§16. A New Diagnostic for Particle Transport Study with Tracer-encapsulated Solid Pellet Injection

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Transport of a magnetic confined plasma is still one of the key subjects to be clarified because of its importance for fusion reactor development. In order to promote particle transport study, the concept of tracer-encapsulated cryogenic pellet (TECPEL) has been proposed [1], and the technology of a TECPEL injector has been substantially developed [2]. The basic concept is to observe behavior of tracer particles deposited locally for local transport measurement. For proof of principle, a tracer-encapsulated solid pellet (TESPEL) is injected into the Compact Helical System (CHS). TESPEL consists of polystyrene (polymer: $-CH(C_6H_5)CH_2-$) as an outer part and LiH as an inner core, while TECPEL consists of hydrogen isotope as an outer part and low Z material as an inner core. Therefore, TESPEL can be handled at room temperature, and therefore the device can be much simpler, so it is more appropriate to a medium size plasma experimental device such as CHS. The diameter and thickness of the typical polystyrene shell are 300 μm and 50 μm, respectively. The tracer core is a LiH block with a typical diameter of 50 μm. The method for accelerating a pellet is pneumatic. A typical accelerating pressure for He gas is 10 atm, and the typical pellet velocity with this pressure is about 300 m/s.

The target plasma of CHS is heated by the neutral beam injector (NBI) with power of about 1 MW. This NBI is also utilized as a neutral beam source for the charge exchange recombination spectroscopy (CXRS). The light emission from the pellet is collected with an optical system, and then it is divided by a half mirror to two photomultipliers, each having a filter. Therefore, simultaneously H_α and Li II (or Li I) can be registered with 10 μs time resolution. Furthermore, two CCD cameras are also equipped for observing the images of H_α, and Li II (or Li I). From the CCD images, it is found that the pellet reaches the central region of the plasma. An intense emission region of Li II is localized in the central region of the plasma. Photomultiplier signals of H_α and Li II show that at first H_α appears for about 500 μs and then Li II emits for a short period of about 50 μs. Those results indicate clearly the local deposition of the tracer particles in the core region.

The density increase of ~ 5 × 10^{18} cm^{-3} due to pellet injection (from the typical temporal development of line density in case of R_{ax} = 97.4 cm as shown in Fig.1) is consistent with the particle number contained in the polystyrene shell (the contribution of the core is negligible). The wavelength of 449.9 nm (LiIII) is adopted for CXRS of Li ions. In contrast to the conventional CXRS systems using CCD, here photomultipliers for higher time resolution (up to 10 μs) are used. Typical LiIII CXRS signals are shown in Fig. 2. The delay of the peak (10 ms in the distance of 4 cm) is seen at the outer radius. The diffusion coefficient D is 0.16 m^2/s at r/a = 0.38. Although the detail comparison between the experimental data and transport simulation is necessary, the important point is that the local analysis is possible. The data are now being accumulated.

In conclusion, a new diagnostic method for particle transport study with TESPEL has been experimentally implemented for the first time. The results from CHS have shown that this method will be a useful technique for studying local particle transport.

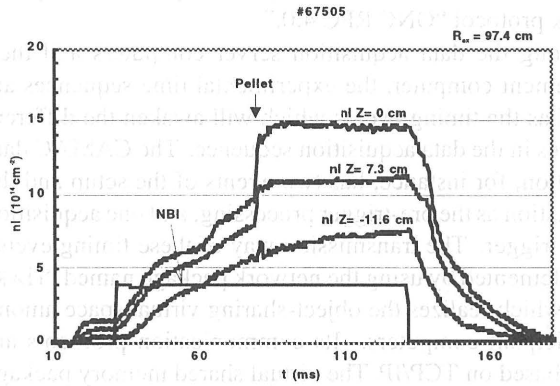

Fig.1 Typical density change by pellet injection at R_{ax}= 97.4 cm.

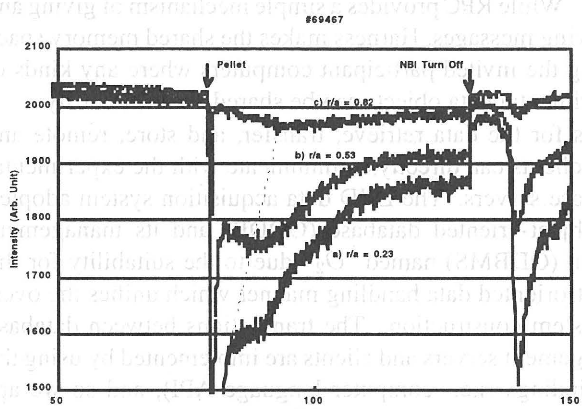

Fig.2 Li III (CXRS) at three different position in case of R_{ax}= 97.4 cm. a) r/a = 0.23, b) r/a = 0.53, c) r/a = 0.82.

References
[1] Sudo S., Journal of Plasma and Fusion Research, **69** (1993) 1349.
[2] Sudo S., et al., Rev. Sci. Instrum. **68** (1997) 2717.