# NEW REGION OF ALPHA RADIOACTIVITY*

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Alpha radioactivity is a mode of decay commonly associated with the heavier elements. In this paper we report on a discovery of alpha decay from nuclides in the region of mass 100.

It has long been recognized from atomic mass data that an enhancement of the alpha-decay energies of the tellurium isotopes is present due to the effect of the 50-proton closed shell. The enhancement, however, is not large enough to produce a detectable instability toward alpha-particle emission among the tellurium isotopes presently known. Some unsuccessful attempts to produce neutron-deficient tellurium alpha emitters by high-energy proton spallation have been previously reported.[1,2] We have obtained results on the alpha radioactivity of the very light tellurium isotopes whose alpha-decay energies are additionally enhanced by the $N = 50$ closed shell.

We bombarded a 90% enriched $Ru^{96}$ target with high-energy $O^{16}$ ions from the Berkeley heavy-ion linear accelerator (Hilac), and obtained alpha-particle spectra of the products using techniques described in an earlier paper.[3] Two weak alpha groups (established by $dE/dx$ experiments) were observed at 3.28 MeV and 3.08 MeV, which decayed with half-lives of 2.2 sec and 5.3 sec, respectively.

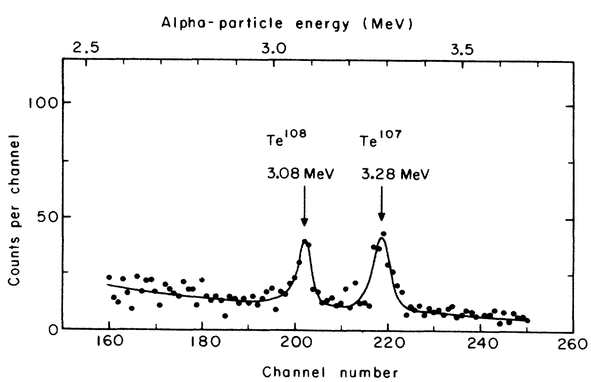


FIG. 1. Alpha-particle spectrum of the products of the reaction $Ru^{96} + O^{16}$ at a bombarding energy of 95 MeV (lab).

An alpha-particle spectrum of these activities is shown in Fig. 1. We established that these activities were due to isotopes of tellurium when we observed that they could not be produced in $Ru^{96} + N^{14}$ bombardments.

We obtained mass assignments for these activities from excitation function measurements using the results of Black on heavy-ion reactions in this mass region to interpret our data.[5] As shown in Fig. 2, the peak cross section for the production of the 3.28-MeV alpha activity falls at a bombarding energy of 104 MeV. This energy compares most favorably with that expected for the reaction $Ru^{96}(O^{16}, 5n)Te^{107}$. The excitation function for the 3.08-MeV group peaks at a bombarding energy of 87 MeV which is close to the value expected for the reaction $Ru^{96}(O^{16}, 4n)Te^{108}$. The results are summarized in Table I.

These nuclides represent the first opportunity to study alpha decay from nuclei where the "valence" neutrons and protons are in the same single-particle level, in this case, the $1g_{7/2}$ level. This may give rise to a kind of "superallowed" alpha decay resulting in large reduced alpha widths. At present, we cannot give any estimates of the alpha reduced widths for $Te^{107}$ and $Te^{108}$ because the alpha branch-

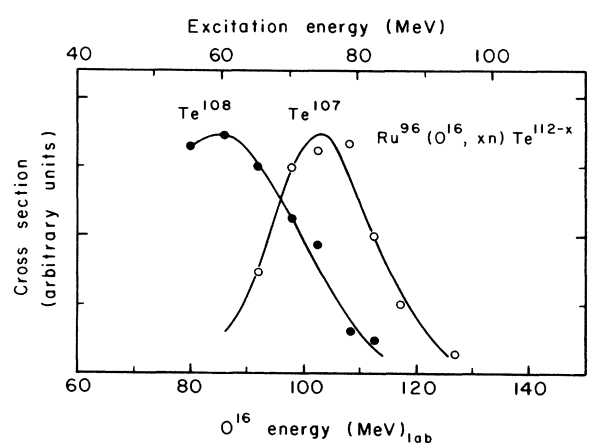


FIG. 2. Excitation functions for the production of the new Te alpha emitters.

Table I. Summary of results.

| Nuclide | $E_\alpha$ (MeV) | $t_{1/2}$ (sec) |
|---|---|---|
| $Te^{107}$ | 3.28 ± 0.03 | 2.2 ± 0.2 |
| $Te^{108}$ | 3.08 ± 0.03 | 5.3 ± 0.4 |

ing ratios are not known.

The most alpha-labile tellurium isotope is expected to be $Te^{104}$ since it can undergo alpha decay to the double-closed-shell nuclide $Sn^{100}$. Our first experiments were directed toward producing this nuclide by the reaction $Ru^{96}(O^{16}, 8n)Te^{104}$. We could not, however, detect any alpha groups at a bombarding energy favorable for this reaction or at energies favorable for the $(O^{16}, 7n)$ and $(O^{16}, 6n)$ reactions. We feel that perhaps part of the reason for the absence of these activities may be due to very small reaction cross sections. However, there is also a possibility that the 52-, 53-, and 54-neutron isotopes of tellurium may be proton-unstable with very short half-lives.

We expect that it will also be possible to observe alpha decay from the very neutron-deficient isotopes of iodine and xenon.

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# EFFECT OF A $Y_{40}$ DEFORMATION ON PROTON INELASTIC SCATTERING*

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The existence of a $Y_{40}$ term in the shape of deformed heavy nuclei has been strongly suggested by the analysis of alpha-decay rates.[1-5] A method is proposed here for measuring the term more directly by means of proton inelastic differential cross-section measurements.

Calculations have been made on the inelastic cross sections for the scattering of 16 and 20 MeV protons on $U^{238}$, using the adiabatic approximation.[6,7] This is equivalent to a full coupled-channels calculation (coupling all states in the $K=0$ rotational band) if the excitation energies can be neglected in comparison with the incident proton energy. The proton-nucleus potential was taken to be that of a deformed optical model,[8] with a Woods-Saxon shape for the real part and a derivative Woods-Saxon shape for the imaginary part, the form factors being the same as those used by Perey.[9] The nuclear shape was taken to be $R=R_0(1+\beta_2Y_{20}+\beta_4Y_{40})$. The potential $V(r,R)$ was expanded in a series of Legendre polynomials, $V(r,R)=\sum_L v_L(r,R_0)P_L(\cos\theta)$, and the functions $v_L(r,R_0)$ were evaluated by numerical integration with respect to $\cos\theta$. The depth of the real part of the potential was obtained by means of the energy-dependent formula given by Perey.[9]

The results are shown in Figs. 1 and 2. The effect of the $Y_{40}$ term on the elastic cross section, $\sigma_0(\theta)$, is too small to be noticeable, and the effect on the first inelastic cross section, $\sigma_2(\theta)$, is not very marked (except over a very small angular region in the forward direction). In the case of the second inelastic cross section, $\sigma_4(\theta)$, the magnitudes at certain angles are changed by factors of up to about 20 for $\beta_4=0.1$, and up to about 6 for $\beta_4=0.05$. In this case the term of first order in $\beta_4$ in the second-excited-state scattering amplitude is competing with second-order terms in $\beta_2$, and at some angles this gives rise to destructive interference and a lowering of the cross section.[10] Over most of the angular range, however, the second-excited-state cross section is strongly enhanced, and an experimental measure-