§16. Tangentially Viewing Fast Camera Measurements during the Radiation Collapse in LHD

Shoji, M.,
Carralero, D., de la Cal, E., van Milligen, B.,
de Pablos, J., Hidalgo, C. (EURATOM-CIEMAT)

A fast visible CMOS camera (Photoron APX-RS) and a bundle fiber (Schott IG-567) are introduced from CIEMAT and installed in a tangential port (6-T) for observation of the behavior of LHD plasmas. The plasma images via an optical zoom lens (Pentax C6Z1218) are transferred through the bundle fiber (4.5m in length) to a CMOS image sensor in the camera controller. The data of the captured images are transferred to RAID disks in a personal computer in the LHD control room via optical fibers at about one gigabit transfer rate. The trigger signals are sent to the camera controller via optical fibers by optical converters (Nanahoshi DPS-016). A graphical programming software (LabVIEW FPGA module) is used for the time delay of the trigger signal transmitted from the computer to the camera controller. The camera can take images as fast as about 100k frames per second, and store the data up to 2.6GByte. In 12th experimental campaign, plain or H_α filtered images were taken by the camera. The intensity was so high that an image intensifier (Hamamatsu C9547) was not necessary during the campaign.

We successfully observed some interesting phenomena in plasma discharges, for example:

1. Outward and inward bright filament propagation on divertor legs in high beta plasmas (low gamma configuration),
2. Gradual formation of a bright core in the plasma central region by sequential fuelling pellet injection,
3. Sudden disappearance of a bright core in the central region after core density collapse (CDC),
4. Strong plasma-wall interactions just after the plasma density drop during the CDC,

Except for the above measurements, the fast camera has successfully observed detailed time behavior of the plasma during radiation collapse. Figure 1 and 2 show two sequential images of the visible light during the radiation collapse at the end of the plasma discharges. In these figures, right and left hand side correspond to the inboard and outboard side of the torus in LHD vacuum vessel, respectively. We found that two different types of the collapse exist: rotational radiation collapse and central radiation one, respectively.

When the plasma density excessively rises due to particle fueling by gas puffers or pellet injector, some bright thin filaments appear in the inboard side of the torus in the first phase [b] as shown in Figure 1(a) and 2(a). The bright filaments move around the inboard side and fluctuation of the intensity of the filaments is observed in the second phase [c]. The tangential view shows that the bright area seems to locate in the inboard side in all toroidal sections. In the rotational radiation collapse, the filaments begin to rotate poloidally around the main plasma and the intensity of the filament increases with time [d]. Finally, the minor radius of the rotation gradually decreases [e], which results in the end of the plasma discharge with formation of a bright central core. In the case of the central radiation collapse, a bright central core suddenly appears after the second phase [d]. The central core radially expands, and spreads over the plasma, leading to the radiation collapse [e].

The observation of the bright area of the filaments in the inboard side just before the radiation collapse is consistent with measurements with a multi-channel bolometer array.[1)] It means that the fast camera was successfully applied to detailed observation of the radiation collapse with high spatial and time resolution from the tangential port.

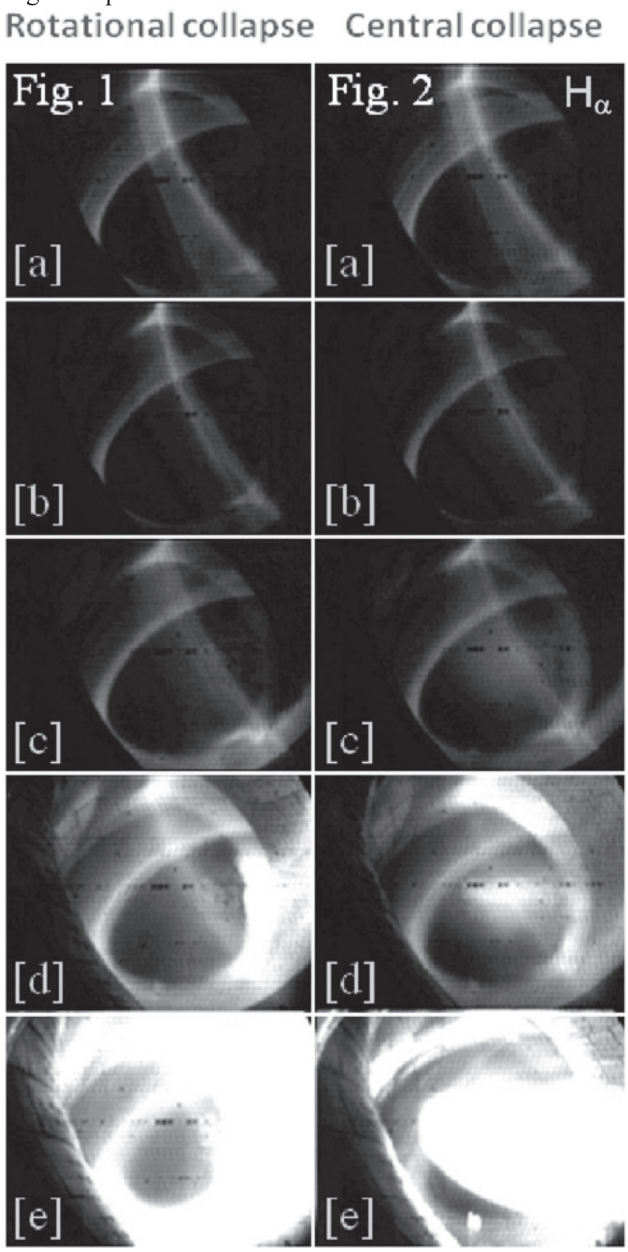

Fig. 1 and 2. Sequential visible images of the LHD plasma from a tangential port during rotational radiation collapse and central collapse, respectively.

1) Peterson, B. et al.: Plasma and Fusion Research 1 (2006) 045