25D02

Radial propagation of blobs in ECR plasmas on QUEST
QUEST のＥＣＲプラズマにおける blob の径方向伝搬

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An investigation of radial propagation of blobs and related particle flux has been performed in non-confined cylindrical electron cyclotron resonance heating plasmas on QUEST using a combination of a fast-speed camera and a Langmuir probe array. The radial propagation of the blobs is found to be driven by **E**×**B** drift induced by charge separation and they had been accelerated in concordance with the previously-proposed model, where **E** and **B** is the respective electric and magnetic fields. It found that radial particle flux related to the blobs sometimes reached to more than 60% of total particle flux. In between the narrow arranged blobs, related inward particle flux of background plasma was observed.

1. Introduction

Recently, intermittent burst ejections of plasma agglomerations called as “blobs” in scrape-off layer (SOL) regions were frequently observed in many types of magnetic confinement devices such as NSTX [1], Alcator C-Mod [2], DIII-D [3] and LHD [4]. They are basically generated from a radially-elongated structure arising from an interchange instability [5] and have a possibility to drive huge amount of energy and particle fluxes in edge regions. As the result, the blobs may force to modify a ready-made concept of SOL plasmas and therefore, many efforts have been made in order to understand the physics mechanism of blobs in many experiments related to fusion research, however their characteristics are not yet well understood because of its complicated nature such as inherently 3-dimentional and adelomorphous structure.

Especially, radial propagation of blobs has been extensively investigated in view of their impact on plasma-wall interaction (PWI) [6, 7]. According to one introductory model describing radial propagation velocities [8], the blobs basically propagated into the low field side riding on **E**×**B** drifts, where **E** and **B** is the respective electric and magnetic fields, here perpendicular to each other. The electric field can be formed initially by a self-induced charge separation due to grad **B** fields and curvature drifts, and maintained at a certain value via current through the sheath at the attachment region of the metallic walls [8], ion polarization current [9], and current induced by an ion-neutral friction force [10].

Instead of directly investigating edge plasmas in fusion related devices, several simulated experiments on well-controlled and diagnosed plasmas have been executed. Blobs have been found out in electron cyclotron resonance (ECR) heating plasma in QUEST and a measurement system combined a Langmuir probe with a fast camera has been applied to investigate their behavior[11,12].

2. Experimental apparatus and results on radial velocity of blobs

The experiments were done in Q-shu Univ. Experimental Steady-State Spherical Tokamak (QUEST), which is medium-sized ST in Kyushu University [13]. A RF system of 2.45 GHz, 50kW, CW was used for ECR plasma production. In Fig 1, a typical behavior of a blob measured by the fast camera is shown.

In Fig. 2, a comparison of $V_{E\times B}$ (velocity of **E**×**B** drift), V_{image} (velocity estimated by a series of fast camera images), and V_{th} (velocity predicted by the theory [14] calculated using the measured plasma parameters) are plotted. Every velocity is coincident each other. This indicates that the blobs are driving on **E**×**B** drift and the formed **E** can be predicted by the previously-proposed theory. In our experiments, it found that the dominant return current process to satisfy grad **j** = **0** was sheath current at the area attaching to plasma facing component (PFC) [15]. This indicates that the blobs in QUEST are in the same situation of those in SOL plasmas on fusion experimental devices such as ITER.

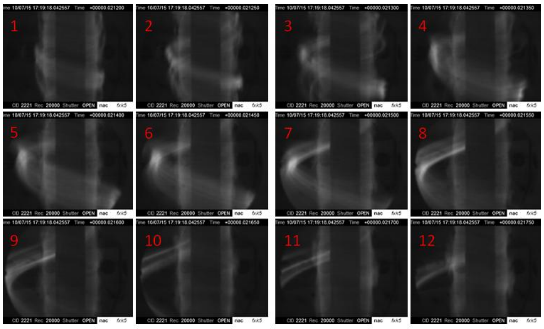

Fig. 1 Time evolution of a typical life of a blob, detach from the main plasma, radially propagate and interact with the first wall. Images were measured with the fast camera of 20000 FPS from 21.2ms to 21.75ms correspond to frame 1 – 12, shot No.:9618#.

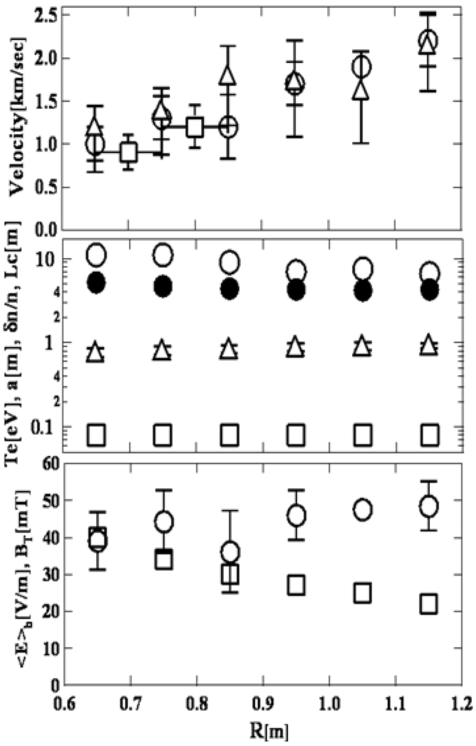

Fig. 2 Top: the radial profiles of the $V_{E\times B}$ (circles), the V_{image}(squares) and V_{th}(triangles). Meddle: Electron temperature (circles), δn/n (squares), blob size (triangles), and connection length (solid-circles). Bottom: the radial profiles of $\langle E \rangle_b$ (circles) and B_T (squares). Where the B_z of ~16mT was applied on the mid-plane region [15].

3. Experimental results on particle flux

For investigating the blob-related interaction with PFC, induced radial particle fluxes related to radial propagation properties of blobs should be investigated. A radial net particle flux due to blobs reached at the maximum value of 3.6×10^{20} $m^{-2}s^{-1}$ near PFC in this experiment. Comparison this flux with parallel particle flux expressed as

$$\Gamma_z \approx 0.5 n_e C_s (B_z / B_t)$$

was done and as the result,the radial particle flux due to blobs reached to more than 60% of total particle flux, where n_e, C_s, B_z, B_t show electron density, sound velocity, vertical and toroidal magnetic field, respectively. More than 60% of total radial particle flux was delivered by high-amplitude fluctuation related to the blobs, which sheared by 10% of total number of fluctuation.

Moreover inward particle flux of background plasmas due to electric field induced by blobs was observed. It seems to be candidate of inward pinch of impurities in SOL plasmas

Acknowledgments

This work was performed with the support and under the auspices of the NIFS Collaboration Research Program (NIFS05KUTRO14, NIFS08KUTRO022).

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