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THE LONG-LASTING QP EMISSIONS OBSERVED ON ARASE SATELLITE AND LOVOZERO STATION

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Abstract

In this work the simultaneous QP emission registered during about 90 minutes on Arase satellite and Lovozero station (Kola Peninsula) of Polar Geophysical Institute are investigated when the Arase satellite and Lovozero station was geomagnetically conjugate. The QP emission was observed on the nightside during low geomagnetic activity, its frequency on the ground and in space was about 20 mHz. It is found that QP emissions are not accompanied by the geomagnetic pulsations with the same period on the ground-based magnetometers. But it is registered the Pc3 geomagnetic pulsations on Arase satellite. The frequency of these pulsations is about twice larger than frequency of QP emissions. When QP envelope and ULF periodicities are different, it can correspond to different harmonics of a same fundamental oscillation of the field line. The small-scale Pc3 pulsations do not seen on the ground due to its damping in the ionosphere. So investigated QP emissions can be attributed neither to QP1 class no QP2 class.

1 Introduction

Very low (VLF) radio emissions naturally presenting in the Earth's magnetosphere have different spectral features [1]. Quasi-periodic (QP) VLF emissions are wideband emissions at frequencies between about 0.5 and 4 kHz which are observed inside or near the plasmapause [2]. They are characterized by a periodic modulation of the wave intensity with typical periods from several seconds up to a few minutes. QP emissions occur primarily on the dayside [3] and typically during geomagnetically rather quiet times. Generation of QP emissions is usually accompanied by precipitation of energetic electrons, which is also modulated with the same period [4]. There are two types of QP emissions: the type1 of QP emissions is accompanied by the simultaneous ground geomagnetic pulsations with the same frequency; the type2 of QP emissions is not accompanied. It was generally believed that QP emissions type 1 and QP emissions type 2 have different spectral properties and generation mechanisms. Periods of QP2 emissions are usually explained in terms of relaxation oscillations of the cyclotron instability [5, 6] or the auto-oscillation regime. However, the generation mechanism of QP2 emissions has not yet been fully understood.

The aim of this research is to study the unique event with long-lasting QP emission when the new Japan Arase satellite was geomagnetically conjugate to the Russian Lovozero station.

2 Data used

The Arase satellite, formerly known as Exploration of energization and Radiation in Geospace (ERG) satellite was developed by the Institute of Space and Astronautical Science of JAXA (Japan Aerospace Exploration Agency) for the study Earth radiation belts [7]. It has apogee about 5.0 Re (L~6.0, 32 110 km), perigee about 460 km. It was launched at 20 December 2016. The PWE (Plasma wave experiment) instrument on Arase satellite [8] was used for the detection VLF wave variations in the magnetosphere. MGF (magnetic field experiment) [9, 10], LEPe [11] and LEPi [12] (Low-Energy Particle Experiment) [10, 11, 13], MEPe [13] and MEPi [14] (Medium-Energy Particle Experiments) instruments was used as well. The conjugate studies of the QP emissions with using Arase (ERG) satellite and ground station was done before in the paper [15].

The Lovozero station (64.22N, 114.6E, LOZ) data of the Polar Geophysical Institute was used in this study. In brackets are corrected geomagnetic coordinates. We used the VLF Lovozero data, fluxgate magnetometer data. For the analyses we will choose the time intervals when the

Arase satellite was geomagnetically conjugate to the Kola Peninsula (Figure 1).

The IMAGE magnetometer data was used for the registration magnetic field variations on the ground. The riometer data in Scandinavia and Kola Peninsula was used for the detection of the level of electron precipitation into the atmosphere during our event.

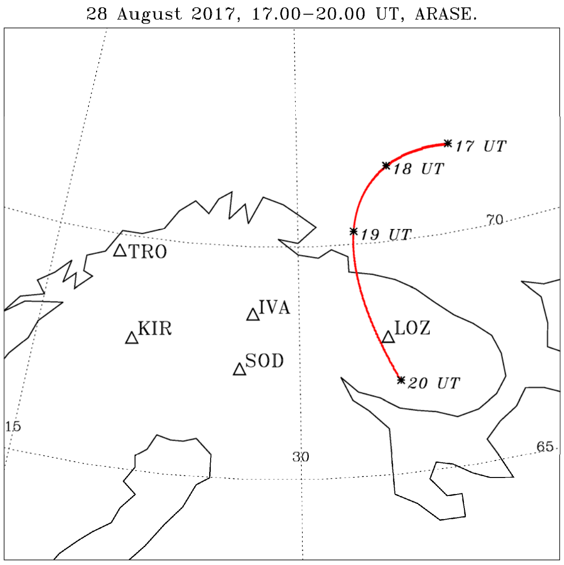

Figure 1. The ionosphere projection of the Arase satellite from 17 to 20 UT on 28 August 2017 near the LOZ station on Kola Peninsula.

