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ITR/P1-30: ITER Implications of the Beta Scaling of Energy Confinement

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There is emerging evidence that the variation in the measured beta dependence of confinement in H-mode plasmas is due in part to different turbulent modes being dominant, with ITG modes being important in weak beta scaling cases and micro-tearing modes being potential candidates explaining strong beta degradation. Additionally, the normalized H-mode pedestal height may not be constant over a beta scan, which affects core transport and global confinement. Determining the beta scaling of transport helps to differentiate between various proposed theories of turbulent transport that are primarily electrostatic or primarily electromagnetic. Initial experiments on JET, DIII-D and NSTX found a weak dependence of confinement on beta; however, this picture of primarily electrostatic transport was brought into question by experiments on JT-60U and ASDEX Upgrade that observed a strong unfavorable beta scaling.
The ITPA topical group on Transport and Confinement has coordinated experimental and modeling activity to better understand the origin of these different beta scalings. An important factor that can impact scaling results is experimental imperfections in the beta scans. For some experiments the normalized H-mode pedestal height decreases with higher beta, which can result in an unfavorable beta scaling even if core transport is primarily electrostatic. A DIII-D experiment with joint participation by the ASDEX Upgrade team found no beta dependence in the local thermal diffusivities outside of the ≈15% error bars, and the magnitude and trend with beta of density fluctuations were in reasonable agreement with GYRO simulations for electrostatic ITG-mode turbulence. In contrast, turbulence modeling of ASDEX Upgrade experiments using GS2 found that micro-tearing modes are unstable in the high beta cases but their contribution to the beta degradation remains to be assessed quantitatively. Micro-tearing modes should be important for high collisionality and flat density profiles, which were the conditions for ASDEX Upgrade and JT-60U. Therefore, the disparate beta scalings may be explained by either different dominant turbulence modes or experimental imperfections such as changes in the H-mode pedestal height during the beta scan.

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