that, in this region of Z, the level density function for a given nucleus is a function of $(N-Z)$ as well as of A. In this case, it was assumed that

$$\omega(E) \text{ for } A^{39}(N-Z=3, J=7/2^-)$$

varied as $\exp(0.07E)$, while

$$\omega(E) \text{ for } Cl^{39}(N-Z=5, J=\tfrac{3}{2})$$

varied as $\exp(E)$. There is evidence supporting this assumption in the work of Gugelot[12] on the nuclear level densities as determined from (p,n) reactions in medium weight nuclei. In the more recent work of Miller, Friedlander, and Markowitz,[13] who investigated the competition between the (α,pn) and $(\alpha,2n)$ reactions in Cr^{50}, this same assumption must be used to explain their results, while still keeping the compound nucleus picture of nuclear reactions. The work of Cohen and Newman[14] on the ratio of the (p,pn) to $(p,2n)$ cross sections in nuclei of mass between 48 and 71 indicated that the ratio of probabilities of proton to neutron emission was much larger than expected on the usual statistical theory of nuclear reactions. These authors considered the explanation that the level density of odd-odd nuclei was very different from that of even-even nuclei of the same mass, which was advanced by Miller *et al.*[13] to explain their results. Cohen and Newman commented that this explanation would introduce difficulties into the explanation of certain results described in their paper. However, the idea is presented here because it does fit the observed facts in the case of the $A^{40}(\gamma,p)$ reaction.

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[12] P. C. Gugelot, Phys. Rev. **81**, 51 (1951).
[13] Miller, Friedlander, and Markowitz, Phys. Rev. **98**, 1197(A) (1955).
[14] B. L. Cohen and E. Newman, Phys. Rev. **99**, 718 (1955), and private communication.

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Disintegration Schemes of the Te^{127} and Te^{129} Ground States*†

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A coincidence scintillation spectrometer was used to study the decay of the 9.3-hour Te^{127} isomer and the 72-minute Te^{129} isomer. The Te^{127} isomer was found to decay by a simple beta ray with an end-point energy of 0.683 ± 0.010 Mev. The beta-ray spectrum of the Te^{129} isomer consists of two beta groups with end-point energies of 1.46 ± 0.01 and 1.01 ± 0.02 Mev. Two gamma rays with energies of 0.450 ± 0.005 and 0.035 Mev were observed, and they were found to be in coincidence. The 0.450-Mev gamma ray was shown to be in coincidence with the 1.01-Mev beta ray, and the 0.035-Mev gamma ray was shown to be in coincidence with the 1.46-Mev beta ray. The results are consistent with level assignments based on the shell model of the nucleus.

INTRODUCTION

THE 9.3 hour isomer of Te^{127} was first studied by Seaborg, Livingood, and Kennedy.[1] Using absorption techniques, they were able to show that it decayed by a simple beta-ray group of ~0.8 Mev. A value of 0.7 Mev. was reported later.[2]

Absorption measurements on the 72-minute isomer of Te^{129} indicated that the radiations consist of two gamma-rays of ~0.3 and ~0.8 Mev and a beta ray of 1.75 Mev.[2] Wilkinson and Rall later reported a beta ray end point of 1.8 Mev as a result of spectrometer studies.[3] Since no coincidence studies on the Te^{129} isomer and no spectrometer measurements of the beta rays from the Te^{127} isomer have been reported, it was felt that further investigation was necessary.

SOURCE PREPARATION

A solution of $H_2TeO_4\cdot 2H_2O$ in 2.4*f* HCl and 1.25*f* HNO_3 was irradiated in the Iowa State College synchrotron. As a result of recoil following the (γ,n) reaction, essentially all of the active tellurium is reduced from the +6 valence state to lower valence states. Since there is no significant electron exchange between tellurate and these lower valence states under ordinary

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† Contribution No. 404. Work was performed in the Ames Laboratory of the U. S. Atomic Energy Commission.
[1] Seaborg, Livingood, and Kennedy, Phys. Rev. **57**, 363 (1940).
[2] The Plutonium Project, Revs. Modern Phys. **18**, 513 (1946).
[3] W. Rall and R. G. Wilkinson, Phys. Rev. **71**, 321 (1947).

conditions,[4] this provides a means of obtaining radioactive tellurium of high specific activity.

After irradiation, 5 mg of Te^{+4} were added as a carrier and precipitated with H_2S.[5] The sources were then prepared by filtration.

EQUIPMENT AND PROCEDURE

The beta-ray and gamma-ray measurements were made with a coincidence scintillation spectrometer similar to that of Johansson.[6] The spectrometer used consists of two scintillation spectrometers that can serve as either beta-ray or gamma-ray detectors, depending on the crystal used.

The beta-ray spectra were determined by the dot method.[7] The pulses displayed on the oscilloscope screen are converted to dots and recorded with a movie camera. The pulse-height distribution is then determined with a multichannel pulse-height analyzer.[8] Gamma transitions were recorded photographically, and their pulse height was determined with a microphotometer.

