High temperature bubble phenomenon in ECR plasmas

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Intermittent phenomena, high temperature bubbles,[1] were observed in cylindrical devices with the electron cyclotron resonance (ECR) plasma production. The bubble is characterized by higher electron temperature than peripheral. It spontaneously and randomly emerges in the plasma with duration time of the order of microsecond. Radial extent is smaller than the plasma radius, while the structure elongated along a magnetic field line. In the first part of this talk, historical review and basic characteristics will be explained. Then, ion temperature variation in the bubbles and spatial structure along the field line will be presented in the middle and the last parts, respectively.

The first observation of this phenomenon was intermittent negative spikes in floating potential, which is explained by a stationary Poisson process.[2] Spatio-temporal localization[3], localized electron temperature increasing,[4] and magnetic fluctuation[5] are clarified. While these are observed in a cylindrical device, HYPER-I, with diverging magnetic field, similar phenomena have recently been observed in NUMBER with a converging field.[6]

In order to measure ion temperature (Ti) variation in localized intermittent phenomena, high time-resolution Doppler spectroscopy has been developed.[7] Measuring center fraction of Doppler broadened spectrum of ion emission using photo multiplier tubes and adopting conditional averaging method, we have obtained T_i variation. Histogram of floating potential and the center fraction of the spectrum is shown in Fig. 1. Left tail component corresponds to negative spikes in floating potential. Higher central fraction of spectrum in this region indicates lower ion temperature than the plasma without negative spikes in floating potential. Using a hollow cathode discharge tube[8] as a calibration light source, ion temperature can be deduced from the central fraction of Doppler broadened spectrum. For a certain condition, T_i = 1.6 eV inside the bubbles, while T_i = 5.0 eV in peripheral.[9] This is contrast to the electron temperature T_e = 27 eV inside the bubbles, 24 eV in peripheral. The ion temperature variation becomes smaller in higher gas pressure condition. A possible mechanism of the ion temperature decreasing is increasing ionization rate followed by production of cold ion in high electron temperature bubbles.

Spatial structure along the field line has been investigated using cross correlations between two electrostatic probes. A reference probe is fixed at r = 0. Movable probes scan radial position. In Fig. 2, radial profiles of the cross-correlation coefficient are shown; one with a distance along the field line of 0.15 m, while the other with a distance of 1 m passing through a magnetic mirror. Even in a magnetic mirror configuration with mirror ratio R ~ 3, strong correlation between the low field side and high field side along the same field line has been observed. The delay between two probes, distance of which is 1 m, is smaller than 1 us. The result suggests that the bubble elongating along the field-line is maintained not by particle transports but by electro-magnetic interactions.

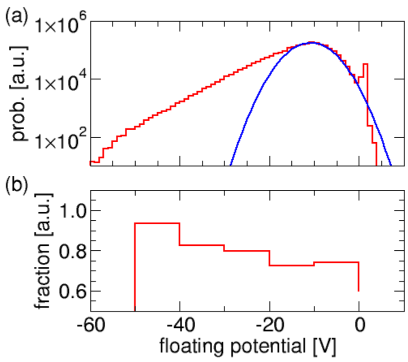

Figure 1 (a) Histogram of floating potential with Gaussian curve and (b) the center fraction of spectrum.

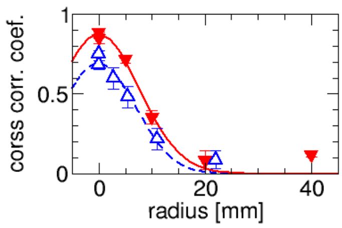

Figure 2 Radial profiles of cross-correlation coefficient of floating potential.

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