Recent Doppler Backscattering Results from DIII-D

L. Schmitz[1]

with G. Wang[1], J.C. Hillesheim[1], W.A. Peebles[1], T.L. Rhodes[1], A.E. White[2], J.C. DeBoo[3], J.S. deGrassie[3], G.R. McKee[4], E.D. Doyle[1], L. Zeng[1], K.H. Burrell[3], C.C. Petty[3], J. Kinsey[3], W.A. Solomon[5], G.M. Staebler[3], and the DIII-D Team

[1]University of California-Los Angeles, Los Angeles, California 90095-1547, USA
[2]Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee, USA
[3]General Atomics, San Diego, California 92186-5608, USA
[4]University of Wisconsin at Madison, Madison, Wisconsin 53706, USA
[5]Princeton Plasma Physics Laboratory, Princeton, New Jersey 08543-0451, USA

Doppler backscattering (DBS) is a versatile diagnostic tool for measurements of turbulence flow and density fluctuation levels in tokamaks. Two tunable DBS system have recently been installed and operated at DIII-D, including a two-channel DBS system (49 Ghz $\leq f \leq$ 72 Ghz) and a tunable five channel system (53 Ghz $\leq f \leq$ 78 Ghz), based on frequency modulation to obtain closely spaced probing frequencies around a carrier (inter-channel separation Δf = 0.35 GHz). Both systems can operate in O- and X-mode polarization.

DBS results provide experimental evidence that intermediate-scale turbulence ($0.8 < k_\theta \rho_s \leq 2.5$) is reduced by at least an order of magnitude across the L- to H-mode transition in the core of high temperature, low density DIII-D plasmas ($0.4 \leq r/a \leq 1$, $T_i/T_e \geq 2$). Concomitantly, a very substantial reduction of the electron heat diffusivity across the minor radius, compared to L-mode values, is inferred from time-dependent transport analysis. Linear stability calculations (using the TGLF trapped gyro-Landau fluid code) indicate intermediate scale turbulence suppression by $\boldsymbol{E}\times\boldsymbol{B}$ shear for $r/a <$ 0.5, and attribute the residual anomalous H-mode electron heat diffusivity to small scale ETG turbulence ($k_\theta \rho_s \geq 4$).

DBS is suitable for perturbative momentum transport studies and has provided initial measurements of the temporal evolution of $\boldsymbol{E}\times\boldsymbol{B}$ plasma flow with co- and counter-neutral beam injection. Doppler backscattering is also utilized to probe stationary and time-dependent shear flows (i.e. Zonal Flows). We present data which clearly indicate the presence of a quasi-stationary shear flow pattern near the q=2 surface in an L-mode electron transport barrier. Zonal Flow levels and Zonal Flow shear are anti-correlated with the amplitude of intermediate-scale density turbulence near the q=2 surface, suggesting that zonal flows play an important role in intermediate scale turbulence/transport regulation.

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