Steady State Scenario Development With Elevated Minimum Safety Factor on DIII-D

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Abstract. On DIII-D [J.L. Luxon, 2005 *Fusion Sci. Tech.* **48** 828], a high β scenario with minimum safety factor ($q_{\min}$) near 1.4 has been optimized with new tools and shown to be a favorable candidate for long pulse or steady state operation in future devices. The new capability to redirect up to 5 MW of neutral beam injection (NBI) from on- to off-axis improves the ability to sustain elevated $q_{\min}$ with a less peaked pressure profile. These changes increase the ideal MHD $n=1$ mode β_N limit thus providing a path forward for increasing the noninductive current drive fraction by operating at high β_N. Quasi-stationary discharges free of tearing modes have been sustained at $\beta_N = 3.5$ and $\beta_T = 3.6\%$ for two current profile diffusion timescales (about 3 seconds) limited by neutral beam duration. The discharge performance has normalized fusion performance expected to give fusion gain $Q \approx 5$ in a device the size of ITER. Analysis of the poloidal flux evolution and current drive balance show that the loop voltage profile is almost relaxed even with 25% of the current driven inductively, and $q_{\min}$ remains elevated near 1.4. These observations increase confidence that the current profile will not evolve to one unstable to a tearing mode. In preliminary tests a divertor heat flux reduction technique based on producing a radiating mantle with neon injection appears compatible with this operating scenario. 0-D model extrapolations suggest it may be possible to push this scenario up to 100% noninductive current drive by raising β_N. Similar discharges with $q_{\min} = 1.5-2$ were susceptible to tearing modes and off-axis fishbones, and with $q_{\min} > 2$ lower normalized global energy confinement time is observed.

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