

EFFECT OF CHEMICAL BINDING ON INTERNAL CONVERSION IN Te^{125} , AND AN
ESTIMATE OF THE CHANGE IN THE NUCLEAR RADIUS

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The effect of chemical binding on internal conversion during the 35.48-keV O-shell transition in Te^{125} is established. Comparison of the results with existing data on the Mössbauer isomer shift shows that $\Delta R/R = (1.3 \pm 0.9) \times 10^{-4}$.

STUDIES of the effect of the chemical state of an atom on the probability of internal conversion in the valence shell are complicated by the low probability of the process and the necessity of using high energy resolution for measurements of the internal conversion spectra. The experimental difficulties are most readily overcome in the case of low-energy M1 transitions for which internal conversion in each electron shell occurs largely in the s subshell.

The effect of chemical binding on internal conversion in the outermost shell was first investigated in^[1], in the case of the Mössbauer γ transition in Sn^{119} , and it was shown that such studies were important for the interpretation of the isomer shift in Mössbauer spectra. In the present paper we report the results of analogous studies for the 35.48 keV Mössbauer transition in Te^{125} for which various estimates of the relative change $\Delta R/R$ in the radius of the excited nucleus have so far led to very different values.

The measurements were carried out with the UMB-1 β spectrometer.^[2] Electron spectra due to internal conversion were recorded using Te^{125m} in the form of a tellurium target and a ZnTe target. The sources were made from Te^{125m} of high specific activity achieved by the activation of TeO_2 enriched with Te^{124} (81.7%) in a reactor over a period of five months in a thermal neutron flux of 2×10^{20} neutron/cm². The activated TeO_2 was then reduced to tellurium by heating in a hydrogen atmosphere, and part of it was used to synthesize the isotopic compound ZnTe^{125m} . The structure of the compound was verified with an x-ray diffractometer. Thin deposits of Te^{125m} and ZnTe^{125m} (10–20 $\mu\text{g}/\text{cm}^2$) for the spectrometric sources were produced by vacuum evaporation onto an aluminum foil.

The spectra were measured using multistrip sources^[3] consisting of 13 parallel strips of 1×20 mm. This ensured that the effective aperture of the β spectrometer could be increased by a factor of 13 without loss of resolution. The line width corresponded to a momentum resolution of $\Delta p/p = 0.22\%$.

The N and O lines in the internal conversion spectrum measured for Te^{125m} and ZnTe^{125m} sources are shown in the figure. They represent the average of 20 series of measurements on the Te^{125m} source and 18 series of measurements on the ZnTe^{125m} source. The spectra are normalized to equal N-line intensity. The vertical bars indicate statistical uncertainties. It is

clear that the relative O-line intensity is lower in the case of the ZnTe^{125m} source. Estimates of the change in the intensity yield the following values:

Source	Te^{125m}	ZnTe^{125m}
O/N	0.152 ± 0.017	0.108 ± 0.015

The reduced O-line intensity of the ZnTe^{125m} source indicates a reduction in the density of the valence 5s electrons in the case of the Te^{125} nuclei. It may be assumed that $N = \text{const}$ (theoretical estimates based on calculations for tin^[4] show that the s-electron density can only change by a fraction of a percent). The ratio of the 5s-electron density in the case of the Te nuclei is then equal to the ratio $(O/N)_{\text{Te}} / (O/N)_{\text{ZnTe}} = 1.41 \pm 0.34$. Comparison of this result with measurements of the Mössbauer isomer shift^[5,6] shows directly that the radius of the Te^{125} nucleus is increased when it is excited to the 35.48-keV state.

The relative change $\Delta R/R$ was then estimated using the well-known relationship between the isomer shift and the change in the electron density.^[7] To calculate $|\psi(0)|^2$ for tellurium and ZnTe we used the formula

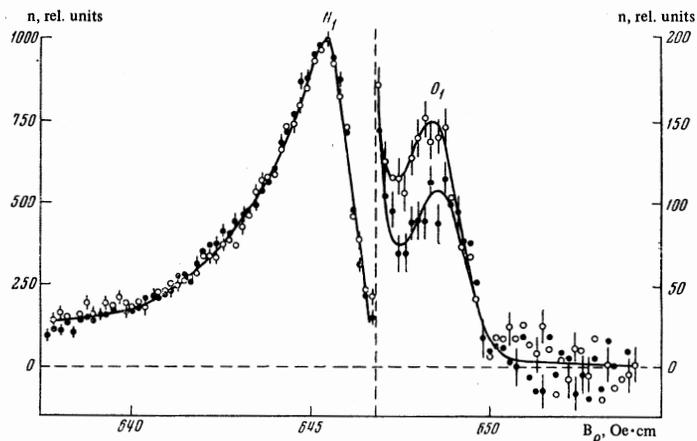
$$\rho(n_s, n_p) = \rho_{\text{res}} + \varphi_s(n_s - 0.017 n_s - 0.065 n_s^2 - 0.056 n_s n_p),$$

obtained in^[4] using the relativistic Weber wave functions for tin, which related the total electron density on the atomic nucleus, $\rho(n_s, n_p)$, and the populations n_s and n_p of the s- and p-states of the valence shell. Since the ratio of 5s-electron densities estimated using the single-electron nonrelativistic wave functions is $\psi_{5s}^2(\text{Te})/\psi_{5s}^2(\text{Sn}) = 1.36$ ^[8], and the correction factor for relativistic electrons is $S'(\text{Te})/S'(\text{Sn}) = 1.06$ ^[9], and if we use the value $\varphi_s(\text{Sn}) = 3.94 \times 10^{26} \text{ cm}^{-3}$ ^[4] we find that for tellurium $\varphi_s(\text{Te}) = 5.66 \times 10^{26} \text{ cm}^{-3}$.

According to the data reported in^[10], $n_{5s}(\text{Te}) = 1.64$, $n_{5p}(\text{Te}) = 4.36$. According to our own results $n_{5s}(\text{ZnTe}) = n_{5s}(\text{Te})/1.41 = 1.16 \pm 0.028$. Because of sp^3 hybridization, $n_{5p}(\text{ZnTe}) = 3n_{5s}(\text{ZnTe})$. Finally, since $R = 1.24 \text{ A}^{1/3}$ ^[4] and the isomer shift of Te-ZnTe is $+0.94 \pm 0.14 \text{ mm/sec}$ ^[5] we find that

$$\Delta R/R = +(1.3 \pm 0.9) \cdot 10^{-4}.$$

The various values available in the literature for $\Delta R/R$ are as follows: $+0.7 \times 10^{-4}$, 2×10^{-4} , $+9 \times 10^{-4}$ ^[9], $+2.4 \times 10^{-5}$ ^[5], $+3.6 \times 10^{-4}$ ^[8], 2×10^{-4} ^[11] and 0.95×10^{-4} ^[12]. Only some of these agree to within experi-



The N and O internal conversion lines measured with $\text{Te}^{125\text{m}}$ (open circles) and $\text{ZnTe}^{125\text{m}}$ (points) sources. The background is subtracted and the solid curves are drawn through the experimental points.

mental error with the result which we have obtained by using the experimental ratio of the 5s-electron densities for Te nuclei in tellurium and ZnTe.

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