Core Transport Studies in Tokamaks Plasmas via Surrogate-based Optimization Techniques


1MIT Plasma Science and Fusion Center, Cambridge, USA
2Commonwealth Fusion Systems, Cambridge, USA
3Max Planck Institut für Plasmaphysik, Garching, Germany
4FOM Institute – DIFFER, Eindhoven, The Netherlands
5Princeton Plasma Physics Laboratory, Princeton, USA

Understanding transport and validating computer simulations in magnetically confined plasmas is critical for developing predictive models and designing scenarios for future burning plasmas, such as ITER and SPARC. However, the highly nonlinear nature of turbulence means that simulations of plasma behavior are very computationally expensive and very sensitive to small changes in input parameters. Optimization techniques combined with surrogate models are very promising to reduce computational cost of validation exercises, flux-matching frameworks and scenario optimization studies. The Validation via Iterative Training of Active Learning Surrogates (VITALS) framework [1] exploits surrogate strategies and a genetic-algorithm-based optimizer to test whether a combination of plasma parameters exists such that experimental transport measurements are reproduced by a transport model. For the first time, additional measurable quantities, such as incremental electron thermal diffusivity, temperature and density fluctuation levels, cross-phase angles, and particle diffusion and convection coefficients can be used simultaneously along with transport fluxes to study model validation. VITALS has been implemented to validate TGLF and QuaLiKiz turbulent transport models, and has been successfully used in the Alcator C-Mod and ASDEX Upgrade tokamaks to study the importance of multi-scale transport [2]. These results indicate that these machine learning algorithms are suitable and adaptable as a self-consistent, fast, and comprehensive validation methodology for plasma transport codes.


This work was supported by US DOE Awards DE-SC0014264, DE-FC02-99ER54512, DE-FC02-04ER54698, DE-SC0017381 and DE-FG02-91ER54109. P.R.F. was also supported by Fundación Bancaria “la Caixa” under Award LCF/BQ/AN14/10340041.