COSMIC RADIO NOISE ABSORPTION AND HYDROGEN EMISSION IN THE AURORAL SUBSTORM

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Abstract

From a study of records from Mawson, Kiruna, and Murmansk it is shown that slowly varying ionospheric absorption (SVIA) and Hβ emission are characteristic of the region behind the midnight poleward bulge of the auroral substorm, in accord with the model of Akasofu (1968).

I. INTRODUCTION

Akasofu's (1968) model of the proton aurora substorm is illustrated in Figure 1 superimposed upon the visual aurora substorm scheme at four stages in its development. During quiet periods between substorms, the proton precipitation occurs along an oval band which is located a little equatorwards of the auroral oval. Following onset of the substorm the precipitation area expands rapidly equatorwards and eastwards from the midnight meridian behind the poleward bulge of the visual aurora. Akasofu's models for ionospheric absorption of cosmic radio noise and for energetic ($\sim$ 50 keV) electron precipitation in the late evening to early morning hours are very similar to that for proton precipitation.

Eather and Jacka (1966), at Mawson, found that evening sudden ionospheric absorption (SIA) events, typically of about 10 min duration, were associated with discrete auroral forms. During SIA a correlated increase in [OI] λ 5577 Å intensity was recorded, but Hβ emission showed no such correlation. Night-time slowly varying ionospheric absorption (SVIA) events (Akasofu's M type) of duration $\frac{1}{2}$ to $1\frac{1}{2}$ hr were associated with diffuse auroral luminosity and were characteristic of the post "breakup" period. The intensity of λ 5577 Å was typically low and poorly correlated with absorption, while Hβ intensity was enhanced and well correlated. Frequently SVIA events were initiated by SIA.

Francis and Jacka (1969), from time-lapse pictures obtained with an image intensifier at Mawson, observed a midnight poleward bulge in the Hβ emission zone associated with the onset of an auroral substorm.

II. RESULTS AND DISCUSSION

The present work, which is based on photometer records from Mawson and 30 MHz riometer records from Mawson, Kiruna, and Murmansk, provides further evidence in support of the substorm model of Akasofu (1968). The relative positions

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of Murmansk, Kiruna, and the magnetic conjugate of Mawson are shown in Figure 1, which is plotted in L-latitude–time coordinates (Kilfoyle and Jacka 1968; Schaeffer 1970).

The photometer used 8 Å bandwidth filters to select λ 5577 Å of [OI], λ 4278 Å of N_2^+, and λ 4855 Å (doppler-shifted Hβ) with one at 4875 Å to allow a background correction to the Hβ measurements. Following Eather and Jacka (1966), ionospheric absorption events were classified as SIA or SVIA.

