

OBSERVATIONS OF HIGH-FREQUENCY PULSATING AURORA AT SPITSBERGEN

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Abstract

Based on TV and magnetic pulsation data recorded at Barentsburg (Spitsbergen) and Lovozero, with using advanced data processing procedures, some fine and new details of high latitude auroral activity were revealed. We found several examples of high-frequency regular auroral pulsations (the period is 4-10 seconds). The pulsations exist for 2-10 minutes, close to the local sunrise, have unusually stable period and in the filtered TV frame look like very weak diffuse luminosity bands. These bands occasionally move from the south to the north, with the speed of 2-10 km/sec. Wavelet analysis of magnetic pulsations revealed a weak magnetic effect of optical pulsations at Barentsburg. In Lovozero data fast auroral pulsations have noticeable effect in VLF emissions.

Introduction

There has always been a big interest for high latitude observations of auroral and magnetic pulsations. Only PGI in 1980-1990 years organized annual expeditions to Spitsbergen and Heis-island, using equipment for photometric, TV and magnetic pulsation observations. Many new and interesting details were revealed. With the use of photometers, morphology of daytime high latitude auroral pulsations, their relation to magnetic variations and possible source locations were studied. Noticeable activation of daytime magnetic pulsations in the period ranges of 3-10 and 40-80 seconds were found during nighttime substorm activations [Vorobjev et al, 1999; Yagodkina, Vorobjev, 2000].

Though during that period TV-observations at Heis-island and Spitsbergen were conducted as well, there was no serious systematic study of pulsating aurora because of the absence at that time modern equipment for data processing (computers, videosegment digitizing, etc.). Besides, high-latitude pulsating aurora is much weaker than in the auroral zone. Nowadays, modern opportunities give quite another perspective. Especially useful are different methods of image improvement and filtering [Kornilov, 2003].

Study of high-latitude pulsating aurora is also very interesting from the viewpoint of magnetosphere topology diagnostic. Existence of regular magnetic pulsations definitely proves observational point to be located on the close magnetic field lines. For all

modern theories of pulsating aurora this point is of primary importance.

Results

During 2001-2002 observational seasons PGI used two cameras for TV observations. One of them was all-sky camera with the field of view of $\sim 180^\circ$, the other was 70° narrow field TV camera, which had 45° inclination to the southern horizon. That permitted, along with all-sky images, to control the most interesting parts of the sky with a good spatial resolution

Fig.1 (a1 and b1) presents gradient-filtered keograms for two sequential time intervals (04.40-05.40 UT and 05.40-06.40 UT). Pulsations with the period of 40-80 seconds are well pronounced. They initially appeared to the south of discrete auroral arcs (05.00-05.40), and then in the northern part of the sky (06.10-06.40). One can also see Lovozero records of magnetic pulsations for 10-100 second period range (a2 and b2) and VLF-emissions, integrated for 0.6-0.8 kHz (a3 and b3). Unfortunately, we had no equipment for that type of pulsations and VLF-emissions registration at Barentsburg, so that only flux-gate-magnetometer data are available. One can notice a weak correlation of magnetic pulsations with a large-scale aurora arcs motion (4.55 and 5.50 UT). No connection between VLF and aurora is distinguished, with exception for the end of the second time interval (near 06.35), where high-frequency pulsations are observed at the southern horizon. Let's consider this interval in more details.

Fig.2 (1) presents an ordinary non-filtered keogram of narrow field TV camera for 04.02.2002, time interval 06.20-06.40 UT. The moment of high-frequency pulsation appearance is marked by the horizontal line. An intense background luminance due to sunrise did not permit to reveal high-frequency pulsations for the all-sky keogram without filtering. Gradient filtering (2) made these pulsations well recognized on the all-sky keogram. High-frequency pulsations appear for a short time interval (about 2 minutes) along with persistent 'normal' pulsations of 40-80 second periods. Fig.2 presents recordings of magnetic pulsations (3) and VLF-emissions (4) in Lovozero. The amplitude of the pulsations is very small (lower than 0.1 nT) and does not display any correlation with auroral

