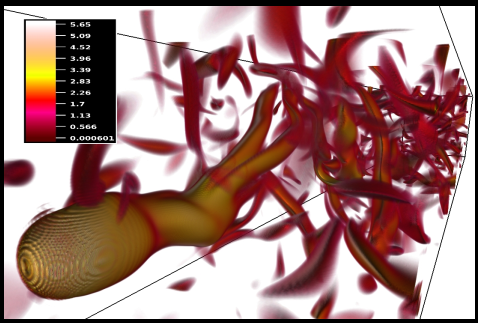
High Performance Computing for Fluids



SUMMARY.
Numerical simulations are an indispensable tool in studying astrophysical problems. The development of new algorithms and the increasing computational power of supercomputers consisting nowadays of nearly a million computing cores allows realistic simulations of complex environments. This meteor provides the fundamental know-how that is behind these demanding simulations. The students will learn to code numerical schemes for compressible fluids such as the interstellar medium. For this, a modern algorithm called Discontinuous Galerkin (DG) will be introduced. The students turn theory into practice and implement short but challenging applications.

OBJECTIVES

- Numerical schemes employed in modern codes to study gases include finite difference (FD), finite volume (FV), discontinuous Galerkin (DG) methods. The students will understand the main differences between these methods.
- C++ is a computing language that is not only used in scientific computing but also in many other performance critical applications. It allows user friendly abstractions while keeping optimal performance. The students will learn modern C++ through practice.
- Today's supercomputers are massive parallel. They contain fast-interconnected nodes equipped with several multi-core CPUs and accelerators such as graphics processing units (GPU). The students will learn how to use such super-computers by adapting theirs algorithms for parallel computing.

PREREQUISITES

Numerical methods & Fluid mechanics

THEORY

by Holger Homann

- Numerical methods have to be fast and precise. The students will understand why the order of convergence matters. Why high-order (complicated) methods are faster than low-order (simple) methods.
- The students will understand critical ingredients of numerical schemes such as conservation, Riemann problems and dissipation.

APPLICATIONS

by Holger Homann

- Astrophysical problems often involve the formation and dynamics of shocks. The students will understand main properties by studying a model problem - the Burgers equation.
- Today's algorithms have to be designed for super-computers. The students will understand how to implement cache friendly data structures and to parallelize algorithms.

MAIN PROGRESSION STEPS

- Understanding of main differences between different numerical schemes
- Study of relevance of DG schemes for astrophysical applications (study of paper).
- Study of benefits of C++ for scientific computing
- Parallelization for super-computers

EVALUATION

- Type of examination: oral presentation and code evaluation

BIBLIOGRAPHY & RESSOURCES

Reference

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