Investigation of pellet cloud dynamics in the magnetic geometry of Wendelstein 7-X stellarator

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Cryogenic pellet injection is one of the prime candidates to fuel large-scale fusion devices such as tokamaks and stellarators. In the second experimental campaign (OP1.2a) of the Wendelstein 7-X (W7-X) stellarator, started in 2017, a cryogenic pellet injector capable of both inboard and outboard injection was began operation. Additionally, a tangentially viewing fast-frame video observation system, designed for ultra fast (up to 600 kHz) pellet observation, was also developed and commissioned. The system observes both inboard and outboard injected pellets and is triggered for each individual pellet by the light emission from the ablating Hydrogen pellets.

For OP1.2a island divertors were installed to ensure good pumping and controlled plasma-wall interaction. The island divertor is implemented by creating large 5/5 magnetic islands at the plasma boundary intersected by the divertor plates. Significant pellet ablation was observed only when pellets penetrated into the confined plasma region, independently of the pellet injection direction. No significant pellet ablation was observed in the island region, independently of whether the pellet trajectory crossed the O or X point regions.

Similar to the fast-frame video observations in ASDEX Upgrade pellet experiments, the radiation from both the cloud attached to pellet and from drifting (already detached) clouds could be observed if the temporal resolution was better than 10 µs. The W7-X video observation system allowed us to track both the attached and the drifting clouds, which showed that the pellet cloud always drifts outward from the plasma for both inboard and outboard injected pellets. This observation is in contradiction with tokamak results where the inboard injection case is always accompanied by favourable inboard pellet cloud drift. It appears that at the W7-X stellarator, the inboard pellet injections did not show this advantageous behaviour for fuelling which can be the consequence of the complex 3D stellarator magnetic geometry.