DPP05-2005-000622

Abstract for an Invited Paper
for the DPP05 Meeting of
the American Physical Society

Access to Sustained High-Beta With Internal Transport Barrier and Negative Central Shear in DIII-D[1]

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High values of normalized pressure ($\beta_N \sim 4$) and safety factor ($q_{min} \sim 2$) have been sustained simultaneously for ~2 s in DIII-D, suggesting a possible path to high fusion performance, steady-state tokamak scenarios with a large fraction of bootstrap current. The combination of internal transport barrier and negative central magnetic shear results in high confinement ($H_{89p} > 2.5$) and good bootstrap current alignment ($_{BS} \sim 60\%$). Previously, stability limits in plasmas with core transport barriers have been observed at moderate values of β_N (<3) [R.C. Wolf, Plasma Phys. Control. Fusion **45**, R1 (2003)] because of the pressure peaking which normally develops from improved core confinement. In recent DIII-D experiments the internal transport barrier is clearly observed in the ion temperature and rotation profiles at $\rho \sim 0.5$ but not in the electron temperature profile, which is very broad. The misalignment of T_i and T_e gradients may help avoid a local pressure peaking. Furthermore, at low internal inductance ~0.6, the current density gradients are close to the vessel and the ideal kink modes are strongly wall-coupled. Simultaneous feedback control of both external and internal sets of n=1 magnetic coils was used to maintain optimal error field correction and resistive wall mode stabilization, allowing operation above the free-boundary beta-limit. Large particle orbits at high safety factor in the core help to broaden both the pressure and the beam-driven current profiles, favorable for steady state operation. At plasma current flattop and $\beta \sim 5\%$, a noninductive current fraction of ~90% has been observed. Stability modeling shows the possibility for operation up to the ideal-wall limit at $\beta \sim 6\%$.

[1]Supported by the US DOE under DE-FG02-89ER543297.