§12. Space Resolved Density and Temperature Distributions in Ablation Clouds of Hydrogen Pellets

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In the present state of the art, pellet injection is mandatory for the fueling of ITER and DEMO. Nevertheless, the experimental reproduction of the conditions expected in these machines is not possible in present day tokamaks. Predictions are thus exclusively based on modeling, a consequence of which is that it is mandatory to validate the available ablation/deposition codes as thoroughly as possible. In a reactor grade device, the pellet fueling capability is essentially linked to the magnitude of the drift of the deposited material down the magnetic field gradient. The drift dynamics depends on the cloudlet/plasma pressure ratio in what concerns the leading term, and on the cloudlet self-connection length, which is inversely proportional to the cloud radius, for the damping term. Determining accurately the ablation cloud shape and physical parameters, which are the drift initial conditions, is therefore of crucial importance for the input of drift simulations.

The purpose of this study is to estimate space resolved density and temperature measurements of ablation clouds of hydrogen pellets injected in LHD. Measurements are

(i) fast camera images of the ablation clouds (exposure time: 10 μs) using several filters (H_α, H_β, H_γ and the continuum close to $\lambda = 576$ nm),

(ii) the high-resolution spectrum in the wavelength domain $\lambda = 300 - 700$ nm with a time resolution of 16 μs.

The determination of the cloud physical parameters (dimensions, density and temperature distributions − distribution of the different atomic excited states) is done through a radiation model coupled to a 3-D radiative transfer calculation. The phenomena taken into account are the line emission, the Bremsstrahlung, and the radiative attachment and recombination. The influence of the $\nabla \boldsymbol{B}$-induced velocity, of the line of sight geometry and of the transfer function of the optical system are also investigated.

Fig. 1 shows comparison of the pellet ablation cloud between the experimental observation and computational simulation. The first camera image and visible spectrum, which were obtained in the LHD (#126636, first pellet at $t = 5.203141$ s) experiment, have been adequately reproduced by the computational simulation. This simulation enables to derive the three-dimensional distribution of the temperature and density in the pellet ablation cloud.

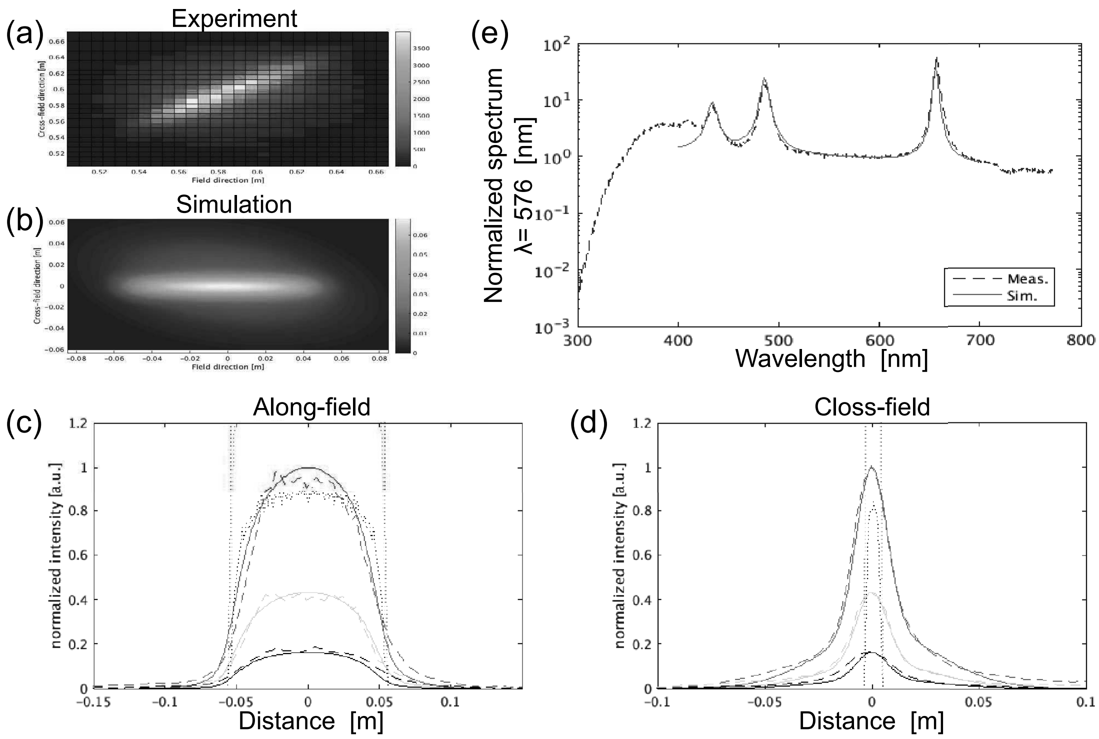

Fig. 1: .Comparison between the experimental observation and computational analysis. (a) Fast camera image, (b) simulated light emission distribution, light emission profiles of H_α (red), H_β (green) and H_γ(black) along-field (c) and cross-field (d) directions, and (e) visible spectrum. Measured and calculated values are denoted by dashed lines and solid lines, respectively.