Development of advanced inductive scenarios for ITER

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Abstract. Since its inception in 2002, the International Tokamak Physics Activity topical group on Integrated Operational Scenarios (IOS) has coordinated experimental and modeling activity on the development of advanced inductive scenarios for applications in the ITER tokamak. The physics basis and the prospects for applications in ITER have been advanced significantly during that time, especially with respect to experimental results. The principal findings of this research activity are as follows. Inductive scenarios capable of higher normalized pressure ($\beta_N \geq 2.4$) than the ITER baseline scenario ($\beta_N = 1.8$) with normalized confinement at or above the standard H-mode scaling are well established under stationary conditions on the four largest diverted tokamaks (AUG, DIII-D, JET, JT-60U), demonstrated in a database of more than 500 plasmas from these tokamaks analyzed here. The parameter range where high performance is achieved is broad in q_{95} and density normalized to the empirical density limit. MHD modes can play a key role in reaching stationary high performance, but also define the limits to achieved stability and confinement. Projection of performance in ITER from existing experiments uses empirical scalings and theory-based modeling. The status of the experimental validation of both approaches is summarized here. The database shows significant variation in the energy confinement normalized to standard H-mode confinement scalings, indicating the possible

[a] See the Appendix of F. Romanelli et al., Proceedings of the 24th IAEA Fusion Energy Conference 2012, San Diego, US

influence of additional physics variables absent from the scalings. Tests using the available information on rotation and the ratio of the electron and ion temperatures indicate neither of these variables in isolation can explain the variation in normalized confinement observed. Trends in the normalized confinement with the two dimensionless parameters that vary most from present-day experiments to ITER, gyroradius and collision frequency, are significant. Regression analysis on the multi-tokamak database has been performed, but it appears that the database is not conditioned sufficiently well to yield a new scaling for this type of plasma. Coordinated experiments on size scaling using the dimensionless parameter scaling approach find a weaker scaling with normalized gyroradius than the standard H-mode scaling. Preliminary studies on scaling with collision frequency show a favorable scaling stronger than the standard H-mode scaling. Coordinated modeling activity has resulted in successful benchmarking of modeling codes in the ITER regime. Validation of transport models using these codes on present-day expeirments is in progress, but no single model has been shown to capture the variations seen in the experiments. However, projection to ITER using these models is in general agreement with the favorable projections found with the empirical scalings.

PACs Nos: 52.55.Fa, 52.55.Dy, 52.25.Fi, 52.35.Py, 52.65.Tt