Impact of rotation on the confinement and current profile evolution of the ITER Baseline Scenario in DIII-D

F. Turco[1], T. C. Luce[2], J. M. Hanson[1], A. Turnbull[2], G.A. Navratil[1], C. Paz-Soldan[2], W. Solomon[3]

[1]Columbia University, New York, New York, USA
[2]General Atomics, PO Box 85608, San Diego, CA 92186-5608, USA
[3]Princeton Plasma Physics Laboratory, Princeton, NJ, USA
email: turcof@fusion.gat.com

Demonstration discharges in DIII-D have achieved performance in normalised parameters that projects to the conditions required for the ITER Baseline Scenario (IBS), which is tasked to reach Q=10 and 500 MW of fusion power for >300 s (1-2 τ_R in ITER) at 15 MA. These plasmas are operated in the scaled ITER plasma shape, with q_{95}=3.1, q_0=q_{min}~1 and fixed β_N~1.8-2.2, in the range of torque~3-4 Nm, down to low ITER relevant torque (0.5-1 Nm), both with neutral-beam (NBI) heating and partial direct electron heating (with ECH power). Analysis of a database of ~180 IBS discharges shows that the confinement properties of NBI-heated and of ECH-heated plasmas differ. The confinement of NBI-only heated IBS shots does not seem to degrade with lower torque at low to intermediate density levels, unlike the higher β_N, higher q Advanced Inductive plasmas. Conversely, for these shots, a confinement reduction is indeed observed when the density rises above ~50% of the Greenwald fraction. On the other hand, IBS plasmas with direct electron heating do show a degradation of confinement with torque, and have lower confinement than low torque NBI-only shots for comparable density levels. Finally, reducing the torque at fixed NBI power to the ITER equivalent torque of ~0-1 Nm causes the ELM character to change, with the frequency generally decreasing by 20-50%.

The rotation profile in these plasmas evolves at fixed torque in the β_N flattop phase, producing changes in the global confinement and the local current density profile (*j*) and safety factor. When the rotation decreases, the pedestal temperature $T_{e,ped}$ and the $T_{e,ped}$ width increase, while the pedestal density and Z-effective do not show this trend. The current density profile is dominated by bootstrap current in the pedestal region ρ~0.7-1. Since the bootstrap current is proportional to $T_{e,ped}$ and $p_{e,ped}$, a broader and higher pedestal is likely the cause of the increased current density in this region for the lower torque plasmas. Therefore, when the rotation decreases, j_{ped} grows, the current "well" inside the pedestal deepens, and *j* at mid radius increases.

With the q profile fixed between q_{min}~1 by sawteeth and q_{95}~3 by the I/aB scenario choice, the q=2 surface location is located around the current "well" inside the pedestal. A reduction in rotation tends to move the q=2 surface from inside to close to the "well" and in some cases past the "well" towards the region of positive current gradient and towards the pedestal, which tends to have a deleterious effect also on the stability of the 2/1 mode limiting the duration of these plasmas.

Work supported in part by the U.S. Department of Energy under DE-FG02-04ER54761[1], DE-FC02-04ER54698[2] and DE-AC02-09CH11466[3].

Please select ________ Poster or <u>X</u> Oral

Topical Area: Plenary: controlling transport through q profiles