Dependence of the Core Radial Electric Field on Ion and Electron Temperature in W7-X

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The dependence of the core radial electric field (E_r) on the ion and electron temperatures in the Wendelstein 7-X stellarator is investigated. The core radial electric field plays an important role in stellarator plasmas, and is expected to have a strong effect on both the particle and heat fluxes. Because the neoclassical particle fluxes in a stellarator are not intrinsically ambipolar, the E_r is strongly tied to the ion and electron temperature and density profiles. In W7-X a large positive radial electric field is expected in cases in where Te >> Ti, while a smaller negative electric field is expected when the temperatures are close to equal (Ti ~ Te). This dependence of E_r on the temperature ratio is investigated experimentally in W7-X, and compared to expectations from neoclassical theory. Determination of the E_r profile is made possible by utilizing the X-Ray Imaging Crystal Spectrometer (XICS). This diagnostic is able to measure perpendicular plasma flow ($u_\perp$), which is closely related to the radial electric field through the radial force balance. Experimentally inferred E_r profiles are then compared with predictions from the neoclassical code SFINCS, which are based on measured temperature and density calculations from the Thomson Scattering, XICS and Interferometer diagnostics. Finally the evolution of the E_r profile during high performance plasmas with pellet injection is investigated. These discharges demonstrate a clear dynamic change in the E_r profiles commensurate with the increase in density and equilibration of the ion and electron temperatures. Comparisons between measured and predicted values of E_r are used to better understand the validity of neoclassical calculations during the dynamic phases of these plasmas.