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Kinetic modelling of ion impact energy and material erosion during edge localized modes on EAST and JET

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Operation in high-confinement mode (H-mode) for tokamak devices is preferable due to improving particle confinement time and increasing density and temperature. However, quasi-periodic occurrence of edge localized modes (ELMs) in H-mode plasmas leads to a strong power leakage of the plasma stored energy into the scrape-off layer (SOL). Major fraction of expelled high-energy particles ends up at the downstream divertor, which results in hazardous impacts such as severe wall erosion and short divertor lifetime. Therefore, studies of ELM-induced sputtering of divertor targets are important for understanding the underlying mechanisms to explore the compatibility between H-mode plasmas and divertor performance.

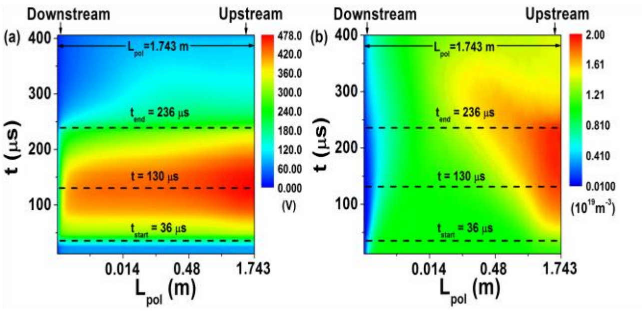

Figure 1. Spatial and temporal evolutions of the electric potential (a) and ion density (b) during ELM. The start and end times of ELM burst are t_{start} = 36μs and t_{end} = 236μs, respectively.

The particle-in-cell (PIC) modelling has been performed to investigate the impact of the energy loss during edge localized modes (ELMs) on the plasma potential and ion impinging energy on the divertor target. A double-peak structure of the ion impinging energy has been identified under JET-relevant ELM conditions. The ELM burst leads to a strong increase in the potential drop in front of the target plate, which accelerates the cold ions from the downstream divertor and accordingly causes a peak value of ion impinging energy. Moreover, the great potential drop helps confine the fast electrons and leads to a reduction in the potential drop and ion impinging energy. The arrival of the upstream hot ions results in the second peak value of ion impinging energy. The maximum potential drop and ion impact energy show a linear dependence on the pedestal temperature. Further, a nonlinear dependence of the peak potential drop and ion impact energy on the ELM energy loss can be ascertained based on the PIC simulations.

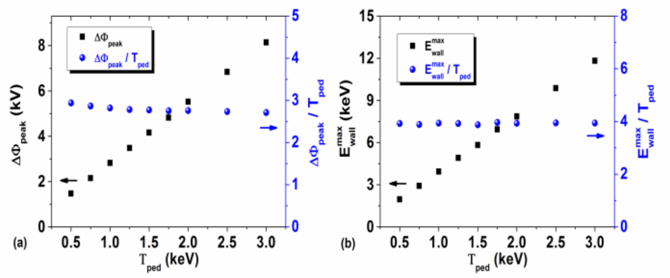

Figure 2. Profiles of the maximum potential drop ($\Delta\varphi_{peak}$) and the ratio $\Delta\varphi_{peak}/T_{ped}$ (a) and the peak value of ion impact energy (E^{max}_{wall}) and the ratio E^{max}_{wall}/T_{ped} (b) against the pedestal temperature T_{ped} for JET case.

Reference

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[2] Shuyu Dai, *et al.*, Nuclear Fusion, 58,014006, (2018).
[3] Shuyu Dai, *et al.*, Nuclear Fusion, 55, 043003 (2015).