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Plasma Rotation and Radial Electric Field Response to Resonant Magnetic Perturbations in DIII-D[1]

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Analysis of DIII-D experiments have revealed a complex picture of the evolution of the toroidal rotation v_{tor} and radial electric field E_r when applying edge resonant magnetic perturbations (RMPs) in H-mode plasmas. Measurements indicate that RMPs induce changes to the plasma rotation and E_r across the plasma profile, well into the plasma core where islands or stochasticity are not expected. In the pedestal, the change in E_r comes primarily from the $v \times B$ changes even though the ion diamagnetic contribution to E_r is larger. This allows the RMP to change E_r faster than the transport timescale for altering the pressure gradient. For $n = 3$ RMPs, the pedestal v_{tor} goes to zero as fast as the RMP current rises, suggesting increased toroidal viscosity with the RMP, followed by a slow rise in co-plasma current v_{tor} (pedestal "spin-up") as the pedestal density pumps out. This spin-up could result from a reduction in ELM-induced momentum transport or a resonant $j \times B$ torque due to radial current. As v_{tor} becomes more positive and the pressure pedestal narrows, the electron perpendicular rotation $\sim$0 point moves out toward the top of the pedestal; increasing the RMP current moves this crossing point closer to the top of the pedestal. These changes reduce the mean $E \times B$ shearing rate across the outer half of the discharge from several times the linear growth rate for intermediate-scale turbulence to less than the linear growth rate, consistent with increased turbulent transport. Full-f kinetic simulations with self-consistent plasma response and E_r using the XGC0 code have qualitatively reproduced the observed profile and E_r changes. These results suggest that similar to their role in regulating H-mode plasma transport and stability, plasma rotation and E_r play a critical role in the effect of RMPs on plasma performance.

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