Direct measurement of neoclassical currents using motional Stark effect polarimetry

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March 24, 2005

Abstract

The radial profile of the Pfirsch-Schlüter current has been measured directly for the first time in a tokamak using motional Stark effect (MSE) polarimetry. The MSE diagnostic measures the vertical component of the magnetic field (B_z) as a function of the plasma major radius. The analysis technique presented here converts the experimental B_z profile into a flux-surface-average current density as well as a local current density. Taking the appropriate difference between these two quantities yields a direct measurement of the Pfirsch-Schlüter current density, and consequently a MSE-based measurement of the plasma pressure profile. The bootstrap current density can also be directly determined from the B_z profile (with greater approximation) in the collisionless limit. An equilibrium reconstruction is not required for this MSE analysis technique, although a few basic geometric parameters such as the plasma minor radius, elongation, and triangularity need to be known. The usefulness of this approach for analyzing the current profile is demonstrated using discharges from the DIII-D tokamak.