Contribution ID: **20** Contribution code: **O.7** Type: **Oral**

Prediction of Electron Temperature Pedestals in the JET-ILW Database

Tuesday 3 October 2023 11:40 (25 minutes)

Making use of a large experimental database of pedestals of H-mode ELMy JET-ILW pulses [1], we propose several approaches to systematic prediction of the height of the electron-temperature pedestal and of the electron temperature at the top of the density pedestal, with the engineering parameters and the density profiles as inputs. Simulations of ETG turbulence in steep-gradient regions of the pedestals of JET and other large tokamaks suggest that a simple scaling exists between the (gyroBohm-normalised) heat flux and the the local values of the electron density (R/L_{n_e}) and temperature (R/L_{T_e}) gradients [2]. This has previously been checked on a small subset of this database, and we now confirm that testing it against the entire database leads to consistent prediction of the electron temperature within 50% of the experimental values. The scaling proposed in [2] includes departures from the marginal stability, presumed to be achieved at $R/L_{T_e} = \eta_{e,NL} R/L_{n_e}$, where $\eta_{e,NL}$ is generally speaking a fitting parameter. Taking a simpler approach that assumes a definite local relationship between the gradients, we find that a range of power law scalings $R/L_{T_e} = A(R/L_{n_e})^\alpha$ with α between 0.33 and 1 correctly capture the behaviour of the electron temperature at the density-pedestal top. For $\alpha = 1$, $A \equiv \eta_{e,cr}$, which governs the turbulence saturation in the standard picture of slab-ETG modes. Measuring it halfway between the pedestal-density top and the separatrix yields a distribution of values (Figure 1) that lie considerably above the linear threshold $\eta_{e,lin} = 0.8$ [3]. This implies either that a nonlinear effect analogous to Dimits shift lifts $\eta_{e,cr}$ to an effective value just above 2 or that turbulent transport predominantly occurs in an order-unity-supercritical regime, characterised by this higher-than-marginal gradient ratio.
Figure 1: distribution calculated between top of electron density pedestal and separatrix for 1148 pulses.
Finally, we present a simple machine learning algorithm which, given the same experimental inputs as theory-based modelling, is able to predict the electron temperature within similar error bars for 20% of the database after being trained on the other 80%. This result confirms the conceptual possibility of accurate prediction and offers a baseline quality benchmark for improved models that rely on traditional theoretical understanding of turbulent transport.
References:
[1] L. Frassinetti et al. 2021 Nucl. Fusion 61, 016001.
[2] A.R. Field et al. 2023 Phil. Trans. R. Soc. A 381, 2021022.
[3] F. Jenko, W. Dorland, G. W. Hammett 2001 Phys. Plasmas 8, 4096.

Author: TURICA, Leonard-Petru (Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford, OX13PU, UK, United Kingdom Atomic Energy Authority, Culham Science Centre, Abingdon, OX14 3DB, UK, University College, Oxford, OX1 4BH, UK)

Co-authors: Dr SCHEKOCHIHIN, Alexander (Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford, OX13PU, UK, Merton College, Oxford, OX1 4BH, UK); Dr FIELD, Anthony (United Kingdom Atomic Energy Authority, Culham Science Centre, Abingdon, OX14 3DB, UK); Mx JET CONTRIBUTORS (see the author list of J. Mailloux et al., Nucl. Fusion 62(2022) 042026); Dr FRASSINETTI, Lorenzo (KTH Royal Institute of Technology, Stockholm SE-100 44, Sweden)

Presenter: TURICA, Leonard-Petru (Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford, OX13PU, UK, United Kingdom Atomic Energy Authority, Culham Science Centre, Abingdon, OX14 3DB, UK, University College, Oxford, OX1 4BH, UK)

Session Classification: Oral session 6 - Pedestal and PFCs