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Radiative divertor compatible with RMP-driven, ELM-crash-suppression in fusion DEMO-type devices

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The edge-localized-modes (ELMs) in magnetic fusion reactor raise a major concern not only due to the degraded core confinement, but also due to the adverse effects against plasma facing components [1]. In the existing medium size tokamaks, the application of resonant magnetic perturbation (RMP) has proven effective in suppressing ELMs without being limited to ELM-crash-mitigation. Nonetheless, the RMP-driven, ELM-crash-suppression often elevates the peak of divertor heat flux at least by a factor of 2 or 3, in comparison with that of inter-ELMs without RMPs [2]. In that regard, the impurity seeding and deuterium gas puffing in the periphery of the plasma column had been expected to play a role in releasing the excessive energy in a radiative manner, which is essential to reach detached plasmas in divertor power exhaust handling.
However, whenever RMP-driven, ELM-crash-suppression becomes gradually radiative with either impurity seeding or gas puffing, it loses the high quality of ELM-crash-suppression. On the other hand, once high density, near-detached plasmas are accessed by RMPs, it has been nearly impossible, if not forbidden, to achieve the RMP-driven, ELM-crash-suppression at least based on the KSTAR experiments for more than a decade. Interestingly, in terms of 'wetted area', the strongly mitigated ELM-crashes in radiative divertor could be more favorable than the full ELM-crash-suppression [3]. For that reason, it is quite important to address whether radiative divertor, which is expected to be a routine in fusion reactor, would be compatible with RMP-driven, ELM-crash-suppression sooner rather than later. In recent KSTAR experiments, a series of promising results show that ITER-like 3-row RMP-driven, ELM-crash-suppression would be much better than 2-row counterparts in terms of the divertor thermal loading, while such 3-D configuration would be more amenable to radiative divertor [4]. At the same time, depending on the scrape-off-layer conditions, both RMP-driven, ELM-crash-suppression and detachment conditions vary significantly. Considering a preliminary K-DEMO design study shows an enormous challenge of power handling capability in divertor [5], a more comprehensive understanding of radiative divertor should be prioritized in reactor study, while its compatibility with ex-vessel RMP control needs to be addressed, if standard H-mode with ELMs remains a baseline scenario in fusion reactor.

References
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