Sensitivity of Radiating Divertor Performance to Magnetic Balance in DN Plasmas in DIII-D*

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Advanced tokamak scenarios lead to higher fusion performance, but also a greater challenge to power handling in the divertor. Radiation enhancement is a proposed solution, but must be consistent with the core conditions. DIII-D experiments have shown that radiating divertor performance in H-mode regimes with edge localized mode (ELM) is very sensitive to variation in magnetic balance near the double-null (DN) configuration. In addition, the success in concentrating injected impurities in the divertor region is found to depend on the direction of the ion ∇B drift. The best prospect of successfully coupling a radiating divertor with an advanced tokamak plasma is shown to be a DN shape magnetically biased in the direction *away* from the ∇B ion drift direction. Here, exhaust-to-core impurity (argon) concentration ratios ≈35 were achieved under this scenario, with good hybrid scenario performance: $\tau_E/\tau_{89P} = 2$, $\beta_N = 2.4$, $n_e/n_{eG} = 0.6$, $P_{RAD}/P_{inj} \approx 0.6$, $Z_{eff} \approx 2$, and a peak heat flux reduction at the outer divertor target of ≈2.5. For these experiments, argon impurities were injected into the private flux region of one divertor, along with enhanced deuterium flow into both divertors by a combination of midplane gas puffing and divertor cryopumping. To quantify "magnetic balance," we use the parameter *dRsep*, which is the radial distance between the upper and lower divertor separatrices at the outboard midplane.

Under otherwise similar conditions, argon impurities are more readily concentrated in the divertor in magnetically *unbalanced* DN (UDN, dRsep = ±1.2 cm) plasmas than in magnetically *balanced* DN (BDN, dRsep = 0) plasmas. For BDN plasmas operating in the radiating divertor mode, our results highlight the difficulty in balancing radiated power between divertors during argon injection. Increases in radiated power and argon concentration were always higher in the divertor that was *opposite* to the ion ∇B drift direction than in the other divertor, *regardless* of the divertor into which the argon was injected. For UDN plasmas operating in the radiating divertor mode, there was a 3-4 times lower concentration of argon in the core plasma when the ion ∇B drift was away from the dominant X-point. In addition, argon accumulated in BDN plasmas at ≈2 that in UDN plasmas having the *same* ∇B drift direction. Experiments on DIII-D in ELMing H-mode UDN discharges comparing plasma behavior in the open lower divertor to that of the more closed upper divertor demonstrated that density control of deuterium and argon was far more sensitive to the ion ∇B drift direction than to the relative closure of the divertor. The roles of particle drifts in the divertor(s) and scrape-off layer will be discussed in the context of UEDGE analysis.

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