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Favorable Impact of RMP ELM Suppression On Divertor Heat Fluxes at ITER-like Conditions

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RMP ELM suppression experiments at ITER-like conditions (shape, collisionality, RMP spectrum) in DIII-D show little splitting of the heat flux to the divertor targets, despite robust splitting in the particle flux. This lack of divertor heat flux splitting is a potentially important result for ITER because splitting of the divertor heat flux into multiple lobes displaced from the primary strike point could complicate heat flux handling during RMP ELM suppression in ITER and other tokamaks with tight divertor baffling. In DIII-D, strike point splitting is routinely observed in the divertor particle flux during RMP operation. The observed splitting is consistent with the toroidal mode number n of the perturbation, but the measured separation of the divertor particle flux lobes exceeds predictions of a vacuum model by factors of 3-5. Similar splitting in the heat flux profile would have serious consequences for heat flux handling during RMP ELM suppression in ITER. However, there is little impact of these particle flux lobes on the measured divertor heat flux. The large particle flux lobe separations present a challenge for plasma response modeling, because the predicted response using linear, resistive MHD simulations is dominantly a screening response, which should reduce the divertor lobe splitting below the vacuum model predictions.

Current ramps, which were limited in amplitude for a subset of RMP coils to be consistent with force limits on the RMP coils in ITER, were used to modify the divertor lobes from an n = 3 to an n = 2 pattern. The particle flux lobes changed during the RMP current ramps, but the heat flux profile was not affected, consistent with the lack of heat flux lobe structure. Possible synergistic effects of impurity gas injection and RMP current ramps were also examined using neon and argon gas injection into the ELM suppressed phase. Both gases produced stable radiating mantles between $0.95 \leq \Psi_N \leq 1$, a 60% radiated power fraction, and significantly reduced heat flux to both strike points while ELM suppression was maintained. These results show that RMP ELM suppression in ITER-like conditions is compatible with an impurity radiation-enhanced boundary.

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