JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN Vol. 17, SUPPLEMENT A-I, 1962
INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-2-12. Measurements of Localized Distortions in the Earth's Magnetic Field Near The Auroral Zone+

Robert S. LEONARD*

Geophysical Institute, University of Alaska, College, Alaska

Radar echoes from aurorally associated ionization are quite sensitive to the angle between the ray from the radar and the direction of the earth's magnetic field. In the work reported here, this feature of the auroral echoes is utilized to measure changes in the orientation of the magnetic field. The experiment was performed in Alaska with a 41 Mc/s auroral radar. The antenna had an aperture eight wavelengths wide in the horizontal plane and was directed in the magnetic meridian. A remote receiver was located 130 km magnetically north of the radar station. A recording was made of the amplitudes of the echoes received simultaneously at the radar and at the remote receiver; from these records the ratio of the two amplitudes was calculated. The ratio was found to fluctuate widely which is interpreted as being caused by changes in the direction of the magnetic field. On special occasions, the ratio is less than one, implying a field distortion greater than two degrees. These distortions are noted to be very localized however, suggesting the presence fairly restricted line currents in the *E* layer of the ionosphere.

A feature that was noted early in the study of radar echoes from the aurora was that the echoes were only detected when the radar was looking toward the magnetic pole[1),2)]. Tests were made from stations located on the northern edge of the north auroral zone which confirmed that echoes were only obtained to the north, despite a majority of the auroral disturbances to the south of the radar[3)]. The interpretation of this was that the auroral scatterers were aligned along the earth's magnetic field and were only effective in returning energy to the radar when they were viewed nearly normally. A theoretical treatment by Booker[4)] has provided an acceptable description of this behavior, usually referred to as "aspect sensitivity," despite a flaw in the mechanism he used in creating the field-aligned scatterers. Later work has confirmed this aspect sensitivity[5),6)].

A statement should be made at this point that the word "aurora" as used here means radar aurora and should not be confused with visual or optical aurora. The relationship between these two phenomena is not well understood.

The experiment reported here was originally undertaken to measure the scattering polar diagram of the field-aligned scatterers and, thus, to determine their electrical length. The method employed was to direct an auroral radar in the magnetic meridian and to measure the strength of the scattered energy at two separated receivers located in the same magnetic meridian. Thus, the strength of the scattered signal could be determined at two different angles from the scatterer.

The transmitting antenna was 8 wavelengths wide and 1 wavelength high, giving a fairly narrow fan beam directed in the magnetic meridian. The radar operated on 41 Mc/s with a pulse power of 5 kW. The scattered signal was received on identical 4-element Yagi antennas having a field of view large compared with the transmitting antenna. One receiver was located at the transmitting site, Healy, Alaska, and the other was located 135 km north at College, Alaska. The geometry is illustrated in Fig. 1 which shows the meridian plane. The angle between the rays to the two receivers from the scatterer is a function of the distance or range to the auroral scatter allowing mea-

* Now with Stanford Research Institute, Menlo Park, California.

+ This work was supported by the Electronics Research Directorate, Air Force Cambridge Research Laboratories, Bedford, Massachusetts, under Contract AF 19(104)-7446.

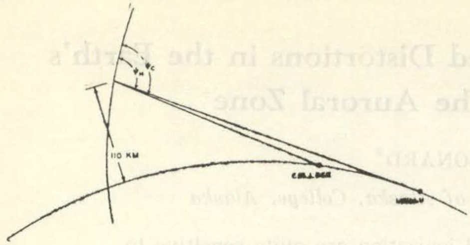

Fig. 1. Experimental Geometry.

surements to be made at several different angles. The height of reflection was not measured in this experiment but is assumed to be 110 km, the most probable height as determined by other workers[7].

The data was taken by photographing the range-amplitude or *A*-scan display once a minute for one second at exactly the same time at both stations. The data was then scaled from the film in terms of the range and amplitude for each echo. These echoes were matched in range and time and their amplitude ratio determined. This was then squared to give the power ratio and corrected for experimental constants.

In Fig. 2 the solid lines represent the expected values of the corrected power ratio, *p*, as a function of range with the length of the scatterers as a parameter. The orientation of the magnetic field at *E*-layer heights was determined by extrapolating the surface field with a dipole model, a method that has proven very satisfactory in studying the influence of the magnetic field on radar echoes.

The solid circles are the measured values of the ratio. It is quite clear that the fit is poor. There are even cases where the ratio is less than one—cases where the only explanation can be a shift in the field direction. From this we can conclude that the field experiences appreciable changes in orientation, but it is difficult to estimate the magnitude and duration of these changes. From the concentration of points above the calculated curves, one would conclude that the predominate change was for the field to become more vertical. As all the samples were taken before local midnight, it may be that this is the influence of the disturbance current flowing above the echoing layer. Unfortunately, no data is available to test if there is an opposite trend after midnight.

