indicated on the graphs. Measurements were made at 4600, 4900, 5200, and 5500 Mc/sec in a guide with cutoff at 4430 Mc/sec, over a range of gas pressures from 0.5 to 100 mm Hg, and at various dc pulse currents and voltages.

The results obtained are readily explained in terms of decomposition of the "linear" TE_{11} wave into two oppositely-rotating circularly-polarized waves, an "anomalous" and a "normal" wave. The "anomalous" wave exhibits, in the region of gyromagnetic resonance, very strong attenuation and a reversal of the sign of its phase shift with respect to propagation in vacuum. The "normal" wave is only slightly attenuated in this region and accounts for the circular polarization observed at gyromagnetic resonance.

The roles of "anomalous" and "normal" waves are interchanged if the sense of the magnetic field is reversed. Consequently, each of the circularly-polarized waves is heavily attenuated by one or the other of two opposing magnetic fields, both at gyromagnetic resonance. This fact enabled the construction, with two independent solenoids, of a microwave analogue of crossed Nicol prisms.

The circularly-polarized waves are not true propagating modes through the plasma in these experiments. Our interpretation remains, however, valid because a short section of plasma was employed. The theoretical details have been worked out for the case of the unbounded anisotropic plasma, including electron collision effects. Further theoretical work remains for the wave guide case.

These results hold promise as a tool for the study of gas discharge phenomena. They are applicable also to switching, amplitude, phase or frequency modulation, and polarization control in an electronically controllable medium.

* This work was sponsored by the Signal Corps Engineering Laboratories of the United States Army.

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Evidence for Ionosphere Currents from Rocket Experiments Near the Geomagnetic Equator*

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(Received April 19, 1951)

RECORDS of magnetic field as a function of altitude have been obtained from total-field magnetometers mounted in two Aerobee sounding rockets which were fired from the seaplane tender USS Norton Sound in March, 1949, off the west coast of Peru. The flights were made 60 miles apart at 89° west longitude, 11° south latitude or geomagnetic longitude 341°, geomagnetic latitude −1°.

The purpose of the flights was to obtain experimental evidence concerning the existence of an ionosphere current system. Harmonic analysis of the diurnal variation of the earth's magnetic field recorded at the earth's surface has shown that it could be represented as the field produced by a current system and that it was largely produced by an external source. It has been generally accepted, although not experimentally verified, that the source was a current system in the upper atmosphere. Several theories of the origin of such a current system have been proposed.[1]

A previous flight at White Sands, New Mexico, had shown the feasibility of the method and instrumentation.[2] The location at the geomagnetic equator was most favorable for detection of the ionosphere currents with a total-field magnetometer which measures the scalar value of the field without regard to direction. The field of the predicted currents in this region is parallel to the main field of the earth; also, the diurnal variation is anomalously large at Huancayo, Peru.

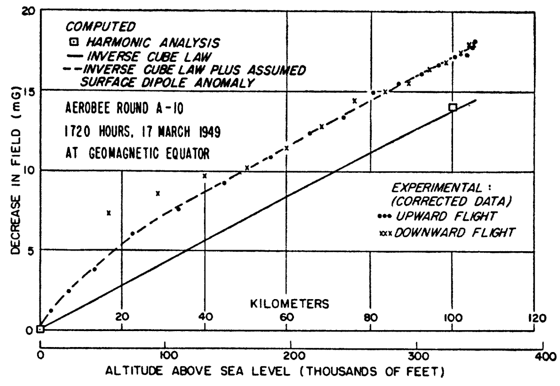

FIG. 1. Decrease of earth's magnetic field (from actual field at sea level) *vs* altitude above sea level for Aerobee A-10 flight.

Aerobee Round A-10 was fired on March 17, at 1720 hours 90th meridian time. Figure 1 shows that the field decreased between 20 km and 105 km, in accordance with the simple dipole field. At that time of day surface measurements show a small value for the diurnal variation, and no evidence of a current layer was obtained in the altitude range covered.

