gamma}(E1) = 6.76\, A^{-2/3}$	$E_\gamma^{-3} \times 10^{-5}$ sec
$T_{(\frac{1}{2})\gamma}(E2) = 9.52\, A^{-4/3}$	$E_\gamma^{-5} \times 10^{-9}$ sec
$T_{(\frac{1}{2})\gamma}(M1) = 2.20$	$E_\gamma^{-3} \times 10^{-14}$ sec
$T_{(\frac{1}{2})\gamma}(M2) = 3.10\, A^{-2/3}$	$E_\gamma^{-5} \times 10^{-8}$ sec

The calculated hindrance factors F_W for same transitions in ^{165}Er are shown in table2.

The reduced transition probabilities calculated by Nathan and Nelsson (1965) imply that, if the multipolarity of a gamma-ray between different intrinsic states is $L < |K_i - K_f|$, then such a transition is strictly forbidden within the framework of the Nilsson model, and their transition probabilities are determined by the presence of K - admixtures in the wave functions. On the other hand, for $|K_i - K_f| \leq L \leq K_i + K_f$ the ratio of the reduced transition probabilities for gamma-rays for same multipolarity from an arbitrary state to any two members of a final state K_f is given by

$$A(\pi L) = \frac{B(\pi L,\, J_i K_i J_f K_f)}{B(\pi L,\, J_i K_i J_f K_f)} = \frac{\langle J_i\, L\, K_i (K_f - K_i) | J_f K_f \rangle^2}{\langle J_i\, L\, K_i (K_f - K_i) | J_f K_f \rangle^2}$$

This is called the Alaga branching rule (Alaga et al., 1955).

THE HINDRANCE FACTORS FOR SOME TRANSITIONS IN ^{165}Er :

The hindrance factors F_W with respect to the Weisskopf estimate evaluated for some transitions in ^{165}Er are listed in table 2. It can be seen from fig. 2. that these values fall in the range of hindrance factors (F_W) evaluated for ($\Delta K = 1$, $E1$) ($\Delta K = 1$, $E2$), ($\Delta K = 1$, $M1$), ($\Delta K = 1$, $M2$) and ($\Delta K = 0$, $E1$) (Löbner, 1974). These values are also consistent with the selection rules for the Nilsson states. Thus in the case of 55 keV, 60 keV, 114 keV and 218 keV transitions, the $M1$ multi-

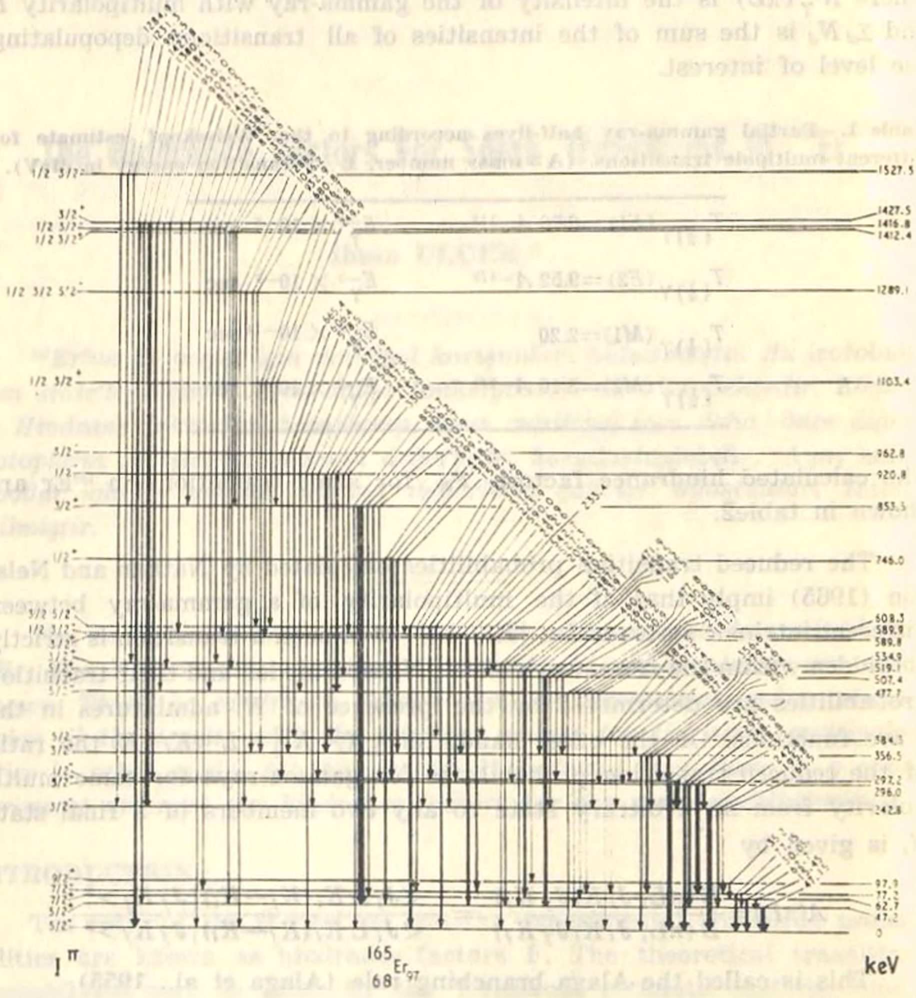

Fig. 1. The decay scheme of ^{165}Er following the EC decay of ^{165}Tm (29.6h) based on the work of Marquer and Chery (1971).

