Multiscale Fusion Plasma Simulations of Varied Tokamak Scenarios within the ComPat Framework

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Fully simulating the impact of turbulence on the performance of fusion devices such as ITER is challenging, especially when fusion plasmas exhibit highly disparate spatio-temporal scales. Currently, there are single-scale models developed to study turbulence (gyrokinetic models) and transport (large-scale simplified models) separately. To go beyond single-scale simulations, the Computing Patterns for High Performance Multiscale Computing (ComPat) project [1] takes the component based approach to construct multiscale simulations by connecting existing single-scale models (submodels) together into a workflow. This approach has simpler algorithm and codebase, therefore each submodel is easier to validate, verify, maintain and optimize. In addition, ComPat incorporates the concept of Multiscale Computing Patterns [2] into its framework, so that applications can run efficiently when one or several submodels require computing capabilities at the petascale.

In this work, the ComPat framework is taken to build a multiscale fusion application that brings equilibrium (fixed boundary codes), turbulence (either local flux-tube or global gyrokinetic code) and core transport (1D code) models together. Using both the unified datastructure developed in EUROfusion and the Multiscale Coupling Library and Environment (MUSCLE2), one can set up a reliable multiscale fusion plasma simulation based on existing single scale codebases. A significant advantage to such approach, is the ease with which individual submodel can be replaced by another that offers similar functionality. However, there are major challenges arise to such framework. Several of these challenges will be addressed, including time bridging between turbulence and transport models, defining quasi-steady state of core plasma, implementing global gyrokinetic code into current simulation framework, and optimizing the overall simulation runtime. All the simulation results presented here are based on initial conditions from ASDEX Upgrade- and JET-sized cases.

References

[1] http://compat-project.eu

[2] S. Alowayyed, D. Groen, P.V. Coveney, and A.G. Hoekstra, Journal of Computational Science **22**, 15-25 (2017)