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Code optimizations in the BSC Advanced Computing Hub: Implementation of matrix compression for the coupling of JOREK to the 3D realistic conducting wall structures

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JOREK [1] is one the most advanced non-linear simulation codes for studying MHD instabilities that can occur in magnetically confined fusion plasmas as well as their control. It leverages extensive parallel programming to obtain accurate results regarding the dynamics of the high-energy magnetically confined plasma inside the vacuum vessel of a tokamak or stellarator. In addition, a free-boundary and resistive wall extension was introduced via coupling to the STARWALL [2] and very recently also CARIDDI [3] codes, which both apply a Greens functions method to calculate densely populated matrices describing the electro magnetic interactions between plasma and conducting structures. MPI and OpenMP parallelization is exploited for the coupling [4]. To perform accurate simulations of the aforementioned interactions, the discretizations of the wall and of the plasma regions should be considered, and the Degrees Of Freedom determining the dimensions of the response matrices depend on these. Currently, due to the state-of-the-art limitations regarding computational resources and available memory, the reachable resolution in such simulations is not sufficient to describe all details of the wall structures of the ITER tokamak, which is under construction.
On the other hand, in the linear algebra literature, there exist factorization techniques that could lead to reducing memory consumption through compression techniques. The present work represents an effort of obtaining such matrix compression with the implementation of the Singular Value Decomposition through the adoption of routines from the ScaLAPACK library [5, 6]. The objective is leveraging matrix compression inside the JOREK code exploiting parallelism to allow handling more complex wall structures than presently possible by reducing memory consumption and computational costs.
After a brief overview of the activities currently carried on at the CIEMAT-BSC Advanced Computing Hub (ACH) in the EUROfusion Horizon Europe Program, this contribution will focus specifically on the effort in the JOREK code, describing the work that has been done so far, both from the theoretical and the implementation points of view. After that, results from preliminary tests will be shown and a glimpse of the next steps will be given.

References

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