9th Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

Investigations of dust and impurities in EAST and HL-3 tokamaks

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ITER has recently switched to full tungsten wall configuration[1].High-Z tungsten dust originated from the Plasma-Surface Interactions(PSIs) may result in the degradation of plasma discharges, the H-L mode back transition or even disruption. The ionization of tungsten atoms leads to the dissipation of the stored energy in the core region. Meanwhile, low-Z impurity pellets such as lithium or boron ones are strong candidates for ELM control with impurity injection. The small or grassy ELMs are triggered before the formation of large type-I ELMs. Consequently, the plasma disruptions can be avoided and the high-confinement, long-pulse discharges are achieved.

In this work, we present our modelings of the tungsten dust with the NDS code package developed under the BOUT++ framework. The dust charging and ablation mechanisms are integrated into the transport process. The transports of tungsten impurities, originated during the dust ablation process as well as the PSI, are investigated with STRAHL. The corresponding core energy dissipation due to radiation during impurity transport is also assessed. Furthermore, the lithium impurity pellet injections are modeled with the NDS-BOUT++ and the BOUT++ transport module. The penetration and the size distribution of the lithium pellet on its trajectory are simulated and compared to experiment diagnostics. The consequent interactions between the lithium atoms and background plasma are simulated to study the lithium ions transport and the formation of plasma pressure perturbation in the pedestal region. The fueling pellets are investigated with PAM code to optimize EAST pellet fueling efficiency, considering the ∇B-induced plasmoid drift. In addition, the pellet ablation trail in tokamak plasma provides significant identifier for tokamak safety factor diagnostic. We will also report our recent work on tokamak diagnostics.

Our simulation results[2] show that the sub-micron sized tungsten dust originated from the EAST upper-divertor region is capable of penetrating through the Separatrix. The dust motion is dominated by the Lorentz force once its radius is ablated to around 100-micron meters. Results from the modeling and the experiment are well consistent. For impurity pellet injections, the lithium pellet is capable of penetrating ~ 20 cm into the HL-2A plasma when injected horizontally from the low-field-side midplane with the initial velocity of 100 m/s. The lithium ablation profiles obtained from both the modeling and experiment fit the Gaussian distribution approximately. The plasma pressure in the pedestal region increased ~ 25% due to the lithium pellet ablation and ionization[3]. On fueling pellets, we find pellet penetration contribute more to the deep pellet deposition than the ∇B-induced plasmoid drifts in low temperature plasma, while deep pellet fueling in reactor relevant high temperature plasma has to rely on plasmoid drifts[4]. Finally, our developed stereo CCD system for tokamak safety factor diagnostic proves to be robust and accurate with the average difference of 6.8% compared the traditional MSE diagnostic in EAST discharges[5].

This work is supported by the National MCF Energy R & D Program of China Nos.2024YFE03160002 and 2022YFE03090000, as well as the auspices of U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract Nos. DE-AC52-07NA27344.

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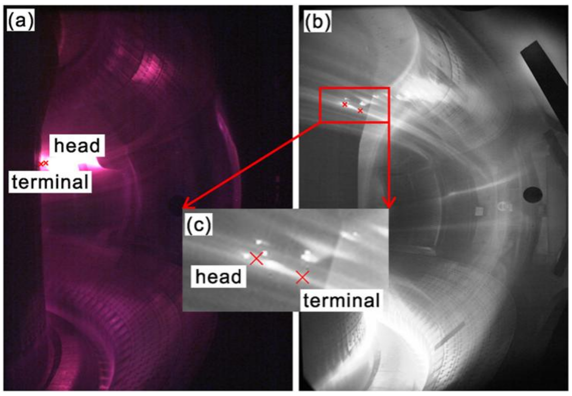

Figure1. One typical pellet ablation trail from EAST discharge