Plasma Wave Observation by LRS/WFC onboard KAGUYA (SELENE)

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Abstract

KAGUYA (SELENE) is a Japanese moon orbiter launched in September, 2007. The waveform capture (WFC) is a subsystem of the Lunar Radar Sounder (LRS) onboard KAGUYA, and measures electric wave signals from 100Hz to 1MHz using the two orthogonal 30m tip-to-tip antennas. The WFC is a software receiver and most of the functions are realized by a DSP (digital signal processor) and PDCs (programmable down converters) implemented in the receiver. By taking advantage of a moon orbiter, the WFC is expected to measure plasma waves related to the solar wind-moon interaction, and radio emissions to be observed from the moon.

1. Introduction

KAGUYA (SELENE) is a Japanese moon orbiter launched from Tanegashima Space Center on September 14, 2007. KAGUYA consists of a main orbiting satellite at an altitude of about 100km, and two small satellites (Relay Satellite and VRAD Satellite) in moon's polar orbit. The waveform capture (WFC) [1] is one of the subsystems of the Lunar Radar Sounder (LRS)[2] on board the main orbiter of the KAGUYA spacecraft. The WFC measures two components of electric wave signals detected by the two orthogonal 30 m tip-to-tip antennas from 100Hz to 1MHz. By taking advantage of a moon orbiter, the WFC is expected to measure plasma waves related to the solar wind-moon interaction, and radio emissions to be observed from the moon. The extension of the two orthogonal antennas and the initial check out of LRS/WFC was successfully performed in the end of October, 2007. In the present paper, we briefly introduce the overview of the WFC, and report some initial results obtained in the initial observation.

2. Scientific Objectives and Instruments Design of the WFC

The scientific objectives of the WFC are roughly classified into two viewpoints. One is the science at the moon (lunar science) and another is the science from the moon (extra-lunar science). The former is the science of the plasma physics related to the moon itself. One of the most specific phenomena of interest to be obtained from the WFC data is the dynamics of lunar wake. Another scientific topic at the moon is the plasma physics related to a mini-magnetosphere caused by the magnetic anomaly of the moon. As for the extra-lunar science, various kinds of plasma waves and radio waves originating from the sun and the earth and other planets are expected to be observed by taking advantage of a moon orbiter.

The main electrics of the WFC consist of two kinds of passive receivers named WFC-H and WFC-L. The signals detected by the two orthogonal 30 m tip-to-tip antennas are processed by a high-performance and multi-functional software installed in the DSP (digital signal processor) implemented in the main electronics. The WFC-H is a fast sweep frequency analyzer covering the frequency range from 1 kHz to 1MHz. By introducing the hybrid IC called PDC in the WFC-H, spectral analyzer with very high time and frequency resolution was realized. On the other hand, the WFC-L measures waveforms in the frequency range from 10 Hz to 100 kHz. New techniques such as digital filtering, automatic filter selection and data compression are also implemented in the DSP software for the data processing of the WFC-L in order to extract the important data adequately under the severe restriction of the total amount of telemetry data. The data rate assigned for the WFC is 4/80/160 kbps. Due to the restriction of the power consumption and telemetry budget, available telemetry rate for the WFC depends on the observation modes of the other subsystems of the LRS. Under the restriction of the telemetry rate, both the WFC-H and WFC-L are operated with various kinds of observation modes controlled by the DSP software.

5. Initial Observation

The extension of the two orthogonal antennas and the initial check out of LRS/WFC was successfully performed in the end of October, 2007. The background noise level of the receiver was firstly examined and we found that the data quality is satisfactory based on the EMC (electro-magnetic compatibility) criteria, which was enacted to meet our scientific requirements.

In the initial checkout phase of KAGUYA from the end of October to middle of November 2007, data acquisition of the WFC was continuously performed almost 24 hours a day. In this period, KAGUYA is in the solar wind and several kinds of natural plasma waves were observed. In the higher frequency range around a few hundreds kHz, radio emissions such as AKR (auroral kilometric radiation) and type III bursts were observed so far.

The most interesting spectral feature obtained by the WFC is intense electrostatic wave, which is assumed to be UHR or Langmuir wave. This wave is constantly observed in the frequency range of 10-20kHz in the sunlit region in the solar wind, while the frequency suddenly decreases in the shade (occultation) region. This feature is quite similar to the observation by the WIND spacecraft [3] when WIND crossed the lunar wake at a distance of ~6.8 lunar radii. On the other hand, KAGUYA orbits the moon at an altitude of 100 km and the encounter of the lunar wake occurs in much closer region and varieties of frequency transition were observed at the boundary of the sun-lit and shade region depending on the orbital condition of KAGUYA, suggesting the spatial structure of the lunar wake.

5. Conclusion

We developed a high performance and multifunctional software receiver named WFC for the measurement of plasma waves and radio emissions onboard KAGUYA. Because of the flexibility of the instruments, various kinds of observation mode were achieved. KAGUYA was shifted to the nominal operation phase in the middle of December, 2007. Detailed analysis is now under going and we expect the WFC to bring a lot of scientific outputs.

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7. References

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