polarity is hindered by $F_W \sim 10^2 - F_W \sim 3{,}5\times10^2$ whereas the $E2$ multipolarity is hindered by $F_W \sim 2\times10^{-1} - F_W \sim 2.7\times10^{-2}$. In the case of 249 keV, 265 keV and 389 keV the $E1$ multipolarity is hindered by $F_W \sim 2.7\times10^4 - F_W \sim 9.3\times10^4$ and the $M2$ multipolarity is hindered by $F_W \sim 1.9\times10^{-1} - 8.9\times10^{-3}$. From Löbner's (1974) results it can be seen that the smallest value for $(\Delta K=4,\ M2)$ is of the order of 2×10^3, for $(\Delta K=3,\ M2)$ $F_W \sim 8\times10^2$, for $(\Delta K=2,\ M2)$ $F_W \sim 10$, for $(\Delta K=1,\ M2)$

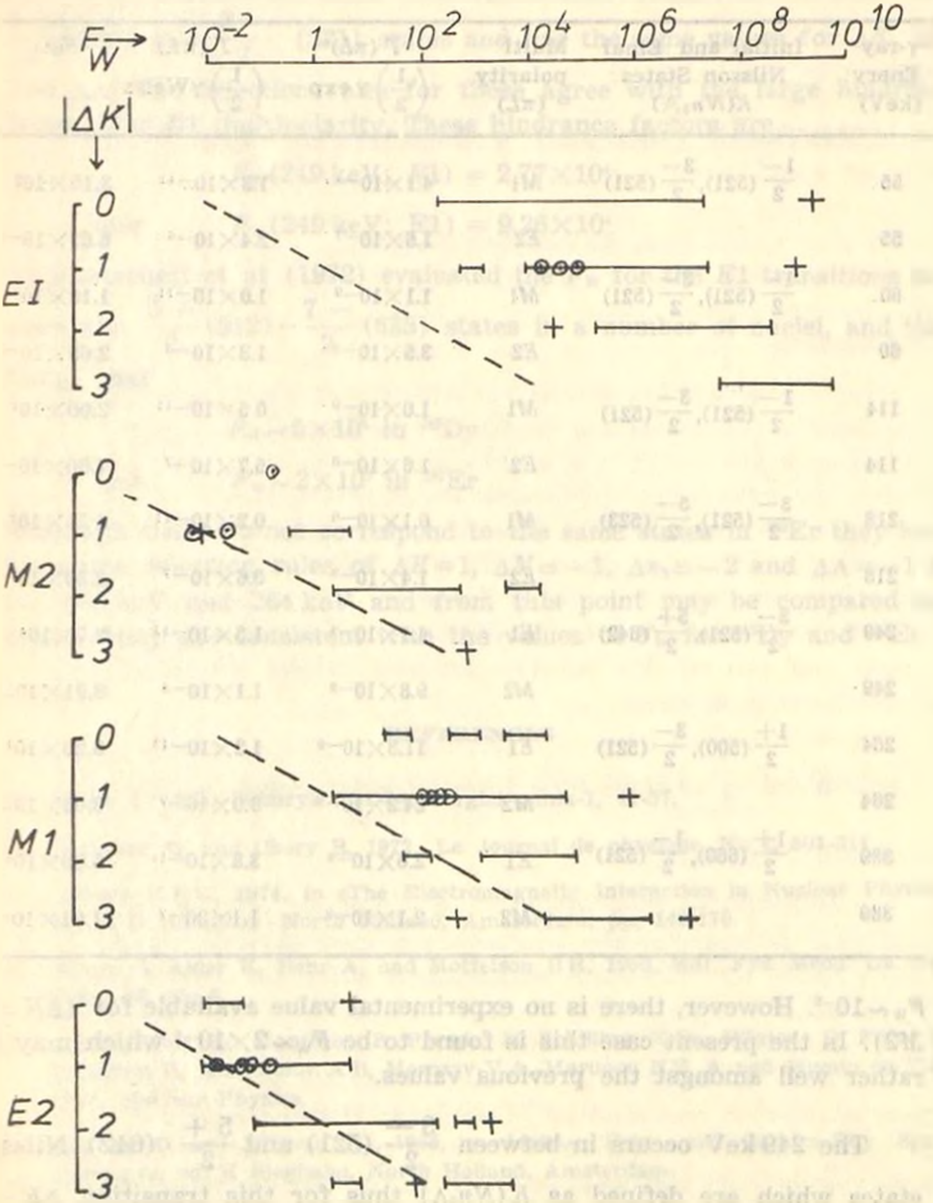

Fig. 2. Range of hindrance factors relative to the Weiskopf estimate F_w. The dashed lines show the dependence of F_w on $|\Delta K|$ according to the emprical rule $\log F_w = 2\ (|\Delta K| - 1)$. The circles show present values. [Taken from Löbner (1974)]