Aerobee A-11 was fired on March 22, at 1120 hours 90th meridian time when the diurnal variation at the surface is near a maximum. Figure 2 shows, in addition to the decrease of the main field of the earth, a decrease of about 4 milligauss between 93 km and 105 km. This decrease at the top of the flight could not be accounted for by sources inside the earth and is attributed to penetration of a current layer by the magnetometer.

Both flights show effects at low altitudes which are attributed to assumed dipole surface anomalies. No other information about surface anomalies in this region is available. The results are, however, consistent with anomalies observed on aerial surveys in other parts of the Pacific.[3]

The estimated accuracy of the decrease in field for the A-10 flight and for the A-11 flight up to 93 km is ±1 milligauss. The decrease in field for the A-11 Flight between 93 km and 105 km is placed at 4±0.5 milligauss.

The expected field discontinuity, if the magnetometer passed completely through the current layer, would be about twice the diurnal variation as measured at the earth's surface. The results of these flights are in reasonable agreement with the magnetograms from the observatory at Huancayo, Peru, for the days of the flights, although accurate correlation is difficult because of a

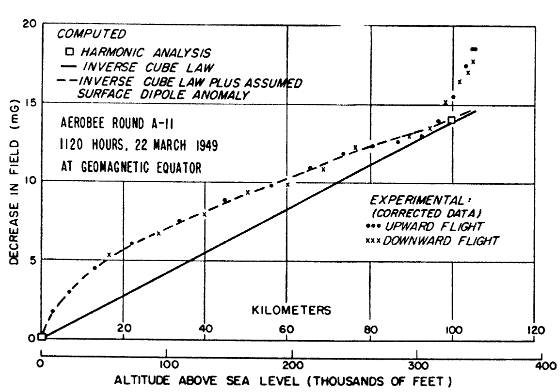

FIG. 2. Decrease of earth's magnetic field (from actual field at sea level) *vs* altitude above sea level for Aerobee A-11 flight.

magnetic storm which was in progress during the week of the rocket firings.

The results of these flights establish experimentally the existence of a current system in the E-region of the ionosphere which is responsible for the sea-level diurnal variation of the earth's magnetic field and lend strong support to the dynamo theory of the current system which was originally proposed by Balfour, Stewart, and Schuster. The observed decrease of 4 ± 0.5 milligauss in the range of 93 to 105 km seems rather large, since the rocket may not have passed completely through the current layer; this fact may be connected with the disturbed magnetic conditions on the day of firing. It is hoped that additional flights which penetrate the entire current layer will help to clear up this question.

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

We wish to thank Capt. T. A. Ahroon, USN, and the other officers and men of the USS Norton Sound who were responsible for the conduct of the expedition and the rocket firings. We would like to express our appreciation to our associates at the Naval Ordnance Laboratory, Mr. L. R. Alldredge, Dr. E. A. Schuchard, and Mr. C. J. Aronson, and at the Applied Physics Laboratory to Dr. J. A. Van Allen and Messrs. L. W. Fraser and A. V. Gangnes.

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

* Supported by the U. S. Navy Bureau of Ordnance and the ONR.

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Total Cross Sections of π-Mesons on Protons and Several Other Nuclei*

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(Received April 20, 1951)

