Letters to the Editor

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Mass Spectrographic Identification of Radioactive Lanthanum Isotopes*

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TWO neutron deficient isotopes of lanthanum, one new and the other previously tentatively assigned, have been given mass assignments by the technique of dispersing the isotopes on a photographic plate with a mass spectrograph. These and other light isotopes of lanthanum were prepared and some of their radioactive characteristics determined by absorption methods and with a low resolution beta-ray spectrometer.

In some experiments, pure $CsNO_3$ was irradiated with 30-Mev alpha-particles and this was followed by the isolation of the lanthanum fraction. The mass spectrograph showed a single radioactivity at mass number 135; and by following the decay of this line on the photographic plate through a slit arrangement, a 19-hour half-life was obtained. This confirms the mass assignment previously made by other methods.[1] Since this irradiation should have produced La^{136} and La^{134} as well as La^{135}, it was inferred that La^{136} and La^{134} have half-lives less than about 20 minutes since it required several hours to make the exposure on the mass spectrograph. The isotope La^{136} had previously been reported as a 2-hour positron emitter,[1] but the observed activity has since been shown to be F^{18} which partially went through the particular chemical separation employed. A search was made for La^{136}, and it proved to be the 10-minute period reported by Maurer[2] from the irradiation of barium with deuterons. The assignment was made to La^{136} since the ratio of the 10-minute period to the 19-hour period increased with decreasing alpha-particle energy on cesium in the range below 30 Mev, as would be expected for the (α,n) reaction in relation to the $(\alpha,2n)$ reaction. Furthermore, the preparation of this activity in good yield by Maurer[2] using 5.8-Mev deuterons on barium would now point to La^{136} in view of the present knowledge of La^{138}, La^{137}, and La^{135}, unless one assumes the 10-minute activity to be a metastable state of one of these isotopes. Very recently Robertson, Carss, and Pool,[3] using separated stable barium isotopes as targets, have definitely proved this period to be associated with La^{136}. The characteristics of La^{136} which we determined are a half-life of 9.5 minutes, positron of 2.1 Mev determined with the spectrometer, and x-rays in high abundance from which it is estimated that about $\frac{1}{3}$ of the decay is by positron emission and $\frac{2}{3}$ by electron-capture.

The irradiation of cesium with 50-Mev alpha-particles resulted in a new lanthanum activity of 4.0-hour half-life. This activity has positrons of about 1.2 Mev, a conversion electron line of 0.26 Mev determined with the spectrometer, a harder gamma-ray of 0.8 Mev measured by lead absorbers, and K x-rays in high yield. This activity apparently decays predominantly by electron-capture since the positrons were only a few percent as abundant as the x-rays.

The 4-hour period was assigned to La^{133} by the mass spectrograph method. Figure 1 shows the original photographic plate

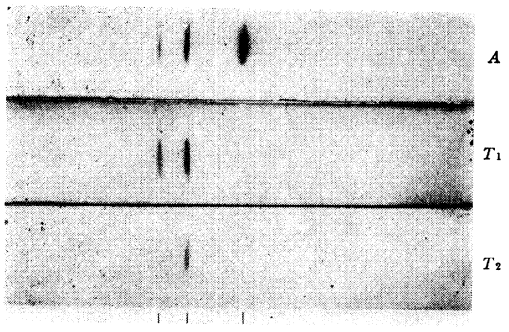

FIG. 1. Mass spectrographic analysis of radioactive lanthanum isotopes by transfer technique. (Exposures for transfer plates T_1 and T_2 given in the text.)

(A) and two transfer plates (T_1 and T_2) made by exposing successively blank photographic plates with the receiver plate. The upper picture, A, shows the receiver plate with the line for stable lanthanum at mass number 139 (actually measured as the singly ionized oxide), and two other lines at 135 and 133. The middle plate, T_1, is the first transfer plate exposed for 24 hours after analysis showing that the lines at 133 and 135 are caused by radioactivities. The bottom plate, T_2, made by a 72-hour exposure following the first one, shows only the 19-hour La^{135} since the 4-hour La^{133} had decayed.

