Precise measurement of α_K for the 88.2-keV *M*4 transition in ^{127}Te: test of internal-conversion theory

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Several years ago, we reported [1] on a measurement of the internal conversion coefficient (ICC), α_K, for the 88.2-keV *M*4 transition in ^{127}Te. At that time, analysis was incomplete and only preliminary results were presented. In the meantime, the analysis has been completed and the results have been recently published [2]. Since the experimental details were described in our earlier progress report [1], we focus here on the analysis.

In simple cases with a single transition that can convert in the K shell, the value of α_K is given by

$$\alpha_K = (N_K/N_\gamma)(\varepsilon_\gamma/\varepsilon_K)(1/\omega_K), \qquad (1)$$

where ω_K is the fluorescence yield, N_K and N_γ are the total number of observed K x rays and γ rays, respectively; and ε_γ and ε_K are the corresponding photopeak detection efficiencies. The decay scheme of the 106-day isomer in ^{127}Te is shown in Fig. 1. With a single electromagnetic decay path, directly feeding

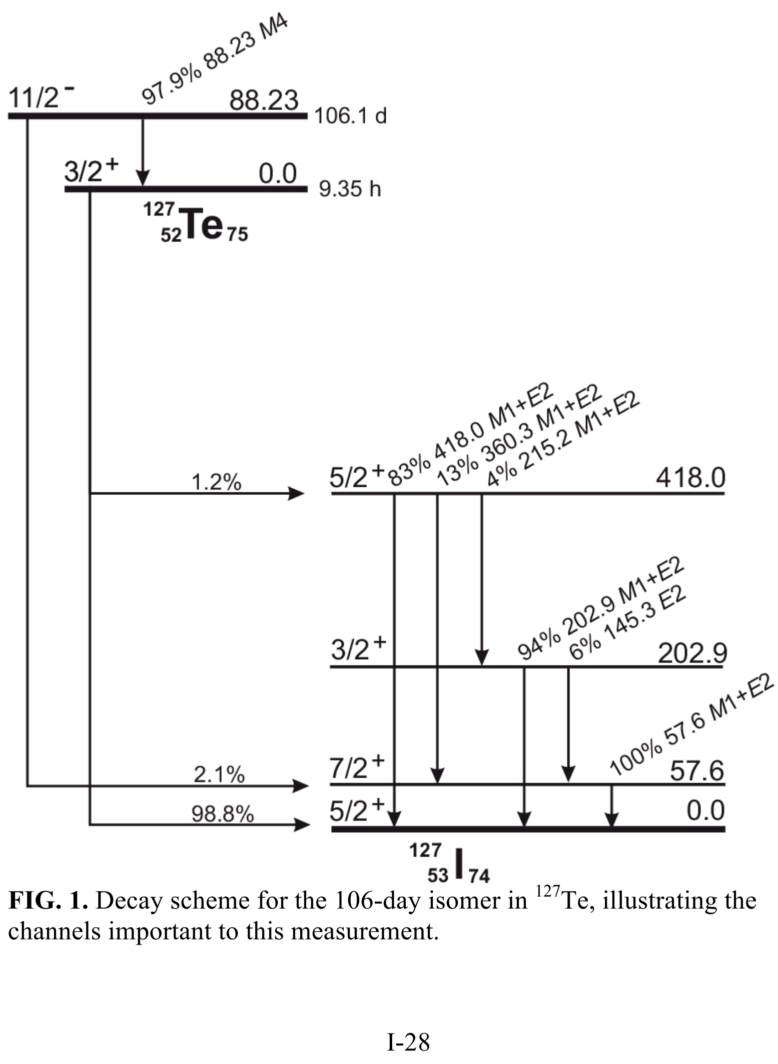

FIG. 1. Decay scheme for the 106-day isomer in ^{127}Te, illustrating the channels important to this measurement.

the ground state, it clearly satisfies the condition required for the validity of Eq. (1).

The only complication is that the isomer also has a 2.1% β-branch to an excited state in ^{127}I, which decays by a 57.6-keV transition with an α_K value of 3.16. This leads unavoidably to the presence of iodine *K* x rays. Though their intensity is only a few percent that of the predominant tellurium x rays, the two groups are unresolved from one another in our detector, so the iodine component must be carefully accounted for. The ^{127}Te ground state β decays as well, but only weakly populates an excited state, the decay of which produces considerably less conversion.

In analyzing our data, we took the *N* values from our spectra and the γ-ray efficiencies from our well-established HPGe detector calibration [3]. The *K* x-ray efficiency, ε_K, we took from a calibration we made more recently with a ^{109}Cd source [4]. The iodine *K* x rays, whose contribution must be subtracted from the measured (unresolved) x-ray peaks, predominantly arise from conversion of the 57.6-keV transition in ^{127}I, which is populated via the β decays of the isomeric and ground states of ^{127}Te. This transition has *M*1+*E*2 character with a measured mixing ratio and an α_{K58} value of 3.16(5). By inverting Eq. (1) we derived the iodine x-ray intensity from this α_{K58} value and the measured number of counts in the 57.6-keV γ-ray peak.

Our result for α_{K88}, the *K*-conversion coefficient of the 88.2-keV transition, appears in the top line of Table I, where it can be compared with three theoretical values, one that was calculated without accounting for the atomic vacancy and two that included the vacancy in different approximations, the "frozen orbital" (FO) or the "self-consistent field" (SCF). Clearly the result for α_K agrees well with the calculations that incorporate the vacancy. This is consistent with all our previous measurements of α_K.

Table I. Comparison of the measured α_K value for the 88.23(7)-keV *M*4 transition from ^{127m}Te with calculated values based on three different theoretical models. Shown also are the percentage deviations Δ from the experimental value, calculated as (expt-theory)/theory.

Model	α_K	**Δ(%)**
Experiment	484(6)	
Theory		
No vacancy	468.6(17)	+3.3(13)
Vacancy FO	486.4(17)	-0.1(13)
Vacancy SCF	483.1(17)	+0.4(13)

As a byproduct of this measurement, we could determine the β-branching ratio of the isomeric state in ^{127}Te. The 57.6-keV level in ^{127}I is populated by two β-decay branches, one from the isomeric state and the other from the ground state of ^{127}Te. Since the ground state has a half-life of 9.35 hours and our spectrum was acquired more than a month after activation, the two decays were certainly in secular equilibrium for our measurement. Under these conditions, we see from the decay scheme that the 57.6-keV state is fed ~13 times more strongly from the isomer than it is from the ground state. As a consequence, it is possible to use the ratio of intensities of the γ-ray peaks at 57.6 and 88.2 keV to extract a rather precise value for the strength of the stronger β branch even though the strength of the weaker branch remains relatively imprecise.

We determined the β branching ratio of the isomeric state to be 2.14(3)%. This compares favorably with, but is 7 times more precise than, the only previous measurement of this quantity, 2.4(2)%, which was published in 1970 [5].

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