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Simultaneous Measurement of q and E_r Profiles Using the Motional Stark Effect in High-Performance DIII–D Plasmas*

B.W. Rice, Lawrence Livermore National Laboratory, Livermore, California†

The Motional Stark Effect (MSE) diagnostic has matured into a reliable and routine technique for measuring the magnetic pitch angle or q profile in tokamaks. The technique relies upon polarization measurements of Stark broadened H_α emission to determine the pitch angle of the Lorentz $\mathbf{v_b} \times \boldsymbol{B}$ electric field, where $\mathbf{v_b}$ is the injected neutral beam particle velocity and $\boldsymbol{B}$ is the total magnetic field. In recently developed advanced confinement regimes in DIII–D, such as negative central magnetic shear (NCS) and VH–mode, large values of the plasma radial electric field (E_r), up to 200 kV/m, are observed. This radial field adds to the $\mathbf{v_b} \times \boldsymbol{B}$ electric field and can affect the interpretation of MSE measurements and subsequent equilibrium reconstructions. It will be shown that viewing fixed locations in the plasma from two different viewing angles allows one to separate the E_r field from the $\mathbf{v_b} \times \boldsymbol{B}$ field, thus providing simultaneous measurement of the E_r and q profiles. A direct measurement of E_r is of great importance in fusion research since shear in the $\boldsymbol{E_r} \times \boldsymbol{B}$ flow is a leading model for explaining the reduction in turbulence observed in advanced confinement regimes. Furthermore, an accurate measurement of E_r is necessary to correctly determine the q profile. To achieve this measurement, the DIII-D MSE diagnostic was recently upgraded from 16 to 35 channels with three independent viewing angles. The new instrument provides an E_r resolution of ~10 kV/m with a time response of ~1 ms. The MSE measurements have been fully integrated into the EFIT equilibrium code, so EFIT can now reconstruct self-consistent E_r and q profiles. Recent measurement results will be presented, including: 1) large $\boldsymbol{E_r} \times \boldsymbol{B}$ flow shear values observed in NCS and VH–mode discharges that exhibit near-neoclassical levels of ion transport; 2) the effect of E_r on measurements of current at the edge in H–mode plasmas; 3) the effect of E_r on the value of $q(0)$ measured during sawteeth. Finally, we will present future plans to use MSE signals for feedback control of q and E_r.

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†In Collaboration with K.H. Burrell, L.L. Lao, General Atomics and D.G. Nilson, Lawrence Livermore National Laboratory.