Pellet fuelling physics studies on MAST
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Pellet injection is foreseen to be the main plasma fuelling technique in large machines like ITER or prototype reactors like DEMO. In order to design an efficient pellet injection system it is important to understand and model the pellet ablation (the process whereby the pellet evaporates in the plasma), the pellet deposition (the fast transport processes redistributing the pellet material inside the plasma) and the post-pellet transport (the way the density and temperature profiles perturbed by the pellet injection relax towards the pre-pellet values).

All these three aspects of pellet-plasma interaction physics have been addressed on MAST. Deuterium pellets of size of the order of 20-30% of the total plasma mass have been injected vertically from the high-field side into a variety of MAST H-mode plasmas with a pneumatic pellet injector at speeds variable between 250 and 400 m/s and pellet penetration has been tuned to be around 0.7-0.8 r/a. In this way we were able to keep the deposition profile close to the one expected in ITER. Extensive data have been collected with a series of diagnostics, among which the event-triggered Thomson scattering system allows high spatial and temporal resolution measurements of the evolution of the electron density and temperature profile during a pellet injection cycle (pellet ablation and subsequent profile relaxation).

The data have been analysed to assess the importance of fast transport of pellet material during the deposition process – a mechanism which is critical in future devices like ITER and appears to be stronger, relative to the machine size, on MAST and DIII-D than on JET and Tore-Supra. In addition, for a number of discharges, images of the pellet cloud in different spectral channels have been recorded and the cloud main parameters, such as density and temperature, have been determined. These data are important to constrain the simulations of the cloud evolution and motion across the plasma, upon which the final deposition profile depends.

As for the post-pellet profile evolution, the effect of ELMs on the relaxation of the density profile has been tested experimentally in discharges with and without ELM mitigation by means of resonant magnetic perturbations. It has been seen that, in some cases, pellets can effectively fuel ELM mitigated discharges, but in other cases post-pellet losses due to large ELMs (or even transient L-modes) can unfavourably change the balance between particle input and output. Moreover, the exceptional space and time resolution of the MAST Thomson scattering system has also allowed an equilibrium reconstruction accurate enough to perform microstability analysis of the post pellet profiles. The analysis shows a complex interplay between ITG modes, TEMs and MTMs, sensitive to the direction of the particle drifts and governed by the large changes in the density and temperature gradients, collisionality and $\beta$ induced by the pellet. The underlying physics is complex and could lead to different results on different machines (e.g. ASDEX-U or JET) depending on the details of the experiment.

In this paper we review and discuss the results obtained on MAST including data from the latest MAST experimental campaign.

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