LOWE HYBRID RESONANCE SPHERICS

J. Bošková, F. Jiřiček
Geophysical Institute of the Czechoslovak Acad. of Sci., Prague*

E. E. Titova, T. A. Yakhnina
Polar Geophysical Institute, Acad. Sci. of the USSR, Apatity**

Summary: After a fractional-hop whistler, a trace of limited frequency range with somewhat higher dispersion, markedly growing when approaching the lower cutoff frequency, is frequently observed on spectrograms of broadband VLF measurements made by satellites moving in the outer ionosphere. This phenomenon, which we have called "LHR spheric", has been studied on VLF measurements made by the Interkosmos-14 satellite in the height range of 500—1700 km. The results show that LHR spheres are created by the same mechanism as LHR whistlers that sometimes appear after ducted whistlers. In this event, it is a part of the electromagnetic energy radiated by a lightning flash which, on passing through the ionosphere, has been transformed to quasi-electrostatic resonance waves. They reach the satellite in the same way as whistler-mode waves. Transformation of a part of the energy radiated by a lightning flash to electrostatic quasi-resonance waves is possible in the ionosphere due to the scattering of the original whistler wave on small-scale turbulence.

1. INTRODUCTION

Broadband satellite measurements in the VLF band have shown that at frequencies close to the lower hybrid resonance (LHR), marked spectral changes of the signals coming through occur which are the result of peculiar propagation features and reflection possibilities of the waves near the LHR. The propagation characteristics and spectral changes of VLF signals at frequencies around the LHR depend, in the first place, upon the value of the angle between the wave normal vector and the magnetic field. The most pronounced changes of VLF signal spectra occur in the case of quasi-electrostatic waves, i.e. the waves whose wave vector lies near the resonance cone.

Among outer ionospheric, LHR associated phenomena, an important position is taken by those originated from, or in some manner connected with whistlers. These are various bursts of noise of a shorter or longer duration after a preceding whistler at frequencies close to the LHR frequency of the ambient plasma, and also effects resembling the traces of ducted or non-ducted whistlers themselves on the spectrogram. After the trace of a ducted whistler arriving at a satellite from above (it can be a one- or two-hop whistler or the corresponding echo) a further trace is frequently observed at middle latitudes which starts at a certain frequency to be separated from the ducted whistler trace, and whose dispersion grows much more rapidly when approaching the lowest frequency contained in the spectrum, this latter frequency being close to the characteristic LHR frequency value in the outer ionosphere. It appears that these so-called LHR whistlers can be created by a mechanism which was described as follows [1, 2]. In a certain magnetospheric region the whistler energy is split into two parts, the first one arriving at the satellite and at the ground by quasilongitudinal propagation (ducted whistler), and the second one transiting to quasi-
resonance propagation which can propagate only in the region where the wave frequency is higher than the LHR frequency. In this event the group delay of waves is determined by the height profile of the LHR frequency, and with the wave frequency approaching the maximum of the LHR height profile, the delay is increasing markedly. A well-formed LHR whistler trace with an asymptotic growth of the delay as it approaches the cutoff frequency is observed if the satellite moves below the maximum of the LHR height profile. The asymptotic frequency (lowest frequency) of the LHR whistler trace corresponds to the maximum LHR frequency above the satellite. If the satellite moves above the maximum of the LHR height profile, the spectrogram of the quasi-resonance trace shows a finite dispersion everywhere, and it ends at the frequency of the local LHR-frequency value [3].

Satellites of the Interkosmos series also observed signals whose the spectrograms were similar to those of LHR whistlers; however, they follow after fractional-hop whistlers. Observed by low-orbiting satellites in the outer ionosphere, fractional-hop whistlers show only a very small dispersion due to the propagation of the spheric from the ground discharge to the satellite. For the sake of simplicity, these signals will hereafter be called LHR spherics. The possibility of explaining their origin by the same mechanism as proposed for LHR whistlers, together with experimental results which may confirm this, are given below.

2. EXPERIMENTAL RESULTS

The spectral similarity of LHR spherics and LHR whistlers (see Fig. 1) enables us to assume the same mechanism of their origin, i.e. that even LHR spherics represent in their substance quasi-electrostatic VLF waves, the characteristics of which are determined, in the first place, by the peculiar features of quasi-resonance propagation of these waves in the vicinity of the LHR maximum. It is then also possible to expect recordings of different spectra of LHR spherics on a satellite moving above or below the maximum of the LHR-frequency height profile. VLF records from the Interkosmos-14 (IK-14) satellite, that has been orbiting within a sufficient height interval, 500—1700 km, were chosen for this reason. The experiment was performed at the

Fig. 1a) Example of spectrogram of LHR spherics recorded by the Interkosmos-14 satellite.

b) Example of spectrogram of LHR whistlers recorded by the Interkosmos-19 satellite.