3 The event 28 August 2017

The clear QP emissions was observed in electric field on Arase satellite (Figure 2) when its ionosphere geomagnetic projection was near the Lovozero station (Figure 1) at 17-20 UT. It is interesting that QP emission was not observed in magnetic field variations. Possibly it's caused different sensitivity of the instruments which measure electric and magnetic field.

The simultaneous very clear QP emission on the ground and in space was observed during about 90 minutes in the evening sector of MLT from 18.30 to 20.00 UT. The Arase satellite at this moment was located on the nightside magnetosphere, near midnight (X = -3.5 Re, Y = 2 Re, Z = -4 Re in GSE coordinate system).

On the Figure 3 it is shown the 10-minutes time interval when QP emission was registered on Arase satellite and LOZ station. There is very high correlation between QP elements on the ground and in space. The QP emissions was registered in a frequency range 1-2 kHz, the period of QP emissions was approximately 40 seconds. Inside the QP emissions the higher frequency fine structures were observed, the physical nature of this fine structure is not well understood.

During the period of the QP emissions appearance the geomagnetic conditions was quite (SYM-H = -20 nT, AE = 100-200 nT). According to the OMNI database solar wind speed was about 300 km/s, Bz-component of the interplanetary magnetic field was positive.

The clear QP emissions on LOZ station was observed until 21.30 UT, when the Arase satellite was far from the conjugate point. The period of these QP emissions are increase with time.

The analysis of the particle data on Arase satellite shows the absence of the pulsations with the same period in the fluxes of charge particles. Possibly due to small amplitude of the geomagnetic pulsations, low level of the geomagnetic activity. According the Scandinavian riometers data there is no strong cosmic noise absorption (about 0.2-03.dB) increase during this event which testify about the absence of strong electron precipitation.

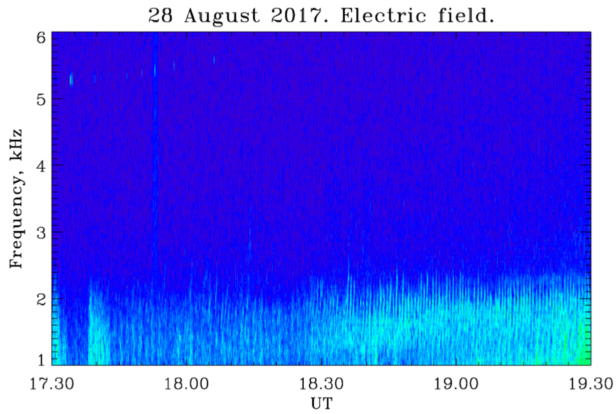

Figure 2. The QP emissions in electric field registred on Arase satellite from 17.30 to 19.30 UT on 28 August 2017.

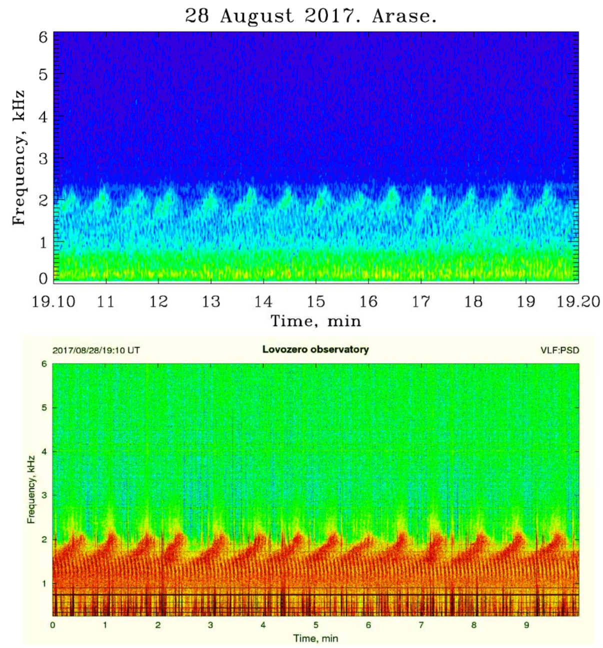

Figure 3. The QP emissions obsereved on Arase satellite (upper panel) and Lovozero station (lower panel) in time interval 19.10-19.20 UT.

