LOCAL PECULIARITIES OF AURORAL HISS OBSERVED IN POLAR ANTARCTIC REGIONS

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***Abstract*:** The simultaneous VLF hiss observations at Syowa and Molodezhnaya Stations, Antarctica, showed that continuous auroral hiss with a narrow spectral band was observed widely over the polar region, whereas the impulsive auroral hiss with the burst-like spectral structure occurred mainly in the localized region of breakup of aurora. Based on the obtained results, the generation mechanisms of the auroral hiss of these two types are briefly discussed in the present paper.

1. Introduction

It is well known that auroral hiss is one of the typical VLF-emissions in high latitudes. According to MAKITA (1978), auroral hiss is divided into two types on the basis of its frequency-time spectrum; *i.e.*, continuous hiss and impulsive hiss. Continuous hiss has a narrow spectral band in the frequency range between 2 and 14 kHz. The auroral hiss of this type is frequently observed during small local magnetic disturbances and accompanied by quiet auroral arcs. Its duration is between 10–15 minutes and 1–2 hours. On the other hand, the impulsive hiss has a burst-like spectral structure with a frequency ranging from 1 to 100 kHz. This kind of hiss is a typical phenomenon during the expansive phase of a magnetospheric substorm (KOKUBUN *et al.*, 1972). The duration of hiss burst is between 1–3 and 10–20 minutes.

Based on the simultaneous VLF observations at Syowa and Mizuho Stations which are located nearly at the same longitude but with a latitudinal difference of about 2.5°, MAKITA (1978) has shown that, as a rule, the properties of continuous hiss are similar at these two stations, while those of impulsive hiss are different.

The purpose of the present paper is the investigation of longitudinal peculiarities of auroral hiss emissions. In the present study, we used the simultaneous data of VLF-observations at antarctic Syowa and at Molodezhnaya Stations during September–October 1973. These two stations are located at nearly the same geomagnetic latitude ($\phi \approx 69°$) with about 250 km difference in the longitudinal direction. Unfortunately we have no VLF data at Mizuho Station for this period.

2. Observational Results

The result of our study showed that the auroral impulsive hiss is a very local phenomenon in longitude as well as in latitude. The emission was mainly observed only at one of these stations (Syowa or Molodezhnaya) (Fig. 1). The impulsive hiss was usually accompanied by pi 2 geomagnetic pulsations and the breakup of aurora. The impulsive hiss occurred most frequently around 21–22 MLT (magnetic local time).

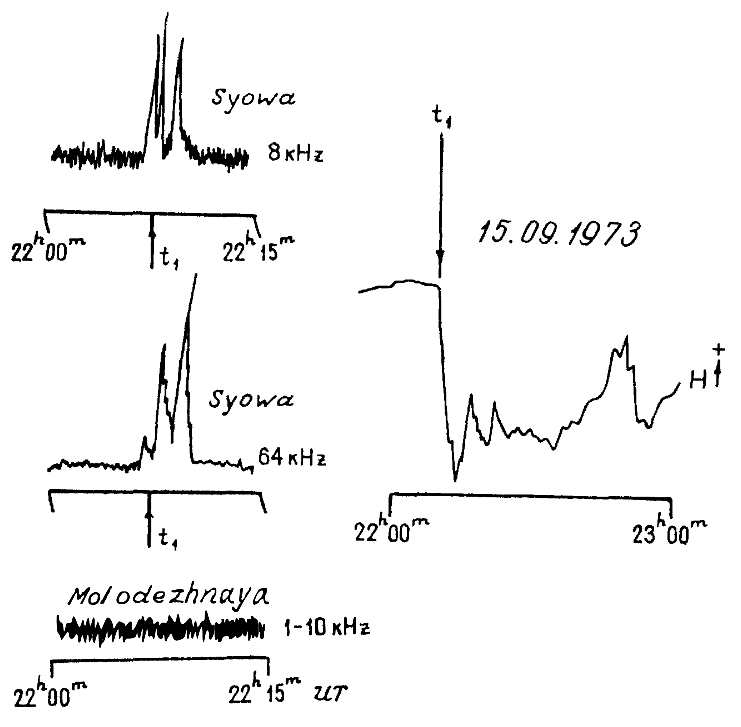

Fig. 1. The intensity record of VLF auroral hiss in the 8 and 64 kHz band observed at Syowa Station and in the 1–10 kHz band at Molodezhnaya Station. The simultaneous magnetic variation at Syowa Station is also shown on the right of the figure.

