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Pellet Physics in Plasmas

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Pellets are of major practical interest as a tool of plasma refueling and disruption mitigation [1]. This talk covers recent theoretical developments in the underlying physics. It addresses the following aspects of the pellet-plasma interaction:

- high-Z pellet ablation;
- thermal electron response to the pellet;
- pellet interaction with runaway electrons;
- ion heating during pellet expansion;
- MHD spectroscopy for pellets.

More specifically,

- The talk presents a first principle kinetic calculation of the power deposition from energetic electrons into the cold halo of an ablating high-Z pellet [2]. The resulting ablation rate is much lower than the pre-existing estimates. The new expression for the heat deposition provides an updated input for fluid simulations of the pellet ablation process.

- A cold pellet absorbs the incident hot electrons and emits secondary electrons to maintain quasi-neutrality. The required balance is governed by a sheath potential. The pellet modifies the distribution of the ambient electrons and the heat flux via energy-dependent absorption [3,4]. Cooling of the ambient electrons is of particular interest for resonant magnetic surfaces.

- In a cold post thermal quench plasma, runaway electrons can carry a significant fraction of the initial plasma current. Our first principle estimates show that any pellet injected to dissipate a 10 MA runaway electron current in ITER will evaporate virtually instantly once exposed to the runaway electrons [5]. This is in line with the recent observations in DIIID, where there was no significant difference between the runaway electron dissipation by pellets or by massive gas injection [6].

- In a plasma with cold ions, ambipolar expansion of the dense ablation-produced plasma should convert electron thermal energy into the ion energy more efficiently then Coulomb collisions in a way similar to ion acceleration in laser-irradiated clusters [7].

- Pellets typically disassemble on timescales of several milliseconds. The ablated material breaks the toroidal and poloidal symmetry of the plasma density profile. This asymmetry modifies the Alfvén continuum and eigenmode structure significantly via coupling poloidal and toroidal harmonics, which is a likely scenario in JET experiments [8].

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