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β-γ Directional Correlation and β-(Circularly Polarized γ) Correlation in the First Forbidden Decay of ^{170}Tm

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The differential β-γ directional correlation and the integral β-(circularly polarized γ) correlation in the decay of ^{170}Tm have been measured on the same metallic source.

1. Introduction

The decay scheme of ^{170}Tm is well established[1] (Fig. 1). Little is known, however, about details of the first forbidden inner β group to ^{170}Yb: spectral shape and β polarization measurements are complicated by the presence of another group of almost the same energy, and β-γ correlation measurements may be strongly influenced by atomic effects due to the long lifetime of the intermediate state, its large quadrupole moment, and the usually strong electric field gradient at the nucleus in Tm sources. The spectral shape does not deviate strongly from the allowed shape[1-4]. The β polarization is complete[1,5]. The reduced β-γ directional correlation parameter

$$\varepsilon' = \frac{\varepsilon}{p^2/W}, \tag{1}$$

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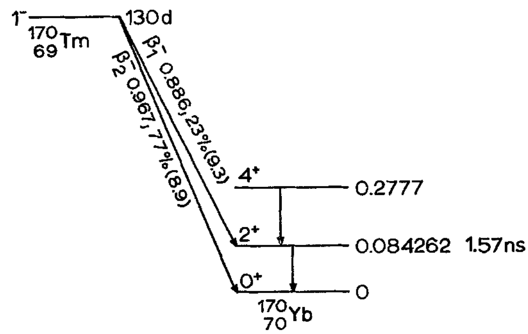

Fig. 1. Decay scheme of ^{170}Tm

with the correlation being given by

$$W(\Theta)=1+\varepsilon P_2(\cos\Theta), \tag{2}$$

is known to be negative but there is no agreement on the numerical value[6–9]. The situation is even worse in the case of the β-(transversely polarized conversion electron) correlation where there is agreement on the absolute size but not on the sign of the correlation[10, 11]. The β-(circularly polarized γ) correlation has not been measured previously. In first forbidden decays this correlation has the form

$$W(\Theta,\tau)=1+\omega\frac{v}{c}\tau\cos\Theta \tag{3}$$

where ω usually depends on β energy and, mostly weaker or not, angle between β particle and γ quantum.

In the present paper experiments on the differential β-γ directional correlation and on the integral β-(circularly polarized γ) correlation are reported.

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2. Experimental Techniques

As the β-γ correlations in rare earth nuclei with chemical compounds as source material may even be attenuated by an energy-dependent attenuation coefficient[12], a metallic source was chosen. This source form is also a favourite for vanishing or small attenuation, although one cannot be certain of measuring the unattenuated correlation. 99.99 per cent pure metallic Tm was irradiated for three weeks by 2×10^{13} n/(cm^2 $\times$ sec) in a reactor. It was then evaporated in vacuo on Al foil of 1.5 mg/cm^2. The source thickness was about 0.3 mg/cm^2. For both the directional and the polarized correlation measurements the same source was used. The polarized correlation was first measured, and then, with the source somewhat weaker due to decay, the directional correlation.

The set-ups and techniques used in this experiment were described previously[12, 13]. Particular attention was given to the bremsstrahlung contribution both to the directional correlation and to the polarized correlation; in the latter case it distorts the single γ-rate and, by random coincidences, also the coincidence rate.

The directional correlation was measured with both a single channel analyser in the β branch and a multi-channel analyser. The results were separately evaluated (Section 3).

The polarized correlation was integrally measured, with the β threshold at 61 keV.

3. Experimental Results and Discussion

Fig. 2 shows the experimental reduced anisotropy coefficient ε' [Eq. (1)] as a function of the β energy. It is, within the errors of the experiment, energy independent, though a slight increase at the lower and upper ends cannot be excluded. The weighted average of the ε' values shown in Fig. 2 is

$$\overline{\varepsilon'} = -0.042 \pm 0.005 .$$

The coefficient ω of the β-(circularly polarized γ) correlation [Eq. (3)], averaged above the threshold of 61 keV, was found to be

$$\bar{\omega} = -0.18 \pm 0.20 .$$

The results of this paper were obtained with metallic sources. Though no larger anisotropy coefficients ε' have been reported in recent papers[1, 6–9] for ^{170}Tm, we feel we cannot be sure of really measuring

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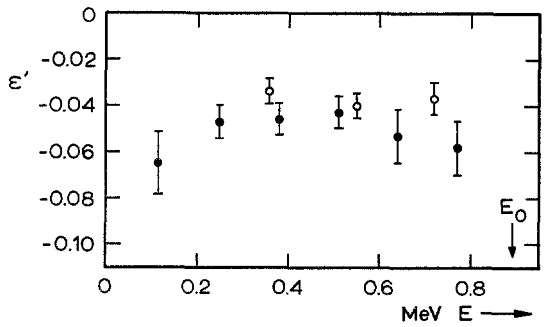

Fig. 2. Experimental reduced anisotropy coefficient ε' versus β energy E. The open circles are points measured with the single channel analyser, and the full circles with the multichannel analyser

the unperturbed correlations [Eqs. (2) and (3)] (anisotropies of the same magnitude have been reported). We suggest rather to use our results in calculations only where one additional parameter for the mean precession angle in the intermediate state is introduced. As the measurements of both ε' and $\bar{\omega}$ were done with the same source, the same mean precession angle is to be taken for both correlations. The attenuation coefficients which result for the two correlations will, however, differ as the angular dependence of the correlations differs.

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