On the other hand, the continuous hiss was observed simultaneously both at Syowa and Molodezhnaya Stations (Fig. 2). The continuous hiss emissions were not accompanied by pi 2 geomagnetic pulsations nor by local significant magnetic disturbances, but very often by quiet auroral arcs appearing at the poleward side of the stations. The maximum occurrence of continuous hiss was at about 19–20 MLT. During the period examined there were 13 examples of simultaneous occurrences of continuous hiss at both Syowa and Molodezhnaya Stations and 3 examples of continuous hiss, which were observed only at one of these two stations.

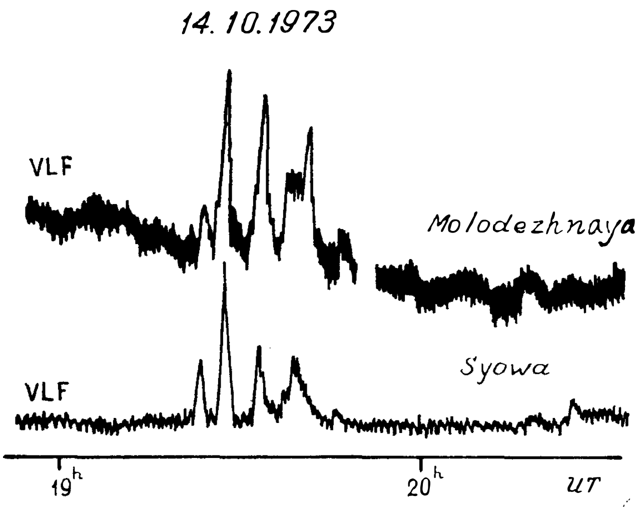

Fig. 2. The intensity of VLF auroral hiss in the 8 kHz band observed simultaneously at Molodezhnaya and Syowa Stations.

We can conclude that the continuous hiss emissions have wider longitudinal extention than the impulsive hiss emissions.

The properties of the continuous hiss are similar to those of hiss observed on the OGO 4 satellite at magnetic latitudes higher than 65°–67°. The hiss emission zone observed on the satellite coincides with the precipitation region of soft electrons with energy less than 1 keV (LAASPERE and HOFFMAN, 1976).

3. Generation of Auroral Hiss

The continuous hiss is assumed to be related to soft electron precipitations. According to GOLIKOV *et al.* (1977), soft electrons could generate whistler mode waves with the frequency ω_w or lower hybrid resonance (LHR) waves with the frequency ω_p. The dispersion relation of these waves is given by the following equations.

$$\omega_w = \omega_H \cdot \frac{k^2c^2}{\omega_0^2} \cdot \cos\theta$$

$$\omega_p^2 = \frac{\omega_0^2\left(\frac{m}{M} + \cos^2\theta\right)}{1 + \frac{\omega_0^2}{\omega_H^2}(1 - \cos^2\theta)}$$

$$\omega_H = \frac{eH}{m_e};\quad \omega_0 = \sqrt{\frac{4\pi Nc^2}{m}}$$

where θ is the angle between $\vec{B}$ and $\vec{k}$, m is the electron mass, and N is the electron density. If $\theta = \pi/2$, ω_p corresponds to the lower hybrid frequency $\omega_{\rm LHP}$.

The threshold beam velocity of precipitating electrons for whistler mode wave generation is $(\omega_0/\omega_w \cdot \sin\theta)^{1/2}$ times as high as the velocity for generation of LHR wave. It means that soft electrons can generate LHR electrostatic waves much easier than whistler mode waves. Because of induction scattering, the maximum in the spectral density of LHR waves moves to lower frequencies. This fact could explain that the intensity of the continuous hiss is stronger at 5–10 kHz than that at higher frequencies. Whistler mode waves may be generated by three waves interaction among two LHR waves and a whistler mode wave. The spectral density of the whistler mode wave energy through such a process will be given by

$$W_w(\vec{k}) = V_j\left(\frac{1}{k\cdot\alpha}\,\frac{\omega_H}{\nu_{ei}}\,\frac{|\cos\theta|}{1+\cos^2\theta}+1-p^2\right)^{-1}$$

where

V_j: junction speed of two LHR waves
α: dimension of generation region
ν_{ei}: electron-ion collision frequency
$p=u/u_{th}$
u: beam velocity
u_{th}: threshold beam velocity.

In the inhomogeneous polar ionosphere which has irregularities of electron density, electrostatic waves can be transformed into electromagnetic waves.

The generation of the impulsive hiss emission is assumed to be associated with energetic electron precipitations. In such a condition, the maximum in spectral density of the impulsive hiss does not move towards lower frequencies so much as the case of the continuous hiss. The impulsive hiss may be accounted for by the convective beam amplification of incoherent Cerenkov whistler radiation caused by a beam of precipitating auroral electrons. The beam amplification mechanism was investigated in detail by MAGGS (1976), using the lowest order WKB kinetic equation and the linear growth rate.

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