Measurement of edge currents in DIII-D and their implication for pedestal stability

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Abstract. The present performance limits of tokamak discharges are strongly coupled to the stability and transport properties of the edge plasma. Both experimental and modeling efforts have shown a clear connection between the edge pressure pedestal height and core plasma confinement. The key to understanding the stability and performance limits of the pedestal revolves around an accurate knowledge of the plasma current in this region. Using the Zeeman effect in an injected 30 keV lithium beam, we have measured the currents in the edge of the DIII-D [J.L. Luxon, Nucl. Fusion **42**, 6114 (2002)] tokamak for various confinement modes. This method of determining $j(r)$ is insensitive to the large electric fields which coexist in the pedestal region and which complicate motional Stark effect measurements. For the high confinement cases, where substantial pedestal pressures exist, we find large $\left(\sim \mathrm{MA/m^2}\right)$, localized ($\Delta R \sim$ 1-2 cm) currents in the pedestal region, located near the maximum in the pressure gradient. These values are consistent with calculations of edge bootstrap current using the neoclassical NCLASS [W.A. Houlberg, *et al.,* Phys. Plasmas **4**, 3230 (1997)] and Sauter[O. Sauter, *et al.,* Phys. Plasmas **6**, 2834 (1999)] models and the measured pedestal density and temperature profiles. The apparent consistency of the measured j_{EDGE} with neoclassical predictions occurs despite the violation of one of the fundamental tenets of the theory, namely $\varepsilon = \rho_i / L_P << 1$, where ρ_i = ion poloidal gyroradius and L_p = pressure gradient scale length. The

measured j_{EDGE} has also been used to generate self-consistent reconstructions using the free boundary equilibrium solvers CORSICA [T.A. Casper, *et al.,* Plasma Phys. Control. Fusion **45**, 1193 (2003)] and EFIT [L.L. Lao, *et al.,* Nucl. Fusion **25**, 1611 (1985)]. These equilibria allow us, in conjunction with the ELITE [P.B. Snyder, *et al.,* Phys. Plasmas **9**, 2037 (2002); H.R. Wilson, *et al.,* Phys. Plasmas **9**, 1277 (2002)] magnetohydrodynamic stability code, to assess the linear stability of the edge to peeling/ballooning modes. These results are then compared to the measured edge localized mode onset conditions and again good agreement is found between the experimental and model limits on the maximum permissible j_{EDGE}.