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

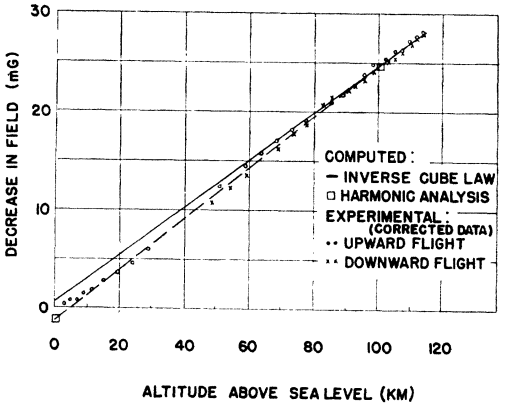

FIG. 1. Decrease of earth's magnetic field (from actual field near the surface) *vs.* altitude above sea level. Aerobee A-6 Flight, White Sands, New Mexico, April 13, 1948. Calculated curves adjusted to fit experimental points at 100 km.

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.

* Supported by the Navy Bureau of Ordnance and the ONR under Contracts NOrd 7386 and NRO81-017.

[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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December 8, 1949

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.

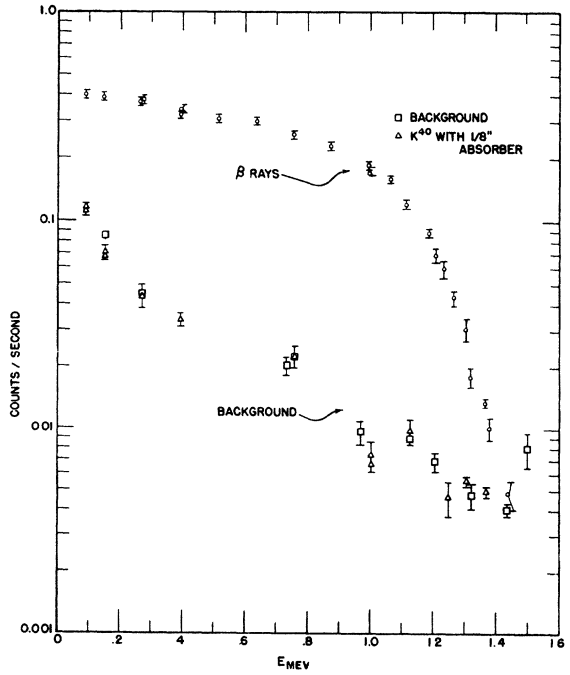

FIG. 1. Pulse distribution with and without absorber. (K^{40} 12.2 mg 1.31 percent.)

The data were corrected for the resolution of the instrument by the method of Owen and Primakoff[1] and a Fermi-Kurie plot made. Figure 2 shows the result as the upper curve. The line is quite

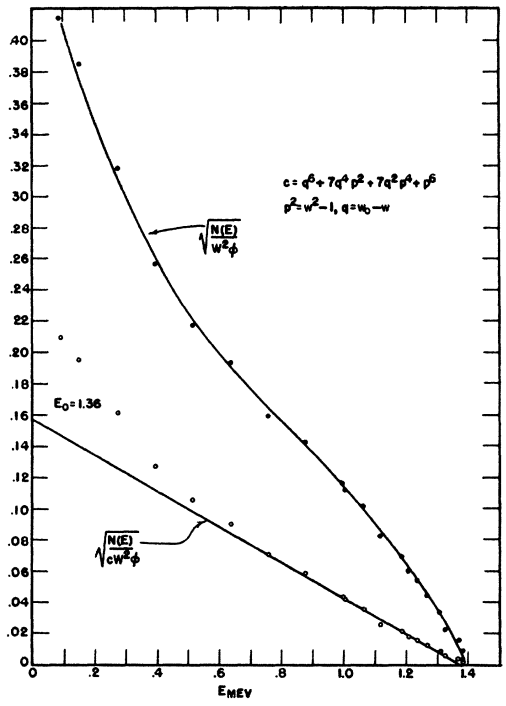

FIG. 2. K^{40} Kurie plot.

concave to the energy axis above 700 kev and the end point is 1.36±0.05 Mev.