THE interaction of mesons with nuclei has previously been studied in photographic emulsions[1–3] and, to a lesser extent, in the cloud chamber.[4] As the first step in a study of the scattering and absorption of mesons by means of counter techniques, we have measured the total cross section of mesons in various elements, including hydrogen. The results are still preliminary, but their interest may warrant their release at this time. We studied the attenuation of a 100-Mev meson beam in the various absorbing materials, in a geometry (Fig. 1) which is poor enough so that the contribution of coulomb scattering to the measured cross section is smaller than the statistical error. The beam is defined by means of a time of flight telescope of sufficient time resolution to reject electrons and protons from the beam of mesons which travel with a velocity of $0.82c$. Actually a comparison of the shapes of the time resolution curves at various distances between the counters shows that the electron and proton components of the beam are negligibly small. The only other possible contamination in the beam consist of mesons with the wrong range, and μ-mesons produced by $\pi-\mu$-decay in flight. The μ-meson flux has been studied as a function of range by means of $\mu-e$-decay, and is 5 percent, concentrated chiefly at the high energy tail of the range curve (Fig. 2). The meson range has been studied by observing the counting rate, demanding a pulse which is several times minimum ionizing in the last counter. This selects mesons nearing the end of their range in this counter. The small counting rate in the short-

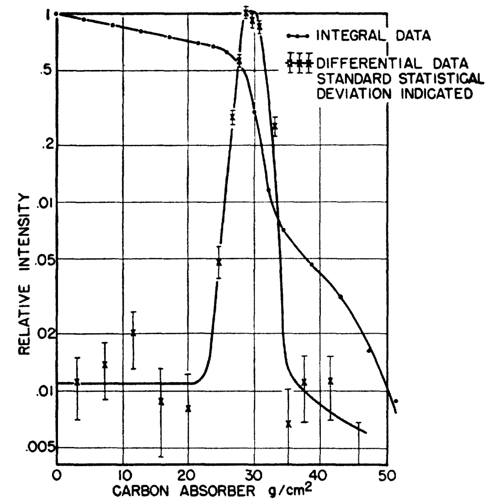

FIG. 2. Counting rate as a function of the delay time between the two beam defining counters.

TABLE I. Total cross sections of various nuclei for 85-Mev π^- mesons.

Nucleus	Mean free path g/cm²	Cross section in cm²	Nuclear area $\pi A^{\frac{2}{3}}\left(\frac{\hbar}{\kappa c}\right)^2$ cm²
H	125 ± 10	$1.33\pm0.11\times10^{-26}$	6.1×10^{-26}
Li	48 ± 2	24.2 ± 1	22.6
Be	59 ± 4	25.3 ± 2	26.5
C	58 ± 2	34.4 ± 1.3	31.9
O	57 ± 2	46.6 ± 1.8	38.9
Al	72 ± 3	62.3 ± 2.5	55.1
Cu	106 ± 5	99 ± 5	98
Cd	117 ± 5	159 ± 7	142
Pb	143 ± 6	240 ± 11	214

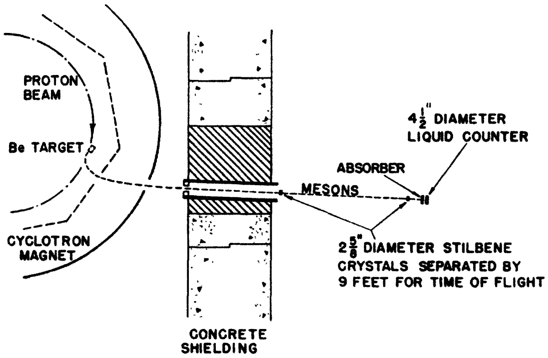

FIG. 1. Experimental arrangement.

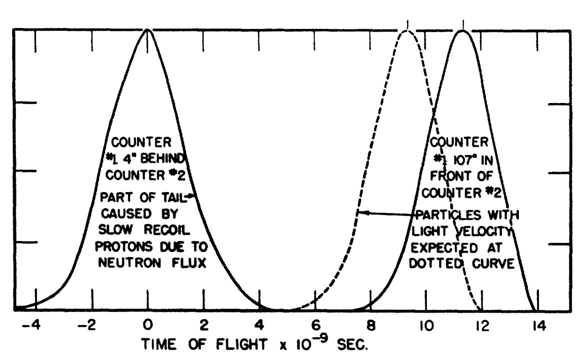

FIG. 3. Integral and differential range of the meson beam in carbon.