One very fortunate case occurred during the observing period when there were five distinct echoes, identifiable at both stations and including one echo for which the ratio was less than one. Fig. 3 shows a plot of these points with the calculated values shown as smooth curves similar to Fig. 2. Here at one time, the shifts in orientation are different in echoes separated by about 100 km of range, or approximately one degree of latitude. This, then, suggests line currents in the *E*-layer with lateral dimensions less than one degree. It is very difficult to com-

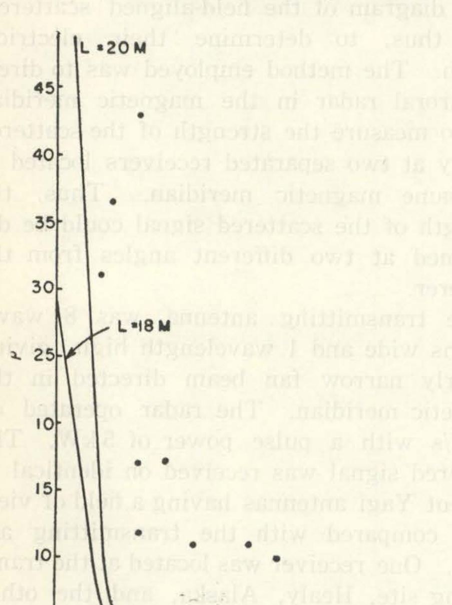

Fig. 2. Power ratios as a function of range.

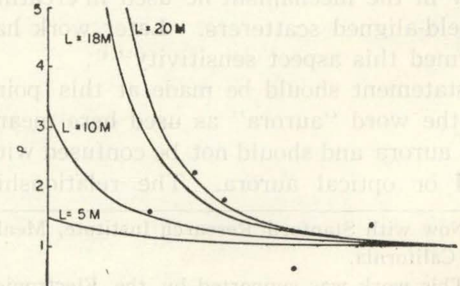

Fig. 3 Power ratios for a multiple echo.

pare these results with surface magnetograms, as the closest magnetic observatory is about 500 km south of the scattering region. Without at least one more receiver spaced remote from the two used in this experiment, it is not possible to measure the magnitude of the field distortions; however, a minimum value of two degrees can be established, based on the smallest value of the ratio measured.

References

1) Currie, B. W., P. A. Forsyth and F. E. Vawter: *Radio Reflections from Aurora,* J. Geophys. Research **58** (1953) 179-200.
2) Harang, L. and B. Landmark: *Radio Echoes Observed during Aurorae and Geomagnetic Storms using 35 and 74 Mc/s Waves Simultaneously,* J. Atmospheric and Terr. Phys. **4** (1954) 322-338.
3) Cyce, R. B.: *Auroral Echoes Observed North of the Auroral Zone on 51.9 Mc/s.* J. Geophys. Research **60** (1955) 317-323.
4) Booker, H. G.: *A Theory of Scattering by Non-isotropic Irregularities with Application to Radar Reflections from the Aurora,* J. Atmospheric and Terrest. Phys. **8** (1956) 204-221.
5) Unwin, R. S.: *The Geometry of Auroral Ionization,* J. Geophys. Research **63** (1958) 501-506.
6) Leonard, R. S.: *Distribution of Radar Auroras over Alaska,* Geophys. Institute Scientific Report No. UA6-R116 (1961).
7) Unwin, R. S.: *Studies of the Upper Atmosphere from Invercargill, New Zealand,* Part I, Characteristics of Auroral Radar Echoes at 55 Mc/s, Annales de Geophysique **15** (1959) 377-394.

Discussion

Wright, C. S.: What micropulsation period was found to correspond to the slow period fluctuations of the radar echoes?

Leonard, R.S.: Approximately 10 seconds—however this answer is very preliminary.

JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN Vol. 17, SUPPLEMENT A-I, 1962
INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-2-13. Spiral Distribution of Ionospheric Magnetic Disturbances*

E. I. DOLGOVA**

Some investigations have been made on diurnal variation of basic disturbance phenomena in ionosphere: absorption, the fall of critical frequency of the *F2* layer, sporadic ionization at the *E* layer level, depending on the place of the station to the auroral zone.

A spiral distribution of moments of the most frequent appearance of ionospheric disturbancse was received, which was identical to O. A. Burdo's, A. P. Nikolski's, and Meek's results referring to the disturbances of the earth's magnetic field.

Ionospheric observations for the period of IGY at 48 stations situated beyond 50°N are used in this paper.

Absorption in Ionosphere

Some cases of absolute absence of reflections from ionosphere determined by symbol *B* were taken as characteristic features of absorption. The study was made separately for absorption of the polar cap and of auroral zone-i.e. the absorption of the 3rd and 2nd types.

For investigation of the 3rd type absorption such days were chosen when there was absorption at Resolute Bay, a typical station on the polar cap, and diurnal variation of the reflection absence was determined by those days at all stations. It turned out that the maximum probability of occurrence of the absorption (70-80%) was observed on latitudes 74-83°N; there was no closed band of high absorption values at that time. On

* This paper was read by N. V. Pushkov.

** U.S.S.R.