The correction term for the third forbidden axial vector or tensor interaction produces the lower curve in Fig. 2 when applied to the data. This curve is about as good a fit to a straight line in the higher energy half of the spectrum as was obtained from P^{32} measured under the same conditions.

* This document is based on work performed under Contract No. W-7405, eng. 26 for the Atomic Energy Project at Oak Ridge.
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[1] G. E. Owen and H. Primakoff, Phys. Rev. **74**, 1406 (1948).

Phase Relations in He^3–He^4 Solutions

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December 12, 1949

IN a previous letter the depression of the lambda-temperature of He^4 by the addition of He^3 was reported,[1] but the question of whether the lambda-transition remains second order, as proposed by Stout,[2] or becomes first order with the consequent existence of two liquid phases below the lambda-temperature, as proposed by de Boer,[3] remained unanswered. It is possible to decide between these two possibilities by means of vapor pressure measurements. To this end, the vapor pressures of 20.3 mole percent and 25.5 mole percent solutions of He^3 in He^4 have been measured.

Before examining the experimental results, consider the phase diagram for He^3-He^4 solutions according to the calculations of de Boer,[3] as shown in Fig. 1. In the regions labeled I and II a single liquid phase exists in equilibrium with the vapor; in the

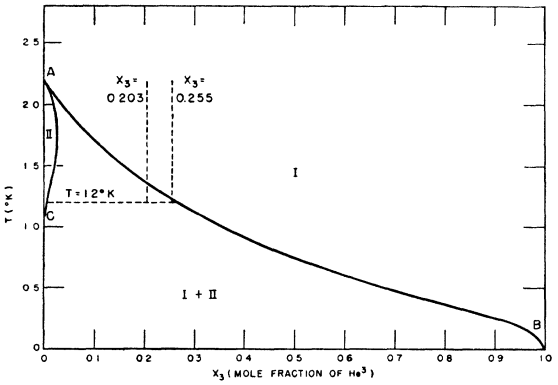

FIG. 1. Phase diagram of He^3-He^4 solutions according to J. de Boer.

region labeled I+II two liquid phases are present in equilibrium with each other and with the vapor. If this diagram is correct, it can be seen that when a 20.3 percent He^3 solution is cooled to 1.2°K, a temperature below the lambda-temperature given by curve AB, two liquid phases are in equilibrium, and the compositions of the liquids are given by the intersection of the dashed horizontal line with the curves AB and AC. When a 25.5 percent He^3 solution is cooled to 1.2°K the same two liquid phases appear;

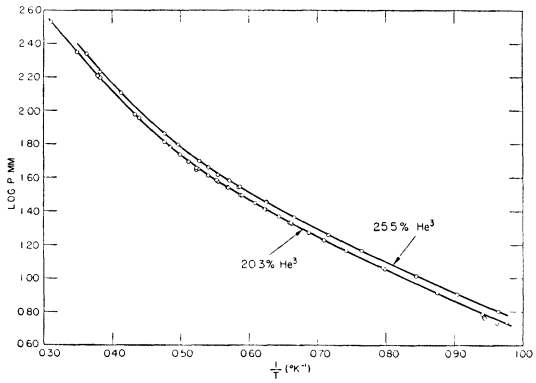

FIG. 2. Vapor pressures of 20.3 percent and 25.5 percent solutions of He^3 in He^4.

their concentrations are the same as for the 20.3 percent solution, but their relative amounts are different. It follows that the vapor pressures of the 20.3 percent and of the 25.5 percent He^3 solutions must be equal at 1.2°K and indeed at any other temperature in the region I+II. The same conclusion can be reached directly by application of the phase rule, for if two liquid phases and a vapor phase are present in equilibrium in a two component system there is only one degree of freedom, and hence the vapor pressure must be a function of the temperature alone and independent of concentration.

The vapor pressure data are plotted in Fig. 2. It can be seen that the vapor pressures of the two solutions are not equal at any temperature down to the lowest temperature studied, 1.04°K, which is well below the lambda-temperatures previously measured, namely 1.65° and 1.56°K,[1] and also below the lambda-temperatures given by the curve AB in Fig. 1. These data eliminate the possibility that two liquid phases coexist in equilibrium with the vapor below the lambda-temperature, at least down to 1.04°K and in the concentration range 0 percent to 20 percent He^3.*