ECPD 2021
European Conference on Plasma Diagnostics

Pedestal Magnetic Field Fluctuation Measurements using the Spatial Heterodyne Spectrometer on DIII-D

M.G. Burke[1], R.J. Fonck[1], G.R. Mckee[1], B. Geiger[1], M. Knolker[2], F.M. Laggner[3], and Z. Yan[1]

1) University of Wisconsin-Madison

E-mail : mgburke@wisc.edu

2) General Atomics

3) Princeton Plasma Physics Laboratory

A novel optical diagnostic for measuring internal electric and magnetic fields in a tokamak plasma has been installed on the DIII-D tokamak. It involves spectrally resolving the Balmer alpha neutral beam radiation split by the Motional Stark Effect (MSE) with an ultra-high resolution-luminosity product spatial heterodyne spectrometer (SHS). The spectral separation measurement provides both the local magnetic field magnitude perpendicular to the neutral beam velocity, $|B_\perp|$, and the plasma electric field magnitude. The magnetic field measurement gives access to the dynamics of the edge current density, which is essential to understanding and predicting the performance, stability limits and edge localized mode generation of high-confinement (H-mode) tokamak plasmas. The technique is less sensitive to the non-statistical populations of excited states and polarization angle contamination, allowing for $\sim 0.2\%$ deviations in the local magnetic field to be measured at high speed (200 μs). The high throughput of the SHS is effectively utilized by incorporating a novel geometric Doppler broadening compensation technique. This correction technique significantly reduces the spectral resolution penalty inherent to using large area, high-throughput collection optics, allowing for practical, higher sensitivity systems to be designed. Measurements of $|B_\perp|$ during the H-mode formation show a large increase at radial position $\psi_N = 1.0$ with little change at $\psi_N = 0.9$, consistent with the formation of the edge bootstrap current density peak. An increase in neutral beam injected power later in the H-mode phase results in higher measured $|B_\perp|$, consistent with increased pedestal pressure and edge current density. In addition, significant changes in the local magnetic field strength are observed during ELM crashes, with some changes occurring 5-10ms before the ELM and in <0.5 ms across the ELM crash. Poloidal electric field fluctuations can in principle be simultaneously measured using the SHS with an upgraded detection system. Work supported by US DOE under DE-FC02-04ER54698, DE-FG02-89ER53296, and DE-FG02-08ER54999.