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Section 4. Whistlers and VLF emissions

a) Whistlers

The study of whistlers is divided into two principal subjects. The first subject is concerned with the whistler penetration characteristics through the ionosphere. And the second one is to know their propagation features in the magnetosphere and also to deduce the magnetospheric properties.

As for the first subject, the propagation features of upgoing whistler waves are investigated by means of full-wave theory. It is found from the study of longitudinal propagation that the density gradient of the D-region influences seriously on the whistler penetration and we have to take into account the wave-interference effects. Next the equatorial penetration of upgoing ELF and VLF waves is studied by means of full-wave theory, from which it is found that there exists a narrow band of possible tunneling transmission around 1 kHz (Hayakawa and Ohtsu, 1973a). Experimentally, the propagation characteristics of whistlers in the lower ionosphere is examined using the measurement on board the K-9M-26 rocket (Hayakawa et al., 1973). Moreover, the transmission properties of downgoing whistlers are studied theoretically (Hayakaw, 1974) as well as experimentally (Iwai et al.).

As for the second subject, the current attention is paid to the evidences of the presence of low-latitude whistler ducts. Hayakawa and Ohtsu (1973b) have found a strong indirect evidence of ducted propagation. Then Iwai et al. have carried out the measurement of wave normal direction of whistlers in the ionosphere and got an in-situ evidence of ducted propagation for low-latitude sunset whistlers. Their results have also supplied us with the clear picture on the transmission and trapping cones for downcoming whistlers. Additionally, Hayakawa and Tanaka (1973) have found that the echo-train and hybrid whistlers observed at Sakushima are attributed to the guided propagation along thin ducts in the equatorial ionosphere.

Non-ducted whistler propagation in the inner magnetosphere is discussed using the rocket measurement. The observed resulrs are consistently explained in terms of the propagation in the magnetospheric model with including the effect of the equatorial anomaly (Hayakawa, 1974).

The remarkable phenomena of low-latitude whistlers during magnetic disturbances are currently studied, such as the enhancement of occurrence rate and diffuseness and the diminution of dispersion. Using the date at Moshiri, Tanaka and Hayakawa (1973a) have found that the enhanced diffuseness of whistlers during disturbances is the consequence of the broadening of ducts region consisting of many elemental ducts. Then the enhanced occurrence rate is found to be closely associated with the ionospheric spread-F irregularities (Tanaka and Hayakawa, 1973b). Lastly, by comparing the whistler dispersion at Moshiri with the density profile in the topside ionosphere, Tanaka and Hayakawa have found that the depletion in dispersion is caused by the depletion in electron density along the whistler path and the inward movement of ducts is negligible.

Kashiwagi (1974) have carried out the observation of low latitude nose whistlers at Moshiri. He tried to determine the path latitude in the following way. In the calculation of dispersion, he adopted the gyro-frequency and exponential models for the magnetospheric density profile. First, the observed dispersion in the routine-base observation or in the low frequency range is utilized to determine the unknown factors specifying the models for varying path latitudes. The nose effect is calculated for such models and is compared with the observation. Then the path latitude is determined such that the observed nose effect is closest to the calculation. And it is found that the path latitude determined for the exponential model is closer to the latitude derived from the experimental formula by Allcock.

Closely related with the first as well as second subject, Iwai and a master course student, Okada have carried out the direction finding for low-latitude whistlers by means of four-parameter method at Takayama. According to their preliminary observation of this winter, they have come to the conclusion that the available S/N ration is only ～ 10dB and then the measuring accuracy is not sufficient. Therefore, to improve the accuracy, the direction finding will be made at stations such as Moshiri where high S/N ratio can be obtained.

b) VLF emissions

VLF hiss events observed at Moshiri from Jan. 1964 to Dec. 1968 have been investigated by Tanaka et al. Then it is found that 56 percent of all events are associated with magnetic storms. Examining, for these hiss events, the time delay of occurrence of hiss behind the commencement of storm, they have found that the energy of electrons responsible for the generation of VLF hiss is of the order of 5kev. It is, also, suggested that these storm -associated hisses are generated inside the plasmapause by drifting soft electrons accompanied with the ring currence flowing at 3-4 Re geocentric distance. The remaining events which are not related with storms may correspond to the equatorial VLF hiss observed around the equatorial region of very low L values during quiet periods.

The in-situ characteristics of VLF hiss events during disturbances are being studied by making use of the data observed by Ariel-3 satellite. The generation region of VLF hiss is found to rotate eastward during disturbances. This means that the hiss is associated with drifting electrons and is quite consistent with the results based on the above ground observations.

The above-mentioned low-latitude VLF hisses are, so far, considered to be the consequence of waveguide mode propagation below the ionosphere of auroral hiss. However, our recent studies are inconsistent with such an idea. So we are now examining the morphological differences between the low-latitude and auroral VLF hiss with special reference to their diurnal, seasonal variations, Kp dependence and frequency spectrum etc.

c) Location of Atmospherics

In order to improve the ambiguity for the fixing of the sources of atmospherics along the base lines of three DF stations, especially for the sources of South-East Asia, test observations for measuring the distances from the sources have been carried out since last year. The principle employed in this measurement is the digitalized GDD method which is an improved one of Heydt's method developed in Germany. The estimation of measuring accuracy for individual atmospherics has been continued at Moshiri, Sakushima, and Kagoshima.

Using the same stations mentioned above, the observation for fixing the atmospheric sources in and around Japan has been carried out by adopting the direction finders operating at the frequency of 50 kHz (Nishino, 1973). The results observed in this winter show good correlations between the distributions of the atmospheric sources and the activity of the cold front (Nishino, 1974).

For the purpose of the ranging of thunderstorms within 300 km, test observation of the peak pulse amplitudes of atmospherics emitted from the lightning discharge was made this summer.

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