【2004／成果発表会】プロジェクトNo.3 宇宙の神秘を探る 担当教員：斎藤郁夫 Vladmir B.Riabov 川口聡

木星からの電波信号解析
The Study of Radio Signals from Jupiter.

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内容 Content

Jupiter

前期の学習で、木星の衛星イオの荷電粒子と木星の相互作用によって、木星デカメートル電波というものが発生する事を学んだ。この電波の構成要素の一つであるＳバーストは、周波数が磁場の強さに比例する特徴がある。また、木星の磁場の強さは木星中心からの距離に反比例する。これらのことをもとに、私達はＳバーストの周波数帯を探ることによって、Ｓバーストの発生源を把握しようと試みた。

In last term, we studied the Jovian decametric radio emission that occurs due to interaction of charged particles with magnetic field near one of the Jovian moons Io and Jupiter. The frequency of S-burst, which is a component of Jovian decametric radio emission, is proportional to the magnitude of the magnetic field. Furthermore, the magnitude of the Jovian magnetic field is inversely proportional to the distance from Jupiter. Taking this into account, we study the frequency band of S-burst and try to find out S-burst location.

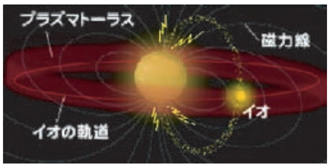
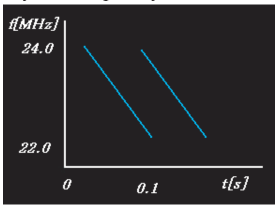


Fig.1 Jupiter and Io

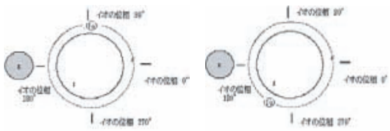
Io Plasma Torus is formed by the particles ejected from volcanoes on the surface of one of the Jovian moons Io along its orbit. When the electric current between Io and Jupiter composed of the charged particles from the Io Plasma Torus captured by Jovian magnetic field breaks, decametric radio emissions, and S-bursts in particular, are emitted.



S-burst is called the radio emission which drifts down on the time-frequency plane, a few MHz in about 0.1sec.

◀ Fig.2 Character of S-bursts

▼ Fig.3 Relation of S-bursts and Io phase



If Io orbital phase is about 90 or 240 degrees, the probability of S-burst Io-related storm is high.

Windowed Fourier Transform & Continuous Wavelet Transform

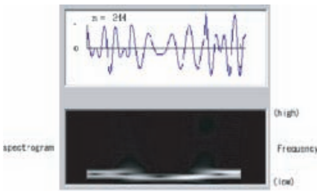


Fig.4 Windowed Fourier transform

Windowed Fourier Transform (WFT) is a method of signal processing designed to analyze periodic components contained in the signal of finite duration (finite size of the time window). Both the frequency and time resolution depends on the window size, which is fixed.

Continuous wavelet transform is a method of analysis aimed at detecting certain patterns (called wavelet) in the signal.

The difference compared to the windowed Fourier transform consists in the changing shape and duration of the time window, depending on frequency resolution.

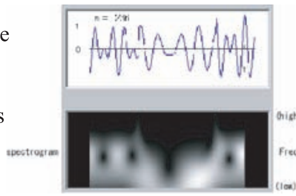
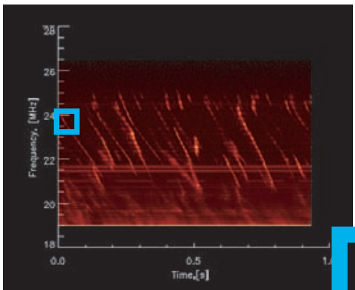


Fig.5 Continuous wavelet transform

Data Analysis

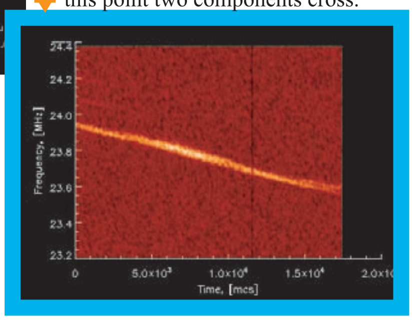


▲ Fig.6 S-burst spectrogram

We analyzed several S-bursts and forcused on the study of their frequency band.

The signal analysis on the time-frequency plane was performed with WFT. The pattern shows frequency going down a few MHz in about 0.1 sec.

This is the starting segment of the S-burst shown in Fig.6. If the frequency resolution is high enough (depends on size of time window in WFT), we can identify two crossing components. The center of the signal has higher intensity, because at this point two components cross.



▶ Fig.7 Zoom of an S-burst

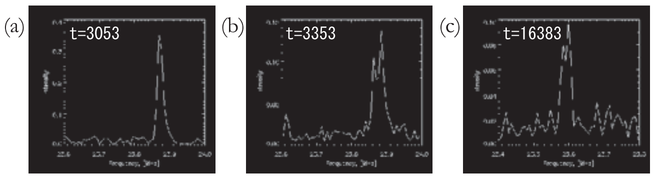


Fig.8 Power spectra before and after crossing point of the two S-bursts

Instantaneous power spectra of S-bursts shown in Fig.7: before the second component appears (a); double peaks at the left of the crossing point (t=3,353 mcs) (b) and at the right of the crossing point (t=16,383 mcs) (c).

考察と結論 Discussion and Conclusion

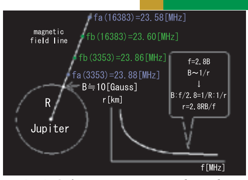


Fig.9 S-burst starts and ends at certain distance from Jupiter

From Maxwell theory, high frequency of S-burst means small distance from Jupiter. Jovian radius R is about 70,000 km. First burst (a) starts at ~12,077 km and ends at ~13,121 km from the surface of Jupiter. The second burst (b) starts at ~12,146 km and ends at ~13,051 km from the surface of Jupiter.

Both methods, WFT and CWT, brought similar results that make very little difference in the two images. Because shape of window function and wavelet are very similar, same results was obtained.

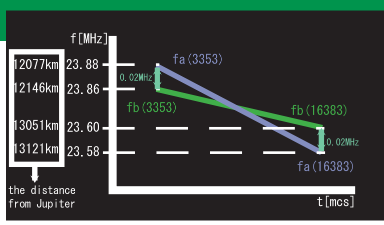


Fig.10 S-burst starts and ends at certain distance from Jupiter