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P1.1102 Simulation of ablation of Ne pellets and SPI in tokamaks

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Detailed numerical studies of single neon pellets and multiple pellet fragments have been performed in support of the shattered pellet injection (SPI) concept for the plasma disruption mitigation system [1].
Two codes have been developed to study details of the evolution and properties of ablation clouds in the tokamak plasma based on the physics models and algorithms developed in [2] for deuterium pellets. Simulations of the single pellet ablation in spherically symmetric (SS) and axisymmetric 2D approximations have been performed using the hybrid Eulerian-Lagragian code FronTier [3] and 3D simulations of single pellets and multiple pellet fragments have been performed based on the Lagrangian particle (LP) code [4]. These are in excellent agreement in the SS approximation with the semi-analyticial model of Parks [5]. The LP code optimally resolves large changes in the cloud density and avoids numerical difficulties associated with the background plasma. Both codes while different in their numerical approaches, include the same set of physics models: pellet surface ablation, kinetic models for the energy deposition of hot plasma electrons into the ablation cloud, ionization in the cloud, radiation, and the low magnetic Reynolds number approximation for the ionized cloud channeling along the magnetic field lines. Effective ablation channel lengths were estimated based on the B-drift model [6].
Using FronTier and the LP code, we computed single pellet ablation rates for a range of plasma densities, temperatures, magnetic field strengths, and pellet radii. In addition, the Lagrangian particle code was used to compute ablation rates of several pellet fragments by resolving partial screening and cooling of the hot electrons penetrating the cluster cloud formed by the ablated sacrificial front. The present work focuses on the multiscale coupling of the Lagrangian particle SPI code to global tokamak MHD codes such as M3D-C1 and NIMROD.

References

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