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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-4-4. Horizontal Auroral Motions and Magnetic Disturbance at the Auroral Zone

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A comparison of the direction of instantaneous horizontal magnetic disturbance and the alignment of nearby auroral forms shows that the disturbance tends to be perpendicular to the auroral alignment at the auroral zone. Thus the ionospheric current tends to be parallel to the auroral alignment; its sense is in the direction opposite to the motion of irregularities on the auroral forms. The data are suggestive, but do not show, that the auroral electrojet is filamentary in nature and flows within the auroral forms.

Interest was aroused towards study of the direction of auroral motions by the report of Meinel and Shulte (1953) describing observations of east-west motions at Yerkes Observatory. They found westward auroral motion in evening and eastward auroral motion in morning, with the direction and speed of motion being dependent upon local time. Later work by Meek (1954); Bless, Gartlein, and Kimball (1955); Nichols (1959); and others indicated that the description of auroral motion given by Meinel and Shulte could not be extended to all auroral displays. In general it was found that auroral motions are westward in evening and eastward in morning, but that the direction of motion is not sharply controlled by local time.

An analysis of a number of displays of 1957-58 using all-sky camera data from Alaska leads to further insight into the nature of the auroral motions. By cinematic projection of the all-sky photographs (of 15 sec duration and taken at intervals of 1 min) it is possible to follow the auroral motions and to recognize that most auroral forms exhibit motion in the east-west direction, as well as in the north-south direction.

During the simplest type of auroral display, one accompanied by positive disturbance of the horizontal magnetic field in evening and negative disturbance in morning, the auroral motion is westward during the positive disturbance and eastward during the negative disturbance. The reversal from westward to eastward auroral motion is abrupt to within 30 min and occurs at the time of, or some minutes after, the change in sign of the horizontal disturbance at College. Fig. 1 presents an example of the directions of auroral motion within a very weak display. Short arrows represent motions observed at the several locations indicated on the left (see Davis, 1961); solid and dashed lines indicate the limits of the display, and the line AA′ separates the regions of primarily westward and eastward motion. The lower portion of the diagram is a reproduction of the College magnetogram with the zero-disturbance level of the horizontal component

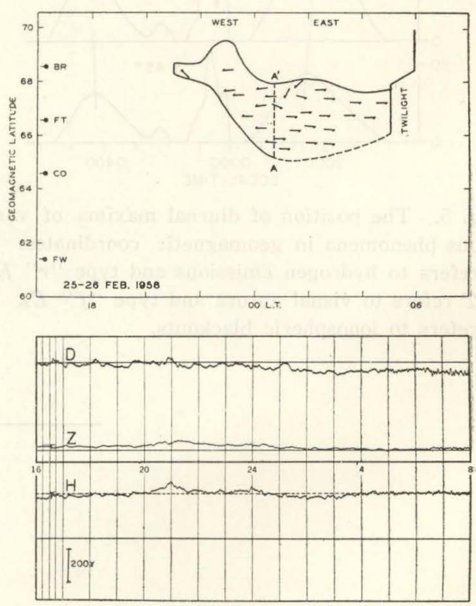

Fig. 1. Above: Directions of auroral motions observed over Alaska on February 25-26, 1958 L.T.
Below: Reproduction of the College magnetogram for this period.

indicated. In general, both the auroral motions and the magnetic disturbance are more complicated at the auroral zone than that during the weak display shown in Fig. 1.

The moderate evening aurora at the auroral zone is typified by the existence of a partial or complete array of west-opening loop structures along which clockwise (as seen from above) motions of irregularities occur. These motions are superimposed on the general westward drift of the auroral forms. Following the change from positive to negative horizontal disturbance broken forms are prevalent, but now counterclockwise motions occasionally can be seen. Displays accompanied by magnetic disturbance of variable sign have correspondingly complicated auroral motion. However, the general tendency is for westward motion during positive disturbance at College (Geom. Lat. 64.6°N) and eastward motion during negative disturbance. Since the change from positive to negative disturbance does not occur at the same local time each night there is no sharp local time control over the direction of auroral motion.

A further association between magnetic disturbance and aurora is demonstrated in Fig. 2. This diagram shows in plan view the configuration of the auroral forms (medium weight solid and dashed lines) over Alaska at a time when the evening loop system is in existence. Heavy bars represent the magnitude and direction of horizontal disturbance at several magnetic stations in Alaska. Vertical disturbance, reckoned positive downwards, is indicated by numerals placed near each station location. The remarkable perpendicularity of the horizontal disturbance vectors to the nearby auroral forms indicates current parallel to the auroral forms; the direction of current is opposite to the direction of motion of luminous irregularities along the auroral forms.

