§15. Lithium Doped Tracer-encapsulated Solid Pellet Measurement with a Fast Framing Camera in LHD

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A fast visible CMOS camera (Photoron APX-RS) and a bundle fiber (Schott IG-567), which were introduced from CIEMAT, has been applied for the measurement of the trajectory and ablation process of Lithium doped tracer-encapsulated solid pellets (TESPEL) and a impurity transport analysis in Large Helical Device (LHD) plasmas.[1] The fast visible camera system is equipped with two filter wheels (Optec IFW) with relay lenses. An interference filter can be selected from eight ones (H_{α}, CII, CIII, Brems., LiI, LiII, and two ND filters) by rotating the wheels being controlled from the LHD control room via mediaconverters and a RS-232C serial device server (Moxa NPort 5210). An image intensifier was not used in the last experimental campaign (14th cycle) for taking highly spatially resolved images of the ablation cloud of the TESPEL. The camera system was installed in an outer port (3-O) where the trajectory and ablation cloud are observed with a high spatial resolution and a good viewing angle from an upper side of the TESPEL injection port.

Figure 1(a) gives a typical picture of an ablation cloud of a pellet launched from an outer port (3-O) to the plasma central region without interference filters in a plasma discharge heated by tangential neutral beam injectors (NBIs). This is a superimposed picture of a LHD main plasma and a pellet ablation cloud, because the emission of the ablation cloud is too high to observe it with the LHD main plasma.

The right and left side on this picture correspond to tangentially counter and co-direction for the NBIs. The upper left side on the picture is equivalent to the plasma central region. A white rectangle indicates the observation area dedicated for fast framing measurement of ablation clouds with interference filters.

Figure 1(b), (c) and (d) shows temporally integrated images of LiI(λ=671nm) emission which were taken during TESPEL injection in balanced, counter and co-NBI heating conditions, respectively. The frame rate of the camera was set to 50,000fps in these measurements. The shapes of the observed emission are like small bright spots or ellipsoids. The trajectory of the emission for the balanced NBI condition is almost straight toward the plasma central region as indicated by an arrow. In the counter NBI case, the spot of the emission abruptly turned to the right side in the middle of the penetration into the main plasma. In the co NBI configuration, the spot moved to the left side with acceleration. The direction of the movement of the emission in both counter and co NBI conditions qualitatively agrees with direction of the fast ions injected by tangential NBIs into LHD plasmas.

Figure 1(e), (f) and (g) indicate pictures of LiII(λ=549nm) emission profile taken after a time delay (~20ms) from a TESPEL injection time in balanced, counter and co-NBI heating configurations, respectively. The frame rate of the camera was set to 50,000fps in these measurements. The emission in the balanced NBI case is distributed in both right and left side almost uniformly along magnetic field lines at the pellet ablation point shown by small white circles which are indicated by white arrows. In the counter and co NBI heating configurations, the emission is distributed in the left and right side of the pellet ablation point, respectively.

The behavior of the trajectory of the LiI emission and the LiII emission profiles in the three NBI heating configurations can be qualitatively explained by a jet-effect caused by ablation of the external layer of the TESPEL due to high energy ions which are produced by the NBIs. For detailed analysis of the three-dimensional trajectories of the pellets and the diffusion mechanism of the ablation cloud, stereoscopic measurement of the pellet is planned in the next experimental campaign.

1) Tamura, N. et al.: Rev. Sci. Instr. **79**, No. 10 (2008) 10F541-1.

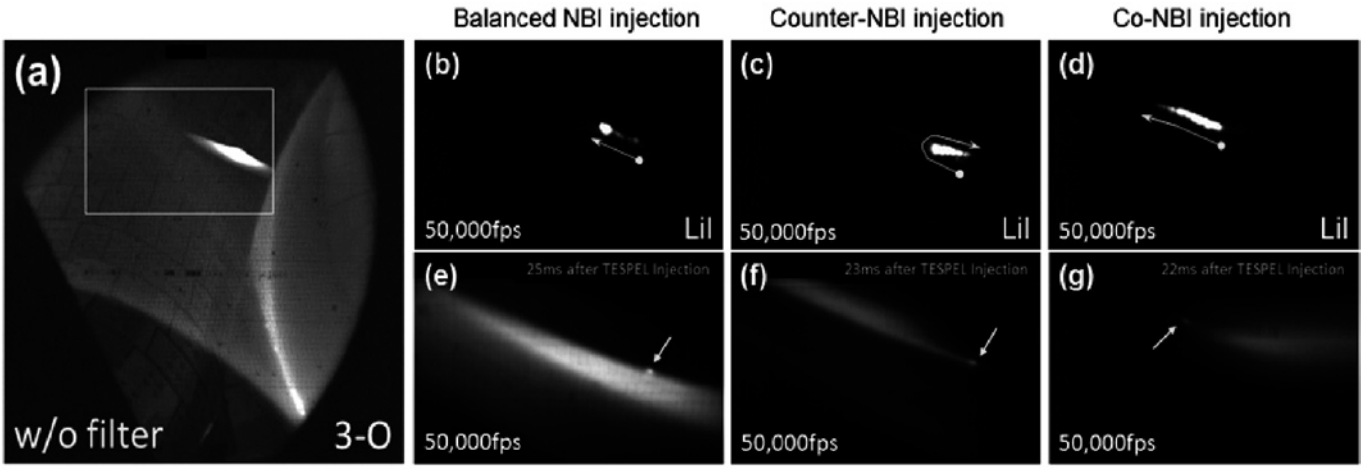

Fig. 1 A superimposed image of the LHD main plasma and an ablation cloud of an impurity doped pellet (TESPEL) (a), temporally integrated images of the trajectory of LiI emission in balanced, counter and co-NBI heating configurations (b, c, d), pictures of the LiII emission profile after the pellet injection in balanced, counter and co-NBI heating cases (e, f, g).