New Plasma Measurements with a Multichannel Millimeter-wave Fluctuation Diagnostic System in the DIII-D Tokamak*

J.C. Hillesheim, W.A. Peebles, L. Schmitz, T.L. Rhodes,
A.E. White[a], T.A. Carter, and the DIII-D Team

University of California, Los Angeles, Los Angeles, California 90095, USA
[a]Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

jchillesheim@physics.ucla.edu

A novel multichannel, tuneable Doppler backscattering (DBS)/reflectometry system has recently been developed [1] and applied to a variety of DIII-D plasmas. The system has a compact array of five frequencies, which are spaced 350 MHz apart, that can be tuned across a wide band (53-78 GHz). Doppler backscattering [2] measures the propagation velocity of turbulent structures in the laboratory frame and the relative level of intermediate-k density fluctuations ($k_\perp \sim$ 2–15 cm^{-1}; $k_\perp \rho_i \sim$ 1–4, with ρ_i being the ion gyroradius), while reflectometry is sensitive to low-k density fluctuations ($k_\perp \rho_i < 0.5$). A flexible quasi-optical antenna system allows either DBS or reflectometry to be easily configured for use in a wide range of plasma conditions, providing radially localized ($\Delta r \sim$ 0.5 cm) measurements with high time resolution (~1 μs). The multiple closely spaced channels, when combined with other fluctuation diagnostic systems, have opened up new measurements of plasma properties. For example, the toroidal and fine-scale radial structure of coherent plasma oscillations, such as Geodesic Acoustic Modes, have been probed simultaneously in the core of high temperature plasmas by applying correlation analysis between *two* toroidally separated DBS systems, as well as within the multichannel array. When configured for DBS, the system has allowed monitoring of local modifications to ExB flow, ExB flow shear, and intermediate-k turbulence levels associated with a range of plasma phenomena, such as sawtooth crash events and momentum input from short duration neutral beam pulses. Finally, when configured as a reflectometer, cross-correlation with electron cyclotron emission data has uncovered detailed information regarding the crossphase relationship between density and temperature fluctuations. The density-temperature crossphase measurement yields insight into the physics of tokamak turbulence at a fundamental level that can be directly compared with predictions from nonlinear gyrokinetic simulations. The system design, analysis techniques, and sample data demonstrating the above measurement capabilities will be presented.

[1] J.C. Hillesheim, W.A. Peebles, T.L. Rhodes, L. Schmitz, T.A. Carter, P.-A. Gourdain, and G. Wang, Rev. Sci. Intrum. **80**, 083507 (2009)
[2] M. Hirsch, E. Holzhauer, J. Baldzuhn, B. Kurzan, and B. Scott, Plasma Phys. Control. Fusion **43**, 1641 (2001)

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