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Observation of plasma ejection through the last closed flux surface in a microwave spherical torus on LATE

LATE マイクロ波球状トーラスにおける最外殻磁気面からの噴出現象の観測

Kenichi Nagao, Hitoshi Tanaka, Masaki Uchida, Yoshitaka Nozawa, Kengoh Kuroda, Manato Wada, Atsushi Yoshida, Takashi Maekawa

永尾剣一、田中 仁、打田 正樹、野澤 嘉孝、黒田賢剛、和田真門、吉田篤史、前川 孝

Graduate School of Energy Science, Kyoto University
Kitashirakawaoiwaketyou, Sakyo-ku, Kyotocity 606-8502, Japan
京都大学大学院エネルギー科学研究科
〒606-0952 京都市左京区北白川追分町

When we generate a microwave spherical torus in the LATE device by electron Bernstein (EB) wave heating, the plasma density increases along with the increase in plasma current Ip, and the line-averaged electron density amounts to seven times of cutoff density. At this time, When the density increases and the plasma current Ip exceeds ~5 kA, intermittent spikes in magnetic probe (MP) signals is observed. And repetition of this causes saturation of gradual decrease of the density and the plasma current. We investigate by MP signals, and plasma images how this plasma ejection appears when discharge condition is changed.

1. Introduction

The spherical tokamak (ST) is a tokamak with an extremely low aspect ratio (R/a, where R is the major radius and a is the minor radius), and has a large β value, so that it can hold the stable plasma. Microwave spherical tokamak plasma, which has no central solenoid (CS), is started up only by microwave. In this study, we observed the plasma using the LATE device.

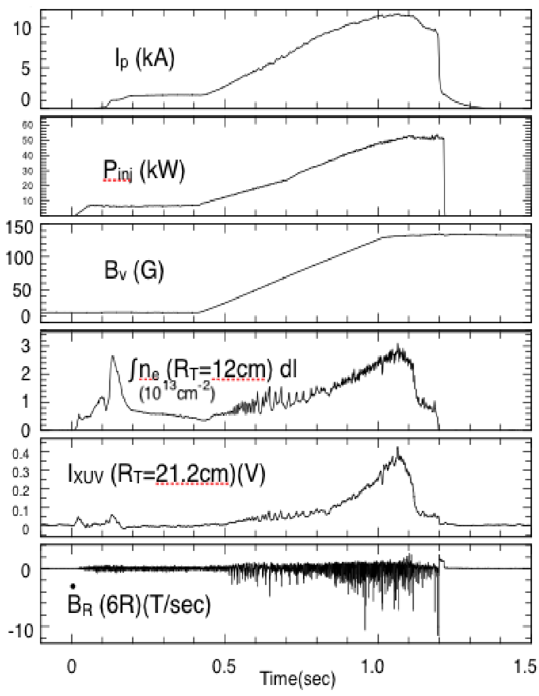

Fig.1. Discharge waveform

Figure 1 shows a discharge waveforms in the high-density discharge experiment which was carried out. In the high-density discharge experiment of the LATE plasma, a phenomenon that plasma ejects to the outside from the inside of the magnetic surface across the last closed flux surface(LCFS) is observed.

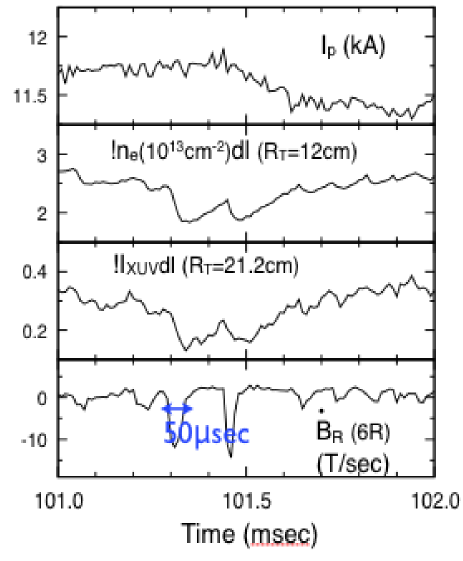

Fig.2. Discharge waveform(time expansion)

When this occurs, in Figure 2, which is time-expansion of Figure1, the spike-like signals of more than one magnetic probe (MP) are observed. Along with then, a decrease of line electron density is also observed.

When the density increases and the plasma current Ip exceeds ~5 kA, intermittent spikes in MP signals is observed. The interval between spikes is not periodic but the averaged interval becomes short as Ip increases. The width of spikes is ~50μsec so that measurement by the magnetic probe which has high time resolution is very effective.

2. MP Signals

In order to improve the reliability of the measurement by the magnetic probe, the frequency characteristics of the magnetic probe is measured.

