nium, from the reaction $^{238}_{\text{U}}(d, n)^{239}_{\text{U}}$. It is impossible to
deduce from the absorption curve the relative intensities of
the new 93 and of $^{93}_{\text{U}}$, since the initial parts of the in-
dividual absorption curves of these two activities might
well be nearly identical. The rate of decay of the high en-
ergy beta-particles (0.5–1 Mev) and gamma-rays from the
93 of uranium plus deuterons was determined. This gave
a half-life of about 2 days for the new 93. This activity is
probably assigned to $^{93}_{\text{U}}$, $^{93}_{\text{Pb}}$, or $^{93}_{\text{Br}}$ formed in the
reaction $^{238}_{\text{U}}(d, 2n)^{239}_{\text{U}}$, $^{238}_{\text{U}}(d, n)^{239}_{\text{Pb}}$, or $^{238}_{\text{U}}(d, 2n)^{239}_{\text{Br}}$,
respectively.

The growth of alpha-particles, which might be due to the
element 94 daughter of the 2-day 93, was then looked for.
We did observe the growth of alpha-particles in the
very carefully purified, as well as in the semi-purified 93
fractions, and the growth curves indicate a half-life of
roughly 2 days for the parent of the alpha-emitter. The
final alpha-particle count amounts to several hundred
counts per minute for a bombardment of 200 microamper-
hours. This work was done with a proportional type
counter. We plan to re-determine the alpha-particle growth
curve more accurately using an ionization chamber and
linear amplifier with the help of a magnetic field to bend
out the very strong beta-particle background. The alpha-
particles have a range of approximately 3.9 cm in air.

This alpha-activity is chemically separable from uranium
and 93. The chemical experiments so far indicate a simi-
larity to thorium and the activity has not yet been sepa-
rated from thorium. More chemical experiments definitely
must be performed before it can be regarded as proved
that the alpha-particles are due to an isotope of element 94.

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Radioactive Element 94 from Deuteron on Uranium

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March 7, 1941

We should like to report a few more results which we
have obtained regarding the element 94 alpha-
radioactivity formed in the 16-Mev deuteron bombard-
ment of uranium. We sent a first report1 of this work in a
Letter to the Editor of January 28, 1941. We have in the
meantime performed more experiments in order to study
the chemical behavior of this alpha-radioactive isotope.
The radioactivity can be precipitated, in what is probably
the + 4 valence state, as a fluoride or iodate by using a rare
earth or thorium as carrier material and as a perox-
hydrate by using thorium as carrier material. However, in
the presence of the extremely strong oxidizing agent per-
sulfate ion ($\text{S}_2\text{O}_8^{2-}$), plus Ag as a catalyst, this alpha-
radioactive isotope is oxidized to a higher valence state which
does not precipitate as a fluoride. The oxidizing agent
bromate ion ($\text{BrO}_3^-$) is not sufficiently powerful to oxidize
it to this higher valence state and hence the radioactivity
comes down as a fluoride even in the presence of bromate
ion. With the help of persulfate ion it has been possible to
separate quantitatively this radioactivity from thorium,
by using the beta-active UX3 as an indicator for thorium.
These experiments make it extremely probable that this
alpha-radioactivity is due to an isotope of element 94.
The experiments are being continued.

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Search for Spontaneous Fission in 94$^{199}$

JOSEPH W. KENNEDY AND ARTHUR C. WAHL
Berkeley, California
December 4, 1941

This report describes the experimental procedure and
gives the results obtained in our search for sponta-
neous fission in 94$^{199}$. The observations were made on a
3.5-microgram sample of 94$^{199}$. The preparation of which
was described in a report of July 24, 1941, from this labora-
tory. This sample, when placed on one electrode of an
ionization chamber connected to a linear amplifier ad-
justed to record counts due to fissions, gave zero counts
in 139 hours. In another, independent experiment, done
in a similar manner with entirely different apparatus,
this sample gave zero counts in 209 hours. These experi-
ments set a lower limit of the order of 10$^{14}$ years for the
"half-life" of 94$^{199}$ with respect to spontaneous fission.
These results show that it is probable that the half-life
for spontaneous fission of 94$^{199}$ is as long or longer than
that of 93$^{189}$, assuming the British results (40 spontaneous
fissions per min. per g of pure 93$^{189}$).

The details follow: The 3.5-microgram sample of 94$^{199}$
was mounted on a platinum-coated copper disk, along with
its cerium fluoride carrier in which the thickness amounted
to ~0.3 mg per cm$^2$. All the measurements described herein
were made with shallow ionization chambers so constructed
that this disk could be inserted to serve as one of the elec-
trodes. Consideration of this geometry indicates that
ionizing particles emitted from a sample on the disk could
be counted with an efficiency of about 45 percent; tests
of the alpha-particle counting rate with a thin, weighed
uranium sample on a similar disk confirmed this estimate
when the gain of the linear amplifier used was set suffi-
ciently high. Since in each fission process two ionizing
particles are emitted in opposite directions, an upper
limit of about 90 percent efficiency for fission counting is
set by the geometrical arrangement. Actually, because of
the fluctuating background ionization due to alpha-
particles from the sample, it was expedient to adjust the
amplifier gain in such a way that a slightly lower counting
efficiency was obtained. With the use of a neutron source
and a thin uranium sample mounted like the 94$^{199}$ sample,
two independent calibrations of this efficiency were made,
as follows: (1) oscillographic observation of pulses showed
the fraction of fission pulses too small to actuate the thyr-
tron recording circuit; (2) the recorded fission rate was
compared with the expected rate calculated from the weight
of the thin uranium sample, the slow neutron fission cross

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section of uranium, and the density of slow neutrons as determined with an indium detector.

