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Development of Glass-Tube-Pair Type Doppler Probe Array for 1D Profile Measurement of Ion Velocity Distribution

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We have been developing a glass-tube-pair type Doppler probe diagnostic[1] with tomographic reconstruction to measure ion velocity distributions in laboratory plasma experiments. During magnetic reconnection, ions tend to have their own local velocity distributions as in PIC simulation[2] and magnetosphere observations[3]. Fig. 1(a) shows internal structure of the new probe array. Each measurement area is surrounded by four flat mirrors and four optical fibers fixed by mirror holders. They receive line spectra emitted from ions along a pair of view-lines: 1a & 1b and the other two view-lines which are inclined to sight 1a by angle of $30°$ or $150°$. For 1D profile measurement, the sets of mirrors and optical fibers mentioned are aligned in the two parallel glass tubes. All optical fibers are led to a spectrometer separately and finally to an ICCD camera for Doppler spectra measurements[4]. Using Doppler shift measurement from bi-directional viewing lines: 1a & 1b, we can significantly decrease the calibration error of the Doppler shifts[1]. As Doppler spectrum profile in each line of sight represents distribution of ion velocity component in the line, distributions of velocity component in three lines of sights can be calculated for each measurement area. By use of these velocity component distributions, we can reconstruct original velocity distribution with tomography techniques.

Figures 1(b)-(d) illustrate simulation results of tomographic reconstruction. Fig. 1(b) shows phantom function of ion velocity distribution with temperature anisotropy. From the function, virtual spectra in each line of sight were calculated as shown in Fig. 1(d) and velocity distribution was successfully reconstructed as shown in Fig. 1(c) by use of these spectra. We are developing this new probe array to realize 1D profile measurement of ion velocity distribution during magnetic reconnection.

References

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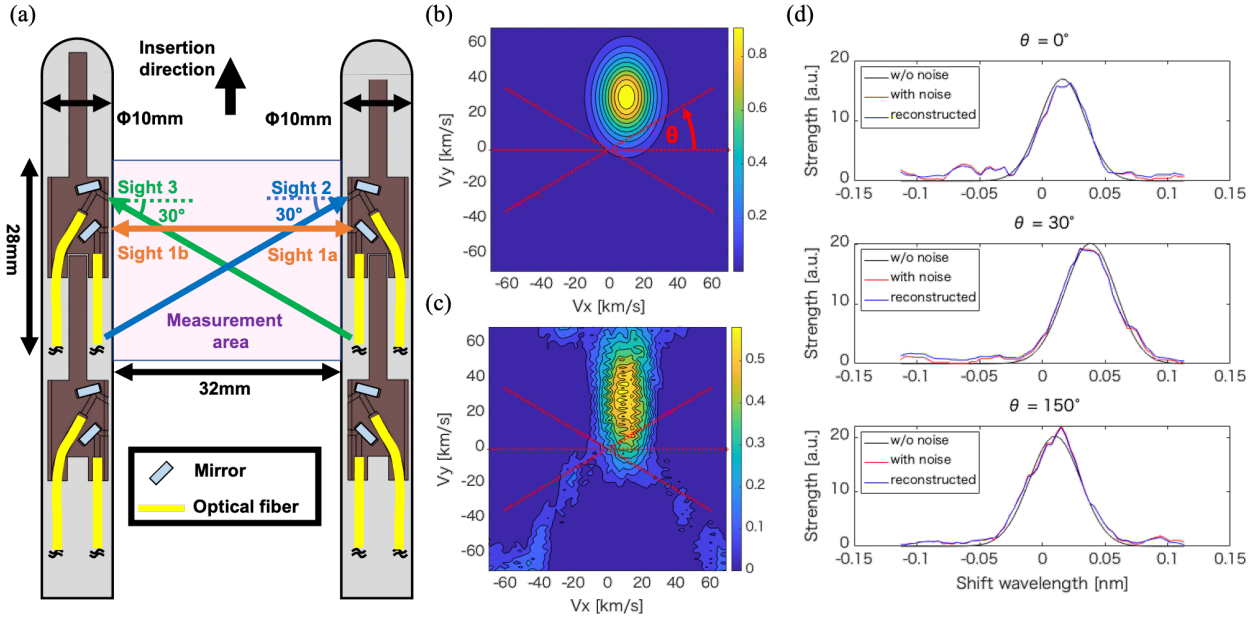

Figure 1. (a) Schematic view of glass-tube-pair type Doppler probe array for measurement of ion velocity distribution, (b) phantom function of ion velocity distribution (contour plot) and line of sights (red crosses), (c) reconstructed ion velocity distribution by our method (contour plot) and line of sights (red crosses), (d) spectra observed in each line of sight ($\theta = 0°, 30°, 150°$); calculated spectra by (b) without noise (black lines), random noise (SNR = 10) added spectra which were used for reconstructing (red lines), and calculated spectra by (c) (blue lines).