§24. Determination of Space Resolved Characteristics of Pellet Ablation Cloud

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Pellet injection, by its capacity to directly deposit the fuel inside the last closed flux surface, is expected to be a highly efficient fueling method for magnetic fusion reactors. However, parameters of present day devices are too different to those expected in a reactor for a simple extrapolation to be reliable. It follows that an accurate characterization of the ablation physics is essential for constraining the pellet ablation-deposition models. In particular, it is crucial to understand the over-ablation associated to the high-energy ions and electrons generated by auxiliary heating.

To investigate the behavior of hydrogen pellet ablation, a novel method of high-speed imaging spectroscopy has been used in the Large Helical Device (LHD) for identifying the internal distribution of the electron density and temperature of the plasma cloud surrounding the pellet. This spectroscopic system consists in a five-branch fiberscope and a fast camera, with each objective lens equipped with a different narrow-band optical filter for the hydrogen Balmer lines and the background continuum radiation [1].

For interpreting the measurements, a 3D model of the cloudlet emission was built, under the assumption of full LTE, as established in [2]. The temperature and density distributions are assumed to be spherically symmetric close to the pellet - at the center of the cloudlet - and to display a cylindrical symmetry in its partly ionized outer part. Values can be either imposed a priori, or taken from a HPI2 pellet ablation-deposition code simulation [3]. The cloudlet spectrum - taking into account radiative transfer effects - is calculated in the $300-700$ μm wavelength range, as well as emission maps corresponding to the different filters of the imaging system described above. Physical phenomena taken into account are line emission (H_α, H_β, H_γ), radiative attachment, radiative recombination and the two bremsstrahlung components (that intrinsic to the cloudlet and that due to the slowing down of the plasma electrons impinging the cloud).

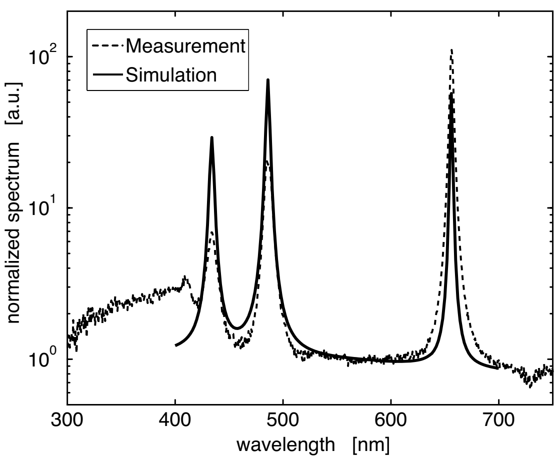

Fig. 1: Measured and simulated spectra.

A preliminary simulation result is displayed in Figures 1 and 2, where the measured and calculated spectrum and light emission profiles (in the parallel and cross-field directions) are compared for the cloudlet. The corresponding density and temperature distributions inside the cloudlet are displayed in Figure 3.

1) G. Motojima *et al.*, *Rev. Sci. Instrum.* **83** (2012) 093506.
2) M. Goto *et al.*, *Plasma Phys. Control. Fusion* **49** (2007) 1163.
3) B. Pégourié *et al.*, *Plasma Phys. Control. Fusion* **47** (2005) 17.

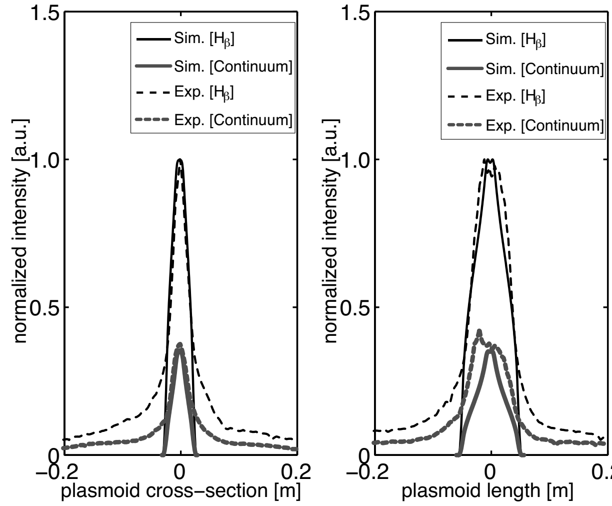

Fig. 2: Measured and simulated radiation profiles in the cross-field (left) and parallel directions (right).

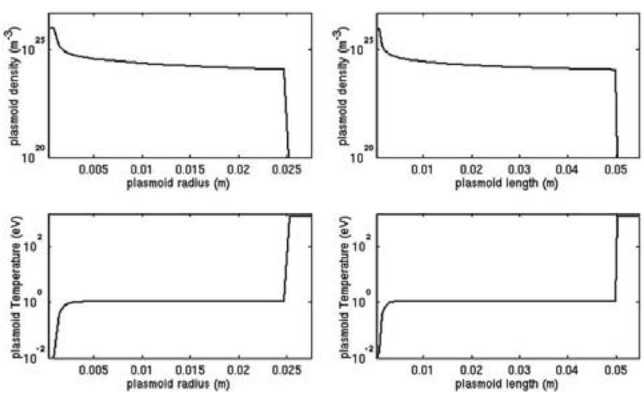

Fig. 3: Cloudlet density and temperature distributions in the cross-field (left) and parallel directions (right).