New millimeter-wave diagnostics to locally probe internal density and magnetic field fluctuations in NSTX-U *

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A set of new millimeter-wave diagnostics will deliver unique measurement capabilities for NSTX-U to address a variety of plasma instabilities believed to be important in determining thermal and particle transport[1] (e.g., MTM, ITG, TEM, ETG, KBM). Understanding these transport mechanisms is necessary to address the key confinement predictions for NSTX-U plasmas[2]. These diagnostics include a new integrated Doppler backscattering (DBS) and cross-polarization scattering (CPS) system (four channel higher frequency, 82.5-87 GHz) to measure density and magnetic fluctuations respectively. In addition, a lower frequency (35-50 GHz) eight-channel fluctuation reflectometer and a mid-frequency (50-75 GHz) four channel tunable fluctuation reflectometer system (for low-k density turbulence and fast ion physics) will be located at a nearby port location. The combined systems cover the near LCFS and pedestal regions (35-50 GHz), the pedestal or mid-radius (50-75 GHz), and core plasmas (82.5-87 GHz). In addition, the tunable mid frequency channels (50-75 GHz) provide for radial density turbulence correlation length measurements important for testing turbulence modeling and theory. NSTX-U (post recovery) has not yet produced plasmas, however, plasma data from similar DBS/CPS systems on both conventional and spherical tokamaks are utilized to examine and illustrate both the capabilities and the challenges of these measurements. Both DBS and CPS are millimeter wave scattering processes that are particularly challenged by the large magnetic pitch angles found in spherical tokamaks. In particular, CPS is a very sensitive polarization measurement which requires minimizing the effects of spurious signals due to improper magnetic pitch angle matching (this is related to the probe beam alignment to the binormal fluctuation wavevector at the cutoff position). Another requirement is the launch of a pure O or X-mode polarized electromagnetic plasma wave (this latter issue concerns the X or O-mode probe beam polarization matching relative to the magnetic field direction near the plasma edge). Data illustrating the importance of these and other effects and methods to address them will be examined in detail (for example, through remote control of the poloidal and toroidal beam aiming and the launch/receive polarization). Finally, a synthetic DBS diagnostic employing a beam tracing code (SCOTTY[3]) will be presented that allows direct comparison of DBS measurements to test linear and nonlinear turbulence modeling.

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