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ELMペーシングのためのペレット入射によるELMエネルギー損失の低減
Reduction of ELM Energy Loss by Pellet Injection for ELM Pacing

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The energy loss caused by the edge localized mode (ELM) needs to be reduced for ITER operations with ELMy H-mode plasmas. The pellet injection is considered as one possible method to reduce the ELM energy loss by increasing the ELM frequency (so called ELM pacing). The ELM pacing requires the significant reduction of ELM energy loss, small impact on the plasma performance, and less particle fueling. The reduction of ELM energy loss by the pellet injection for ELM pacing has been studied by an integrated core / scrape-off-layer (SOL) / divertor transport code TOPICS-IB with an MHD stability code and a pellet model taking account of the *E*x*B* drift of pellet plasma cloud [1].

The dependence of energy loss on the pellet injection timing in one cycle of natural ELM with the time period of τ_{cyc} is studied. Figure 1 shows (a) the time evolution of pedestal stored energy $W_{\rm ped}$ without the pellet and (b) the dependence of normalized ELM energy loss $\Delta W_{\rm ELM}/W_{\rm ped}$ induced by the pellet on the injection timing $\Delta t/\tau_{cyc}$ of both high-magnetic-field-side (HFS) and low-field-side (LFS) pellet, where Δt is elapsed time from previous natural ELM. Early injection (A in Fig.1(b)) reduces the energy loss because the high magnetic shear prevents the onset of lower-n modes, where n is the toroidal mode number, but leads to the reduction of target pedestal pressure and the enlargement of pellet size to trigger the ELM. On the other hand, the late injection (C) induces a large energy loss comparable to the natural ELM.

Figure 2 shows the dependence of energy loss on the pellet radius r_p at the middle injection timing B. The energy loss can be reduced by a small pellet injected from LFS, which penetrates deeply into the pedestal and triggers high-n ballooning modes with localized eigenfunctions near the pedestal top. On the other hand, a small pellet injected from HFS triggers lower-n modes with wide eigenfunctions before the pellet penetrates deeply into the pedestal, resulting in a large energy loss.

Therefore, the small pellet injected from LFS to the pedestal plasma equivalent to that at the middle timing in the natural ELM cycle is found to be suitable for ELM pacing. With these suitable conditions, the ELM pacing with the reduced energy loss is successfully demonstrated in simulations, in which the core density increase due to additional particle fueling by the pacing pellet can be compensated by reducing the gas puff and enhancing the divertor pumping.

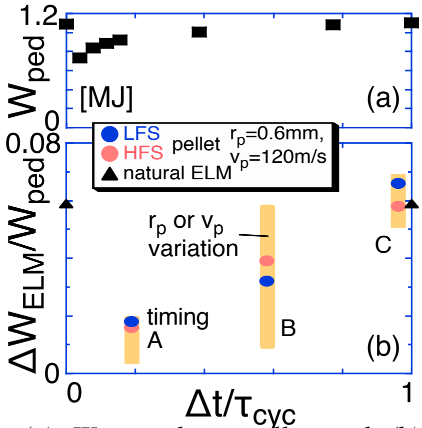

FIG.1. (a) W_{ped} without pellet and (b) ΔW_{ELM} normalized by W_{ped} as functions of $\Delta t/\tau_{cyc}$. In (b), circles denote values of ELM triggered by a pellet injected at each timing, shaded lines ranges for various pellet radius r_p ($\leq$0.7mm) and speed v_p (5m/s$\leq v_p \leq$120m/s), and triangles values of natural ELMs.

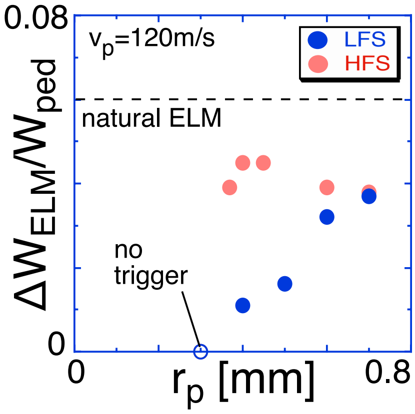

FIG.2. Dependence of ΔW_{ELM} on r_p, where open symbols denote pellets not to trigger ELM and horizontal dotted line does ΔW_{ELM} of natural ELM.

[1] N. Hayashi et al, Nucl. Fusion **51** (2011) 103030.