12th International ERCOFTAC
Symposium on Engineering Turbulence Modelling and Measurements

26–28 September 2018, Montpellier, France

Exploiting modern High-Performance Computing platforms for Large-Eddy Simulation

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Keywords: *high-performance computing, large-eddy simulation, turbulent flows*

1. Context

This mini-symposium focuses on how High-Performance Computing (HPC) helps tackling complex Computational Fluid Mechanics (CFD) problems. During the past two decades, the steady increase in the power of parallel super-computers [1] participated heavily in developing 3D unsteady CFD modeling approaches. In these approaches, where the flow fluctuations are time- and space-resolved on a computational mesh, the cost of a simulation is directly linked to the size ratio between the largest and smallest resolved scales. The modeling of unsteady complex turbulent flows with Large-Eddy Simulation strongly benefited from this evolution as it enabled to increase the range of resolved scales and the problem size, and to include more physics.

Despite this strong increase in computational power, modern super-computers are more and more difficult to exploit. First, massively parallel computers now feature hundreds of thousand cores, which necessitate to have CFD codes with excellent strong and weak scaling. Second, the largest super-computers of the Top500 [1] rely on very different architectures and processors: Many Integrated Cores (MIC) and Graphics Processing Units (GPU) are both well represented along with more traditional processing units. The porting and optimization of CFD codes on these new platforms has become challenging and participates to the choice of the most suited numerical methods for the exascale. Third, since 2008, the exponential increase of computing power slows down [2]. Even if the reasons of this rate decay are not fully explained, technological barriers such as nanoscale chip manufacturing, heat dissipation or memory electricity consumption, make the future of HPC very difficult to anticipate.

2. Content

The presentations of the mini-symposium will detail some recent works, where modern super-computing architectures have been used to address complex CFD problems. The talks will highlight how these modern computing platforms and their massive parallelism can be exploited and they will tentatively give a few lessons learned from the development of high-performance CFD solvers. Finally, the presentations will give some insights into the future of HPC CFD.

Three contributions have already been identified and their authors have given an informal agreement:

- "HPC in Applied and Fundamental Combustion Research", Andreas Kempf, University Duisburg-Essen
- "Legacy combustion applications and modern HPC", Gabriel Staffelbach, CERFACS
- "Large-Eddy Simulation of lean-premixed combustion in a semi-industrial burner with finite-rate chemistry", Pierre Bénard, CORIA

References

[1] http://www.top500.org.
[2] Erich Strohmaier, International Super-Computing Conference, Frankfurt, Germany, June 2017.