Both these calibrations gave the result that about 70 percent of the fissions were being recorded under the operating conditions of our experiments. This slight reduction in counting efficiency is no doubt to be attributed to discrimination against those fission fragments which traverse only a corner of the ionization chamber. It is of course apparent that high precision in the evaluation of this percentage efficiency is not required for our interpretation of the final result; however, the effect of small variations (±0.10 percent) in amplifier gain on this efficiency calibration was investigated and found negligible, showing that the working region approximated a plateau.

Two separate linear amplifier and ionization chamber outfits were used for two independent series of spontaneous fission experiments. At frequent intervals during all measurements the over-all gain of the amplifier was checked by the use of a pulse generator and voltage divider box or by re-testing the efficiency of counting slow-neutron induced fissions in uranium.

The series of measurements with one amplifier and chamber gave zero spontaneous fission counts in 139 hours of operation. With the other amplifier set-up, 209 hours of observation gave zero counts. These results enable us to say something about the spontaneous fission disintegration constant of 94\textsuperscript{m} or, more conveniently, about the half-life for spontaneous fission corresponding to this disintegration constant. In the two experiments taken together zero counts were obtained in 348 hours. From the weight of the sample (3.5 micrograms) and the efficiency of the apparatus for counting fissions (70 percent), one can calculate that for a half-life of 10\textsuperscript{4} years the mean time between counts would be about 20 hours and for a half-life of 10\textsuperscript{4} years the mean time between counts would be about 200 hours. The probability of obtaining zero counts in 348 hours is about 10\textsuperscript{-8} for 20 hours mean time between counts, and about 0.2 for 200 hours mean time between counts. Therefore, it seems fairly safe to say that the half-life of 94\textsuperscript{m} for spontaneous fission is of the order of 10\textsuperscript{4} years or greater.

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Determination of Absolute Neutron Intensities
R. D. O'Neal and G. Scharff-Goldhaber
Department of Physics, University of Illinois, Urbana, Illinois
February 24, 1942*

We have developed a method of measuring the number of neutrons emitted from a given source and used it to determine the neutron intensity of a laboratory standard consisting of 100 mg of radium surrounded by 85 g of beryllium metal. We made use of the main principle of Amaldi and Fermi's well-known method, which consists in slowing down all the neutrons emitted from the source before they are counted. However, we avoided the use of a number of constants and some difficult approximations, which appeared in the original form of this method.

Our procedure consisted essentially of two steps.

(a) Determination of the ratio \( R \) of the number of neutrons activating a MnSO\(_4\) solution with and without the presence of an absorber (consisting of finely powdered manganese).—The volume of the solution was chosen so large that 1 percent of the neutrons was allowed to escape. After irradiation the solution was thoroughly stirred and the decay of its radioactivity observed by means of a large thin-walled Geiger counter (initial activity without absorber 1110 counts/min. above the background of 200 counts/min., with absorber 850 counts/min.).

(b) Determination of the number of neutrons \( N_s \) captured by the absorber per unit time.—After irradiation a fraction of the well-mixed Mn powder was filled into paper shells. These "thick" samples were placed alternately around a thin-walled Geiger counter and their initial activities were determined (6185 counts/min.).

In order to determine the number of disintegrations per gram of manganese (specific activity), we irradiated some manganese powder with neutrons from a very strong source and filled a known amount of it into a paper shell as before. With another part we prepared a thin layer (16 mg/cm\(^2\)) between two pieces of scotch tape, which was placed in a defined position relative to the counter. A similar layer, made of a known amount of fine uranium metal powder, was placed in the same position for standardization. For the calculation of the specific activity of the manganese samples the number of UX\(_2\) nuclei decaying per sec. per gram of uranium was assumed to be 12220.\(^2\) A correction of 2.5 percent was found to be necessary to allow for the slightly stronger absorption of the UX\(_2\) beta-rays in the glass wall of the Geiger counter and in the scotch tape. By multiplying the specific activity of the manganese absorber with the total weight of the absorber (523 g), we obtained \( N_s \) and \( N = N_s/(1-R) \) where \( N \) is the total number of neutrons emitted from our source.

The result was \( N = (8.6±0.8)\times10^2 \) neutrons per sec. The error was calculated by adding up all standard deviations from the mean of the several measurements, which were made for each individual quantity.

The intensity of this laboratory standard has been compared with that of a Ra-α-Be source (see following letter by Gamertsfelder and Goldhaber).

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A Reproducible Neutron Standard
G. R. Gamertsfelder and M. Goldhaber
Department of Physics, University of Illinois, Urbana, Illinois
February 24, 1942*

For some time a need has been felt for a simple, reproducible standard of neutron intensity. It is known that the most commonly used neutron sources, those obtained by mixing Rn or R\(_4\) with Be powder, are not reproducible.\(^1\) By contrast it would appear that a photo-neutron source, obtained by irradiating Be with Ra \( \gamma \) rays under exactly defined geometrical conditions, could