§ 20. Active Particle Diffusion Measurement of Helical Plasmas by Use of Compact Torus Injection

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Since 1999, we have been developing a new active particle diffusion measurement by combining a visible-light tomography system with a well-controlled compact toroid (CT) injection system that will be installed by the other group within two or three years. The coaxial plasma gun will deposit impurity plasma at an arbitrary spatial position of the Large Helical Device (LHD) plasma at an arbitrary time. Its injection time is much shorter than the conventional pellet injection, leading us to a new fast particle diffusion measurement in MHD time scale. The 2-D visible light tomography system was designed to measure directly 2-D profiles of its ion diffusion, temperature and velocity.

In 2002, it was applied both to LHD and TS-4 to measure (1) impurity transport of helical plasmas, such as heavy impurity accumulation and (2) global instabilities of high-ß helical plasma, especially localized reconnection activity of ballooning mode. In the tomography system, a polichrometer, optical fibers, optical lens systems and a CCD camera (Fig. 1) were used to measure the line integrated signals of line spectrums and then those signals were converted into the local spectrums through the tomography or Abel inversion software. In the fiscal year 2002, we renewed its optical fiber system optimized for passive light measurement of LHD and TS-4 plasmas as shown in Fig.1. It is simply because the CT injector takes another two or three years to complete its installation. The new fiber / optical lens system increases the sensitivity of light emissivity by factor of 100, enabling us to measure the ion temperature / density profiles without CT injector.

Figure 2 shows reconstruction processes of ArII spectrums which are integrated signals along eight radial viewing codes. The integrated signals were transformed into eight local spectrums in the radial direction and after the Gausian fitting for ion temperature (T_i) measurement, the seven radial profiles of T_i were finally transformed into r-z contours of ion temperature in the TS-4 merging experiment.

Figure 3 shows the r-z contous of T_i in the ArII discharge experiment of TS-4. As shown in the poloidal flux contours of Fig.3, two tokamak plasmas were merged together to produce magnetic reconnection point. It is claearly observed that the reconnection out flow heated the plasma preferentially around the downstreaming area. This fact is the first direct evidence for the reconnection heating by the plasma outflow.

References
1) Balandin, A. L. et al,, Eur. Phys. J. D. 17, 337, (2002).
2) Y. Ono, to be published in Nuclear Fusion Jul. 2003.

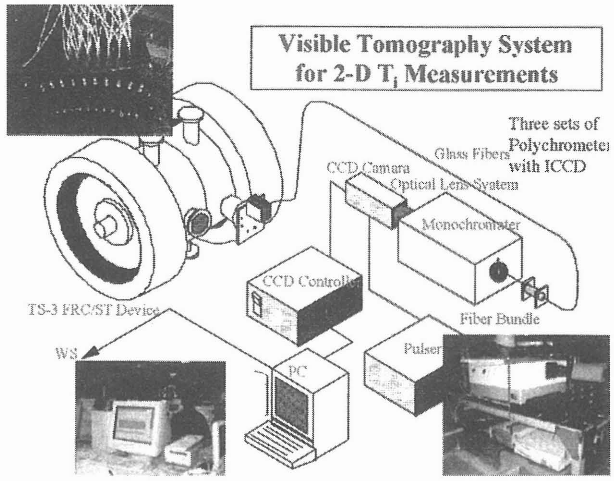

Fig.1 Visible light tomography system for LHD and TS-4

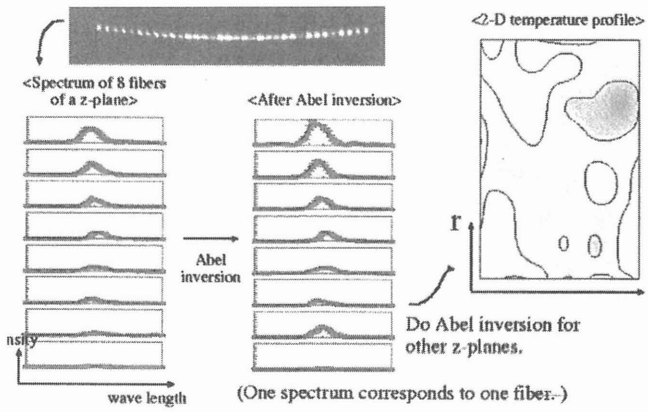

Fig. 2 Measured light spectrums at six radial positions, their reconstructed spectrums and the obtained 2-D ion temperature profiles with red color.

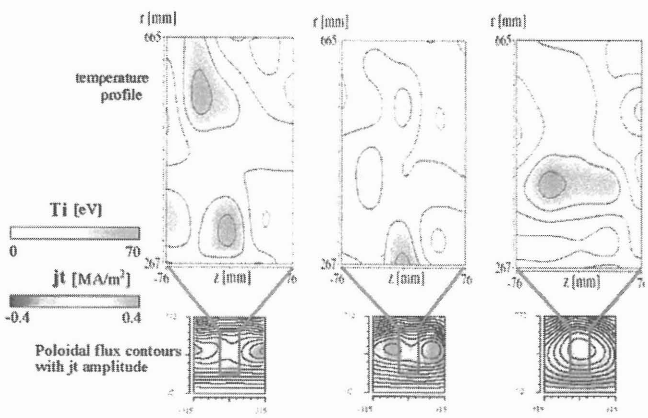

Fig. 3 r-z contours of ion temperature T_i and the corresponding poloidal flux contours with toroidal current density j_t in TS-4 (ArII spectrum)