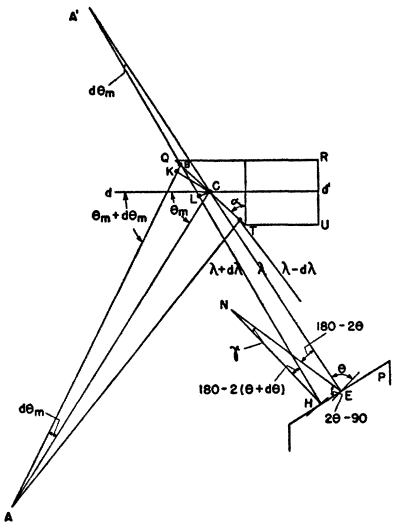

FIG. 1. Principle of the achromatization method.

of the sample P for the wave-length λ, and α is the angle between the normal to the lattice plane and the ground surface QT of the crystal. If an x-ray source of finite width S is substituted for the point source A, then the width of the achromatized image near N is

$$S' = S\cos 2\theta \frac{\cos(\theta_m+\alpha)}{\cos(\theta_m-\alpha)}.$$

By proper choice of θ_m and α, the image can be made much narrower than the source.

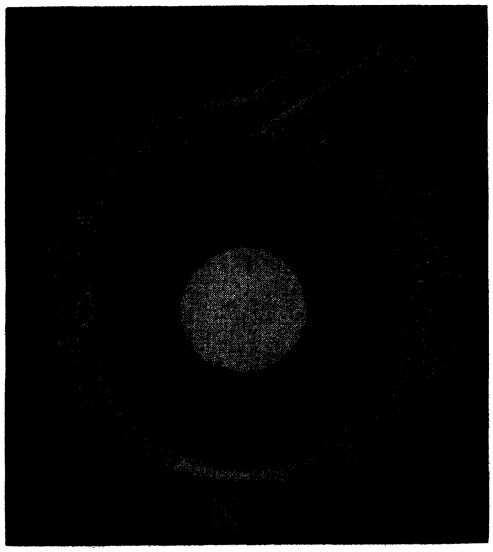

FIG. 2. Photograph of achromatized CoK_{α}- doublet. Annealed steel, 310 reflection. $\alpha = 90$, $\theta_m = 72.°2$, $F = 7.92$ cm.

The relative difference $|\Delta d/d|_R$ of two lattice parameters of the sample giving rise to two lines which are just resolved in the Rayleigh sense is

$$\left|\frac{\Delta d}{d}\right|_R = \frac{1.22S}{2F}\cot\theta\frac{\cos(\theta_m+\alpha)}{\cos(\theta_m-\alpha)},$$

whereas for the Debye-Scherrer method with an infinitely narrow collimator

$$\left|\frac{\Delta d}{d}\right|_R = \frac{1.22w}{\lambda} \approx 5\times 10^{-4},$$

where w is the spectral width of the characteristic line. Thus, it should be possible to increase the resolution by an order of magnitude beyond the ultimate limit inherent in the conventional method.

Figure 2 illustrates the achromatization principle for a case where the two components of a $K\alpha$-doublet are brought to an approximate focus at N. Our ultimate aim, however, is to achromatize a single α_1 line, using a fine focus tube now under construction.

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A New Isomer of Element 43 (Tc) of Very Small Excitation Energy

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AMONG the numerous isotopes of element 43 (technetium) which can be produced by (p,n) reactions from those of Mo, there is one with a half-life of 53 minutes. It decays by positron emission [$E_{max} = (2.45\pm0.03)$ Mev] and by orbital electron capture,[1] and emits nuclear γ-rays of (0.380 ± 0.004) Mev, (0.873 ± 0.004) Mev, (1.48 ± 0.01) Mev, (1.85 ± 0.01) Mev, and (2.74 ± 0.01) Mev. It has presumably a mass number of 92 or 94. We have observed electron lines of (13.0 ± 0.8) kev, (31.5 ± 0.5) kev, and (33.0 ± 0.4) kev in a magnetic semicircular spectrometer, the intensities of which decrease with same half-life as the positron intensity. The differences between the energies of these electron lines indicate that they arise from K, L, and M conversions in Tc. Hence the excitation energy amounts to (33.4 ± 0.4) kev. In order to check that these electron lines are not due to transitions of the excited residual Mo nucleus but arise from an isomeric state of Tc, we have investigated the x-rays associated with the conversion. Photographs taken with a crystal spectrograph of the Cauchois type showed the $K\alpha_1$, $K\alpha_2$, and $K\beta_1$ lines of both Tc and Mo, those caused by Mo being weaker. The x-ray decay period was likewise about one hour. The Mo lines obviously originate from K-capture. Since besides the above-mentioned low energy conversion

lines no intense converted radiation is observed, the presence of the Tc x-radiation proves that the 33.4-kev transition is an isomeric one of the Tc nucleus. The half-life (53 minutes) is in good agreement with the value derived from a semi-empirical energy-lifetime relation[2] for 33.4 kev and an angular momentum change $\Delta L=4$.

