Temporal parallelization of advanced operation scenario simulations of fusion plasma

D. Samaddar[1], T.A. Casper[2], S.H. Kim[2], L.A. Berry[3], W.R. Elwasif[3],
D. Batchelor[3], W.A. Houlberg[3]
1. Culham Science Centre, Abingdon, Oxon OX14 3DB, UK
2.ITER Organization, Route de Vinon sur Verdon, 13115 Saint Paul Lez Durance, France
3. Oak Ridge National Laboratory, Oak Ridge, USA

This work explores the application of the Parareal algorithm[1] to advanced operation scenario codes in tokamak plasmas, using the CORSICA[2, 3] code as a test bed. CORSICA is an advanced free-boundary equilibrium and transport simulation code used to study plasma scenarios in burning plasma experiments and is of particular importance for making predictions for the ITER experiment under construction.

The "Parareal Framework" developed at the Oak Ridge National Laboratory as part of the SWIM IPS project[4] has been used for implementing the algorithm. This framework allows efficient use of processors using the "moving window scheme"[5] along with multiple levels of concurrency.

In the past the Parareal algorithm has been successfully applied to multiple problems including fully developed plasma turbulence simulations which are high dimensionally chaotic initial value problems[6]. However, temporal parallelization of CORSICA introduces new challenges compared to previous applications.

Since the Parareal algorithm involves a predictor-corrector technique, applying the algorithm in this case requires a new approach to the coarse solver necessary for the algorithm. The integration of the Parareal algorithm into the parallelization of CORSICA also allows multiple levels of concurrency. With temporal parallelization being the highest level of parallelization in this case, different levels of simplification are possible when selecting the coarse solver. For example, the source terms and transport properties may not be updated in the coarse solution.

Successfully implementing the Parareal algorithm to codes like CORSICA generates the possibility of time efficient simulations of ITER-like plasmas.

References:

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