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

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We have been developing a new active particle diffusion measurement by use of a visible-light tomography and a well-controlled compact toroid (CT) injection. In this system, the compact coaxial gun deposits impurity plasma at arbitrary spatial position of the Large Helical Device (LHD) plasma at arbitrary time. The visible light tomography system measures directly its particle diffusion, temperature and velocity. It will enable us to study

(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 fiscal year 1999, we almost completed the visible light tomography system and several tomography softwares to reconstruct 2-D emissivity / temperature profile. This system is composed of 36 optical fibers, a monochrometer, an optical lens system and a CCD camera as shown Fig. 1. The Fourier-Bessel method and the maximum entropy method were used to optimize the tomography softwares for TS-3 and for LHD, respectively. This system has been tested / optimized using various compact toroids: a compact RFP, a spheromak, a spherical tokamak and an FRC produced in the TS-3 device, University of Tokyo.

Figure 2 shows the r-θ contours of $H_ß$ emissivity on the midplane for the compact RFP and the spheromak which were sustained by the OH coil current (V_{loop}). The center black circle and the edge circle represent the center OH coil and r=0.32m (≈separatrix position), respectively. It was clearly observed that an oscillation of toroidal mode n=3 appeared in the sustained RFP and that of n=2 in the sustained spheromaks. These unstable modes: n=2 and 3 were almost consistent with peak q-values: q≤1/3 of RFP and q≤1/2 of spheromak, respectively. The unstable modes were attributed to the dynamo activities or flux conversions from poloidal to toroidal, because the CT with excessive poloidal flux self-generated toroidal flux through the mode activities when their toroidal current were driven by the center ohmic heating coils. The reconstruction accuracy of ion temperature (Doppler broadening) was improved by factor 2 by introducing Gaussian profile assumption to the Fourier-Bessel emissivity reconstruction software.

Finally, a new localized 3-D reconnection was investigated in the TS-3 experiment using non-symmetric partial reconnection of two merging STs in collaboration with the ECE group of LHD. It was found that the reconnection speed increases significantly when the reconnection sheet is transformed from 2-D toroidally symmetric shape to 3-D localized one. The current sheet broke at specific toroidal position and then propagated toroidally, recovering its toroidal symmetry. This fast reconnection is attributed to larger mass ejection of 3-D current sheet and is probably useful to interpret the ballooning mode reconnection in LHD.

Based on those results, we will develop the compact CT injector suitable for particle diffusion measurement and will start installation of visible light tomography system in LHD around the end of the fiscal year 2000.

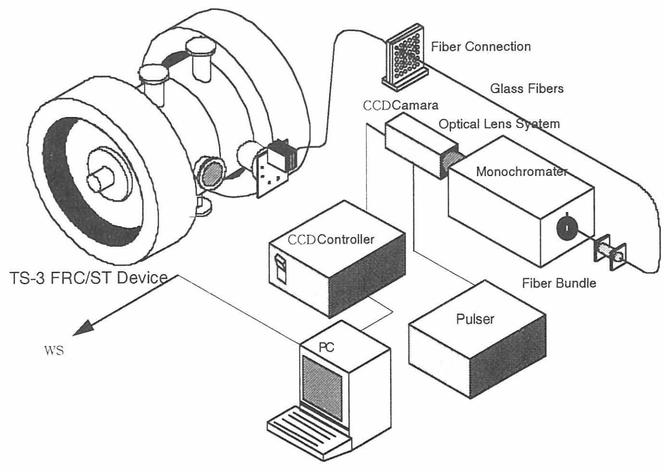

Fig. 1. Visible light tomography system and its tentative set-up at University of Tokyo.

References

1) Y. Ono, to be published in Physics of Plasmas.
2) M. Inomoto and Y. Ono, to be published in Kakuyugokenkyu.

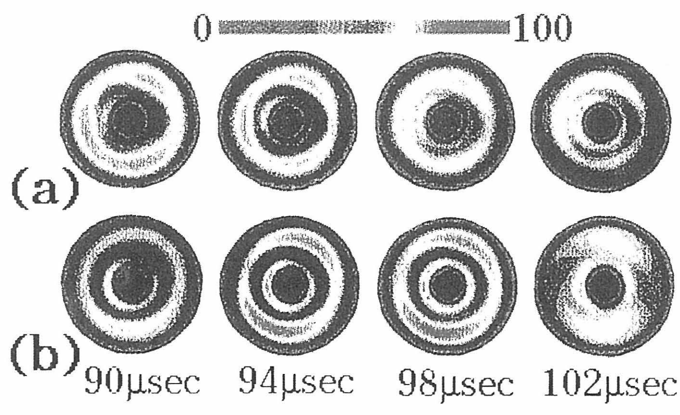

Fig. 2. $H_ß$ emissivity contours of compact RFP and that of spheromak on the midplane.