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Measurement of ion temperatures in plasma blobs by using statistical analysis methods

統計的解析手法を用いたPlasma Blob中のイオン温度計測

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Heat load caused by plasma blobs is thought to be attributed by the energy of ions. Thus, measurement of ion temperature in plasma blobs is important. In this research, we measured the ion and electron temperatures in plasma blobs observed in a linear plasma device by using an improved ion sensitive probe and statistical analysis methods. As a result, it was found that ion and electron temperatures in the plasma blobs decrease more slowly than those outside of plasma blobs in the radial direction

1. Introduction

Intermittent convective plasma transport in fusion edge region called a blobby plasma transport is thought to be one of the most important phenomenon. The plasma blob propagates toward the cross-field direction in scrape-off layer of tokamak devices. The blobby plasma transport is thought to enhance particle and heat fluxes onto a first wall and total kinetic energy of plasma blobs near the wall could be mainly determined by ion temperature (T_i). Therefore, the ion temperature in plasma blobs is necessary to estimate the convective heat transport by the plasma blobs.

The blobby plasma transport has been widely investigated at not only tokamaks but also linear and helical devices. In this study we will investigate radial distribution of ion temperature to investigate how the cross-field transport could affect the temperature distribution by using an ion sensitive probe (ISP) and statistical analysis methods in the linear divertor plasma simulator NAGDIS-II [1].

2. Experimental Setup

In order to measure the T_i in plasma blobs, an ISP [2,3] that was combined with a single Langmuir probe (LP) was newly developed, as shown in Fig. 1. In addition, it is necessary for precise measurement of the T_i to reduce noise components in high-frequency domain as much as possible, because the blobby plasma transport is a high-speed phenomenon. Therefore, we have reduced noise level by an improvement of measurement system, as described in Fig.1. In this circuit, two electrodes of the ISP were isolated by using two bipolar power supplies and two wave generators. Moreover, length of transmission cables between the electrodes and the digitizer were set as short as possible.

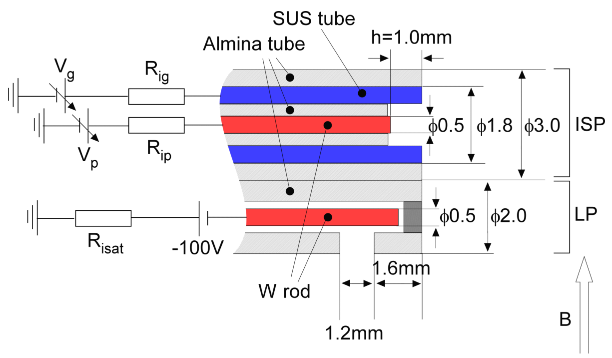

Fig.1. Improved measurement system and structure of the new probe head composed of ISP and single LP.

3. Analysis Procedure

Figure 2 shows a diagrammatic illustration of the analysis procedure. A positive spike in ion saturation current (I_{sat}) was observed when a plasma blob passed across the LP because the fluctuation of I_{sat} is mainly proportional to that of plasma density. Thus, we can detect the times when plasma blobs passed and didn't pass through the LP by setting a proper threshold value for the I_{sat} fluctuation. Before detecting the positive spikes in the I_{sat}, numerical low-pass filter based on fast Fourier

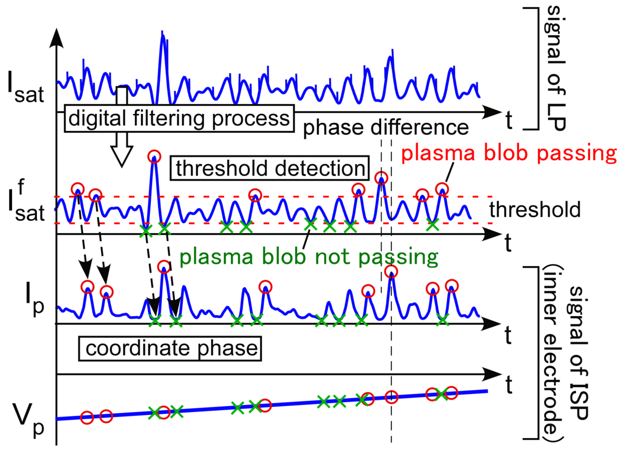

Fig.2. Outline of analysis procedure.

transform was applied to the I_{sat} signal in order to obtain the filtered I_{sat}^f, because the high frequency noise in I_{sat} attributes a false detection of the positive spikes which correspond to the plasma blobs.

