§5. Spontaneous Excitation of Pulsed Magnetic Fluctuations in HYPER-I

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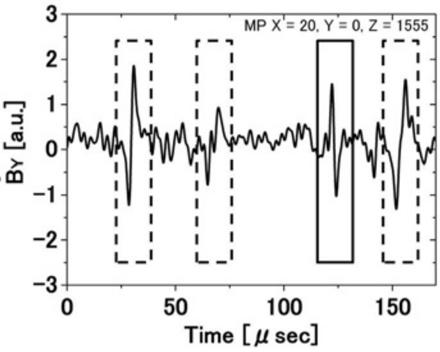
Spontaneous excitation of pulsed fluctuations has been observed in various regions of the geomagnetosphere. Excitation of electrostatic solitary waves (ESWs) due to highly nonlinear evolution of the electron beam instability is a representative example. Intense magnetic field fluctuations associated with magnetic reconnections have also been observed. Recently, the spontaneous excitation of pulsed magnetic fluctuation has been observed in the HYPER-I device.[1] However, the detailed spatial structure and the excitation mechanism have not been elucidated yet. Here we report the experimental results of waveform measurement with a magnetic probe (B-dot probe).

Helium plasmas were used in the present experiments, where the input microwave power and the helium gas pressure were 20 kW and 1.5 mTorr, respectively. The typical electron temperature and the electron density measured with a Langmuir probe were 10 eV and 10^{17} m^{-3}, respectively. The magnetic probe consists of a pickup coil (100 turns, 1.5 mm diam.) made of polyimide insulated copper wire whose diameter is 0.1 mm. An alumina insulating tube (8 mm diam.) is used for protecting the pickup coil from surrounding plasma. This magnetic probe can measure the magnetic fluctuation whose frequency is up to 400 kHz. The magnetic probe was installed in a radial probe-driving system located at the axial position of z=1555 mm from the microwave injection window.

In the magnetic probe measurement, the magnetic fluctuation was observed as a solitary-wave-like structure in the y-axis direction that is perpendicular to the external magnetic field. The width and amplitude of the magnetic fluctuations are obtained by integrating the magnetic probe signals. The typical pulse width determined with the conditional averaging method was of the order of 10 μs. The maximum amplitude of the magnetic fluctuations was 60 μT, which is approximately 0.1 % of the external magnetic field intensity.

Typical time-series data of the magnetic probe signals measured at x=±20 mm are shown in Fig. 1, where the rectangle of solid line and the rectangle of dotted line indicate a positive magnetic fluctuation and a negative magnetic fluctuation, respectively. It is evident that the solitary-wave-like magnetic fluctuations are excited intermittently. The polarity of the predominant magnetic fluctuations in Fig. 1(a) is negative; on the other hand, that in Fig. 1(b) is positive. By comparing Fig. 1(a) with Fig. 1(b), it is clearly shown that the polarity of the predominant magnetic fluctuations is reversed at different radial positions. In order to clarify the spatial structure of the magnetic fluctuations, we measured the radial distribution of the positive and negative magnetic fluctuations. Figure 2 shows the radial distribution of the number of magnetic fluctuations. The polarity of predominant magnetic fluctuations is reversed at the center of the device. It is suggested that the magnetic fluctuations consist of an azimuthal component. This result implies that the excitation of the pulsed magnetic fluctuation is attributed to an intermittent current induced along the magnetic field lines at the center of the plasma.

(a)



(b)

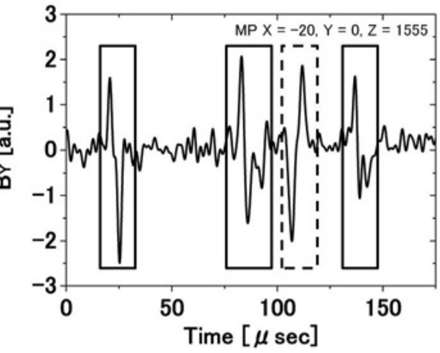


Fig. 1. Examples of the magnetic fluctuations observed with a magnetic probe located at the radial position of (a) x=+20 mm and (b) x=-20 mm. Waveform data are shown over a 175 μs time interval.

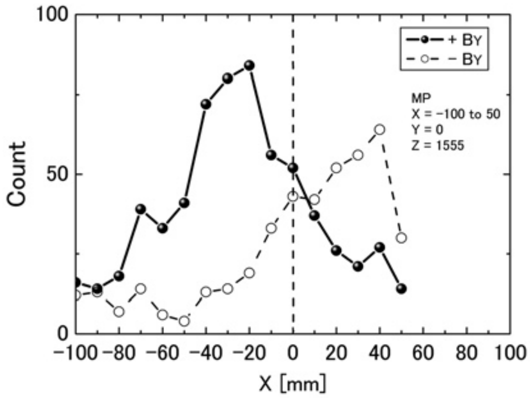


Fig. 2. Radial distributions of the number of magnetic fluctuations observed at z=1555 mm. The vertical axis is the number of magnetic fluctuations exited in the time interval of 10 ms. The closed circle and the open circle indicate the number of positive magnetic pulses and that of negative ones, respectively.

1) Nakano, H., et al., ICPP2008 Abstracts, 249 (2008).