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ドップラー分光トモグラフィーによるイオン温度・流速場の再構成

Reconstruction of Ion Temperature and Velocity Profile with Tomographic Doppler Spectroscopy

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Spectral line profiles of plasma ions/neutrals have been measured to analyze ion temperature and flow velocities on fusion plasma devices. An important disadvantage of spectroscopic measurements of plasma emission is that the measured spectrum profiles are the results of line-integrals of the local plasma quantities along the line of sight. The Doppler shift of the signals contains both the plasma velocity and temperature information, indicating that a proper inversion technique is needed to obtain the local parameter f. This paper presents the 2-D r-z profile of the ion temperature and 3-D ion flow velocity on the poloidal plane, reconstructed from 35 channels of measured emission signals.
As a reconstruction method, we employed the Abel inversion method to reconstruct the temperature profile and the vector tomography method to reconstruct the velocity vector field. The axisymmetry condition was assumed to be satisfied in the plasma merging devices TS-3 and TS-4. The projection of the toroidally tangential line-integrated emission could be transformed to the radial profile. Unless the emission is extremely localized, this transformation was applied to the intensity of the emission at each wavelength; then, Doppler broadening from the reconstructed spectram gives the radial profile of ion temperature. We expand this method to 2-D measurement to use 35 (7 chords on 5 planes) channel optical fibers. The 2-D projection from them is re-aliened to 1-D to overcome the dimensional constraint of the input slit of monochromator. We carried out a simulation of the reconstruction from TS-3 and TS-4 Doppler measurement and the result shows the least number of line-of-sight is depend on the shape of emission and temperature profile and the cost effective number of projection is 7 to 8. We have achieved encouraging results of radially double-peak Ti profile, indicating significant ion heating at the outflow region during magnetic reconnection. We have also developed the flow diagnostic system using the 3-D vector tomography to technique to verify the ion acceleration from the X-point. Stereoscopic measurement of the 5 sets of 7 line-of-sight fan-beam projections gives 2-D ion flow velocity field at the measurement plane. Furthermore, we are on the stage of trying to calculate 3-D velocity profile on the poloidal crosssection of the plasma or another set of toroidal flow measurement.

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