CEMRACS 2019 Project

Adaptative wavelet schemes and finite volumes for a reduced magnetohydrodynamic model

The physical phenomenon of magnetic reconnection occurs in an ionized medium at the heart of magnetic confinement fusion plasmas but also at the interface between the solar wind and the terrestrial magnetosphere and explains the aurora borealis.

This phenomenon results from a very localized magneto-hydrodynamic instability in space and time. To simulate this singularity, adaptive mesh refinement schemes allow very small scales to be reached that are inaccessible to uniform grid schemes.

However, the equations of the 2D reduced MHD models used involve high order derivatives and require high order approximations, which are difficult to implement with adaptive meshes. The method presented in [1] is based on finite differences, which poses conservation problems. The goal of the project is to translate this adaptive scheme into finite volumes. To do this, we can rely on the [2, 3, 4] wavelet approach, with interpolettes and interpolation wavelets, which are similar to the one adopted in [1].

Before simulating reduced HDM, finite volume / high order / adaptive mesh algorithms can be tested on simpler problems such as :

- convection by a constant velocity $\vec{\mathbf{a}}$ or persistent $\vec{u}(x, y)$,
- the Burgers equation,
- the incompressible Euler equations.

References

[1] D. Del Sarto, E. Deriaz, *A multigrid AMR algorithm for the study of magnetic reconnection*, J. Comput. Phys. **351** 511–533 (2017)

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[3] D. Rossinelli, *Multiresolution flow simulations on multi/many-core architectures*, PhD thesis ETH Zurich (2011)

[4] D. Rossinelli, B. Hejazialhosseini, W. van Rees, M. Gazzola, M. Bergdorf, P. Koumoutsakos, *MRAG-I2D: Multi-resolution adapted grids for remeshed vortex methods on multicore architectures*, J. Comput. Phys. **288** 1–18 (2015)