Variation in Particle Pumping Due to Changes in Topology in High Performance DIII-D Plasmas*

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Advanced tokamaks will likely have a high triangularity, divertor cross-section for optimizing fusion performance. In turn, this will require that their divertors, whether single-null (SN) or double-null (DN), remove particles efficiently in order to maintain density control over the core plasma. Recent experiments on DIII-D have demonstrated the key role that divertor magnetic balance (i.e., the degree to which the divertor topology is SN or DN) plays in determining the rate at which deuterium particles are pumped at the divertor targets. The discharges from these experiments are characterized as "high performance" H-mode plasmas, where $H_{89P} \approx 2.1$-2.7, $\beta_N \approx 3$, $q_{MIN} > 1$, and pedestal density $n_{e,PED} = (0.25\text{-}0.50)\text{x}10^{20}\ \text{m}^{-3}$. The ∇B_T ion particle drift was directed toward the upper divertor, and only the inner and outer legs of the <u>upper</u> divertor were pumped.

Changes in divertor plasma geometry near the DN shape have a much stronger effect on the pumping rate at the *upper inner* divertor target (Γ_{IN}) than on the pumping rate at the *upper outer* divertor target (Γ_{OUT}). While Γ_{IN} and Γ_{OUT} were comparable in the upper SN cases, shifting the magnetic balance from upper SN to DN reduced Γ_{IN} by ≈55% and Γ_{OUT} by ≈15%. This sensitivity can be understood in terms of the scrape-off layer (SOL) geometry and the poloidal distribution of particles entering the SOL from the core plasma. The lower pumping rates measured in the DN plasmas resulted in higher average $n_{e,PED}$ in comparison with the SN plasmas. Under similar operating scenarios, the pedestal density of DN plasmas could be ≈15%-20% higher than $n_{e,PED}$ of comparable SN plasmas. Both Γ_{IN} and Γ_{OUT} were also shown to depend strongly on edge density in both SN and DN discharges, i.e., $\propto [n_{e,PED}]^{1.8\text{-}2.8}$. DN plasmas can transiently maintain the same $n_{e,PED}$ as SN plasmas, when the graphite tiles, which protect the DIII-D vessel, are well-conditioned and "pump" (i.e., absorb) deuterium in the lower divertor. The recycling activity and particle flux observed at the (presently non-pumped) lower outer divertor target during DN operation suggest that adding pumping capability at that location would significantly increase the range of density control for high performance DN plasmas. Our results are shown to be largely consistent with simple modeling of the SOL and divertor plasmas (e.g., "two-point" SOL model).

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