The role of a spectral motional Stark effect diagnostic in equilibrium reconstruction and diamagnetic measurement in low-|B| plasmas*

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A spectral motional Stark effect diagnostic is a powerful tool for internal measurement of magnetic field in high-temperature, low-field (≤0.5 T) plasmas. This diagnostic has been applied to make first-time internal local measurements of |**B**| in the Madison Symmetric Torus (MST) reversed-field pinch (RFP) and the Gas Dynamic Trap (GDT) axially symmetric magnetic mirror. These measurements of |**B**| are critical because the equilibrium magnetic field profile is determined by plasma dynamo current in the RFP and by diamagnetic current in the GDT mirror. The spectral motional Stark effect diagnostic technique requires the injection of a ≥30 keV low-divergence neutral hydrogen beam into the plasma, perpendicular to the magnetic field. The beam-emission Hα spectrum is Stark split by the $\mathbf{v}_{\mathbf{beam}} \times \mathbf{B}_{\mathbf{axial}}$ force. Analysis of the splitting of the components of the Stark spectrum directly results in a measurement of local |**B**|. In the MST RFP, a single on-axis measurement of |**B**| provides a strong constraint for the equilibrium reconstruction code MSTfit [J. K. Anderson *et al.*, Nuclear Fusion **44**, 162 (2004)]. This new code is well-suited to the unique magnetic structure of the RFP. It finds an axisymmetric solution of Maxwell's equations while satisfying radial force balance and finding the best fit to all available data. In the GDT magnetic mirror, measurement of the radial profile of the Δ**B** diamagnetic modification of the vacuum axial **B** directly yields an estimate of the plasma β profile. Measurements have confirmed that on-axis transverse β approximately equal to 40% is achieved in the fast ion turning points [A.A. Ivanov *et al.*, Phys. Rev. Lett. **90**, 105002 (2003)].

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