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Update of the global energy confinement scaling in tokamak ELMy H-mode plasmas

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The multi-machine International Tokamak Physics Activity (ITPA) Global H-mode Confinement Database has been upgraded with new data from JET with the ITER-like wall and ASDEX Upgrade with the full tungsten wall [1, 2, 3]. Both JET [4] and ASDEX Upgrade [5] have contributed new data from plasmas in the presence of fully metallic walls. Robust Bayesian regression and a minimum distance approach based on the Rao geodesic distance have been applied to estimate the parameters in a power law scaling of the global energy confinement time in ELMy H-mode plasmas, expressed either in terms of engineering or dimensionless variables. Transformation of the new scaling from engineering variables to dimensionless quantities is shown to result in large error bars on the dimensionless scaling. On the other hand, regression analysis in the space of dimensionless variables yields acceptable estimates for the dimensionless scaling. When accounting for model uncertainty, the uncertainty on the exponents for multiple scaling variables is shown to be considerable, both in engineering and dimensionless form. Nevertheless, several trends of the energy confinement with plasma parameters can be derived with good confidence. The new scaling, which is dimensionally correct within the uncertainties, suggests that some dependencies of confinement in the multi-machine database, which previously where in disagreement with parameter scans in individual devices, can now be reconciled. This includes vanishingly small dependence of confinement on line-averaged density and normalized plasma pressure (β), as well as a noticeable, positive dependence on effective atomic mass and plasma triangularity. Extrapolation of this scaling to ITER yields a somewhat lower confinement time compared to the prediction from the widely used IPB98(y,2) scaling, possibly related to the considerably weaker dependence on major radius in the new scaling. Further studies are needed to compare more flexible regression models with the standard power law, while addition of data from more devices, including possible 'hidden variables', may contribute to further disentangling some of the global confinement dependencies in tokamak plasmas.

References

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[c] See Labit et al. (https://doi.org/10.1088/1741-4326/ab2211) for the EUROfusion MST1 Team.

[d] See the author list of "Overview of JET results for optimising ITER operation" by J. Mailloux et al., to be published in Nuclear Fusion Special Issue: Overview and Summary Papers from the 28th Fusion Energy Conference (Nice, France, 10-15 May 2021).