VLF QUARTER-GYROFREQUENCY PLASMASPERIC EMISSIONS
AS OBSERVED BY INTERCOSMOS 24 AND MAGION 2 SATELLITES

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Summary: Quarter-gyrofrequency plasmaspheric emissions with spectral properties differing from those of discrete plasmaspheric emissions, usual in active intervals, have been observed by low-altitude Intercosmos 24 and Magion 2 satellites during periods in which geomagnetic activity decreases. Their occurrence in satellite records shows very good correlation with simultaneously observed subauroral electron temperature enhancements and increase of electron temperature anisotropy ($T_{e_A}$ being larger than $T_{e_L}$). An analysis of the observed wave characteristics is given. Propagation of the emissions within the plasmasphere is discussed. It is shown that the region where they are observed at low altitudes can be closely connected along geomagnetic field lines with the equatorial region of their origin.

1. INTRODUCTION

In the series of observations performed by low-altitude (up to ~1700 km) Intercosmos satellites, high-intensity, discrete VLF emissions of an impulsive nature were observed within the plasmasphere at $2.3 < L < 4.0$ during periods of increasing geomagnetic activity [1]. The emissions were found above the local LHR frequency only and, in addition, they do not seem to be observed on the ground. Their characteristic feature is the continuous variation with geomagnetic latitude of the lower cutoff frequency of the emission band which appears to be more or less close to one quarter of the equatorial electron gyrofrequency $f_2^{eq}$ at the L-shell of observation. The emissions were termed „quarter-gyrofrequency” plasmaspheric emissions. (This term is used only for those VLF emissions 1. which were recorded within the plasmasphere, 2. whose lower cutoff frequency, when recorded at low altitudes, varies roughly as $1/4 f_2^{eq}_L$.)

A detailed description of the mechanism of generating these emissions during periods of increasing geomagnetic activity proposed by [2, 3] is given in a companion paper [4]. The propagation of these emissions in the dense plasma of the plasmasphere is well described by the quasi-resonance approximation [3]. The earthwards wave propagation in the quasi-resonance regime is accompanied by a decrease of $L$-values and, therefore, by a decrease of the normalized frequency $\omega/\Omega_2^{eq}(L)$. The values of this normalized frequency at low altitudes are close to 0.25 for a wide range of initial parameters.

Emissions of the same type were mentioned briefly for the first time in a preliminary report by [5]. Observations of discrete VLF emissions at $L < 4$ obtained by the high-altitude DE 1 and the low-altitude (~1400 km) ISIS 2 satellites were described in [6]. The spectral characteristics and $L$-variation of the lower cutoff frequency of the emissions recorded by the low-altitude ISIS 2 satellite within the plasmasphere are coincident with those observed by low-altitude Intercosmos satellites. Despite the different interpretation, the observations reported by [6] do not contradict the hypothesis of the possible quasi-electrostatic nature of these emissions. High-altitude discrete VLF emissions were recorded by DE 1 in a transition region located more or less near the equatorial zone of their generation. According to [2], if they were quasi-electrostatic, with an unstable band of frequencies at the equator above $0.5 \Omega_2^{eq}$, the normalized

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frequency of their lower boundary would increase towards the equatorial generation region up to 0.5 (and above). This tendency really appears in the published DE 1 data.

In the broadband VLF electric field measurements made by the Intercosmos 24 and Magion 2 satellites (launched on 28 September 1989 with orbital parameters 500/2500 km altitude and 83° inclination), apart from discrete quarter-gyrofrequency plasmaspheric emissions usual in the active phase of disturbances (Fig. 1), also VLF quarter-gyrofrequency emissions of different spectral properties were found within the plasmasphere during periods in which the geomagnetic activity decreases. Their experimental characteristics indicate connection with some processes taking place within the plasmasphere during the recovery phase following magnetospheric storms.

Our suggestion of the generating mechanism of these emissions is given in a companion paper [4]. The purpose of this paper is to describe their experimental characteristics and to discuss their propagation within the plasmasphere. Section 2 describes the experimental characteristics of the quarter-gyrofrequency plasmaspheric emissions observed by Intercosmos 24 and Magion 2 during the period of decreasing geomagnetic activity and the main differences between them and the plasmaspheric emissions of the discrete type. The close relation between the occurrence of plasmaspheric emissions and the simultaneously measured subauroral electron temperature enhancements is mentioned. Section 3 gives a brief outline of the plasmasphere during the period of increasing geomagnetic activity and the recovery phase. The substantial difference between them led us to propose the fan instability as the source of the quarter-gyrofrequency plasmaspheric emissions during periods in which magnetic activity decreases. Section 4 discusses the propagation of the quasi-electrostatic whistler waves from the equatorial region to low altitudes. The main results of our study are presented in the last part of the paper.

2. EXPERIMENTAL OBSERVATIONS

Let us briefly summarize the basic experimental characteristics of the discrete quarter-gyrofrequency plasmaspheric emissions as determined from the VLF data of low-altitude Intercosmos satellites during periods of increasing geomagnetic activity. 1. Quarter-gyrofrequency plasmaspheric emissions have only been observed on satellites; they are apparently not observed on the ground. 2. They are observed within the plasmasphere in the interval 2.3 < L < 4.3. They occur mostly in the morning local time sector at frequencies above the local f_{lhr}-value. 4. Their lower cutoff frequency varies continuously with geomagnetic latitude approximately as 1/4 of the equatorial electron gyrofrequency corresponding to the L-shell of the observing point. 5. They are structured markedly; on spectrograms they appear as rising, more rarely as flat or falling elements of various df/dt slopes, with maximum