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# Radiation Laboratory

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# SUMMARY OF THE RESEARCH PROGRESS MEETING

April 14, 1949

H. P. Kramer

Berkeley, California

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Univ. of California
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# SUMMARY OF THE RESEARCH PROGRESS MEETING

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Some New Rare Earth Isotopes. H. Hicks.

The inability on the part of the speaker and G. Wilkinson to recognize some of the spallation products of tantalum from bombardment with 280 Mev deuterons has led to an investigation of the entire rare earth group.

This sort of investigation has at last been made possible by the perfection of techniques in the use of resin ion exchange columns for the separation of the rare earth elements. The methods of multistage fractional separation that were previously available did not at all lend themselves to radiochemical research where it is necessary to identify short half-lives. The principle of operation of the ion exchange resin column is briefly stated as follows: a solution containing the ions to be separated is placed on the resin column. The different ions are bound with varying degrees of firmness to the resin. A complexing agent that is then put on the column is able to extract different ions in varying concentrations. This process makes possible a rapid and relatively complete separation. The success of the chemical separation was in all cases checked spectrographically.

The rare earth elements from $_{60}Ne$ to $_{71}Lu$ were investigated. The isotopes with odd atomic numbers were bombarded with $\alpha$-particles from the 60 inch cyclotron and the $(\alpha, n)$, $(\alpha, 2n)$ and $(\alpha, 3n)$ reactions were observed. As a check, the even numbered elements were bombarded with deuterons. The same isotopes were produced in both bombardments. The yields were determined by means of G.M. counters. Predominant among the radiations given out by the spallation products were K-capture X-rays.

Forty new isotopes of the rare earths have been found. For an example, the thulium isotopes that were produced are given in the following table:

| A \ Z | 165 | 166 | 167 | 168 | 169 |
|---|---|---|---|---|---|
| $_{69}$Th | | 7.7 hr. $\beta^+$, K | 9.6 d. K | 85 d. ($\beta^-$?), K | |
| $_{68}$Er | | | | | |
| $_{67}$Ho | | | | | |

The cross-sections for the production of the three thulium isotopes as a function of the energy are given in the table below. The energy of the $\alpha$ beam was varied in the usual manner by placing absorbers in the beam. The values presented below were calculated solely on the basis of the intensity of the K-capture X-rays.

| | $\alpha$ energy in Mev | | | |
|---|---|---|---|---|
| Tm | 38 | 31 | 19 | |
| 7.7 hr. | 1.1 b. | $5 \times 10^{-4}$ b. | none | ($\alpha$, 3n) |
| 9.6 d. | $7 \times 10^{-3}$ b. | 0.1 b. | $10^{-3}$ b. | ($\alpha$, 2n) |
| 85 d. | $10^{-4}$ b. | $3. \times 10^{-3}$ b. | 0.2 b. | ($\alpha$, n) |

The 7.7 hr. isotope was not seen at 19 Mev even though it is a $\beta^+$ emitted and the means of detection were very sensitive to positrons. The values of the cross-section are in doubt by as much as a factor of 2.

All of the odd-odd isotopes in the region of atomic numbers that were investigated emitted hard $\gamma$ rays and possessed an n/p ratio $n/p \leqq 1.43$.

A search is being continued for $\beta$ emitters among the odd-odd isotopes in the range under consideration.

Synchrotron Magnetic Field Measurements. R. Robertson.

Satisfactory operation of the synchrotron demands that the magnetic field be independent of the azimuth and that the betatron condition

$$\mathring{\Phi} = 2\pi r_o^2 \mathring{H}$$

($r_o$ = radius of the orbit; $\Phi$ = flux that is enclosed by the orbit; and H = the field intensity at the orbit) be fulfilled. Measurements were carried out in order to determine whether the magnet satisfied the design specifications and to indicate what corrections were needed.

The magnetic field intensity at any point between the pole pieces is a periodic function of time. In order to establish its variation with azimuth its amplitude was measured at a sequence of points on the orbit by a system of search coils and the variation in phase from point to point on the orbit was measured with peaking strips in terms of the time that transpired between instants at which the field strength passed through a preassigned value.

