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Physics General

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SUMMARY OF THE RESEARCH PROGRESS MEETING OF MAY 11, 1950

Henry P. Kramer

October 20, 1950

Berkeley, California

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	98

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Physics General

SUMMARY OF THE RESEARCH PROGRESS MEETING OF MAY 11, 1950

Henry P. Kramer

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

October 20, 1950

Mass Spectrograph Work on the Transuranium Elements. F. Reynolds.

The design for an instrument to be used for a number of purposes in connection with the work of the Chemistry Division was completed about two years ago. Successful techniques for mass separation in the transuranic range of elements have since been developed and shall be described here.

The transmission of the instrument is about 1 percent. That is, about 1 of every hundred ions that are emitted by the heated filament coated with the dry residue of a nitrate solution of the element in question is ultimately received by the collection device. Collection is carried out by means of photographic plates (Ilford Q-2, Eastman SWR) that contain an extraordinarily high fraction of AgCl in thin emulsions or by means of electronic devices. The resolution of the spectrometer is such that two hypothetical isotopes of mass 800 and 801 could be separated. The total quantity collected is measured by means of a conducting wire mounted on the photographic plate and leading to an electrometer.

The instrument has been used to make mass assignments, measure the abundance ratios of elements, and to carry out electromagnetic separation on a minute scale.

Some work has recently been done with plutonium obtained from Hanford. The efficiency of the hot filament for the production of plutonium ions is such that 1 ion is obtained for every 5×10^5 neutral atoms.

The most prominent ion that has been collected has been PuO^+ although Pu^+ and PuO_2^+ have also been observed. 1-2 micrograms of material have been sufficient for several runs of the instrument. However, for abundance ratio measurements it has been found that 8 to 10 times this amount was necessary. Pu^{242} was discovered by analyzing Hanford produced plutonium. The intensity of the line compared to that of Pu^{239} and the α-emission count made by counting the α-tracks on a nuclear emulsion exposed to the Pt collecting foil indicate that the half-life of this isotope exceeds 10^5 years. The half-life of Pu^{240} found with the mass spectrograph is 6850 ± 150 years which compares favorably with the value found by Cunningham of 6650 ± 150 years.

The machine has been used to prepare extremely small amounts of pure Am and Cm isotopes (10^{-10} grams). The 10 year Cm activity has been identified as Cm^{244} and Pu^{238} has been observed to grow from Cm^{242}.

42 Mev Neutron Cross Sections. C. Leith and R. Hildebrand.

Neutron cross sections are best explained in the range of incident energies to 25 Mev by the opaque model of the nucleus whereas at energies exceeding 90 Mev the theory of the transparent nucleus of Serber offers the best interpretation. It was therefore considered to be of interest to make an experimental investigation of the transition region between the two theories. For this reason neutron cross sections for 32 elements were studied with an incident beam energy of 42 Mev.

The experiments were carried out in the manner indicated schematically in Fig. 1. Detection of both the incident as well as the transmitted beam was carried out by measuring the activity induced in C^{12} by the mechanism $C^{12}(n,2n)C^{11}$. Although the energy distribution of the 40 Mev neutron beam arising from the stripping of deuterons in 1.27 cm Be

at a cyclotron radius of 55 in. has not been measured, a theoretical calculation was carried out and is shown in Fig. 2 as curve A. Since deuteron stripping theory as developed by Serber has proved to be reliable at 90 Mev, the result of the calculations on the basis of this theory at 40 Mev was accepted. Although the excitation function for the reaction $C^{12}(n,2n)C^{11}$ is not known experimentally, the average cross section for the 40 Mev and the 90 Mev spectrum are known and are approximately equal. Theoretical calculations of the $C^{12}(p,pn)C^{11}$ excitation function have been confirmed thus giving some credence to the analogous calculations for the $C^{12}(n,2n)C^{11}$ excitation function shown in Fig. 2 as curve B. However, because of the equality of the average cross sections over the 40 Mev and 90 Mev neutron spectra, curve B must be taken as an upper bound on the actual function. Complete elimination of the peak in the function at about 40 Mev must give a lower bound B'. C^{11} activities calculated on the basis of the two functions B and B' and the spectrum A yields the two curves C and C' as limiting curves. The curves indicate that the mean energy detected by the carbon monitor falls within the interval (41.3-43.2 Mev). Hence the value 42 Mev has been selected for the energy that is most sensitively detected by the monitors used.

Fig. 3 summarizes the results in the form of a plot of collision radius $R = \sqrt{\sigma_t/2\pi}$ against (mass number)$^{1/3}$. The lower plot accentuates the non-linearity of the data by showing $R-0.132\times10^{-12}M^{1/3}$.

The work is reported in greater detail in UCRL-701 "Total Cross Sections of Nuclei for 42 Mev Neutrons", Roger H. Hildebrand and Cecil E. Leith, May 9, 1950.

