Tokamak operation with $q_{95} < 2$ via control of MHD stability in DIII-D

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Abstract

Magnetic feedback control of the resistive-wall mode has enabled DIII-D to access stable operation at safety factor $q_{95} = 1.9$ in divertor plasmas for 150 instability growth times. Magnetohydrodynamic stability sets a hard, disruptive limit on the minimum edge safety factor achievable in a tokamak, or on the maximum plasma current at given toroidal magnetic field. In tokamaks with a divertor, the limit occurs at $q_{95} = 2$, as confirmed in DIII-D. Since the energy confinement time scales linearly with current, this also bounds the performance of a fusion reactor. DIII-D has overcome this limit, opening a whole new high-current regime not accessible before. This result brings significant possible benefits in terms of fusion performance, but it also extends resistive wall mode physics and its control to conditions never explored before. In present experiments, $q_{95} < 2$ operation is eventually halted by voltage limits reached in the feedback power supplies, not by intrinsic physics issues. Improvements to power supplies and to control algorithms have the potential to further extend this regime.

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