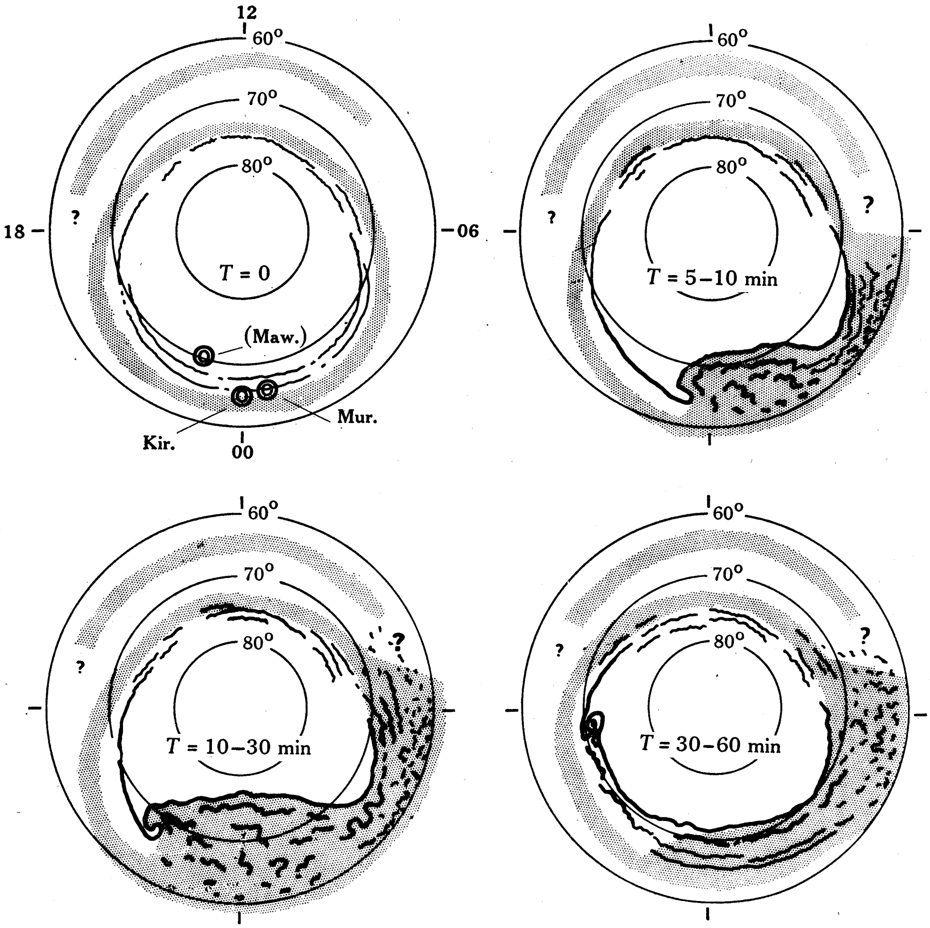

Fig. 1.—Proton precipitation, indicated by stippling, superimposed on the visual aurora substorm scheme at four stages of its development (after Akasofu 1968). Relative positions of Kiruna, Murmansk, and the magnetic conjugate of Mawson are indicated in L-latitude–time coordinates.

It is found that all the features of SVIA can be associated with aspects of the auroral substorm. The small SIA events that initiate the SVIA correspond to the poleward bulge front passing overhead. The SVIA are associated with the diffuse luminosity and faint patches behind the bulge front. All of the night-time SVIA events recorded between March and September 1966 at Mawson and Kiruna and between July and September 1966 at Murmansk occurred within 4 hr of local L

midnight, the frequency of occurrence being sharply peaked at L midnight; their durations ranged from $\frac{1}{2}$ to $1\frac{1}{2}$ hr. These observations are consistent with the association of SVIA with the region behind the poleward bulge illustrated in Figure 1. Hβ emission occurred during every SVIA event recorded at Mawson and, as found by Eather and Jacka (1966), was well correlated with absorption.

Figure 2 shows a plot of the half-hour averages of the λ4278 Å, λ5577 Å, and Hβ emissions with the SVIA onset time as origin. Each emission follows the same pattern with the intensity rising to a maximum at the SVIA onset, displaying a minimum just prior to the onset, and a period of enhancement 4–6 hr before the onset. In the model represented by Figure 1, at the latitude of Mawson, the evening Hβ emission occurs about 1 hr before the visual aurora which passes over Mawson $4\frac{1}{2}$–5 hr before L midnight. Bearing in mind that the SVIA onset times are sharply peaked about L midnight, we see that the broad features of Figure 2 are consistent with the model.

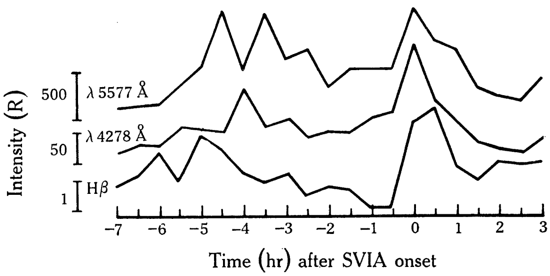

Fig. 2.—Mean variations of the intensities of λ5577 Å, λ4278 Å, and Hβ emissions at Mawson plotted with the time of onset of the SVIA as origin.

During the period February to September 1966, 26 SVIA events were recorded at Mawson and 27 at Kiruna. Of these, 18 started at the same Universal Time at both stations. Only records from July to September 1966 were to hand for Murmansk. During this period 9 SVIA events were recorded at Murmansk, 18 at Mawson, and 12 at Kiruna. Kiruna and Murmansk recorded 6 events with simultaneous onset times for this period, whilst Mawson, Kiruna, and Murmansk recorded 3 simultaneous onset SVIA events.

One might expect some difference in onset times at the three stations since the bulge front has a velocity of order 1 km s^{-1}. The time resolution of the riometer records from Kiruna and Murmansk is, however, about 10 min. The apparent simultaneity of SVIA onsets at Mawson, Kiruna, and Murmansk is therefore consistent with the auroral substorm model.

The appearance of SVIA at one station and not at the others is also explainable. The size of the quiet auroral oval prior to the substorm onset varies and substorms differ in regard to the size and shape of the auroral bulge. Hence any permutation of occurrence and non-occurrence of SVIA at the three stations is consistent, except that one would expect simultaneous occurrences at Mawson and Murmansk to be accompanied by an event at Kiruna also (unless the emission in the bulge was very patchy). On the three occasions when SVIA events were simultaneous at Mawson and Murmansk an SVIA occurred simultaneously at Kiruna.

III. Acknowledgments

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IV. References

Akasofu, S. I. (1968).—"Polar and Magnetospheric Substorms." (Reidel: Dortrecht, Holland.)
Eather, R. H., and Jacka, F. (1966).—*Aust. J. Phys.* **19**, 215.
Francis, R. J., and Jacka, F. (1969).—*J. atmos. terr. Phys.* **31**, 321.
Kilfoyle, B. P., and Jacka, F. (1968).—*Nature* **220**, 773.
Schaeffer, R. C. (1970).—*Aust. J. Phys.* **23**, 941.