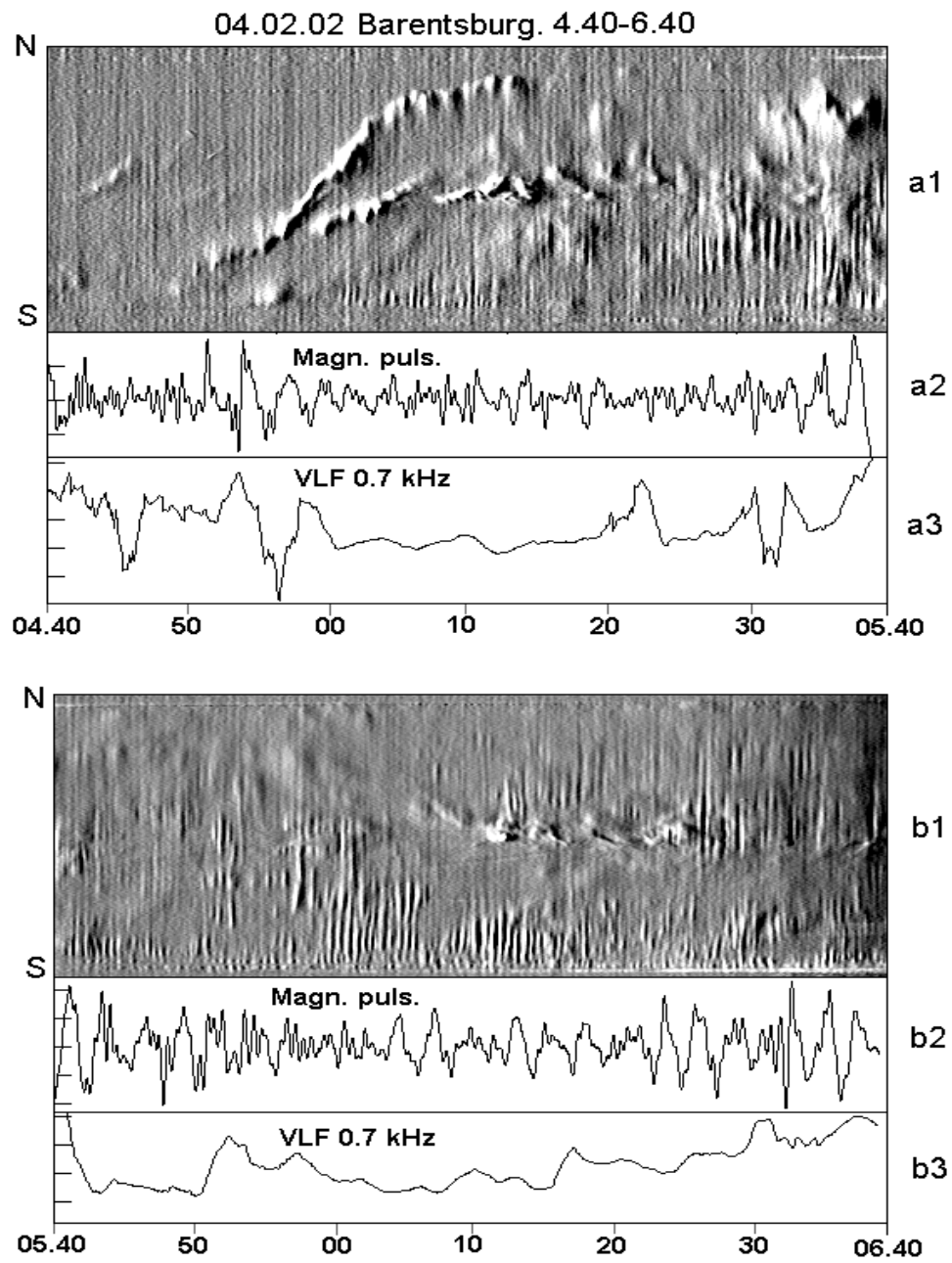


Fig.1. Gradient -filtered Barentsburg keograms for two sequential time intervals (a1 and b1). Corresponding Lovozero recordings of magnetic pulsations (a2 and b2) and average amplitude of VLF-emissions (a3 and b3).

