IAEA FEC 201

Contribution ID: **673** Type: **Oral**

Advances in the high bootstrap fraction regime on DIII-D towards the Q=5 mission of ITER steady state

Wednesday, 19 October 2016 17:00 (20 minutes)

Extension of large radius internal transport barrier (ITB), high bootstrap current fraction scenario toward low plasma rotation and q95 relevant to steady state operation at Q=5 in ITER has been successfully demonstrated in DIII-D. New DIII-D experiments have shown that the key feature of large radius ITB and excellent energy confinement when the scenario is extended inductively to higher plasma current, for lower q95, and more balanced neutral beam injection (NBI), for lower plasma rotation. Large radius ITBs can be maintained at significantly reduced values of q95 and of the plasma rotation, compared to earlier experiments. The weak sensitivity of confinement on rotation by energy transport modeling indicates that ExB shear does not play a major role in the turbulence suppression. Neoclassical transport is predicted to be the dominant transport mechanism for the main ion energy. Experimental fluctuation measurements show no long wavelength turbulence at both high and low torque conditions. Experiments also show that a flat carbon density profile is observed inside the ITB and there is no obvious accumulation of impurities despite the excellent energy confinement quality. TGLF-SAT1 modeling indicates that the impurity transport is indeed much stronger than neoclassical. Experimental results and ideal MHD stability analysis show how wall stabilization can enable a high betaN limit even in presence of strong ITBs. The larger ITB radius improves the wall-stabilization effect, enabling a higherbetaN. The experimentally measured maximum stable betaN agrees well with the ideal MHD, ideal wall limit predictions. Extrapolating the DIII-D results using a 0-D model shows that with the improved confinement of the scenario, the high bootstrap fraction regime could achieve Q=5 in ITER at betaN ˜2.9 and q95˜7. Results from self-consistent, 1.5D modeling of ITER steady state using TGLF-SAT1 will also be presented.

Paper Number

EX/4-2

Country or International Organization

China

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Session Classification: Steady State and Hybrid scenarios

Track Classification: EXC - Magnetic Confinement Experiments: Confinement