To measure the maximum field variation, three coils of accurately known effective area were arranged as shown in Fig. 1. $A_1$ and $A_2$ are placed at a reference point on the orbit and $A_3$ rides freely on a track that is coincident with the stable orbit. $A_2$ can be rotated about an axis perpendicular to the field so that its effective area can be varied at will. $A_1$ and $A_2$ are connected so that the induced emf's will augment each other and the system $(A_1A_2)$ is connected to $A_3$ so that the outputs will oppose each other. The resultant voltage is then

$$E = B_1 \frac{df_1(t)}{dt} \left[ A_1 + A_2 \cos \theta \right] - B_2 \frac{df_2(t)}{dt} A_3$$

If one assumes that the two points $(A_1A_2)$ and $A_3$ are very nearly in phase, $\frac{df_1}{dt} \cong \frac{df_2}{dt} = \frac{df}{dt}$ and one can write

$$E = \left[ B_1 \left[ A_1 + A_2 \cos \theta \right] - B_2 A_3 \right] \frac{df}{dt} .$$

This voltage can be integrated by a simple RC circuit to give a voltage that is proportional to $B_1 (A_1 + A_2 \cos \theta) - B_2 A_3$.

By placing $A_3$ in coincidence with $A_1$ and $A_2$, one can determine the angle $\theta_r$ for which $B_1(A_1 + A_2 \cos \theta_r) = B_1 A_3$. If $\theta$ represents the angle that causes the expression $B_1(A_1 + A_2 \cos \theta) - B_2 A_3$ to vanish, the ratio $B_1/B_2 = A_1 + A_2 \cos\theta_r / A_1 + A_2 \cos\theta$ is expressed in conveniently measured geometric quantities. The integrating circuit that is required for the adjustment of $\theta$ is shown in Fig. 1.

Peaking strips are used for the measurement of phase differences. A peaking strip is a very convenient instrument for announcing by a curt signal the passage of a magnetic field through a prescribed intensity. It consists of a winding about a core of permalloy which is a metal that has the unique property of possessing a permeability of about 50,000 within a short interval of -0.1 to +0.1 oersted and being saturated by larger magnetic fields. Therefore, the peaking strip generates a very short and powerful voltage surge as the magnetic field passes through zero. By imposing an initial magnetic field on the peaking strip through self-induction with a suitable DC current it is possible to make the peaking strip sensitive in a similar manner to other values of the magnetic field. Two such peaking strips were placed at different points on the orbit and their pulses were received on a synchroscope. In this way it was possible to measure the difference in time between the instants that the magnetic field passed through the same value at the two points.

The betatron condition $\dot{\Phi} = 2\pi r_0^2 \dot{H}$ was measured by placing a single loop of wire on the orbit to encircle the flux through the center and matching the induced voltage with that of a search coil placed at a point of the orbit.

After the measurements had been completed, adjustments were made. The devices that were used consisted of coils that were placed around various portions of the magnetic circuit in order to augment or diminish the magnetic field and thus smooth it out.

The details of this work are set down in "The Adjustment of the Magnetic Field in the University of California Synchrotron" by Raymond David Robertson, UCRL 347.

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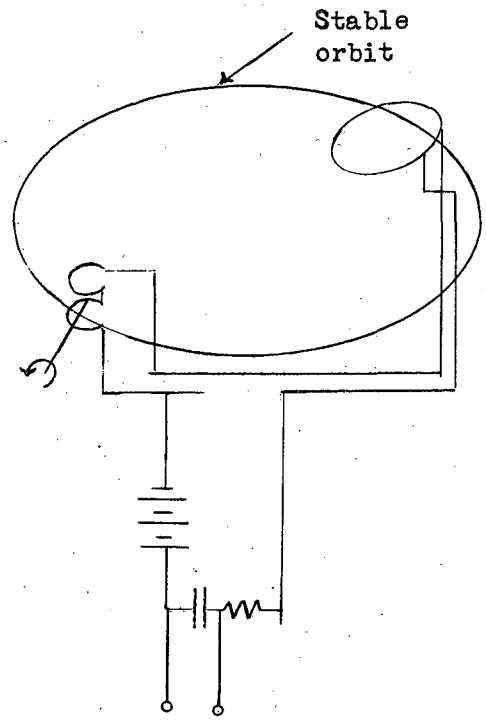


Search Coils and Integrating Circuit

Fig. 1.