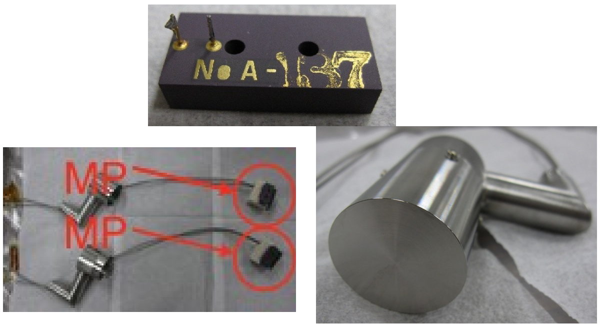

Fig.3. Photographs of magnetic probe

Figure 3 shows photographs of magnetic probe(single) and magnetic probe(stainless steel shield box). Magnetic probe (single) is put into stainless steel shield box to protect a noise by the microwave in this experiment.

Frequency characteristic of MP(single) is several hundreds kHz. On the other hands, this of MP (stainless steel shield box) is unknown, so measurement of this is important.

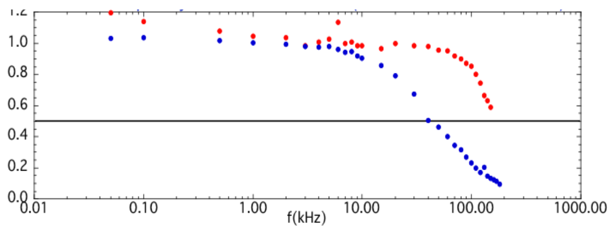

Fig.4. Frequency characteristics

Figure 4 is the result. A horizontal axis is frequency, and a vertical axis is the value which is normalized by the constant value of up to 10kHz of the magnetic probe signal. Frequency characteristics of MP (single) shown in red is above 100kHz. Frequency characteristics of the magnetic probe(stainless steel shield box) shown in blue is about 40kHz. This result shows that further improvement of the stainless steel shield is required.

3. Plasma Images

Figure 5 (A)(B)(C) is the plasma images which are made to correspond to the start point, lowest point , and finish point of magnetic probe(MP) spike.

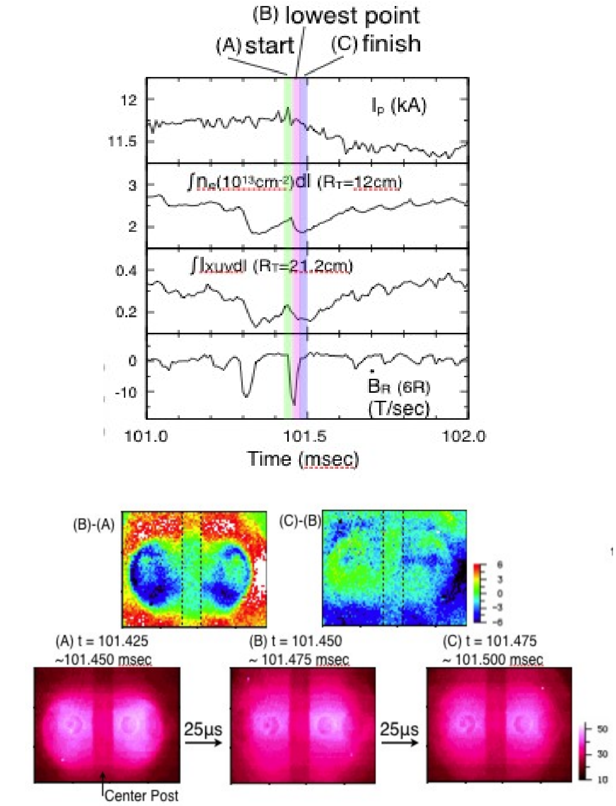

Fig.5. plasma images which are made to correspond to (A)the start point, (B) lowest point, (C) finish point of MP spike

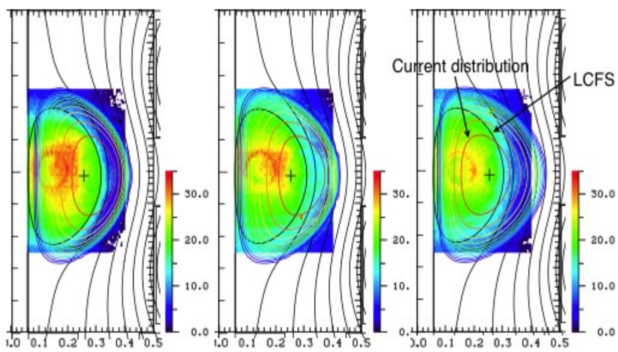

Fig.6. LCFS and current distribution

The differences between the emission intensity of each image are shown as (B)-(A) and (C)-(B). In addition, the LCFS and the current distribution which are superimposed on the plasma images at each time is displayed in Figure 6. Figure 6 shows that the plasma protrudes to the outside of the LCFS at the lowest point of the spike, and at the same time, plasma is reduced in interior of the flux surface. This shows that a spike signal of magnetic probe is an ejection phenomenon that plasma flows out from LCFS.