Transport and Stability of High-β_N, High Noninductive Fraction DIII-D Discharges*

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The physics of fully noninductive, high-β_N discharges is characterised by a nonlinear coupling between the bootstrap current magnitude and location (J_{BS}) and the evolution of the safety factor profile (q), through the effect of transport on the density and temperature profiles. Experiments to determine the role of the electron cyclotron current (J_{EC}), J_{BS} and the optimum q profile for stable noninductive operation show that the T and n profiles vary systematically with q_{min} and q_{95} at both fixed and maximum β_N. Due to this nonlinear dependence of the pressure profile peaking on both the q profile and β_N, the bootstrap fraction (f_{BS}) does not scale linearly with q in the experiment. In an effort to investigate the systematic variations of the kinetic profiles observed in the discharges, drift wave stability analyses were performed by means of the TGLF model. The results show trends in the linear growth rates that are at odds with the variations of the experimental low-k_θ density fluctuations and the experimental transport analysis. The discharge duration and the attainable β_N are often limited by n=1 tearing modes, which both depend on the current profile and perturb it in a way that is not recoverable with the available current drive sources. Systematic scans of electron cyclotron deposition width and radial location show that a broad J_{EC} profile at ρ~0.3–0.55 yields a J profile that is less prone to these instabilities. The modes appear when J_{EC} is turned off, and always appear for the outermost J_{EC} depositions. The broad J_{EC} that provides tearing stability differs significantly from that needed for direct stabilization. Tearing stability calculations explain the extreme sensitivity of the stability to the details of the experimental equilibria, and the modelling results are able to provide guidance on how to modify the experimental current profile in a way that increases the discharge stability. The new off-axis neutral beam injection capability will be used to explore higher q_{min} scenarios and different current alignments in the next experimental campaign.

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