Internal Transport Barriers with Counter-Neutral Beam Injection in DIII–D*

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Internal transport barriers are frequently formed in discharges with weak or negative central magnetic shear and moderate neutral beam (NBI) heating in the DIII–D tokamak[1]. In this regime, toroidal rotation, driven by co-directed (parallel to the plasma current) NBI, is the primary driver of the sheared **E**×**B** velocity believed to suppress turbulence and its associated transport. With co-injection, the pressure gradient and toroidal rotation terms of the radial force balance equation $(E_r = (Z_i e n_i)^{-1} \nabla P_i - v_{\theta i} B_\phi + v_{\phi i} B_\theta)$ are in opposition, so that one must dominate in order to form a large radial electric field. Experiments are underway in DIII–D to evaluate the potential for extending both the spatial extent and duration of these barriers through the use of counter-NBI. In these plasmas, the pressure gradient and rotation terms of the force balance add to each other, offering the potential for increased **E**×**B** shear over an extended region of the plasma. At the same time, however, it is expected that the shearing rate[2] $\omega_{E\times B}$ will be smaller in the vicinity of the magnetic axis, suggesting a larger power threshold for establishing the barrier in this case. Experimental results thus far are consistent with this expectation. Transport barriers are difficult to form with moderate neutral beam heating, requiring a pellet trigger for formation, as was observed in TFTR[3] with balanced NBI. It is also expected that counter-NBI will aid efforts to extend the duration of the ITB by supporting an elevated minimum safety factor q_{min} with counter-directed neutral beam current drive in the plasma core. Results of these experiments, both with higher power NBI and pellet assisted ITB formation will be discussed.

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