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Edge Flow from Momentum Transport by Neutrals

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The accessibility and performance of the H-mode are critical to tokamak fusion reactors. While the physics of the pedestal is complicated and far from fully understood, it is clear that flow shear plays an important role. One of the mechanisms that may regulate flow velocity in the plasma edge is momentum transport by neutrals. Due to their high cross-field mobility they may be the most significant momentum transport channel even at low relative densities. There have also been experimental observations suggesting an important role for neutrals in determining pedestal properties and showing strong variation of confinement with the strike point position (as the target configuration changes). We have developed novel numerical tools to determine the radial electric field and plasma flows just inside the separatrix by coupling a kinetic, short mean-free-path model of neutrals to a neoclassical solver. This allows us to compute the momentum flux due to the neutrals that corresponds to specified plasma profiles. The flux must vanish in steady state and this constraint then determines the radial electric field given the density and temperature gradients. As an example we demonstrate the effect of X-point position on edge flow in ITER-like geometry. The major radius of the X-point has a strong effect both on the magnitude of the flow and its collisionality dependence, suggesting that altering the X-point position may offer a means to manipulate the edge flow shear. Beyond this particular scenario, it is clear that in the edge region of the plasma where neutral densities are relatively high the neutrals can have important effects on the radial momentum transport, flow and flow shear. Consequently they are likely to affect both the L-H transition and H-mode confinement, and they should be accounted for in the interpretation of current experiments and in the design of future machines.

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