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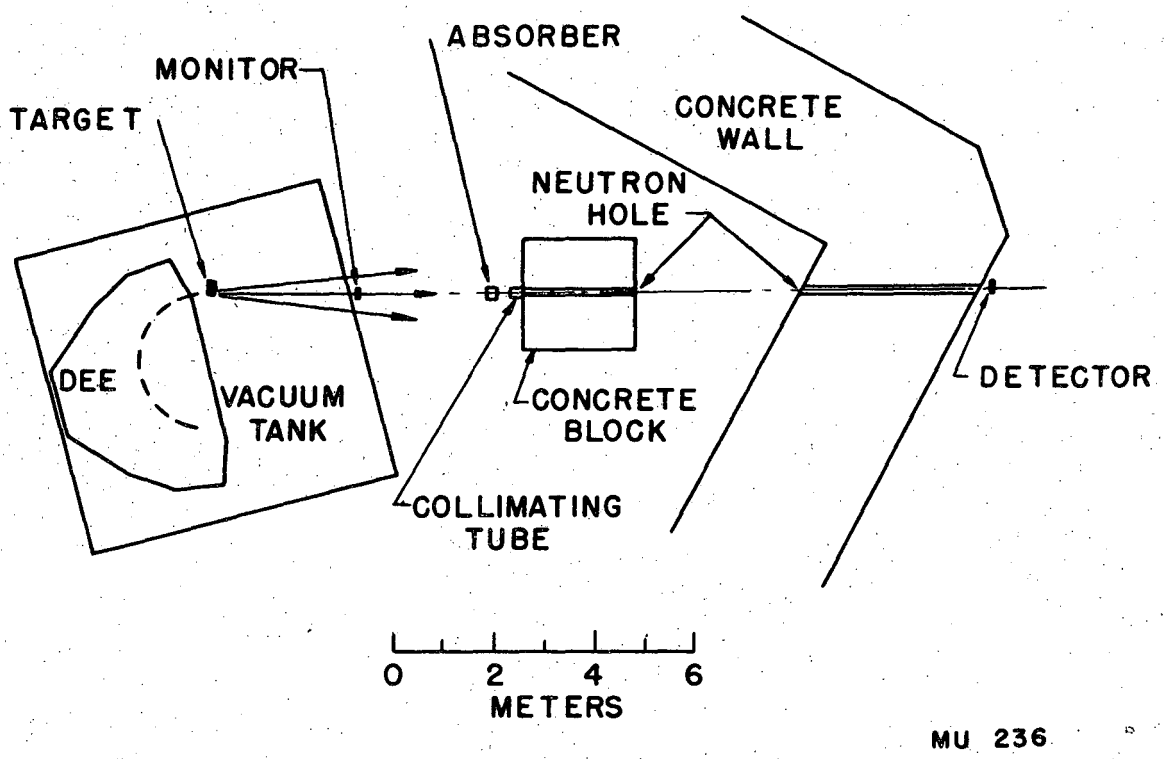
ABSORBER
MONITOR
TARGET
CONCRETE WALL
NEUTRON HOLE
DEE
VACUUM TANK
CONCRETE BLOCK
DETECTOR
COLLIMATING TUBE
0 2 4 6
METERS
MU 236

Figure 1

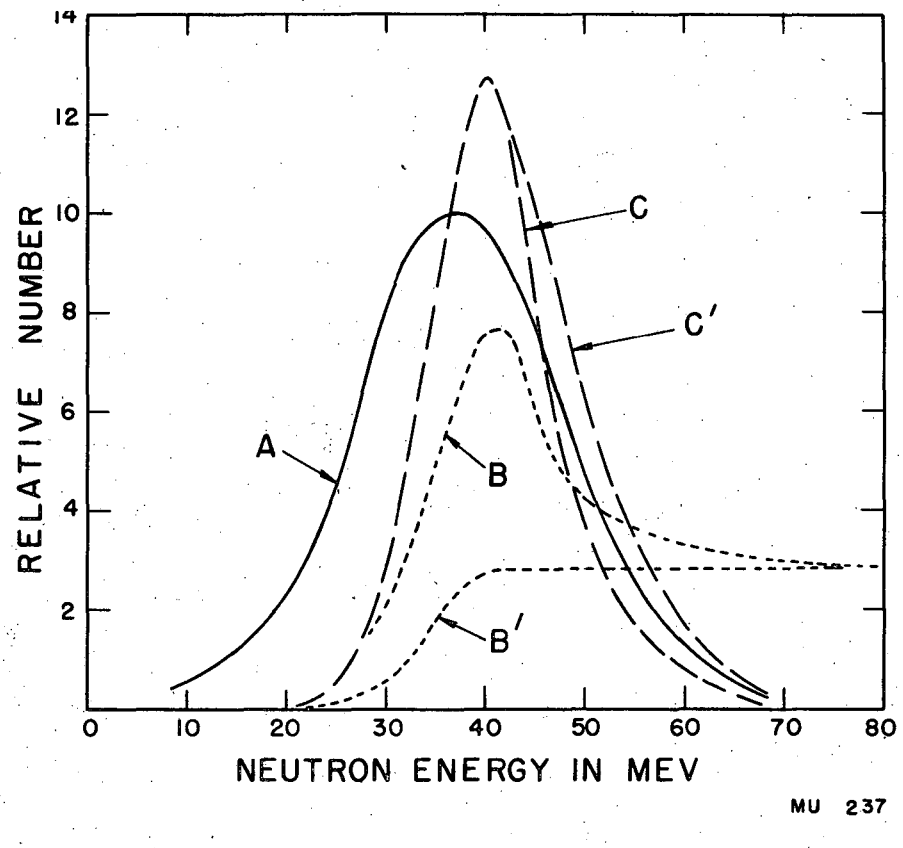
RELATIVE NUMBER
NEUTRON ENERGY IN MEV
A
B
B′
C
C′
0
10
20
30
40
50
60
70
80
2
4
6
8
10
12
14
MU 237
14855-1

