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Stability of high-performance, negative central shear discharges

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DIII-D experiments demonstrate high-performance, negative central shear (NCS) equilibria with enhanced stability when the minimum safety factor qmin exceeds 2, qualitatively confirming theoretical predictions of favorable stability in the NCS regime. The discharges exhibit good confinement and performance (H89 = 2.5, H98,Y2 = 1.5, βN = 4), and are ultimately limited by the ideal-wall stability boundary predicted by ideal MHD theory, as long as tearing mode (TM) locking events, resistive wall modes (RWMs), and internal kink modes are properly avoided or controlled. Although the discharges exhibit rotating TMs, locking events are avoided as long as a threshold minimum safety factor value qmin > 2 is maintained. Fast timescale magnetic feedback control ameliorates RWM activity, expanding the stable operating space and allowing access to βN values approaching the ideal-wall limit. Quickly growing and rotating instabilities consistent with internal kink mode dynamics are encountered when the ideal wall limit is reached. Ideal MHD stability analysis predicts that the ideal-wall limit can be further increased to βN > 4 by broadening the current profile. This path toward improved stability has the potential advantage of being compatible with the bootstrap-dominated equilibria envisioned for advanced tokamak (AT) fusion reactors.

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