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Author:

Leininger, R.F.; Segre, E.; Wiegand, C.

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ON THE DECAY CONSTANT OF Be^7

R. F. Leininger, E. Segré and C. Wiegand

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R. F. Leininger, E. Segré and C. Wiegand

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

ABSTRACT

A comparison of the decay constants of Be^7 in beryllium oxide and in beryllium fluoride has given $\lambda_{BeO} - \lambda_{BeF_2} = (+1.375 \pm 0.053)10^{-3} \lambda_{BeO}$ thus showing a definite effect of the chemical binding on the radioactive decay constant.

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In previous papers on this subject[1] we pointed out the possibility of altering the half life of Be^7 by chemical binding and we compared the decay constants of beryllium metal and beryllium oxide[2]. This experiment was not too conclusive because the effect $\lambda_{BeO} - \lambda_{Be} = (-3.0 \pm 1.8)10^{-4}\lambda_{Be}$ was only about 1.7 times the standard deviation of the measurement and for this reason we decided to try another pair of compounds, using also stronger samples. Our choice was BeO and BeF$_2$ and this time we have observed a definite effect, namely $\lambda_{BeO} - \lambda_{BeF_2} = (+1.375 \pm 0.053)10^{-3}\lambda_{BeO}$.

The apparatus used was the same as that described in (2), the only change being that we enclosed the ionization chambers by a thermally insulating box. This provision kept the temperature of the two chambers equal to each other and effectively reduced the tendency of ambient temperature gradients to alter the relative sensitivity of the chambers. This effect of the temperature gradients was inconvenient, although it did not affect the results of the previous experiments because samples were interchanged between the chambers every 20 minutes. Also the positioning of the sample was carefully rechecked in order to have the sources in a position in which they would give a maximum of ionization. Small displacements from this position affect the sensitivity of the chamber only by a term quadratic in the displacement.

The Be^7 was obtained from a proton bombardment of lithium with the 60-inch Crocker cyclotron. The beryllium was purified as follows:

The bombarded lithium was dissolved in dilute hydrochloric acid containing approximately 20 milligrams of beryllium. Carriers of cadmium, cobalt, copper, nickel

and zinc were added and the beryllium was precipitated by excess ammonium hydroxide

from a hot solution. After cooling the precipitate of beryllium hydroxide was

washed two times by dilute ammonium hydroxide. The precipitate was re-dissolved in

dilute nitric acid and precipitation by ammonium hydroxide after the addition of the

carriers was repeated four times.

The last by-product of added carriers had a small amount of activity, but

on adding to it normal beryllium and re-separations no activity was found in the

fraction containing the carrier and all went with the inactive beryllium, showing that

the activity was due to Be^7 and not to isotopes of the carrier. At this point an

aluminum absorption curve was run on the purified beryllium and failed to show the

presence of any extraneous beta-ray activity.

The beryllium hydroxide was then converted to the basic beryllium acetate

and dissolved in chloroform. The chloroform solution was washed by water two times

to remove all water soluble impurities. The basic acetate-chloroform solution was

evaporated to dryness and the residue dissolved in nitric acid.

To prepare beryllium fluoride, beryllium hydroxide was first precipitated

and the washed precipitate dried at 110° C in a platinum boat. The platinum boat

protected by a platinum shield was placed in a monel metal tube and the beryllium

hydroxide converted to the fluoride by hydrofluorination with anhydrous hydrofluoric

acid at 200° - 220° C for two hours. The temperature was then increased to 500° C

for five hours to sinter the product and to convert it to a definite crystalline form.

In the previous experiment there could be no doubt as to the compounds

being measured since the metal and the oxide were used. However, for the second

experiment absolute evidence that the beryllium fluoride measured was actually the

fluoride and not an oxyfluoride or oxide was considered necessary. X-ray diffraction

studies were used as a method of analysis since the samples used are small and even

radioactive preparations can be easily checked.

Crystallographic measurements were made for us by Dr. D. Templeton. The active beryllium fluoride had the same crystal structure as that which was observed for a previously submitted inactive sample. This structure is not the same as that usually reported for beryllium fluoride. Chemical determination of the formula of this material gave BeF_2. The structure was hexagonal with constants of A = 4.72A C = 5.18A in agreement with a beryllium fluoride structure observed by A. V. Novoselova, et al[3].

In order that the beryllium involved in the two compounds should have as nearly as possible the same treatment it was all converted to the fluoride and thereafter one half was dissolved in water and converted to the hydroxide and then to the oxide at 1000° C.

