EPSC Abstracts
Vol. 7 EPSC2012-186-3 2012
European Planetary Science Congress 2012

Search and study of electrostatic discharges in the Solar System with the radio telescope UTR-2

V. Zakharenko (1) , K. Mylostna (1), **A. Konovalenko** (1), V. Kolyadin (1), P. Zarka (2), J.-M. Griessmeier (3), G. Litvinenko (1), M. Sidorchuk (1), H. Rucker (4), G. Fischer (4), B. Cecconi (2), A. Coffre (5), L. Denis (5), V. Shevchenko (1), V. Nikolaenko (1)

(1) Institute of Radio Astronomy of NASU, Kharkiv, Ukraine, (2) LESIA, Observatoire de Paris, CNRS, UPMC, Universite Paris Diderot; 5 Place Jules Janssen, 92190 Meudon, France, (3) LPC2E, 3A, Avenue de la Recherche Scientifique, 45071, Orleans cedex 2, France, (4) Space Research Institute, Graz, Austria, (5) Station de Radioastronomie, Observatoire de Paris, CNRS, 18330 Nancay, France (zakhar@rian.kharkov.ua)

Abstract

Successful ground-based detection of Saturn's lightning despite terrestrial interferences is the necessary basis for further detailed study of their characteristics. Modern observational equipment provide high temporal and spectral resolution and allows to resolve the fine structure of lightning. Also it give us a hope to detect much weaker electrostatic discharges in the atmospheres of another planets of the Solar System.

1. Introduction

Planetary lightning was first discovered by Voyager-1 as visible flashes on Jupiter and radio bursts on Saturn. After successful detection [1] and identification [2] of Saturn Electrostatic Discharges (SED) by UTR-2 radio telescope the program of long-term study of SED emission and a search of electrostatic discharges in the atmospheres of other planets was started.

Due to the rapid progress in the receiving equipment with high temporal and frequency resolution [3] and the possibilities of recording and processing enormous data volumes, the ground-based observations provide new information about ED parameters and the characteristics of physical processes generating them. Specially designed methods of observation and identification of ED provide reliable signal detection.

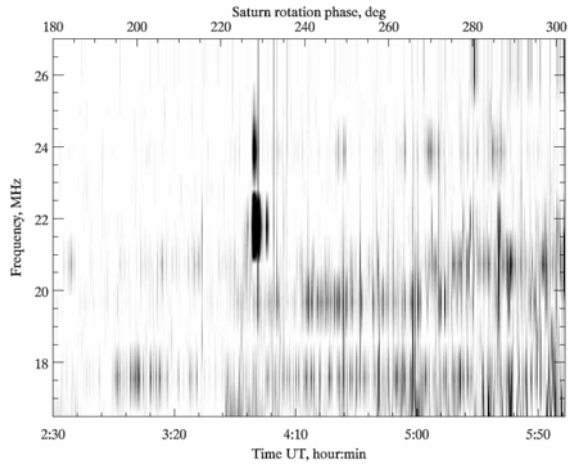
For these experiments we used multi-beam observational mode. One central beam is directed towards the source (ON beam), two other beams symmetrically pointed at 1 angular degree apart from the source (OFF beams). In the records we search for only those signals that are present in the ON beam, and absent in the OFF beams. We record sum, difference, multiplication and correlation signals of UTR-2 NS and EW antennas in the frequency band 16.5...33 MHz. The receivers were used in spectrum mode with 4096 channels and time resolution 0.25...128 ms. Separate receiver recorded waveform broadband data of sum signal in the ON mode with a time resolution of 15 ns. Despite the fact that sensitivity falls as a square root of ratio of time constants in “spectrum” and “waveform” modes (~ 10^2 ... 10^3 times) we can analyze the most intensive lightning bursts even if their durations amount to tens of nanoseconds. The planetary ED identification process consists of several stages and is described in details in [2].

2. Results

Previous results [2] confirmed the high degree of coincidence between the events detected by UTR-2 and Cassini spacecraft. In December 2010 one of the most powerful storms started on Saturn. Observations were carried out from the 20 to 28 December with duration of about 7 hours each day, using all available time for Saturn observations from Earth. It is more than duration of a Saturn's storm episode, and one can analyze storm activity variations and identify the moments of sunrise and sunset. Fig. 1 shows the 200 minutes of record on the December 23 started from the sunrise (2h 34m UT). Both the storm intensity and the upper frequency limit of SED increase by the middle of the episode. This effect could not have been detected earlier because the Cassini broadband long-term studies were restricted by the upper frequency of 16 MHz.

After preprocessing of the storm intensity data for the session the most powerful events in the waveform records were analyzed. For example, such event is shown on Fig. 1 near the time 3h52m UT. The analysis of waveform records allows us to study the time structure of ED and to determine the lightning

power and spectral characteristics of every short part of lightning.



The successful investigations of SED initiated a new project - the search for SED-like radiation in the atmospheres of Uranus and Venus by means of UTR-2 telescope. The UED (electrostatic discharges on Uranus) were discovered by spacecraft Voyager 2. Their parameters are close to the Saturn's lightning. However, in contrast to SEDs (with flux density 1000 Jy from Earth [4]) the lightning on Uranus has much lower flux density (30 Jy from Earth) but sometimes bigger duration of events. This distinctive feature allows us to raise the sensitivity due to averaging. To date three sessions of observations: March and October 2011 and May 2012 have been carried out. These data require the development of additional software for more accurate eliminating of terrestrial interference.

Another object of our research program is Venus. There are controversial facts [4] about existence of lightning in the atmosphere of Venus. So there are no reliable a priori data for lightning search in the decameter range. We also have conducted three sessions of observations, and as well as for Uranus no broadband signals were detected.

3. Conclusions

Ground-based investigations of planetary lightning allow deep study of cosmic ED. Due to high temporal resolution, broadband registration, and big amount of recorded data the different possibilities of analysis provide further progress in the SED researches as well as give a hope for detection of lightning on the planets near which there is currently no spacecraft.

Acknowledgements

This work partly supported by ANR Program NT05-1 42530 ''Radio-Exopla'', and pursued in the frame oft he NASU-CNRS PICS program ''Development of LF radio astronomy with ultra high sensitivity and resolution'' (Grant1.33.11). Cassini activities in LESIA are supported by the CNES (Centre National d'Etudes Spatiales). This work is also supported by the National Academy of Sciences of Ukraine and the Russian Foundation for Basic Research (Ukrainian-Russian Project 2012)

References

[1] Konovalenko A., Lecacheux A, Rucker H., Fischer G. et al., Ground-based decameter wavelength observations of Saturn electrostatic discharges, European Planetary Science Congress 2006, EPSC2006-A-00229, 2006.

[2] Zakharenko V., Mylostna C., Konovalenko A., Zarka P. et al. Ground-based and spacecraft observations of lightning activity on Saturn, Planetary and Space Science, Vol. 61, pp. 53-59, 2012.

[3] Konovalenko A., Falkovich I., Rucker H. et al. New antennas and methods for the low frequency stellar and planetary radio astronomy, Proc. of PRE VII edited by H. O. Rucker, W. S. Kurth, P. Louarn, and G. Fischer, Aus. Ac. of Sci. Press, Vienna, pp. 521-531, 2011.

[4] Zarka P., Farrell W., Fischer G., Konovalenko A.. Ground-Based and Space-Based Radio Observations of Planetary Lightning, Space Sci Rev, Vol. 137 pp. 257-269, 2008.