Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM26-P01 Room:Convention Hall Time:May 23 18:15-19:30

Spectral Analysis of the Electron Density Fluctuation in the Solar Corona obtained by Radio Occultation Experiments

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Coronal radio occultation experiments were carried out using the Akatsuki spacecraft from June 6, 2011 to July 8, 2011. The radio waves were transmitted from the spacecraft toward the Earth and probed the plasma in the solar corona on the way to the ground station. Due to the movement of small-scale density irregularities across the ray path, the frequency and intensity of the received signal undergo temporal variations. The frequency fluctuation is proportional to the rate of change of the electron column density along the ray path. Based on the substantial interest in the acoustic waves in the corona, we examined the radial dependence of the characteristics of the waves, such as the period, the density amplitude and the energy flux, by wavelet analysis of the electron density fluctuations in the region from 1.5 to 20.5 Rs (solar radii) obtained by radio occultation.

The overall spectral fluctuations at 3.5-20.5 RS have near power-law dependences over the frequency interval 10^{-3} Hz $< f <$ 10^{-1} Hz (periods of 10-1000 s) and those at closer heliocentric distances have prominent excess power above the background. By further investigation, quasi-periodic disturbances having periods of 100-3000 s were detected at 3.5-10.5 Rs, while periods exceeding 3000 s were also observed at 1.5-2.4 Rs. Our result suggests that quasi-periodic fluctuations occur also at closer distances than suggested by previous studies. It was also found that the coherence time of each event is typically comparable to its period. Amplitudes of the density fluctuations were estimated to be 0.2-40% of the background density in the maximum estimate. We also estimated the energy fluxes of these sporadic events on the assumption that the observed fluctuations are manifestations of acoustic waves. The maximum estimates of the energy fluxes are about 10 erg cm^{-2} s^{-1}, which does not satisfy the coronal heating requirement, although we cannot directly compare the present estimate with the requirement at the bottom of the corona. The estimates are also much smaller than the previous theoretical prediction of acoustic wave fluxes secondary generated from Alfven waves.

Keywords: corona, radio occultation, sound wave, wavelet, Akatsuki

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PEM26-P02 Room:Convention Hall Time:May 23 18:15-19:30

Similarities of upstream whistler-mode waves observed in the solar wind

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Narrowband whistler-mode waves whose frequencies close to 1 Hz have been observed near the Moon by WIND [Farrell et al., 1996], Geotail [Nakagawa et al., 2003], Lunar Prospector [Halekas et al., 2006, 2008], and Kaguya spacecraft [Tsugawa et al., 2011]. These waves are propagated upstream against the solar wind and Doppler-shifted in the spacecraft frame to be left-hand polarized. Similar waves have been observed in the upstream regions of many solar system bodies over four decades and have been called '1 Hz waves' [e.g., Heppner et al., 1967; Russell et al., 1971; Fairfield, 1974; Orlowski et al., 1990, 1995; Brain et al., 2002]. However, some unclear issues in their propagation and generation processes have not been solved, such as required condition to observe the waves, spectral formation mechanism, and the frequency dependences of the processes.

In the present study, we compare the waves in different regions to answer the issues. We investigate common properties of the waves observed by Kaguya at 100 km altitude of the Moon and by Geotail in the upstream region within 20 R_E from the Earth's bow shock. Group velocity vectors of the waves in both regions are going to cancel the solar wind velocity vector. This condition is required to observe the waves and would make the narrowband spectra. We suggest that the wave frequency is determined so as to satisfy the condition. We reveal that the wave propagation angles in the upstream region of the Earth's bow shock are typically in the range of 20?40 degrees and are smaller than those near the Moon which are in the range of 20?70 degrees. This result suggests differences of the wave generation and damping processes.

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PEM26-P03 Room:Convention Hall Time:May 23 18:15-19:30

Fine spectral structures of a solar radio type-II burst observed with AMATERAS

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Solar radio type-II bursts are metric to hectometric radio bursts that show frequency drifting spectral structures caused by the plasma emission from shock-accelerated electrons. The emitting frequencies of them are close to the local electron plasma frequency and/or its harmonics. The burst has a rapidly drifting fine structure in their spectra called "herringbone" [Roberts, 1959], which is composed of both negative (toward Interplanetary) and positive (toward sun) drifting burst elements. They are interpreted as the motion of non-thermal energetic electron beams accelerated by the shock. However, the particle acceleration mechanism of them has not been fully understood. The purpose of this study is to extract characteristics of the fine spectral structures of type-II bursts from high-resolution observations and investigate the acceleration processes.

