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Overview of Magnetospheric Line Radiation observed by the DEMETER spacecraft

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Abstract

Magnetospheric Line Radiation (MLR) events are electromagnetic waves in the frequency range from about 1 to 8 kHz that - when represented in a traditional form of frequency-time spectrograms - consist of several nearly parallel and almost equidistant intense lines. These may drift in frequency with the drift rate up to about 100 Hz per minute. Although MLR events have been observed both by low-altitude satellites and by the ground-based instruments for several decades, their origin is still not understood. More than 6 years of data from the DEMETER satellite (altitude about 700 km, nearly Sun-synchronous orbit at 10:30/22:30 LT) enabled us to compile the largest data set of the satellite observations of MLR available up to date. These are analyzed both in a systematic way and on a case-by-case basis. Moreover, high-resolution WBD measurements performed by the Cluster spacecraft and ground-based measurements performed in northern Finland are used in order to provide multipoint data. General characteristics of MLR events are determined and possible sources are discussed.

1. Introduction

When represented in the form of frequency-time spectrograms, electromagnetic waves observed in the inner magnetosphere sometimes consist of several lines, nearly equidistant in frequency and with a rather slow frequency drift. Such emissions are usually called Magnetospheric Line Radiation (MLR). Although they have been reported both in ground observations and low-altitude satellite data, their origin is still unknown. A careful analysis of satellite observations of such events [1, 6] has shown that it is possible to distinguish clearly MLR and Power Line Harmonic Radiation (PLHR, events with a line structure generated due to the radiation from electric power systems on the ground). A case study of a large-scale MLR event has been reported [4] and it has been shown that MLR can trigger emissions and influence the particles in the radiation belts [5], so their role may be rather important.

2. DEMETER Satellite

DEMETER was a low-altitude French satellite launched in June, 2004 on a circular orbit with an altitude of about 710 km. This was decreased to 660 km in December, 2005 and the mission ended in December, 2010. Due to the nearly Sun-synchronous orbit DEMETER always recorded data either around the time of the local day (10:30 LT) or local night (22:30 LT), and for all geomagnetic latitudes lower than 65 degrees. A power spectrum of one electric and magnetic field component with the frequency resolution of 19.53 Hz and the time resolution of 2 s or 0.5 s was calculated on board. Additionally, when the Burst mode was active, high resolution data were measured above areas of special interest. These provided us with waveforms of one electric and one magnetic field component in the VLF range (sampling frequency 40 kHz) and, moreover, waveforms of all the six electromagnetic field components in the ELF range (sampling frequency 2500 Hz) were measured. Although the Burst mode is very useful, because it allows us to perform a detailed analysis, we are forced to use the Survey mode for a systematic analysis of MLR events, because it is used all along the orbit and its occurrence is not limited to any specific areas.

3. Example of an MLR Event

An example of a frequency-time spectrogram of the power spectral density of electric field fluctuations corresponding to an MLR event is shown in Figure 1. Two MLR events can be seen at frequencies between about 2 and 4 kHz, with the first event being more pronounced and covering somewhat larger frequency range.

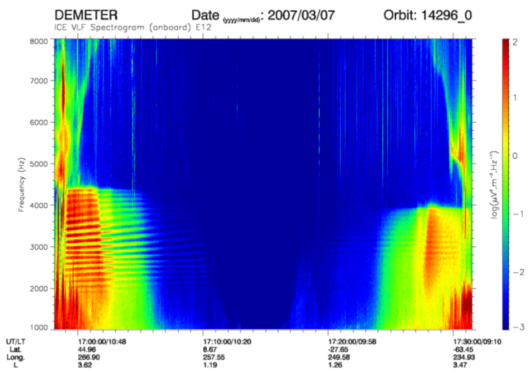

Figure 1: Frequency-time spectrogram of power spectral density of electric field fluctuations measured during a DEMETER half-orbit. Two MLR events can be identified.

4. Summary and Conclusions

Our results [2, 3, 4] show that:

- Less events are observed at geomagnetic longitudes corresponding to the Atlantic Ocean. This might be related to the South Atlantic geomagnetic anomaly and insufficient amount of energetic electrons possibly needed to generate MLR.
- The events tend to occur during or after the periods of enhanced geomagnetic activity. Their longitudinal dimensions can extend up to about 100 degrees and they can last for as long as a few hours. However, they seem to be limited within the plasmasphere.
- Neither the frequency drift nor the frequency spacing of individual lines forming the events depends on the L-shell where the event was observed. The frequency drift is generally positive.
- Simultaneous observations of the same event at several different points allowed us to distinguish spatial and temporal variations of the events. It is found that during the MLR event exactly the same wave pattern is observed over a significant portion of the inner magnetosphere.

Although much progress has been done, the ultimate understanding of the generation mechanism of MLR events still remains a task for the future.

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