The samples were sealed in glass so that no moisture would affect them during the course of the measurements. Initially each sample gave in our chamber an ionization equivalent to 317 micrograms of radium. This comparison was made by using the same ionization chambers and electrometer tube arrangement, but shunting the galvanometer and inserting a grid leak on the electrometer tube according to the intensity of radiation to be measured. With the grid leak we observed steady deflexions of the galvanometer. We found that on the scale used in Fig. 1 the BeO sample gave initially a rate of drift of 280 mm/sec. This was not of course measured directly, but by a ladder of successive comparisons of the strong beryllium oxide sample with a series of radium standards, the weakest of which could be measured using the same sensitivity as in the differential measurement. The same procedure had been used in the experiments referred in (2) but the shunt used then was different and for this reason 1 mm sec^{-1} in the two experiments correspond to different activities.

In Fig. 1 we plot the difference of the activities of BeO and BeF_2 corrected for decay. This figure is analogous to Fig. 2 of our previous paper (2) and the slope of the line connecting the circles gives $\Delta\lambda/\lambda$. A least square reduction of the

observed data gives

$$\lambda_{BeO} - \lambda_{BeF_2} = (1.375 \pm 0.053)10^{-3}\, \lambda_{BeO}$$

This datum combined with our previous one on $\lambda_{Beo} - \lambda_{Be}$ gives

$$\lambda_{Be} - \lambda_{BeF_2} = (1.675 \pm 0.19)10^{-3}\, \lambda_{Be}$$

Recently this quantity has also been measured by Bouchez, R. and P. Daudel and Muxart[4] and they report a change in decay constant about 5 times larger than we observed.

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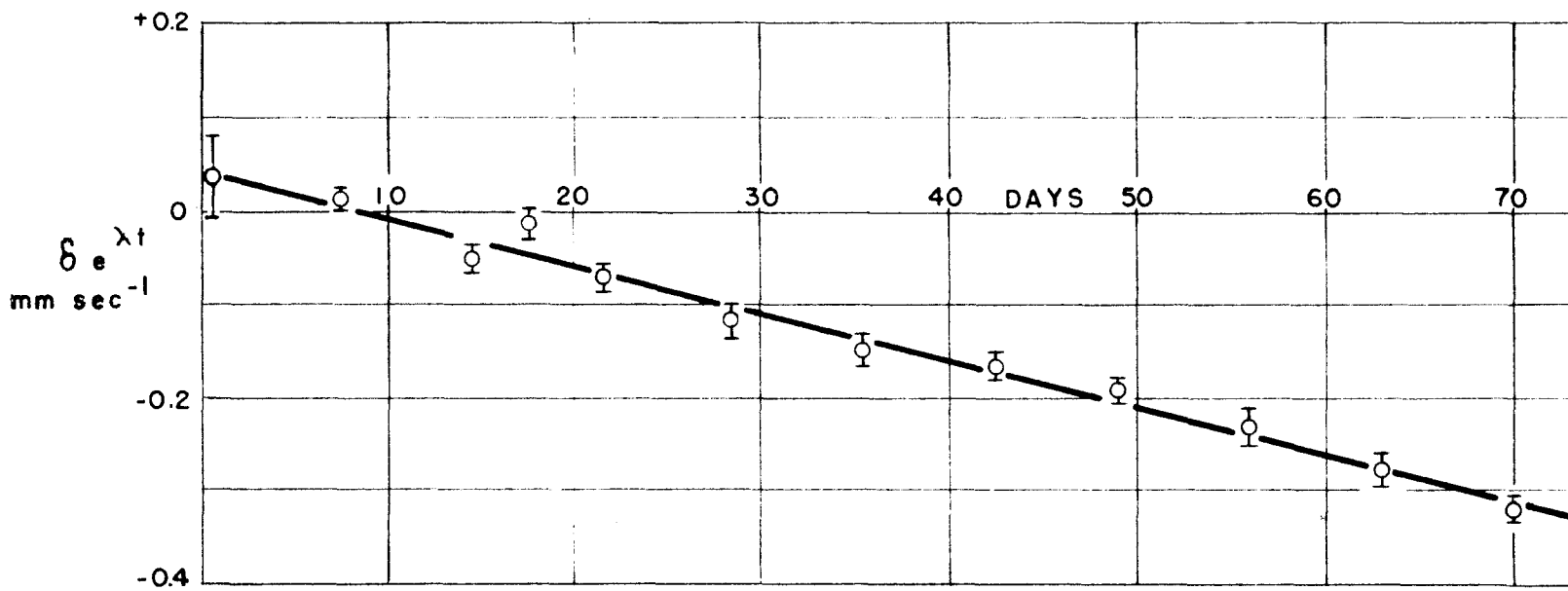
Figure 1

Observed difference of activities of BeO and BeF$_2$ corrected for dec

$\delta\, e^{\lambda t} = \delta_0 + A(\Delta\lambda/\lambda)(t/T)$ in mm sec^{-1}. The initial difference of

activity is 0.04 mm sec^{-1} and the initial activity A 280 mm sec^{-1}.

The scale on the right indicates the slope of the line for various

values of $\Delta\lambda/\lambda$.