Collisionality scaling of turbulence and transport in advanced inductive plasmas in DIII-D*

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The collisionality scaling of multiscale turbulence properties and thermal transport characteristics in high-beta, high confinement Advanced Inductive (AI) plasmas was determined via systematic dimensionless scaling experiments on DIII-D. Preliminary estimate indicates that energy confinement scales approximately as $B_{t}t_{E}\sim(n^{*})^{-0.25}$, consistent with the favorable collisionality scaling of energy confinement in high performance AI regimes observed in an ITPA joint database [1]. Interestingly, low-k density fluctuation amplitudes are observed to decrease at lower collisionality near $\varphi\sim0.75$, apparently consistent with this favorable collisionality trend. During the experiment the collisionality $\nu^{*} \sim(na/T_{e}^{2})$ was varied by a factor of three while other relevant dimensionless parameters ($\rho^{*}$, $\beta$, $q_{95}$, $T_{e}/T_{i}$) are kept nearly constant through advanced plasma feedback control systems. The safety factor, $q_{95}\sim4$ (the value proposed for AI operation in ITER), and $\beta_{N}\sim2.8$ in these plasmas. Electron density and scaled ($\sim B_{t}^{2}$) temperature profiles are well matched during the scan. Ion and electron thermal transport values, computed with ONETWO [2] using experimentally measured profiles and sources, will be presented, along with multi-scale turbulence measurements obtained with various fluctuation diagnostics: 2D BES, DBS and PCI. Altering collisionality should change the relative contribution of ITG, TEM and ETG modes to transport AI scenarios are attractive candidates for achieving the ITER project objectives since they achieve high confinement with $H_{98y}\geq1$ at relatively high normalized pressure of $\beta_{N}\geq2.4$, exhibit no sawteeth and are steady for multiple energy confinement times (several seconds), allowing for improved turbulence measurements of low-amplitude fluctuations through ensemble averaging of long data records. This data set will contribute to validation of transport models in high performance regimes, allowing for the projection of performance from present-day experiments to burning plasma experiments such as ITER.

*Work supported in part by the US DOE under DE-FG02-08ER54999, DE-FG02-89ER53296, DE-FC02-04ER54698, DE-FG02-07ER54917, DE-FG02-08ER54984, DE-FG02-94ER54235, and DE-AC02-09CH11466.