FOREWORD TO THE PROCEEDINGS OF THE CEMRACS 2016

L. GRIGORI, C. JAPHET, AND P. MOIREAU

The CEMRACS (Centre d'Eté Mathématique de Recherche Avancée en Calcul Scientifique) is a scientific event of the SMAI (the french Society of Applied and Industrial Mathematics). The CEMRACS concept was initiated in 1996 by Yvon Maday and Frédéric Coquel and takes place every year at CIRM in Luminy (Marseille, France) during six weeks. The goal of this event is to bring together scientists from both the academic and industrial communities and discuss these topics. During the first week, a classical summer school is proposed. It consists of several lectures given by leading scientists and related to the topics of the research projects. The remaining five weeks are dedicated to working on research projects, after a morning seminar. During these five weeks research session, each participant works as part of a team on a project proposed by either an industrial or an academic partner. The teams consist of young researchers supervised by senior researchers. Experience from previous years has shown the significant impact of CEMRACS, not only in terms of progress obtained on the specific research projects, but also on improving the interaction between academia and industry.

The CEMRACS-2016 was devoted to **numerical challenges in parallel scientific computing**. The main goal of scientific computing players (academic or industrial) is to decrease their numerical simulation's time to solution. To achieve this goal, algorithms and scientific software must be adapted to be able to exploit novel parallel architectures, and, consequently associated parallel paradigms. In this context, it is naively believed that increased computer capabilities will allow to solve more complex models and compare them to even more complex data. We believe, however, that these novel architectures have raised numerous constraints, hence methodological questions in scientific computing in order to enable efficient predictive simulations. Our objective in the CEMRACS-2016 was to show how numerical methods must be re-think to fully benefit from parallel capabilities. More precisely we have identified 3 critical and complementary research fields:

- Solvers and communication avoiding algorithms in high performance computing
- Numerical methods suitable for parallel architecture: domain decomposition, parallelism in time
- Data assimilation strategies suitable for parallel architectures

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Then, the CEMRACS-2016 was the opportunity to understand how current applications benefit from these methods and algorithms for instance in climate modeling, porous media flow and transport simulations, CFD, modeling of living system, astrophysics.

The summer school was the reflection of this vast ambition with a large spectrum of lectures:

- Kees Vuik, (Delft Centre for Computational Science and Engineering DCSE, Netherlands), Matthew Knepley (Computation Institute University of Chicago, USA) *Linear algebra for parallel computing*
- Frédéric Nataf (LJLL, UPMC, France), Martin J. Gander (Université de Genève, Suisse) *Domain decomposition in space and parallelism in time*
- Jack Dongara (University of Tennessee, USA), Jean-François Méhaut with Frédéric Desprez, and François Broquedis (Inria, France) *Background in high performance computing*
- Yvon Maday (LJLL, UPMC, France) *Model reduction and a posteriori estimates* , Frederic Hecht (LJLL, UPMC, France) *Tutorial on Freefem++*
- Vivien Mallet (Inria, France), Sophie Ricci (CERFACS, France) *Data assimilation and high performance computing*

The current proceedings also reflect the variety of the topics covered in this CEMRACS edition. The volume indeed starts with a lecture paper by Kees Vuik on Krylov subspace solvers and preconditionners, followed by 12 research papers about high performance solvers, numerical methods algorithms and data assimilation strategies. They include new research results in particular on parallel algorithms and simulators, code optimization, boundary integral approaches, domain decomposition methods, parallelism in time strategies, reduction approaches, fast data assimilation methods *etc.* Moreover, the underlying applications are also very different, from fluid – with a variety of flow types – and solid mechanics to electromagnetism, plasmas, geophysics, wildfire propagation, *etc.*

Finally, we want to thank all the sponsors of the CEMRACS-2016 who allowed the researcher's facilities. We address our warmest thanks to the whole team at CIRM for their skills and spirit that allowed us to work during these research sessions in such a good mood, to the colleagues from SMAI for their kind and efficient help on the technical matters, to Alexandre Ancel for his valuable expertise in scientific computing, to the mesocentre of Aix-Marseille University for giving us access to its computing capabilities, and finally, to ESAIM: Proceedings and Surveys for publishing the proceedings.

We finally also address our thanks to the participants of the summer school and of the research projects, who happily spent part of their summer with us.

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