In the next step, ion current (I_p) and voltage (V_p) at the detected times were extracted, where the I_p and V_p were measured by the inner electrode of the ISP. Because there was finite internal distance between the electrodes of the ISP and the LP, we took the time delay of those signals into account. Finally, we reconstructed I_p-V_p characteristics inside and outside of the plasma blobs, and then, we calculated T_i of them.

4. Experimental Result

The I_{sat} and I_p fluctuations were measured simultaneously at positions ranging from $r = 10$ mm (edge of the plasma column) to 30 mm every 2 mm in the radial direction.

Reconstructed I_p-V_p characteristics with and without plasma blobs at r = 24 mm are shown in Fig. 3(a). Figure 3(b) shows the radial distributions of T_i evaluated from the reconstructed I_p-V_p characteristics. Additionally T_i obtained by the conventional method with all signal is plotted. It was found that T_i in the plasma blobs is higher than that outside the plasma blobs. This result suggests that the thermal load was increased by existence of the plasma blobs at the plasma periphery .

Next, we evaluated decay rates of the T_i distributions. The decay rate was defined as the following equation:

$$\text{decay rate} \equiv \frac{\Delta T}{\Delta r} = -\frac{T_{r=20} - T_{r=10}}{20-10}. \qquad (1)$$

The decay rates of the ion temperatures with and without the plasma blobs are 0.048 and 0.074, respectively. It was found that the decay rate with plasma blobs tends to be smaller than that outside of the plasma blobs. This result suggests that the T_i gradient would become loose due to the plasma blobs.

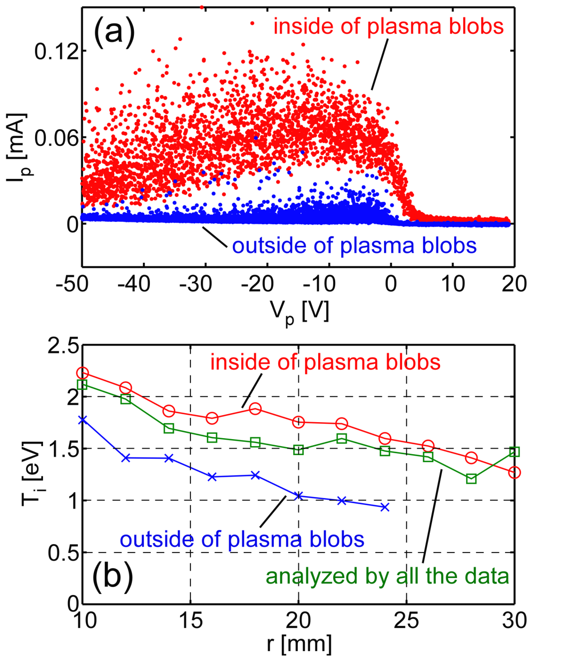

Fig. 3(a) Reconstructed I_p-V_p characteristics at r = 24 mm and (b) radial distribution of the ion temperatures with (circle) and without plasma blobs (cross).

5. Summary

We developed an ion sensitive probe measurement to measure the ion temperature inside and outside of the plasma blobs observed in the linear plasma device. As a result, it was confirmed that ion temperature increase by the coming of plasma blobs, qualitatively. Furthermore, it should be noted that the decay rate of the ion temperature in a radial direction became gradual.

Acknowledgments

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