Figure 2

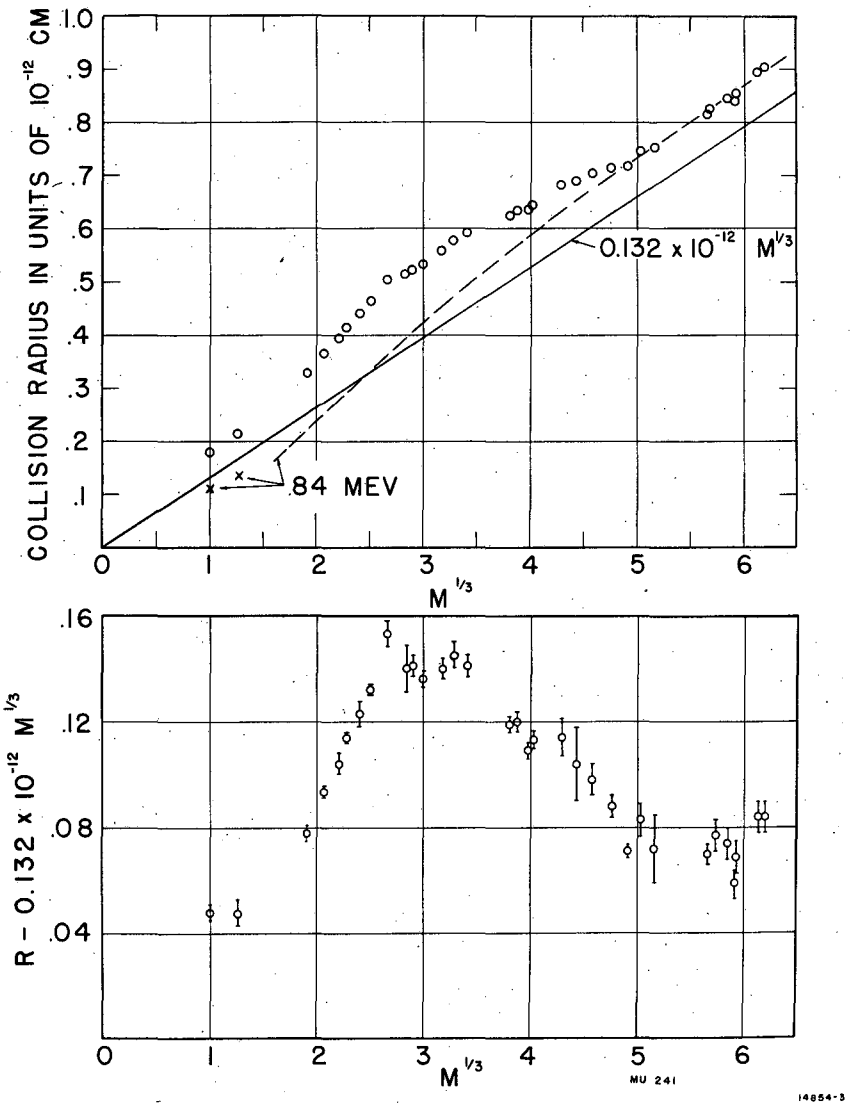
COLLISION RADIUS IN UNITS OF 10^{-12} CM
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.132 x 10^{-12} $M^{1/3}$
.84 MEV
0
1
2
3
4
5
6
$M^{1/3}$
R - 0.132 x 10^{-12} $M^{1/3}$
.16
.12
.08
.04
$M^{1/3}$
MU 241
14854-3

Figure 3