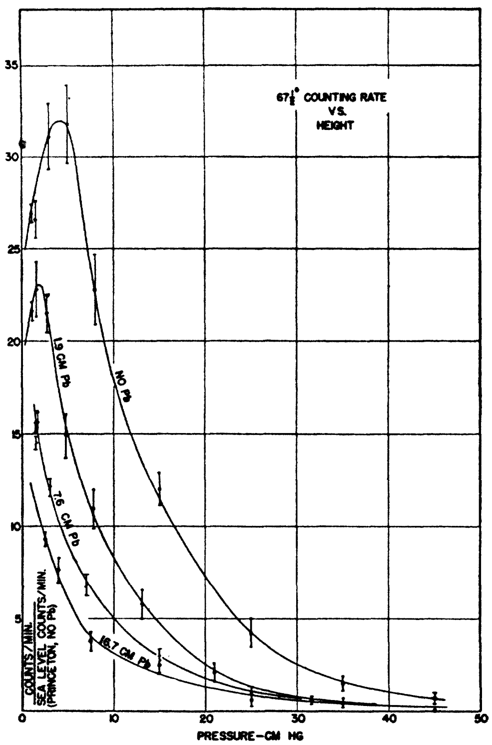

FIG. 2.

secondary rays responsible for the maximum in the intensity height curves, preserve for the most part the direction of the rays producing them.

Absorption curves of the radiation in Pb at different altitudes may be separated roughly into a soft[2] and a hard[2] part and give the results shown in Table I for μ in the

TABLE I.

Altitude cm Hg	μ, g/cm² hard*	soft*	Thickness Pb required to reduce intensity by $1/e$, cm.
1.0	400	400	>20
5.0	220	100	14.6
10	200	60	8.9
20	240	30	3.4

* See reference 2.

relation $I=I_0\exp(-\mu x)$ (for vertical direction). The data suggest that most of the radiation at 1-cm pressure is either extremely penetrating or reacts in the lead to produce one or more penetrating secondaries which continue through the counter telescope. Several of the experiments will be repeated to check this conclusion.

The azimuthal effect was measured with the 45° and 67½° zenith angle telescopes with 7.6 cm of Pb at 1-cm pressure height. The counts were summed up in each 45° sector, but no asymmetry was observed greater than the experimental error of 5 percent.

These experiments were preliminary to a proposed investigation of the directional distribution of the cosmic-ray intensity at high altitudes as a function of latitude, and will be published in greater detail.

The writers wish to express their thanks to Colonel R. A. Rossberg and the Minnesota National Guard, Mr. Henry Stinger and Mr. Thomas James of General Mills Corporation, and Lieutenant M. L. Lewis, United States Navy, for operation of the exceptional balloon facilities used for these experiments.

* See also J. R. Winckler "Directional distribution of the total cosmic radiation at atmospheric heights up to 10 cm Hg at Princeton," Bull. Am. Phys. Soc. **23** (April 29, 1948).
** Assisted by the Joint Program of the Office of Naval Research and the Atomic Energy Commission.
[1] Biehl, Montgomery, Neher, Pickering, and Roesch, Rev. Mod. Phys. **20**, 360 (1948).
[2] The hard radiation is defined essentially as that capable of penetrating >4 cm Pb. The soft radiation is that penetrating <4 cm Pb.

Isotopic Shift in the Helium Line Spectrum

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USING some of the enriched He^3 mixture from the apparatus of Andrew and Smythe,[1] we have prepared a discharge tube in order to photograph the isotopic shift in the spectra.

The mass difference of the nuclei of He^3 and He^4 produces a change in the energy levels of the different states of the extra-nuclear electrons. This effect can be divided into two parts, the normal effect and the specific effect. The former applies to all energy levels and its magnitude is given by

$$\Delta W_1=(m/M)W,$$

where m is the reduced mass of the electron, M is the mass of the nucleus, and W is the term value of the energy level for a nucleus of infinite mass.

For hydrogen-like atoms the normal effect accounts for the total change; however, for more complex atoms the specific effect must be taken into account. This effect amounts to an additional change in the P levels only. Hughes and Eckart[2] have calculated this energy change to be

$$\Delta W_2=\pm(128/3)(m/M)(R_\infty)(Z_1Z_2)^5n^3(n^2-1)\frac{(Z_1n-Z_2)^{2n-4}}{(Z_1n+Z_2)^{2n+4}},$$

where R_∞ is the Rydberg constant for infinite mass, n is the quantum number of p electron, Z_1 is the effective nuclear charge for the $1s$ electron, and Z_2 is the effective nuclear charge for the np electron. The increment of energy is positive for singlets, negative for triplets.

If one considers the line 2^1P-3^1D, λ6678, the normal effect is

$$\Delta\nu_1=\frac{m}{\lambda}\left(\frac{1}{M_4}-\frac{1}{M_3}\right)$$
$$=-0.681\ \text{cm}^{-1}.$$

Eckart[3] has calculated the values of Z_1 and Z_2 and has found

$Z_1=2.003$ for the $1s$ electron,
$Z_2=0.965$ for the $2p$ electron.

