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Development and extension of the non-inductive high beta poloidal regime to ITER relevant dimensionless parameters on DIII-D

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The high beta poloidal scenario on DIII-D has been extended to higher plasma current and normalized plasma pressure in the pursuit of ITER relevant dimensionless parameters. This pursuit is motivated by the fusion gain metric $G = \beta_N H_{89p}/q_{95}^2$, which is predicted to be ~0.27 in the ITER Q=5 steady state mission [1]. High beta poloidal experiments on DIII-D try to match this metric in steady-state relevant scenarios by taking advantage of the formation of an internal transport barrier (ITB) and the resulting high confinement and bootstrap fraction. Inductively-driven DIII-D plasmas with ITBs have reached values of $\beta_N = 2.8$, $q_{95} = 6.0$, and $H_{89p} = 2.7$ at 1MA of plasma current yielding a gain metric of ~0.21. Further advances will involve simultaneous increases in betaN and plasma current while maintaining the high confinement and ITB associated with the high beta poloidal scenario. Progress on the DIII-D tokamak towards such a regime will be presented in this talk, including details of scenario development and increased understanding of the underlying physics. Specifically, efforts to avoid the fast kink-like MHD instability that is the main obstacle to high current operation have achieved some success via control of the outboard midplane wall-plasma gap, while RMP ELM suppression and resistive wall mode feedback appear less effective. Wall interaction with energetic counter-streaming ions is also thought to limit edge stability [2]. New theoretical predictions of the mechanism for establishment of the ITB in this scenario via ELM-driven rearrangement of the kinetic ballooning stability regime [3] will be compared to experiment. Progress towards fully non-inductive operation at high plasma current by increasing the normalized plasma beta concurrently with the plasma current will also be discussed. Future plans for scenario development will be presented, including the installation of a 1MW helicon current drive system that will allow efficient off-axis current drive and greater control over the negative shear current profile required for ITB formation [4].

[1] Poli et. al., Nucl. Fusion 54 (2014) 073007
[2] Garofalo et. al., Nucl. Fusion 55 (2015) 123025
[3] J. McClenaghan et. al., Nucl. Fusion 57 (2017) 116019
[4] C. Lau et. at., Nucl. Fusion 58 (2018) 066004

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