A pulse generator and step attenuator were used to measure the nonlinearity of the electronic system. For beta-ray spectra Cs^{137}, Pb^{207}, and P^{32} were used as calibration sources. The gamma transitions of Sb^{125} and Cs^{137} were used as calibration points for gamma-ray studies.

Except for the purpose of estimating the approximate relative intensities of the two beta-ray spectra, Kurie plots of only the higher energy beta-ray group of the Te^{129} isomer were made from the total beta spectrum. The end-point energy of the lower energy beta-ray group was obtained by coincidence measurements.

In the study of Te^{129}, half-hour irradiations of 0.898 g of $H_2TeO_4 \cdot 2H_2O$ were obtained and the sources were prepared as described earlier. Three-hour irradiations were obtained for the study of Te^{127}, and the Te^{129} was allowed to decay out before the beta spectrum was run. In all cases, the half-life was followed as a measure of the isotopic purity.

RESULTS

Te^{127}

A typical Kurie plot of the Te^{127} beta ray is shown in Fig. 1. The maximum in the beta-ray distribution was found to be 0.683 ± 0.010 Mev. This is in good agreement with the previously reported values. No gamma transitions were observed.

Te^{129}

The Te^{129} isomer was found to have two beta-ray groups with maximum energies of 1.46 ± 0.01 and 1.01 ± 0.02 Mev. Figure 2 shows a typical Kurie plot for the high-energy beta ray. Two gamma transitions were observed at 0.450 ± 0.005 Mev and approximately 0.035 Mev. By means of gamma-gamma coincidence measurements, the two gamma rays were determined to be in coincidence. Beta-gamma coincidence studies were made with the high-energy beta-ray group, and it was found to be in coincidence with the 0.035 Mev gamma ray. The 0.450-Mev gamma ray was shown to be in coincidence with the 1.01-Mev beta ray by means of gamma-beta coincidence measurements, and the coincidence beta-ray spectrum obtained was used to determine the end-point energy of the beta-ray group.

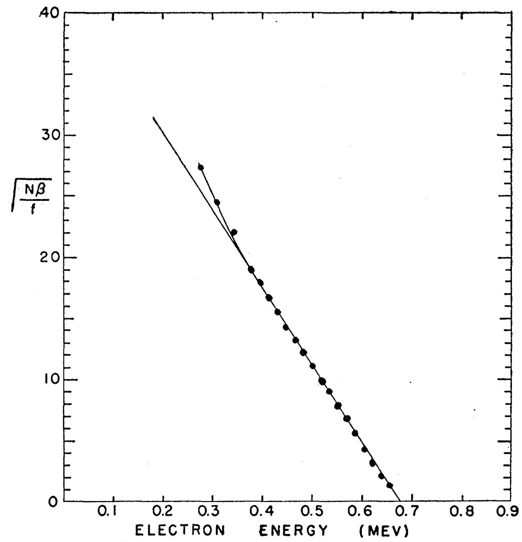

FIG. 1. Typical Kurie plot of the beta spectrum of the 9.3-hour Te^{127} isomer.

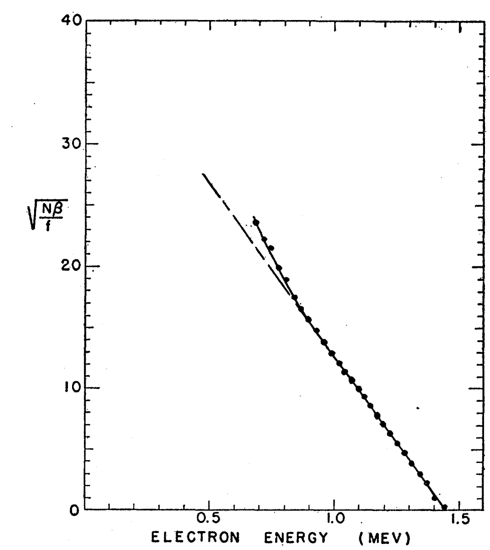

FIG. 2. Typical Kurie plot of the beta spectrum of the 72-minute Te^{129} isomer.

[4] M. Haissinsky and M. Cottin, Anal. Chem. Acta **3**, 226 (1949).
[5] R. Williams, J. Chem. Phys. **16**, 513 (1948).
[6] S. Johansson, U. S. Atomic Energy Commission Report No. ISC 431 (unpublished).
[7] F. T. Boley and D. J. Zaffarano, Phys. Rev. **84**, 1059 (1951).
[8] Hunt, Rhinehart, Weber, and Zaffarano, Rev. Sci. Instr. **25**, 268 (1954).

