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Electric Monopole Transitions in Nuclei with Odd Mass Numbers

L. K. PEKER AND L. A. SLIV

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THE non-radiative wholly converted electric monopole $E0$ transitions between two spin zero levels ($0+ \rightarrow 0+$) have been studied well enough only in three cases (see Table 1). However, $E0$ transitions can take place not only between 0-0 levels, but between any two levels with same spin and parity, because in this case the selection rules are satisfied ($\Delta I = 0$, no). The matrix element for an $E0$-transition has the form

$$H_{if} = \langle f \left| \sum_p r_p^2 \right| i \rangle = \rho R_0^2, \tag{1}$$

where R_0 is the nuclear radius and ρ a parameter, which is of the order of unity in the case of a complete overlapping of the initial and final state wave functions. The monopole transitions, more than the others, depend on the structure of the nucleus; their study can therefore give additional information on nuclear models.

An attempt has recently been made[2] to observe $E0$-transitions between two levels $2 \rightarrow 2$ in even-even nuclei. If one measures the internal conversion coefficient (ICC) for the K-shell, a_k and, by an independent method (e.g., from angular correlation), determines the contribution to the radiation of $M1$ and $E2$-transitions, then

$$\alpha_k = T_e / T_\gamma = \varkappa \alpha_2 + (1 + \varkappa) \beta_1 + T_{e0} / T_\gamma. \tag{2}$$

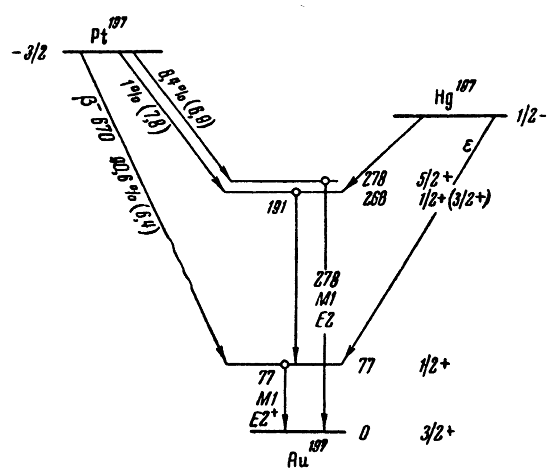
a_2 and β_1 are the theoretical ICC's for $E2$ and $M1$-transitions respectively, κ is the contribution of $E2$ transition, T_γ is the probability of γ-transition equal to $T_\gamma(M1) + T_\gamma(E2)$ and T_e is the conversion probability. The third term T_{e0}/T_γ determines the part of the electrons involved in the monopole transition.

It follows from the experimental values of the ICC for the $2+ \rightarrow 2+$ transitions in Pt^{192}, Pt^{196} and Hg^{198} nuclei, that the part T_{e0}/T_γ is very small and lies within the limits of the experimental errors; theoretical considerations[2] indicate that this part should be of the order of unity. Such a result has been understood after it has been determined that the spin 2 levels in the considered nuclei have a vibrational character, and that the transitions between them involve a change by unity of the vibrational quantum number ν. This strongly forbids $E0$-transitions and reduces their probability by a factor of about 100. The investigation of $E0$-transitions between levels of other type is made difficult by the necessity of independent measurements of the ICC and of the percentage of $E2$ (or $M1$) transitions, which is a very difficult experimental problem at the present time.

The purpose of the present note is to point out the existence of $E0$-transitions between spin $\frac{1}{2}$ levels ($\frac{1}{2} \pm \rightarrow \frac{1}{2} \pm$) in odd A nuclei. In this case, the spin selection rules rule out the possibility of $E2$-transitions ($\kappa = 0$) and Eq. (2) becomes:

$$T_{e0} / T_\gamma = \alpha_k - \beta_1. \tag{3}$$

This simplifies the experimental method a great deal, because it suffices to measure only the ICC a_K.



The best investigated is the level scheme of Au^{197} (see Figure). The latest measurement[3] of the ICC for the 191 kev transition gave the value $a_K = 2.5$. If the transition was a pure $M1$, then $a_K = 1.0$; with a mixture of $E2$, the ICC would be still smaller. The possibility of a higher spin contradicts the β-decay character. It remains therefore to assume that the spin of the 268 kev level is ½ and that the 191 kev transition is a mixture $M1 + E0$. Evaluating T_γ for an $M1$-radiation by Moszkowski's formula[4], we obtain from (3) $T_{e0} \approx 4 \cdot 10^{11}$ sec^{-1}. The corresponding value of ρ is $\rho \approx 0.5$, which is in agreement with the value of ρ obtained from $0+ \to 0+$ transitions. The table gives a compilation of the data on $E0$-transitions.

It seems of interest to determine the contribution of $E0$-transitions to the conversion spectra of other nuclei, *e.g.* In^{115} and Hg^{199}; there are indications[5] that these nuclei have two spin ½ levels with same parity. One would also like to confirm the results of Potnis *et al.*[3], which we used here.

Nucleus	Type of $E0$-transition		E (Mev)	ρ
C^{12}	0+	0+	·7,68	1/2
O^{16}	0+	0+	6,06	1/2
Ge^{72}	0+	0+	0,69	1/9
Po^{214}	0+	0+	1,42	~1/20
Au^{197}	1/2+	1/2+	0,191	~1/2
Pt^{192}	2+	2+	0,30	⩽1/45
Pt^{196}	2+	2+	0,33	⩽1/34
Hg^{198}	2+	2+	0,68	⩽1/14

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Internal Conversion Coefficient of the 53 kev Gamma-Radiation on the L shell of Th^{230}

A. A. VOROB'EV, V. A. KOROLEV, A. P. KOMAR AND D. M. SELIVERSTON

Leningrad Physico-Technical Institute, Academy of Sciences, USSR

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THE energy of the first excited state of Th^{230} is now determined to be of 52.5 kev[1]. From the data available in the literature, it can be concluded that the conversion coefficient of the 53 kev γ-radiation is large[2].

For the measurement of the conversion coefficient we have used the α-γ coincidence method. An enriched source of U^{234} was used. The α-particles were recorded by an impulse ionization chamber,

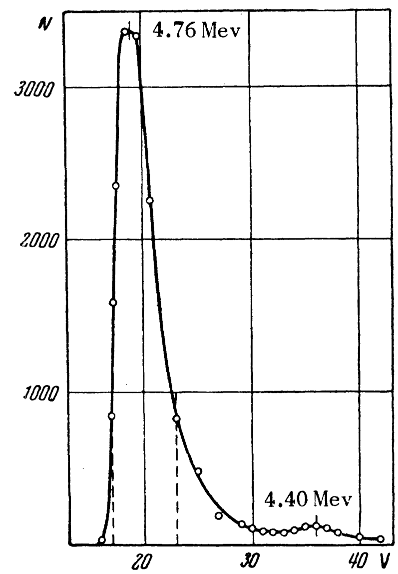

FIG. 1. The volts (V) show the discriminator level.

(the α-spectrum is shown on Fig. 1) the γ-quanta by a scintillation counter with an NaI(TI) crystal. The γ-spectrum was photographed when in coincidence with the α-particles, which gave an impulse on the output of the multiplier in the interval 17 to 23 volts (Fig. 1), *i.e.*, when in coincidence with the α-particles going to the ground and first excited states of Th^{230}. On Fig. 2, the thin line shows the γ-spectrum photographed without absorption. As it can be seen, the main contribution to the spectrum comes from a 15 kev x-ray. Controlling experiments have shown that this radiation can