Mathematical modeling and numerical methods for HPC of multi-scale two-phase flow and combustion engineering applications

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Résumé

The present communication aims at presenting the effort, which has been taking place in the mathematics
team of Laboratory EM2C at former Ecole Centrale Paris, in order to develop new generations of models

and numerical methods for the predictive simulation of multiscale engineering problems. The application

fields are strongly related to the simulation of combustion chambers with liquid fuel injection, which

represent a major challenge for the engineering and industrial communities, but cover also physics of

plasmas, biomedical engineering, etc. The originality of the approach is to tackle the whole range of

disciplines, from mathematical modeling, development of numerical methods and their analysis in sti

multiscale context, to their ecient implementation on parallel architectures in the framework of

HPC and their validation through comparisons with experimental measurements. Once these models and

methods have proved to be scalable and ecient, they can be transferred to semi-industrial and industrial

codes such as AVBP, CEDRE or IFP-C3D. In this presentation, we will mainly focus on mathematical

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modeling and numerical simulation of two major issues in combustion chambers as building blocks

of a long-term project : the description of the liquid spray as well as the resolution of the dynamics of reaction fronts.

After briefly introducing the context, we will highlight the strongly multi-scale character of such flows and the various strategies in

terms of both modeling, numerical methods and implementation on parallel architectures with

two types of HPC strategies : either (1) a scalable and efficient distributed-memory algorithm based on

robust and accurate methods or (2) a shared-memory algorithm which makes it possible to perform a 3D

detailed simulation on a standard computer using adaptation in time and space with error control.