Table 2. The calculated hindrance factors for some transitions in ^{165}Er.

γ-ray Enery (keV)	Initial and Einal Nilsson States $K(Nn_3\Lambda)$	Multi polarity (πL)	$T(\pi L)$* $\left(\frac{1}{2}\right)\gamma$ exp	$T(\pi L)$ $\left(\frac{1}{2}\right)\gamma$ Weiss	F_W
55	$\frac{1-}{2}(521), \frac{3-}{2}(521)$	$M1$	4.1×10^{-9}	1.3×10^{-11}	3.15×10^{3}
55		$E2$	1.6×10^{-7}	2.4×10^{-6}	6.63×10^{-2}
60	$\frac{1-}{2}(521), \frac{3-}{2}(521)$	$M1$	1.1×10^{-9}	1.0×10^{-11}	1.10×10^{2}
60		$E2$	3.5×10^{-8}	1.3×10^{-6}	2.69×10^{-2}
114	$\frac{1-}{2}(521), \frac{3-}{2}(521)$	$M1$	1.0×10^{-9}	0.5×10^{-11}	2.00×10^{2}
114		$E2$	1.6×10^{-8}	5.7×10^{-7}	7.80×10^{-2}
218	$\frac{3-}{2}(521), \frac{5-}{2}(523)$	$M1$	0.1×10^{-9}	0.2×10^{-11}	$3\ 50\times10^{2}$
218		$E2$	1.4×10^{-8}	0.6×10^{-7}	2.30×10^{-1}
249	$\frac{3-}{2}(521), \frac{5+}{2}(642)$	$E1$	4.1×10^{-9}	1.5×10^{-13}	2.7×10^{4}
249		$M2$	9.8×10^{-9}	1.1×10^{-6}	8.91×10^{-3}
264	$\frac{1+}{2}(500), \frac{3-}{2}(521)$	$E1$	11.3×10^{-9}	1.2×10^{-13}	9.26×10^{4}
264		$M2$	24.2×10^{-9}	8.0×10^{-7}	3.03×10^{-2}
389	$\frac{1+}{2}(660), \frac{1-}{2}(521)$	$E1$	2.6×10^{-9}	3.8×10^{-14}	6.80×10^{4}
389		$M2$	2.1×10^{-8}	1.1×20^{-7}	$1.91\times10^{-}$

$F_W \sim 10^{-2}$. However, there is no experimental value available for ($\Delta K=0$, $M2$). In the present case this is found to be $F_W \sim 2\times10^{-1}$ which may fit rather well amongst the previous values.

The 249 keV occurs in between $\frac{3-}{2}$ (521) and $\frac{5+}{2}$ (642) Nilsson states which are defined as $K(Nn_3\Lambda)$ thus for this transition $\Delta K=1$,

* The half lives of the states are taken from Andrejtscheff et al (1974) and they are listed in table 4., The mixing ratios are listed in table 9 reference 1.

$\Delta N=-1$, $\Delta n_3=-2$ and $\Delta\Lambda=-1$. The 264 keV transition is in between $\frac{1}{2}+$ (400) and $\frac{3}{2}-$ (521) states and has the same values for ΔK, ΔN, and $\Delta\Lambda$. The selection rules for these agree with the large hindrance factors for $E1$ multipolarity. These hindrance factors are

$$F_W(249\ \text{keV};\ E1) = 2.77\times10^4$$

and

$$F_W(249\ \text{keV};\ \text{E1}) = 9.26\times10^4$$

Anderstscheff et al (1972) evaluated the F_W for the $E1$ transitions between the $\frac{5}{2}+$ (512) $-$ $\frac{7}{2}-$ (633) states in a number of nuclei, and they found that

$$F_W\sim5\times10^4 \text{ in } ^{165}\text{Dy}$$

and

$$F_W\sim2\times10^5 \text{ in } ^{167}\text{Er}$$

Although these do not correspond to the same states in ^{165}Er they have the same selection rules of $\Delta K=1$, $\Delta N=-1$, $\Delta n_3=-2$ and $\Delta\Lambda=-1$ as the 249 keV and 264 keV and from this point may be compared and indeed they are consistent with the values of F_W for ^{165}Dy and ^{167}Er.

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