AMATERAS (the Assembly of Metric-band Aperture Telescope and Real-time Analysis System; Iwai et al., 2012) is a ground-based solar radio telescope developed by Tohoku University. This system enables us to observe solar radio bursts in the frequency range between 150 and 500 MHz with the 10 ms accumulation time and 61 kHz bandwidth, which is suitable for observing characteristics of fine structures of solar radio bursts. A type-II burst event was observed on November 12, 2010, which showed distinctive fine spectral structures. We derived the following properties of the fine spectral structures;

1. Negative drift elements were found more frequently than positive drift elements.

2. In many cases, the start frequencies of the positive drift elements located near the center frequency of the main spectral structure of the observed type-II .

3. The mean value and standard deviation of the derived beam velocities increased with increasing radial distance of the radio source region from the solar surface.

Keywords: solar corona, particle acceleration, ground-based observation

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PEM26-P04 Room:Convention Hall Time:May 23 18:15-19:30

Narrowband fiber bursts (NFBs) in type IV bursts observed with IPRT/AMATERAS

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Solar Type IV bursts are a type of intense radio phenomenon that accompanies solar flares. Following the discovery by Elgaroy (1959), many observations have suggested that Type IV bursts are accompanied by several kinds of spectral fine structure. One type of prominent fine structure is fiber bursts, which are generally assumed to be emitted through the wave-wave coupling between Langmuir waves and whistler-mode waves propagating in the corona. Recent observations in a frequency range of several GHz with high frequency and time resolution have revealed that narrowband fine structures similar to fiber bursts occur in Type IV bursts. In the meter-wavelength range, however, few spectral observations with high resolution have been carried out, unlike at decimeter wavelengths.

In the present study, we have investigated the fine structures in a wide frequency range from 100 to 500 MHz, obtained with a large-aperture radio telescope and a high-frequency and high-time resolution spectrograph, the Assembly of Metric-band Aperture Telescope and Real-time Analysis System (AMATERAS) installed on the Iitate Planetary Radio Telescope (IPRT) was developed by Iwai et al. (2012) and enables us to observe solar radio bursts in the frequency range from 150 to 500 MHz with a time resolution of 10 ms, a frequency resolution of 61 kHz, and a minimum detectable flux of 0.7 SFU. Moreover, both left- and right-handed polarized components can be observed simultaneously. The resolution of IPRT/AMATERAS for observations of metric solar radio bursts is the highest in the world as of January 2013.

We analyze Type IV bursts observed on 7 June, 2 and 4 August, and 6 September 2011 with IPRT/AMATERAS. They consist of the spectral fine structures drifting within narrow-frequency bands. In this study, these fine structures are termed as narrowband fiber bursts (NFBs). They are similar to the phenomena previously reported by Elgaroy and Sveen (1979) in the meter-wavelength range, and Chernov et al. (2008) in the decimeter range. The present analysis of the event on 7 June 2011 reveals the following results: (i) the individual NFB has a negative frequency drift with about -30 MHz s^{-1}, (ii) NFBs exhibit two types of large-scale frequency drift, characterized by negative and positive frequency drift rates, (iii) the negative frequency drift rate is almost the same as that of the individual NFB, while the positive one is about 90 MHz s^{-1}.

Based on the observed characteristics, we discuss the generation mechanism of NFBs as follows: (i) the observed negative frequency drift rate of NFBs can be explained by the propagation of whistler-mode waves in the corona, (ii) the observed frequency interval of NFBs is too small to account for it by the double plasma resonance (DPR) theory, which was applied to similar phenomena in the frequency range above 1 GHz (Chernov et al., 2008), and (iii) a new model is proposed in which a single NFB is emitted from a localized micro-scale emission region and widely distributed emission regions form a group of NFBs. We suggest in the proposed model that the regions are generated by upward whistler-mode waves and intermittent downward-propagating electron beams.

In this presentation, we report the analysis results of NFBs and discuss the generation mechanisms.

Keywords: Sun, radio, Type IV burst, AMATERAS