The analysis of the IMAGE magnetometer data (LOZ, IVA stations) shows that QP emissions are not accompanied by the geomagnetic pulsations with the same period on the ground-based magnetometers.
But according to the magnetometer data of Arase satellite (MGF instrument) it is found Pc3 geomagnetic pulsations in Bz, By components (Figure 4.). Amplitude of the pulsations is 0.5-0.7 nT. The spectral analysis shows that the frequency of these pulsations is about 38 mHz while the envelope of QP emissions has two spectrum (19 mHz, 22 mHz) peaks (Figure 5). So the frequencies of the ULF Pc3 waves in space and the frequencies of QP emissions does not coincide (it differs almost twice).

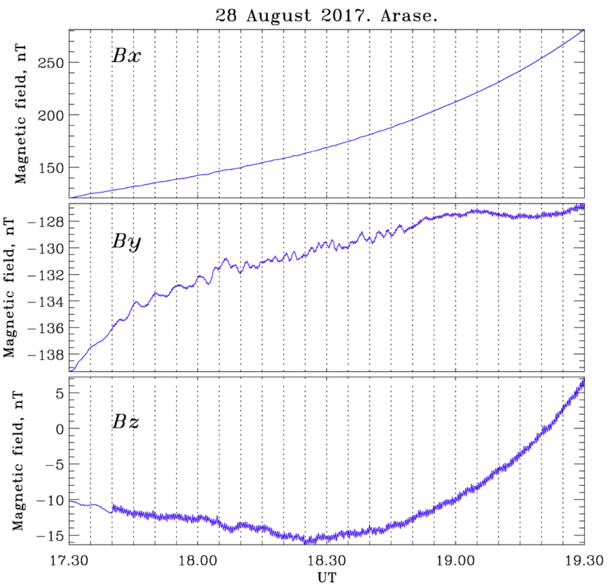

Figure 4. The magnetic field variations (Bx, By, Bz-components) in GSM coordinate system on Arase satellite from 17 to 20 UT on 28 August 2017.

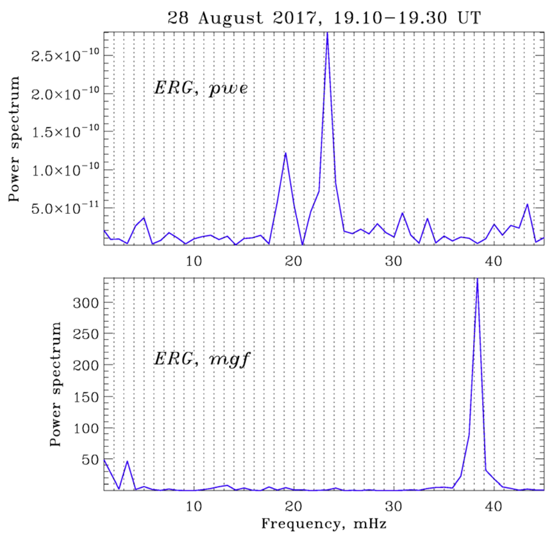

Figure 5. The spectrum of the envelope of QP emissions on Arase satellite (upper panel); the spectrum of the magnetic field variations on Arase satellite (lower panel) for the event 28 August 2017 in time interval 19.10-19.30 UT.

The appearance of these QP emissions can be associated with the small-scale Pc3 pulsations which seen in space and does not seen on the ground due to its damping in the ionosphere. So these QP emissions should not be attributed to the QP1 and QP2 classes. Thus even if we don’t see geomagnetic pulsations on the ground it does not necessarily indicate that this is QP2 class of QP1 emissions.

4 Conclusions

So it is found very clear and long-lasting (1.5 hour) QP emissions which were simultaneously observed on Arase satellite and Lovozero station located on Kola Peninsula. QP emissions were registered on the evening-night side during low geomagnetic activity. These QP emissions are not accompanied by the geomagnetic pulsations with the same period on the ground-based magnetometers. But according to the magnetometer data of Arase satellite it is registered the Pc3 geomagnetic pulsations with higher frequency.
When QP envelope and ULF periodicities are different, it can correspond to different harmonics of the same fundamental oscillation of the field line. The QP emissions on the ground and in space can be caused by the modulation of the growth rate of VLF waves in the magnetosphere by the small-scale ULF waves with different harmonics. The small-scale Pc3 pulsations do not seen on the ground due to its damping in the ionosphere. At the same time the monochromatic Pc3 pulsations on the evening side can be generated due to drift-bounce resonance between protons and field lines oscillations during small proton injection from the night side magnetosphere.
So investigated QP emissions can be attributed neither to QP1 class no QP2 class, because it does not accompanied by the geomagnetic pulsations with the same frequency (QP2 pulsations). But these QP emissions are accompanied by the higher frequency geomagnetic pulsations which were observed only in the magnetosphere (not on the ground).

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The following files were used during analyze of the Arase (ERG) satellite data:

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