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Particle Transport from the Bottom Up

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Exploration of particle transport behavior in multiple devices shows the importance of turbulence in determining particle confinement and the density profile. Behavior on CMOD indicates that as plasma parameters approach ITER, the pedestal and SOL become increasingly opaque. H-mode experiments with density pedestals approaching $4 \times 10^{20}\ m^{-3}$, heated with the maximum auxiliary power available, find that increasing deuterium puffing by a factor of ~2 doubles the SOL density while having <10% effect on pedestal density and core particle inventory. This suggests that high opacity pushes the neutral fueling profile into the SOL, leaving the pedestal density profile to be determined by plasma transport and an inward pinch. Similarly, studies on JET and DIII-D show that the inward pinch plays a crucial role in explaining the time dependent density changes when additional gas fueling is injected. Interestingly, neutral particle fueling does not play a direct role in pedestal density increases since COCONUT (core/edge integrated) modeling shows that the particle source inside the separatrix reduces when gas fueling increases because of higher SOL opacity. Where fueling and opacity play an important role at the plasma edge, in the core particle confinement is strongly affected by changes in turbulence. For example, during strong electron heating in low density H-mode plasmas on DIII-D a strong decrease in particle confinement is observed. This is linked to an increase in ITG drive from ρ~0.6 to ρ~0.8, which causes an increase in density fluctuations at all scales and results in a density pump-out. We find that where the temperature profiles are fairly insensitive to changes in ExB shear, particle confinement is directly linked to increases and decreases in ExB shear. In the core, we observe that the role of NBI fueling on the density profile cannot be neglected in current machines and that local gradients are directly linked to the turbulence frequency. These results indicate that in burning plasma conditions, opaque SOLs may not result in the collapse of the density pedestal owing to the inward particle pinch at the edge, and that a larger ExB shear will be beneficial to higher particle confinement.
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