The specific effect is

$$\Delta\nu_2=\left(\frac{128}{3}\right)\left(\frac{m}{M_4}-\frac{m}{M_3}\right)R_\infty(Z_1Z_2)^5n^3(n^2-1)\frac{(Z_1n-Z_2)^{2n-4}}{(Z_1n+Z_2)^{2n+4}}$$
$$=-0.364\ \text{cm}^{-1},$$

and total change is

$$\Delta\nu=\Delta\nu_1+\Delta\nu_2=-1.045\ \text{cm}^{-1},$$

or

$$\Delta\lambda=0.466\text{A}.$$

Using the Mount Wilson Observatory 15-ft. Rowland mounting with a 5-inch concave grating and a dispersion of 3.60A/mm in the first order, we photographed the line λ6678. From comparator readings, the average value of three different photographs shows

$$\Delta\lambda=0.471\pm0.009\text{A}.$$

The shift was also measured with a Fabry-Perot Interferometer. With a 3 mm etalon we obtained photographs of two interference patterns of λ6678. Measurements of the shift in six successive orders of the two microphotometer tracings give

$$\Delta\lambda=0.467\pm0.004\text{A}.$$

The agreement is well within experimental error.

We wish to express our gratitude to Professors W. R. Smythe and R. B. King for valuable discussions and suggestions.

[1] A. Andrew and W. R. Smythe, Phys. Rev. **74**, 496 (1948).
[2] D. S. Hughes and Carl Eckart, Phys. Rev. **36**, 694 (1930).
[3] Carl Eckart, Phys. Rev. **36**, 149 (1930).

Disintegration of Tc^{95} and Tc^{96}

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In a preliminary note[1] we have communicated that irradiation of molybdenum with 7-Mev protons leads to the formation of several Tc isotopes, which decay by emitting γ-lines in the range between 770 and 880 kev. A 873-kev line could be assigned to 53-min. Tc^{94}[2] and another one, of 810 kev, to 62-day Tc^{95}.[3]

The Tc isotope of mass number 96 (which disintegrates by K-capture[4,5] with a 104-hr. period) has now been investigated in more detail. While the curve of the γ-ray absorption in lead seemed to suggest a homogeneous γ-line of about 800 kev, a weak component of about 1100 kev resulted from coincidence absorption measurements of the secondary electrons. A sample, chemically separated from Mo and electrolytically deposited on a foil, was used for investigating (in a magnetic lens spectrometer) the conversion electrons. This analysis showed further complexities in the γ-radiation associated with the 104-hr. period. (Fig. 1.) Three strong electron lines at 751, 786, and 822 kev were found, which correspond to γ-energies of 771 ± 2, 806 ± 2, and 842 ± 2 kev, respectively. Furthermore, weak conversion lines of γ-rays of 1119 ± 2 and 312 ± 2 kev are present. $\gamma-\gamma$-coincidence measurements which were carried out with Bi cathode counters showed, in accordance with measurements performed in the same calibrated arrangement with Al cathode counters, that the γ-ray components of 771, 806, and 842 kev are emitted in threefold cascade. Both from the intensity of the 1119-kev line (which was estimated from the recoil electrons from brass in the spectrometer) and the coincidence rate, we must conclude that this γ-line is also emitted in cascade with the 771- and 842-kev γ-lines. The weak 312-kev γ-line could only be observed through its converted part and its energy fits very well the difference between 1119 and 806 kev. The ratio of K-capture X-quanta to γ-quanta was determined by measuring the absorption in aluminum with counters of known sensitivity, the electrons from the sample and the recoil electrons from the absorber being deflected magnetically. Taking into account the fluorescence yield for Mo $K\alpha$-radiation and the L-capture, one finds that the number of cascade transitions is equal to the number of orbital electron captures. No positron tracks were found on cloud-chamber photographs.—We therefore suggest a decay scheme as in Fig. 2, in which the order of succession of the last two γ-ray transitions is as yet arbitrary. The lines due to conversion electrons were backed by a weak continuous spectrum extending up to 0.8 Mev. It could not be decided whether this background is simply due to scattered electrons or to an actual β^--spectrum. The existence of a stable ruthenium isotope of mass number 96 leaves the possibility of a dual decay open.

In the course of the investigation of the 104-hr. period further details of the 20-hr. period of Tc^{95} came to light. Spectrometer measurements indicated three conversion lines corresponding to γ-energies of 762 ± 2, 932 ± 2, and 1071 ± 2 kev, the strongest component being that at 762 kev. On the other hand, we were unable to detect the 200-

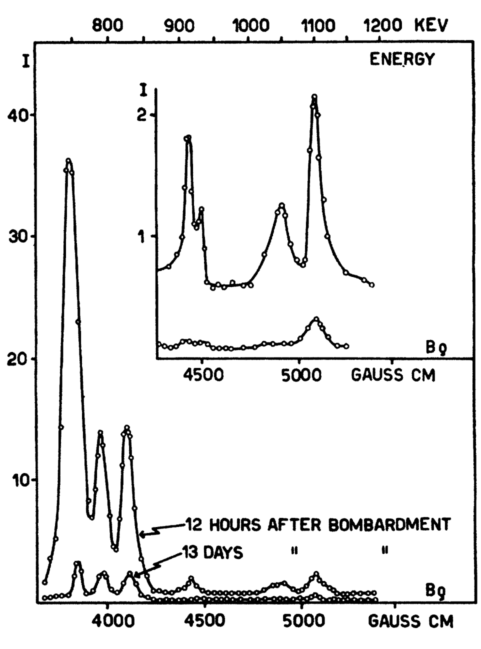

Fig. 1. Conversion electrons from 20-hr. Tc^{95} and 104-hr. Tc^{96}.