§29. Pellet Injection Experiments into Toroidal Plasmas for Studying Plasma Transport in Stochastic Magnetic Field

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We have been studying Ultra-low-q (ULQ) plasmas not only for exploring compact fusion reactors but also for understanding plasma physics in the intermediate regime between tokamak and RFP (e.g., in ULQ plasmas the stability with negative shear configuration has been intensively studied, and dynamo effect plays an essential role, as well.[1]). In ULQ plasmas some interesting features such as anomalous plasma resistance, strong ion heating and high energy electrons have been observed experimentally, similar with those in RFP plasmas. Especially, production mechanism and radial transport of these high energy electrons give a fruitful information on ULQ/RFP plasma dynamics such as MHD/kinetic dynamo mechanism and stochastic transport due to electromagnetic fluctuations. MHD dynamo predicts that the high energy electrons might be produced at the core region[2], while kinetic dynamo, where electrons are accelerated by the applied electric field during the travel along stochastic magnetic field, produces a large population of high energy electrons at the edge region of the plasma column[3]. To this end various experiments have been conducted in RFP plasmas[4]. Here we have studied the behavior of high energy electrons in REPUTE-1 ULQ plasmas with low-Z pellet injection.

A small piece of plastic pellet with a size of 0.3 – 0.5 mm diameter is injected from the top in the REPUTE-1 device, and the trajectory of the pellet inside the plasma is measured by CCD camera system equipped at the horizontal port. We have observed a clear deflection of the pellet trajectory to the toroidal direction opposite to the plasma current (i.e., the electron drift side). This suggests that a pellet is ablated selectively only from one side due to the high energy electrons with a large heat flux. Figure 1 shows the relation between the local intensity of CI line and the local deflection rate (i.e., the 2nd derivative of the pellet trajectory), suggesting a strong correlation between each other. Around the plasma center a strong deflection of the pellet trajectory takes place, accompanied by the remarkable increase of the intensity.

Here let us discuss on the heat flux carried by high energy electrons, by evaluating the deflection of the pellet trajectory. We assume that the electron drift side of the pellet is selectively ablated by the heat flux of high energy electrons and the neutral gas spouts only from the electron drift side with the thermal velocity of the evaporation temperature. Neutral gas, therefore, yields the repulsion force acting on the pellet itself to the toroidal direction. Since the repulsion force to the pellet is calculated with the 2nd derivative of the pellet trajectory, we can estimate the heat flux of high energy electrons, and the maximum heat flux around the plasma center is calculated to be 20 – 40 MW/m^2. Since the ohmic input power is around 10 MW, a few tens percentage of the input power might be carried by the high energy electrons.

We have observed that the pellet trajectory is strongly bended around the plasma center, suggesting a large population of high energy electrons. It is also confirmed in the EEA data that the population of the high energy electrons around the edge region is small. Therefore, our results on EEA measurements and low-Z pellet experiments could support MHD dynamo mechanism for the production of the high energy electrons.

In conclusion, it is confirmed that the high energy electrons are carrying the dominant part of the plasma current and large fraction of the heat input. Experimental data by EEA measurement and low-Z pellet ablation show the large population of the high energy electrons at the core region in comparison with the edge region, suggesting a MHD dynamo mechanism for the production of the high energy electrons.

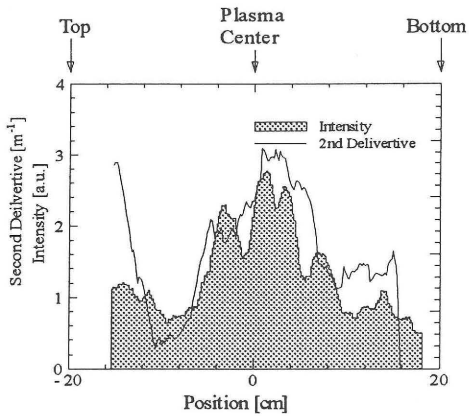

Fig. 1. The intensity of the CCD camera and the 2nd derivative of the pellet trajectory.

Reference

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