We hope to succeed in determining, by means of an isomer separation, the shorter lifetime, caused by the ground state of Tc, from which the positron emission and electron capture result.

A more extensive report on these measurements will appear in Helv. Phys. Acta.

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On the Radioactivity of K^{40}

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SEVERAL recent papers in this journal[1-3] have dealt with the decay of K^{40} by following Bleuler and Gabriel[4] in assuming $(7\pm1)\times10^8$ years for the beta-decay period, $(2.4\pm0.5)\times10^8$ years for the total period, and a branching ratio corresponding to 1.9 capture processes per beta-decay. It should be pointed out that the interpretation Bleuler and Gabriel gave of their experimental observations does not agree with the following:

A branching ratio of 1.9 would mean a yield of argon sufficiently large to make it easily detectable in old rocks and gaseous exhalations.[5,6] No excessive abundance of argon, however, has yet been reported in such cases. A careful investigation of two samples of sylvine and one of carnallite has been carried out recently[7] in order to reach a final conclusion on this question. From the data of Bleuler and Gabriel a content of at least 1.5×10^{-2} cm^3 argon per gram sylvine, was to be anticipated, as the sylvine's age exceeded 2×10^8 years. Analysis of the gases collected from the samples, however, gave an upper limit of 0.02×10^{-2} cm^3 argon. The carnallite analysis gave a similar result. These results indicate that only a few percent of the decaying K^{40} can yield A^{40}. This, as well as geochemical evidence as a whole, makes it seem most unlikely that more than 10 percent of the decaying K^{40} is converted into argon.

From the general systematics of the abundance of nuclei in the universe[8] it is possible to estimate the concentration of K^{40} at the time of its formation. It can in that way be estimated that the K^{40} content of potassium hardly exceeds the Lu^{176} content of lutetium, which is 2.5 percent. The age of the elements is certainly greater than 33×10^8 years, the figure given by Holmes[9,10] for the age of the earth. A total period of 2.4×10^8 years leads to an improbable value of more than 60 percent K^{40} in potassium at the time specified. A total period of 7×10^8 years, however, leads to 1 percent K^{40} in potassium 45×10^8 years ago; both these values do not seem far wrong for the original concentration of K^{40} and the age of the elements, respectively.

By considering the fact that the large concentration of A^{40} in the atmosphere has undoubtedly originated from K^{40}, we find from the present amount of atmospheric argon[11] and the present amount of K^{40} in the earth[12] and assuming a total period of 7×10^8 years, that approximately 0.5 percent of the total amount of the decay products produced during the last 33×10^8 years is now present in the atmosphere in the form of argon. The major part of A^{40} is probably left occluded in the earth's interior; yet the proportion of atmospheric to occluded argon is not necessarily as small as assumed previously[6,13] because a large part of the earth's surface was probably in a molten liquid state during the long period extending from 33×10^8 until 20×10^8 years ago. We can thus take 0.5 percent as a lower limit for the branching ratio for the decay of K^{40}.

The conclusion from geochemical evidence, that more than 0.5 percent and less than 10 percent of the decaying K^{40} is converted into A^{40}, seems to make it most probable that, as in the case of Lu^{176},[15] the full number of capture processes is accompanied by the emission of hard gamma-quanta known to be emitted by excited A^{40} nuclei[1,14]. The hard quanta are emitted at a rate of 3 quanta according to Gray and Tarrant,[16] or at a rate of 7 ± 1.5 quanta according to Gleditsch and Gráf,[3] per 100 beta-rays. Geochemical evidence seems to make the lower value appear slightly more probable. A value of 5 ± 2 percent for the branching ratio might be considered to be within the limits of error if all the data concerned.

The suggested scheme (Fig. 1) makes it necessary to regard the soft radiation with an approximate intensity

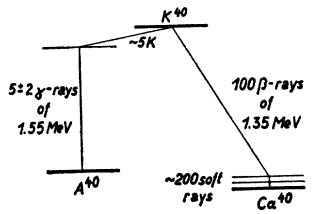

FIG. 1. Disintegration scheme of K^{40}. Total half-life period 7×10^8 year.

of 2 quanta per beta-ray[4,5] as connected with the beta-process. Haxel and Houtermans[17] have recently observed a soft radiation of similar quality from Rb^{87} coinciding with the beta-emission. It seems reasonable to assume a similar process to occur in the beta-process of K^{40}.

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