§56. Imaging of Radiation from TESPEL Injected into a Magnetic Island in LHD

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Confinement and transport of impurities in plasma is an important topic for reducing radiative cooling and fuel dilution in a fusion reactor. Magnetic islands form and grow in magnetically confined plasmas through perturbations either external or internal to the plasma and can have a deleterious effect such as with neoclassical tearing modes in tokamaks or can be used to control the plasma such as with a Local Island Divertor in LHD. Advanced tomography techniques applied to the signals of arrays of highly sensitive photodetectors with fast time response can give information on the two-dimensional evolution of the radiation and hence of its source impurity [1]. Previous work has shown that an impurity tracer can be injected into and can be confined by a magnetic island (MI) [2]. In this article we show images of radiation from Titanium (Ti) locally deposited in an externally induced magnetic island, which provide new information on the confinement of impurities by a magnetic island.

The experiment is carried out by using TESPEL to inject a Ti tracer into an m/n=1/1 MI produced by the LID coils on LHD. Care is taken to adjust the density to reduce the background radiation from the polystyrene shell of the TESPEL and to match the electron temperature profile to the MI location such that the radiation of Ti from the MI is optimized. The tracer deposition position is determined by the trajectory and speed of the TESPEL and the density and temperature profiles. The resulting radiation is measured by two 20-channel AXUVD arrays which view the same semi-tangential cross-section from upper and outer ports [3]. A method combining Tikhonov-Phillips and minimum Fisher regularization techniques is used to compute the tomographic inversion and produce two-dimensional images of the plasma radiation. The TESPEL injection was carried out with the positive and negative phases of the MI, which effectively exchanges the positions of the X-point (zero MI width) and the O-point (maximum MI width) of the MI and for the case of a small natural MI.

The results can be seen in Figures 1 to 3. In Figure 1 the Ti tracer is injected to the MI near its O-point. The peak in the radiation is localized to within the MI and disperses slowly. This indicates that the impurity is well confined for over 8 ms by the MI both radially and poloidally. In Figure 2 the case with the oppositely phased MI is shown which results in the Ti impurity being deposited near the X-point of the MI. In this case the radiation disperses radially and poloidally within 4 ms, which indicates that the impurity is not well confined by the MI. In the case of Figure 3 the LID coils are not energized, leaving only a small natural MI. In this case the radiation is seen to disperse poloidally in one direction indicating that the impurity is rotating around the plasma. Therefore the impurity is either well confined or restricted from rotating poloidally depending on where in the MI it is deposited.

References
1) Y.Liu et al., Rev. Sci. Instrum.**74** (2003) 2312.
2) N. Tamura, et al., J. Plasma Fusion Res. **78** (2002) 837.
3) B.J.Peterson et al., Plasma Phys. Contr. Fusion **45**(2003)1167.

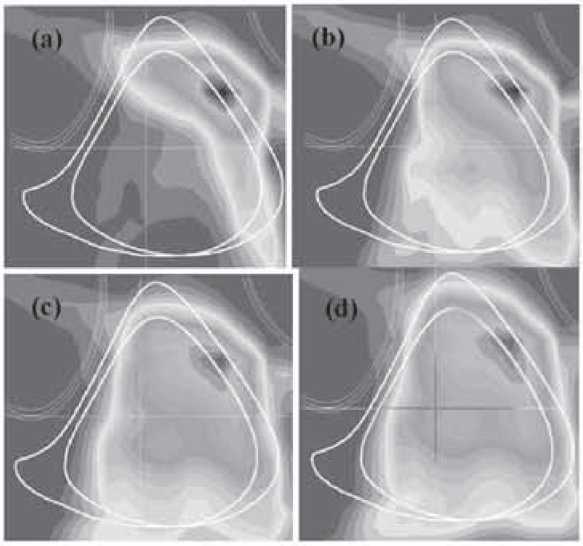

Fig. 1. Radiation intensity at (a) < 1 ms, (b) 2 ms, (c) 4 ms and (d) 8 ms after Ti TESPEL injection into the O-point of the MI (white).

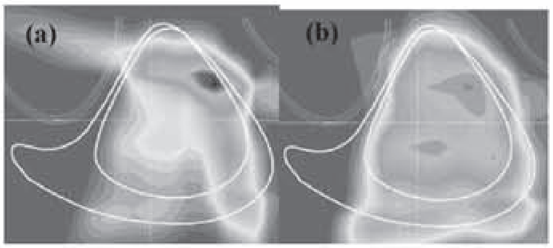

Fig. 2. Radiation intensity at (a) < 1 ms and (b) 4 ms after Ti TESPEL injection into the X-point of the MI (white).

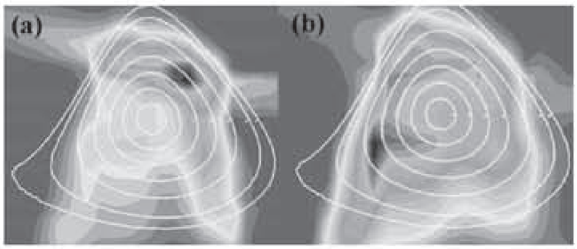

Fig. 3. Radiation intensity at (a) 1 ms and (b) 1.3 ms after Ti TESPEL injection into the natural (small) MI (flux surfaces shown in white).