Our thanks are due Mr. B. Rossi, Mr. J. Vale, and the members of the groups operating the 60-inch and 184-inch cyclotrons, and Mr. J. G. Conway for showing the $CsNO_3$ used to be spectrographically pure.

* The work described in this paper was performed under the auspices of the AEC.
** Now at Princeton University, Princeton, New Jersey.
[1] J. B. Chubbuck and I. Perlman, Phys. Rev. **74**, 982 (1948).
[2] W. Maurer, Zeits. f. Naturforschung **2a**, 586 (1947).
[3] Robertson, Carss, and Pool, Bull. Am. Phys. Soc. **24**, No. 7, 14 (1949).

Measurement of the Earth's Magnetic Field at High Altitudes at White Sands, New Mexico*

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AN Aerobee[1] rocket containing a total field magnetometer was fired at the White Sands Proving Ground, New Mexico (geomagnetic latitude 41° North) on April 13, 1948, at 1441 MST. The rocket reached a height of 372,000 feet (114 km) above sea level. Telemetered data gave the value of the earth's magnetic field during flight. The magnetometer measured the sum of the squares of three perpendicular components of the field so as to give an output independent of its orientation and thus obviate the need for stabilization of the instrument inside the rolling and precessing rocket. The magnetic effects of the rocket and instrumentation were quite small and were canceled by means of a system of compensating coils placed around the magnetometer. The residual error was mainly due to the inherent orientational error of the magnetometer itself and produced a roll-modulation of amplitude less than one milligauss. In analysis of the data, this error was averaged graphically over each roll period (about 1 second). A

system of magnetic calibrations applied periodically during the flight checked the magnetometer for possible drift or change in sensitivity. The over-all accuracy of the corrected data is estimated to be 1.0 mG or better.

The principal results of this first flight are:

(i) *The field strength decreases with altitude in accordance with calculations based on potential theory.* The experimental data (Fig. 1) show a decrease in the magnetic field with altitude which

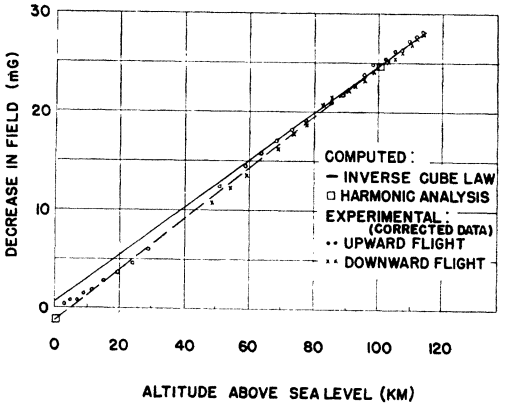

FIG. 1. Decrease of earth's magnetic field (from actual field near the surface) *vs.* altitude above sea level. Aerobee A-6 Flight, White Sands, New Mexico, April 13, 1948. Calculated curves adjusted to fit experimental points at 100 km.

agrees within 2 milligauss with the inverse cube fall-off based on the simple approximation that the earth's field can be described by that of a dipole. The accuracy of the determination of the missile altitude is ±1 km. The experimental decrease from sea level to 114 km is 28 mG, the calculated decrease 26.9 mG. It can be seen from Fig. 1 that the experimental data are in somewhat better agreement with a calculation of the altitude variation near White Sands based on harmonics up to the sixth degree[2] as used in achieving an empirical description of the magnetic field at the earth's surface.

(ii) *No evidence could be obtained, either for or against the existence of circulating current sheets in the upper layers of the atmosphere in view of the smallness of the expected effect at the latitude of the experiment.* This experiment was the first step in an attempt to obtain direct evidence concerning the existence and nature of circulating current sheets in the upper atmosphere. These current systems have been proposed in order to explain the regular diurnal variation of the magnetic field at sea level and are by some theories assumed to be located primarily in the *E* layer of the ionosphere.[3] This first flight at geomagnetic latitude 41°N was intended chiefly as a test of the method and instrumentation. The discontinuity expected in passing through the postulated current-layer is only 10 to 20 gamma (0.1 to 0.2 mG)[4] compared to a decrease in the main field of 28 mG over the total flight. This effect is too small to be detectable by the present equipment. However, a flight is forthcoming at a more favorable location. At the geomagnetic equator the expected discontinuity is 2 to 3 mG compared to a decrease in the main field of only 13 mG.

