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Ion Velocity Distribution Measurement for Reconnection Heating / Acceleration Study

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We had developed a glass-tube-pair type diagnostic[1] with tomographic reconstruction[2] in velocity space to measure local ion velocity distributions in laboratory reconnection experiments. This new diagnostic reveals the radial asymmetricity of energy conversion from ion outflow energy to ion thermal energy during reconnection of two merging tokamak plasmas.

Fig. 1(a) shows the internal structure of our probe array. Each measurement area is surrounded by four flat mirrors and four optical fibers enabling us to receive ion line spectra along each view-line. For 1D profile measurement, the sets of mirrors and optical fibers are aligned in the two parallel glass tubes. All fibers are led to a spectrometer separately and finally to an ICCD camera for Doppler spectra measurements[3]. Doppler spectrum profile in each line of sight represents the distribution of the ion velocity component in the line. Using velocity component distributions in three different view-lines, we can reconstruct 2D velocity distribution with tomography techniques.

With this system, we successfully measured the radial profile of ion velocity distribution function around the diffusion region of two merging tokamak plasmas. Since all measured velocity distributions had single peaks, we defined temperature in Z and R separately as a square of each velocity component dispersion and mean velocity as a primary moment of velocity distribution for studying reconnection heating and acceleration. As shown in Fig. 1(b)(c), we observed high velocity / low temperature on the inner side of the X-point and low velocity / high temperature on the outer side of the X-point. Fig. 1(d) summarizes these results. It is probably due to ion viscosity damping of reconnection outflow. We found for the first time that the damping ratio – temperature/velocity ratio is much higher on the inner side of the X-point than that on the outer side probably due to some toroidal effect of outflow damping.

References

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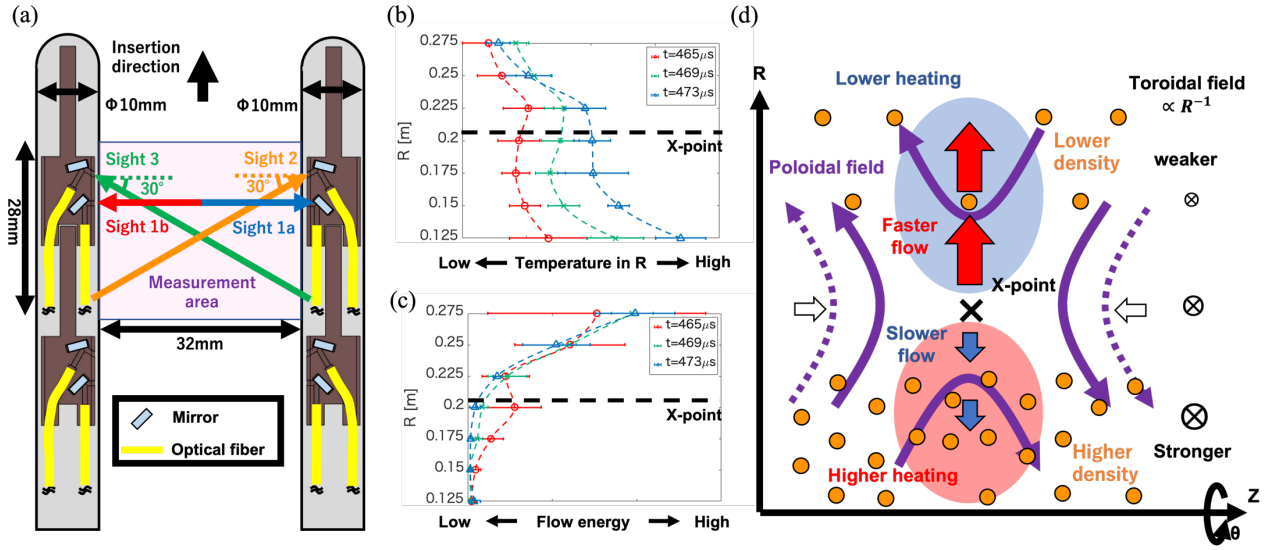

Figure 1 (a) Schematic view of glass-tube-pair type Doppler probe array for measurement of ion velocity distribution, (b) time evolution of the radial profile of ion temperature in R direction measured by our probe, (c) time evolution of the radial profile of ion flow energy measured by our probe, (d) conceptual diagram of radially asymmetric energy conversion from ion outflow energy to ion thermal energy in diffusion region of merging tokamaks.