



**Barcelona
Supercomputing
Center**

Centro Nacional de Supercomputación

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Physical and Numerical Modelling



The team develops numerical models to solve complex multi-physics problems. The main design requirement is that the resulting algorithms are efficient on massively hybrid supercomputers, for both distributed and shared memory systems.

Objectives

Formed by a dedicated team of experts in physics, mathematics, and computer science, the Physical and Numerical Modelling Group focuses on developing advanced numerical models to tackle complex multi-physics problems. Their primary goal is to ensure the efficiency of these algorithms on massively hybrid supercomputers, catering to distributed and shared memory systems as well as accelerators.

Why the emphasis on numerical modelling? It's essential to meet the dual requirements of accuracy in problem description and efficiency in parallel system implementation. Choosing between accuracy, complexity, and efficiency is crucial in modelling physical phenomena, especially when dealing with massively parallel supercomputers. Therefore, the group aims to strike a balance between quality and cost, providing transversal and application-based algorithms tailored to solve a wide array of complex physical problems.

Their objectives encompass a range of areas, including:

- Algebraic solvers (pipelined CG, Deflated CG, GMRES) and preconditioners (RAS, Gauss-Seidel, Linelet, coarse space corrections)
- Domain decomposition tools (Chimera, multi domain coupling, element search)
- Adaptive mesh refinement
- Stabilization strategies (VMS, shock capturing)
- Multiphysics coupling (FSI, Fluid-particle, Fluid-rigid body interactions)

These algorithms are implemented using various programming models such as MPI, openMP and OpenACC. The different scientific areas of applications are mainly biomedicine as well as industrial processes, involving fluid dynamics, solid mechanics, chemistry, electro-physiology, free surface flows, and heat transfer among others.

In addition to their multi-disciplinary activities, the group is also in charge of leading the developments of the High Performance Computational Mechanics code Alya, providing to the researchers of the department with support in parallelization, CI/CD, benchmarking, performance optimization and analysis.

The group is actively involved in several projects, including RAISE, EOCOE3, EXCELLERAT2, CEEC, DIDEAROT, CAELESTIS, PLASTICS2OLEFINS, DREAMS, MEHEART, SGR MULTIPHYSICS, CREXDATA, and DISC4ALL_2020, contributing significantly to advancements in computational science and numerical modelling.

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