A fuller account of this work is being submitted to the *Journal of Geophysical Research.*

We wish to thank the Navy Bureau of Ordnance and the ONR for their support of this project and the U. S. Naval Unit at the White Sands Proving Ground for its capable performance of the field operations involved in firing the Aerobee. We would like to express our appreciation to Drs. J. A. Van Allen and L. R. Maxwell for their active encouragement, to our associates at the Naval Ordnance Laboratory, in particular Dr. E. A. Schuchard for advice on magnetometer problems and Mr. C. J. Aronson, and at the Applied Physics Laboratory to Dr. F. L. Verwiebe and to Messrs. J. F. R. Floyd, L. W. Fraser, J. E. Sugrue, and B. J. Chaffee.

We are particularly indebted to Dr. E. H. Vestine of the Department of Terrestrial Magnetism, Carnegie Institution of Washington for helpful advice on problems of the geomagnetic field.

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[1] For a general description of the Aerobee Sounding Rocket as a vehicle for research in the upper atmosphere, see: J. A. Van Allen, L. W. Fraser, and J. F. R. Floyd, Science **108**, 746 (1948).

[2] E. H. Vestine, I. Lange, L. Laporte, and W. E. Scott, "The geomagnetic field, its description and analysis," Department of Terrestrial Magnetism, Carnegie Institution of Washington, Publication 580 (1947).

[3] *Terrestrial Magnetism and Electricity*, edited by J. A. Fleming (McGraw-Hill Book Company, Inc., New York, 1939).

[4] E. H. Vestine, APL/JHU CM-480 (1948).

The Beta-Rays of K^{40} *

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THE beta-spectrum of K^{40} has been measured from an enriched sample by use of the scintillation spectrometer. Enriched material was prepared by electromagnetic separation at Y-12. The sample used consisted of 12.2 mg of KCl mounted on 0.5 mg/cm² polyethylene. The surface density of the sample was estimated to be 2.5 mg/cm². The K^{40} content of the potassium in this sample was 1.31±0.05 percent as measured at Y-12 by mass spectrometer.

An anthracene crystal used as the scintillation phosphor was cemented to an RCA C-7132 photo-multiplier. The crystal was covered with an aluminum foil light reflector 0.1–0.2 mg/cm² thickness. The factor relating pulse height to energy was obtained by calibration with the conversion line of Cs^{137}.

The pulse distribution obtained with and without an absorber between the crystal and the sample is shown in Fig. 1. The difference between the background curve and that with sample and absorber is too small to measure accurately.

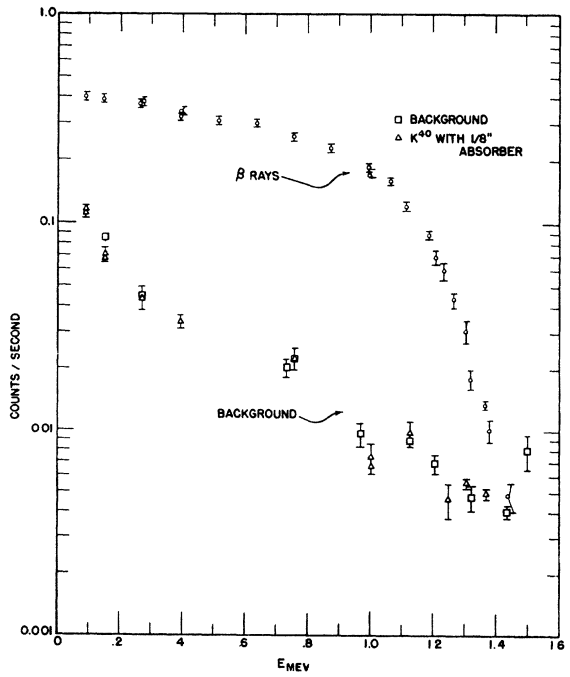

FIG. 1. Pulse distribution with and without absorber. (K^{40} 12.2 mg 1.31 percent.)