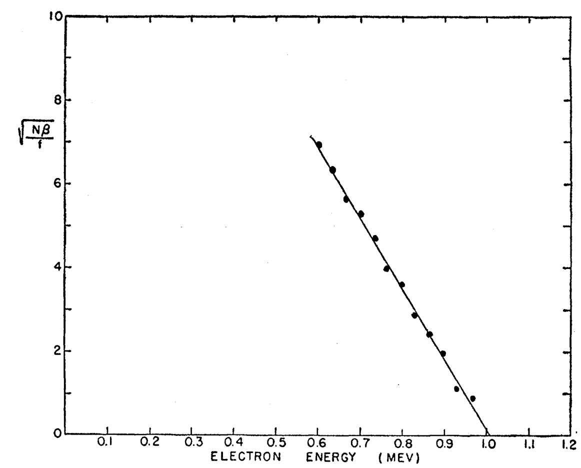

FIG. 3. Kurie plot of the beta distribution in coincidence with the 0.450-Mev gamma ray of the Te^{129} isomer.

The Kurie plot of the coincidence beta-ray spectrum is shown in Fig. 3. The relative intensities of the two beta-ray groups were determined by extrapolating the Kurie plots back to zero energy and reconstructing the energy distribution curves from the Kurie plots. Comparison of the two distribution curves resulted in relative intensities of approximately 80% and 20% respectively for the 1.46- and the 1.01-Mev beta-ray groups, as shown in Fig. 4. The log ft values were calculated to be 5.8 for both transitions.

DISCUSSION

The observed simple beta decay of the 9.3-hour Te^{127} isomer is in agreement with the previous studies. The log ft value of 5.6 is in the allowed range and is therefore consistent with the proposed level assignments of $d_{3/2}$ for the Te^{127} and $d_{5/2}$ for the I^{127} ground states.[9]

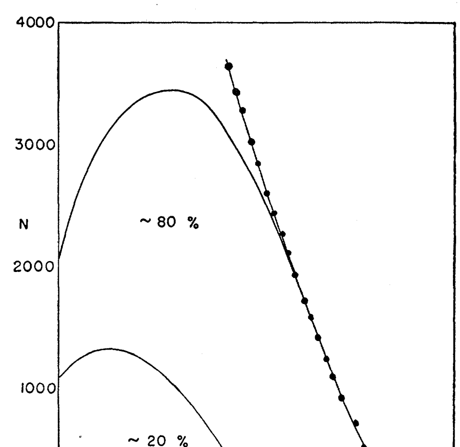

FIG. 4. Beta-ray energy distribution curves of the 72-minute Te^{129} isomer showing the relative intensities of the two beta-ray groups.

[9] M. Goldhaber and R. D. Hill, Revs. Modern Phys. **24**, 179 (1952).

The ground state of I^{129} has been measured as $g_{7/2}$ and Te^{129} has a $d_{3/2}$ ground state.[9] The log ft value for the 1.46-Mev beta ray indicates that it is an allowed transition and would not be expected to go directly to the I^{129} ground state, since this would require a spin change, $\Delta I=2$. In Fig. 5, an energy level diagram for the decay of the 72-minute Te^{129} isomer is presented which is consistent with the reported ground state levels of Te^{129} and I^{129}.

Since no gamma transition was observed from the higher excited state, A, to the ground state, C, it is possible to make some predictions as to the spins of the two excited levels. If the beta transitions are allowed, there can be no parity changes and any combination of spins 1/2, 3/2, or 5/2 is possible for the excited levels. If A is assigned a spin of 5/2, the two possible transitions from A would be of comparable intensity for the case of spin assignments of 3/2 and 5/2 for the lower excited level B, and they should both be observed. For an assignment of 1/2 to B, the low-energy gamma transition (B–C) would be of the $M3$ class. Such a transition would have a lifetime that is long with respect

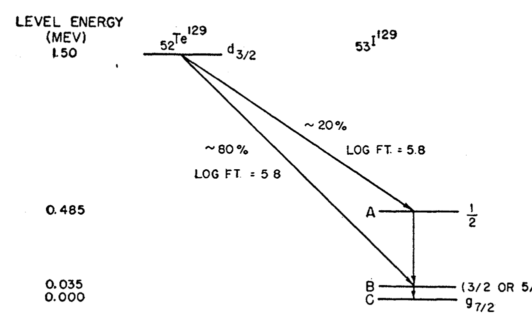

FIG. 5. Proposed decay scheme for the 72-minute Te^{129} isomer.

to the observed 0.450-Mev transition (A–B), and the two gamma rays would not be in coincidence as was observed. For the case of a spin of 3/2 for A, and spin values of 3/2 or 5/2 for B, the competition would be between $E2$ and $M1$ type transitions, and both gamma rays might be expected. A spin assignment of 1/2 for B is not acceptable for the same reason as before. If a spin assignment of 1/2 is given to A, spins of 3/2 or 5/2 for B are consistent with the observed data, since the gamma transition from A to C would be $M3$ and therefore negligible compared to an $M1$ or $E2$ transition to B. The two observed transitions would be of comparable lifetimes which would explain the observed coincidence data.

It appears that the spin of A is 1/2 and that of B either 3/2 or 5/2. According to a single particle model, the higher excited level, A, would probably be $s_{1/2}$ and the lower excited level B, $d_{5/2}$.

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