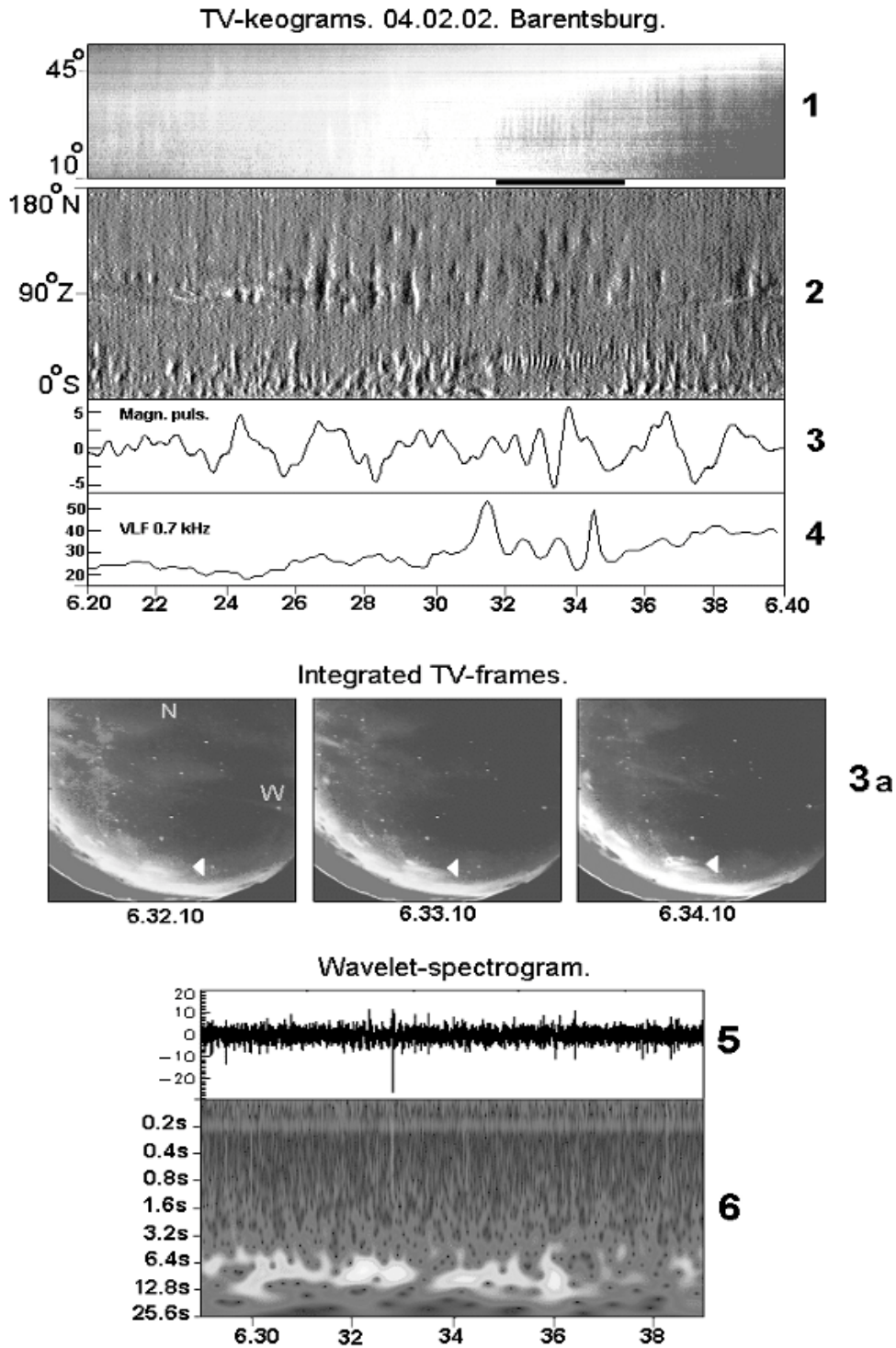


Fig.2. Non-filtered Barentsburg keogram for the narrow-field TV camera (1). Gradient -filtered all-sky keogram (2). Lovozero recordings of magnetic pulsations (3) and VLF-emissions (4). Fragments of TV-frames near southern horizon (3a). Wavelet-spectrogram of magnetic pulsations in Barentsburg (6).

pulsations. At the same time, correlation with the VLF-signal is rather evident (4).

Fig.2 (3a) shows fragments of TV-frame southern parts. Intense parasitic luminosity at the bottom of the frames caused by sunrise is partially removed by high-frequency FFT-filtering. For better revealing faint pulsating fragments, the frames were integrated over 2 seconds (50 frames in total). The arrow points to the pulsation element responsible for high-frequency pulsations detected in the keograms. That is a weak and narrow East-West oriented diffuse band. Such a band with 8-10 second periodicity detaches from the diffuse luminosity at the South, and very quickly (the speed is about 2-10 km/sec at ionosphere height) moves northward.

The results of wavelet analysis of Barentsburg flux-gate magnetometer data are presented in Fig.2 (5 and 6). The top panel presents the signal proper (waveform), and the bottom one shows the spectrogram. The wavelet spectrogram enables to reproduce pulsation spectra in a broad range of periods (0.1-30 seconds) with a good time resolution. We can see a weak magnetic pulsation activation for the periods of 8-10 seconds (06.32-06.36). The band near 0.2 seconds is the magnetometer calibrating signal. Unfortunately, we have no data on VLF-emissions in Barentsburg.

Discussion

High-frequency pulsating electron precipitations at high latitudes were not distinguished earlier, either by optical instruments or in balloon X-ray studying. Optical observations of these pulsations are very difficult because of their weakness and strong parasitic sunrise luminosity. For two years of observations we could reliably reveal only 5 cases of high-frequency optical pulsations. But pulsations of the periods, corresponding to repetition period of chorus element packets, were found earlier in high-latitude VLF-emissions [Bruce et al., 1977]. The emissions were interpreted in terms of VLF generation inside special regions of magnetosphere, so-called 'magnetic pockets'. These are areas of additional magnetic field minimums in the high-latitude morning-daytime region of the magnetosphere associated with solar wind compression. Unfortunately, the lack of VLF-equipment at Spitsbergen does not allow us to search for correlation of high-frequency optical pulsations with VLF-chorus, though this correlation is revealed from Lovozero VLF-data. It is interesting to note that all pulsation events observed are coincident with local

sunrise moments, so may be the role of ionospheric waves generated by solar terminator is also important.

Summary

A new type of high-latitude optical pulsations has been revealed. The pulsations appear for a short period near local sunrise and are accompanied by VLF-emission activation. The physical mechanism of the pulsations is unclear, but they probably can be associated with formation of additional magnetic field minimums at daytime magnetosphere side.

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