Imperial College London

EPSRC
Engineering and Physical Sciences Research Council

PRISM

Platform for Research in Simulation Methods

PRISM provides unrivalled capability and flexibility in the development and application of advanced simulation technology for complex scenarios across science and engineering.

Complex numerics on complex platforms for complex scenarios

PRISM is targeting applications that require advanced, problem-specific numerics. This includes:

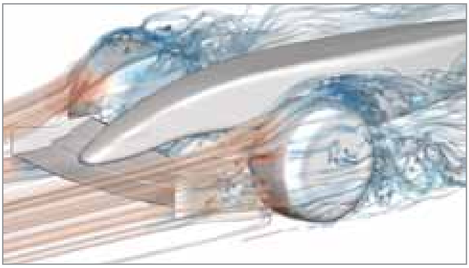
- Transient, separated aerodynamics (e.g. high lift configurations, flow around tailplanes and around road vehicles)
- Multiphase flow (e.g. industrial engineering flows, oil recovery, carbon capture and storage)
- Flows in complex biological organs
- Medical simulation and image processing
- Complex multiscale problems (e.g. optimising farms of tidal turbines)
- Numerical weather prediction, ocean modelling and climate simulation

Scalable science

All of these problems require the development of bespoke numerical approaches that go beyond the capabilities of standard software packages; these approaches must also be demonstrated for challenging testcases of high complexity in massively parallel simulations before they can be adopted by scientists and engineers in industry. In PRISM we are developing software strategies that allow us to move seamlessly from prototype implementations of numerical schemes on a laptop to manycore supercomputers.

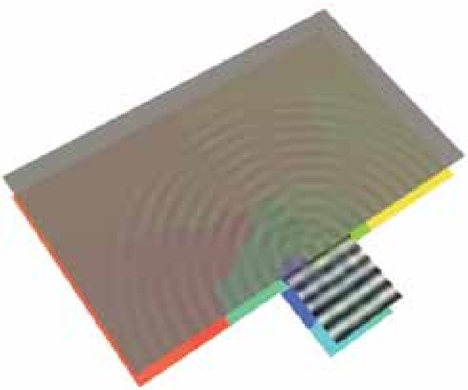
Composable expertise

Achieving scalability with complex numerical algorithms requires genuine collaboration between applications scientists and engineers, computational scientists and computer scientists. It has become impossible to do this if each of these skills is required within the same person! Hence, we are developing a new collaborative model through software, using domain-specific languages that allow computational scientists to convey their algorithms in such a way that they can be implemented without detailed understanding of where the algorithm comes from. In particular, this allows automated performance optimisation, choosing the best way to execute an algorithm in parallel, for a particular architecture or parallel cluster configuration. This will allow numerical software to be moved to a different cloud computer, or different type of accelerator, with minimal intervention from the applications and computational scientists.



Example application using Nektar++

▲ **Transient fluid dynamics past complex geometries:** simulating vortex generation behind the front wing of a Formula 1 racing car.

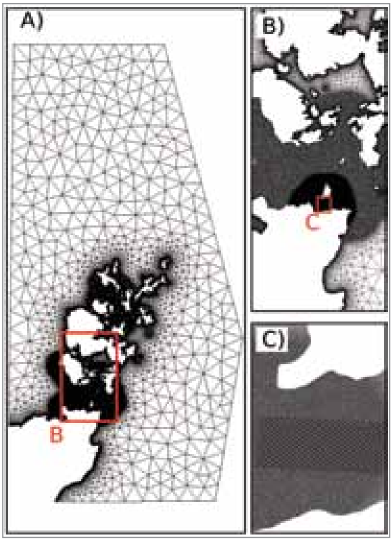


Example application using Firedrake

▲ Interference patterns from a Firedrake simulation of the Young's double slit experiment (foreground), and the MPI decomposition of the problem (background).

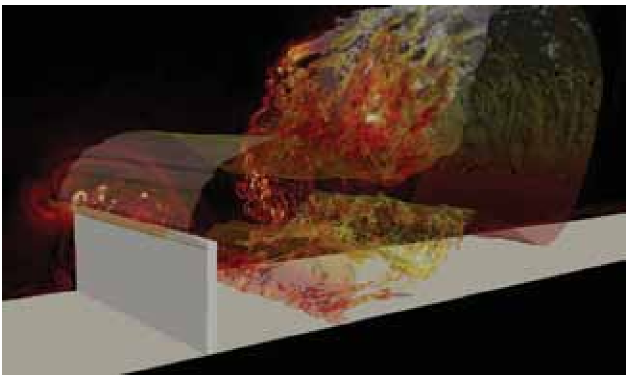
Example application using Fluidity

▼ **An unstructured mesh of the region around the Orkney Islands for a simulation of a tidal turbine array. The multi-scale mesh resolution varies across four orders of magnitude:** from 2m within the turbine array up to 20km in the far-field to efficiently represent the large-scale tidal dynamics.



Example application using PyFR

▼ Flow over a spoiler deployed at 90 degrees to the oncoming flow, computed on a mesh with 1.3 billion degrees of freedom using 184 x Nvidia M2090 GPUs in the Emerald supercomputer.



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