CEMRACS 2016: project "PAMiFLU"
*P*arallel *a*daptive *m*ult*i*resolution methods for *flu*id and plasma flows

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Abstract:

Adaptive multiresolution techniques yield attractive and efficient numerical discretizations of the evolution equations. Their implementation on massively parallel computers is hereby an important ingredient to be able to perform high resolution computations. The aim of the project is to make further progress on this topic using block based data structures which allow efficient load balancing while guaranteeing the numerical precision of the underlying discretization.

Presentation of the project:

Adaptive discretization methods for solving nonlinear PDEs have a long tradition in scientific computing. They are motivated by the huge computational complexity of real world problems, which involve typically a multitude of dynamically active spatial and temporal scales. Adaptivity can be understood in the sense that the computational effort is concentrated at locations and time instants where it is necessary to ensure a given numerical accuracy, while efforts may be significantly reduced elsewhere. Typical applications are combustion problems with thin chemical reaction zones, fluid and plasma turbulence showing self- organization into coherent vortices, and more generally, most kinds of interface and boundary layer type problems implying a multitude of active scales [1]. One of the essential ingredients of fully adaptive schemes is a reliable error estimator for the solution.

The objectives the present project are to investigate and to develop further adaptive multiresolition techniques [1,3,4] and wavelet based approaches for modeling turbulence [2]. The expected results are detailed benchmarking of adaptive multiresolution codes in the incompressible flow limit. Different data structures will be tested (trees versus block based structures) and their computational efficiency will be assessed. We also plan to perform computations of the incompressible 3d Euler equations combined with wavelet filtering to introduce dissipation using denoising, similar to what has been done in [5] for the 1d Burgers and the 2d incompressible Euler equations.

Expected participants and presence at CIRM:

- Margarete Domingues, INPE, Brazil, 10-26.8.2016
- Marie Farge, LMD, ENS Paris, France, 10-26.8.2016
- Odim Mendes, INPE, Brazil, 10-26.8.2016
- Romain Nguyen van yen, Toulouse, France, 10 - 26.8.2016 (to be confirmed)

- Naoya Okamoto, Nagoya University, Japan, 10-2608.2016
- Kai Schneider, I2M, Aix-Marseille University, France, 10-26.8.2016

List of expected participants and their expected presence during the 6 weeks of Cemracs.

- NN

Status of the funding

- Nagoya University, Japan, confirmed
- LMD-ENS, France, confirmed
- FAPESP, Brazil, confirmed
- CNRS, France, pending

References

[1] R. Deiterding, M. Domingues, S. Gomes and K. Schneider.
Comparison of adaptive multiresolution and adaptive mesh refinement applied to simulations of the compressible Euler equations.
SIAM J. Sci. Comput., 03/2016, arXiv:1603.05211, accepted.

[2] M. Farge and K. Schneider.
Wavelet transforms and their applications to MHD and plasma turbulence: a review.
J. Plasma Phys., 81(6), 435810602, 2015.

[3] A. Gomes, M. Domingues, K. Schneider, O. Mendes and R. Deiterding.
An adaptive multiresolution method for ideal magnetohydrodynamics using divergence cleaning with parabolic-hyperbolic correction.
Appl. Num. Math., 95, 199-213, 2015.

[4] N. Okamoto, M.O. Domingues, K. Yoshimatsu, K. Schneider.
Adaptive wavelet simulation of weakly compressible flow in a channel with a suddenly expanded section. *ESAIM: Proceedings and Surveys* 53, 38-48, 2016

[5] R. Pereira, R. Nguyen van yen, M. Farge and K. Schneider.
Wavelet methods to eliminate resonances in the Galerkin-truncated Burgers and Euler equations. *Phys. Rev. E*, 87, 033017, 2013.