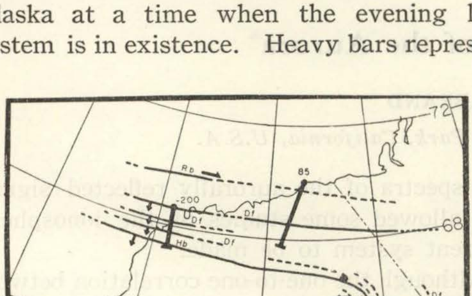

Fig. 2. Synoptic map of the aurora over Alaska at 2320 February 13, 1958 L.T. Heavy bars radiating from the locations of magnetic stations show the magnitude and direction of horizontal disturbance at those stations.

Fig. 3 presents a scatter diagram on which the horizontal disturbance orientation is plotted against auroral orientation for

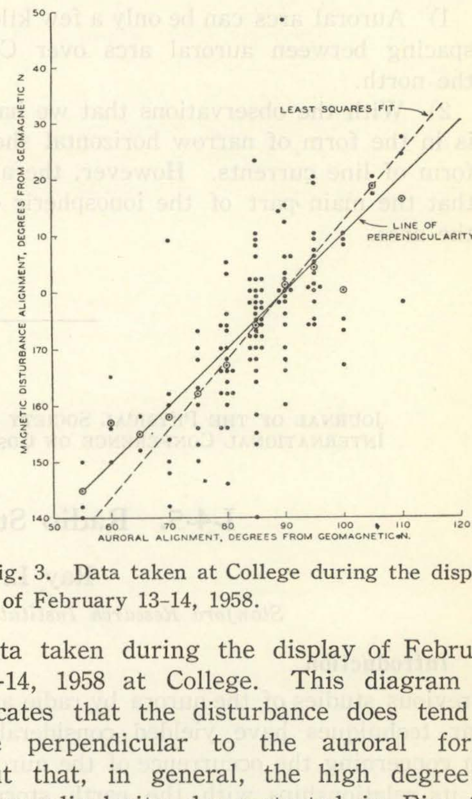

Fig. 3. Data taken at College during the display of February 13–14, 1958.

data taken during the display of February 13-14, 1958 at College. This diagram indicates that the disturbance does tend to be perpendicular to the auroral forms, but that, in general, the high degree of perpendicularity demonstrated in Fig. 2 is not achieved. The lack of perfect perpendicularity may be partly or wholely due to the fact that the currents effective in producing the disturbance at one station may not all be of the same alignment.

The present study, only a part of which is described here, strongly suggests that the bulk of current within the auroral electrojet is filamentary in nature and is contained within the visual auroral forms. However, it is impossible with the data now available to determine the exact current distribution since it is difficult with the ground-based observations to distinguish between line and sheet currents in the ionosphere. If the electrojet current is contained entirely within the visual auroral forms, it is found that currents of 10,000 to 100,000 amperes per auroral arc are required to produce the magnetic disturbance observed at the ground.

References

1) R. C. Bless, C. W. Gartlein, and D. S. Kimball: *Astrophys. J.*, **122** (1955) 205-206.
2) T. N. Davis: Geophysical Institute Report UAG-117, (1961) 107.
3) J. H. Meek: *Astrophys. J.*, **120** (1954) 602-603.
4) A. B. Meinel and D. H. Shulte: *Astrophys. J.*, **117** (1953) 454-455.
5) B. Nichols: Proc. *IRE*, **47** (1959) 245-254.

Discussion

Dungey, J. W.:

1) What is the separation between arcs?
2) Are you suggesting that the current is actually confined to the arcs?

Davis, T. N.:

1) Auroral arcs can be only a few kilometers apart. During the evening the average spacing between auroral arcs over College is near 30 km; the spacing increases to the north.

2) With the observations that we have it is impossible to tell whether the current is in the form of narrow horizontal sheets of 100 or so kilometers width or is in the form of line currents. However, the answer to your question is: yes, I do suspect that the main part of the ionospheric current at the auroral zone is confined within the arcs.

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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-4-5. Radio Studies of the Aurora*

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§ 1. Introduction

Previous studies of the aurora by radio and radar techniques have yielded considerable data concerning the occurrence of the aurora and its relationships with the earth storms and magnetic disturbances. The radar technique of auroral observations has been the principal means of studying the existence and nature of daytime aurora and has been a relatively good method of determining the motions and the position in space of the aurora. In addition, the ability to examine the spectra of the aurorally reflected signals has allowed some studies of the ionospheric current system to be made.

Although the one-to-one correlation between radar auroral echoes and visual auroral forms has not been established, the fact that magnetic disturbances, percent of visual aurora and earth-potential disturbances are well correlated with radar auroral echoes tends to make the radar technique of considerable value. Such a study of the aurora by radar will be presented.

§ 2. Description of rader and data collection procedure

The radar used for these investigations,

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