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New Measurements Shed Light On Improved Confinement Regime

New measurements on the Alcator C-Mod tokamak have enabled detailed calculations of the radial electric field in the C-Mod edge pedestal, providing new insight into the connection between flow shear suppression and H-mode confinement.

The installation of new edge diagnostics has allowed the first detailed calculations of the radial electric field (E_r) in the edge of C-Mod plasmas. The radial field leads to a strongly sheared plasma flow perpendicular to the magnetic field. It is generally accepted that this "**E**x**B**" velocity shear is responsible for the reduction in edge turbulence, which reduces the loss of both particles and energy across magnetic field lines and results in the formation of edge transport barriers and the high-confinement mode of operation known as the H-mode [Groebner et al., Phys. Rev. Lett. 64, 3015, 1990]. However, even after 25 years of study, the physics behind the formation of the electric field, and the transition from "low confinement mode" (L-Mode) to H-mode is still not well understood, nor is the exact nature of the relationship between the electric field, edge pedestal parameters and global plasma confinement.

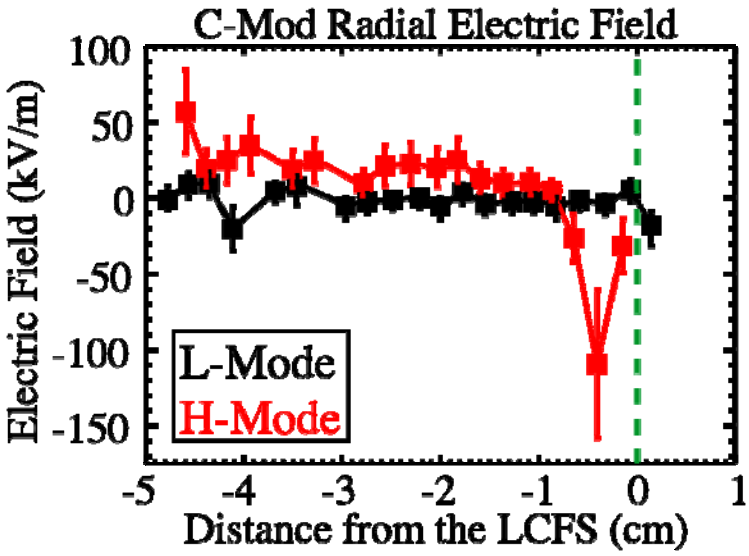
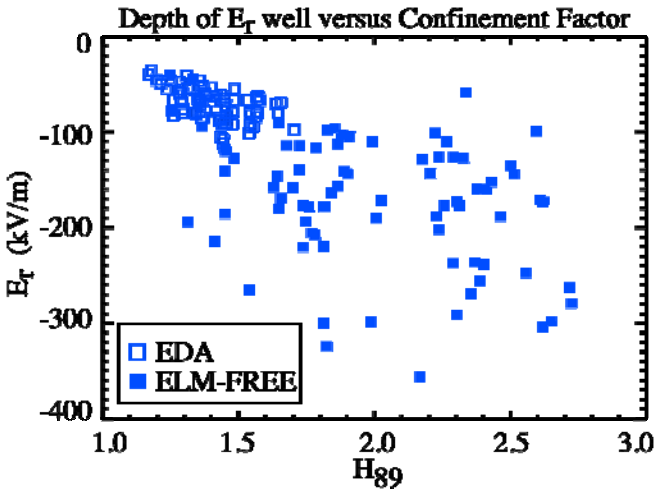


Figure 1: Profiles of the Radial Electric Field from the C-Mod tokamak

The H-mode regime has energy confinement that is roughly twice as good as in L-mode and is accessible to most tokamaks and some other magnetic confinement fusion devices [Wagner et al., Phys. Rev. Lett. **49**, 1408, 1982]. The onset of an H-mode is characterized by a sharp decrease in edge fluctuations and the formation of edge transport barriers (pedestals) in both the ion and electron temperature and density profiles. These barriers lead to significant increases in core temperature, density, and plasma confinement time. In order to reach their operational goals, future fusion reactors, like ITER, must operate in H-mode regimes. However, despite intensive study by both the theoretical and experimental fusion communities, the actual mechanism by which the transition takes place remains unclear.

The radial electric field measurements made on C-Mod are qualitatively consistent with

the idea that **E**x**B** shear is an essential piece to the H-mode puzzle. In L-mode, E_r is small in magnitude and the profiles are relatively flat. In H-mode, however, the electric field at the edge becomes sharply negative, creating a "well" like structure with very strong **E**x**B** shear in the edge pedestal region (Figure 1). The measured E_r well depth on C-Mod, upto 300kV/m, is unprecedented; over twice as deep as on other devices. Additionally, the observed well width is considerably narrower than has been observed on other machines (5mm), suggestive of a scaling of E_r well width with machine size.



E_r profiles have been tracked through H-modes in which there is significant change to the quality of the plasma confinement. These measurements have demonstrated a clear correlation between the magnitude of the edge E_r shear and the quality of the plasma confinement. The depth of the E_r well decays if H-mode confinement degrades due to increases in radiated power (Figure 2).

Figure 2: E_r well depth increases with improved

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