Imperial College London

# Nektar++

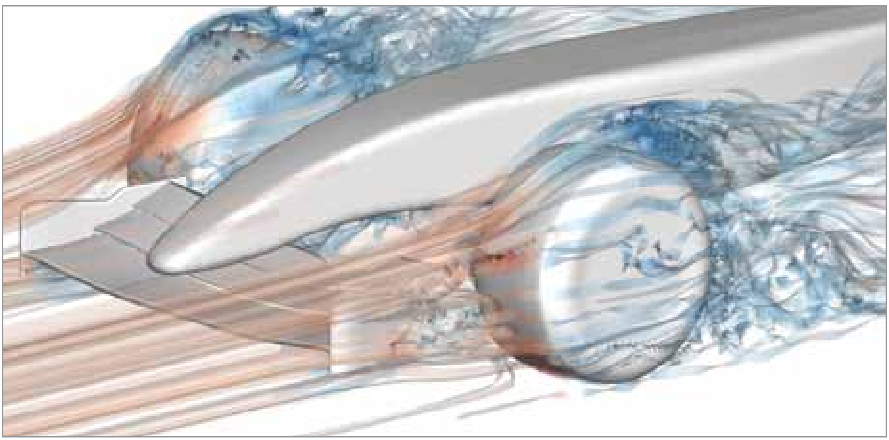
An open source, high-order spectral/hp element framework

Nektar++ is a toolkit of advanced computational methods for solving partial differential equations using parallel high-order spectral/hp element discretisations. These methods are more efficient per degree-of-freedom than traditional finite element methods and are particularly suited to capturing complex transient dynamics observed in applications such as complex geometry industrial flows.

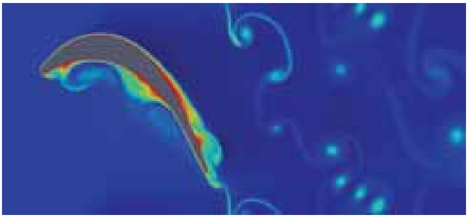
## Key features

- Collection of pre-written solvers for incompressible/compressible Navier-Stokes equations and other advection-diffusion-reaction systems
- Support for a wide range of discretisations: continuous/discontinuous Galerkin/Fourier, modal/nodal arbitrary-order polynomial bases, 1, 2 and 3D, embedded manifolds
- Support for arbitrary-order curvilinear mesh elements for complex domains
- Multiple operator implementations to optimise performance across multiple architectures at different polynomial orders: from h to p
- MPI parallelism and scalable to many thousands of cores
- Modern modular C++ object-oriented design with an extensive testing framework
- Cross-platform (Linux, OSX, Windows)

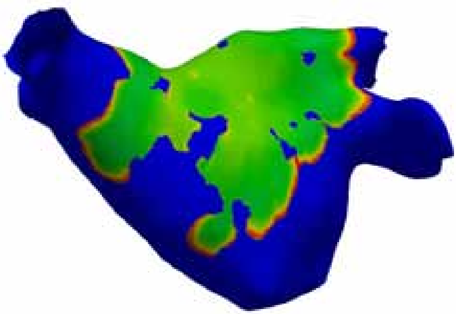
## Applications



◀ **Transitional flow:** understanding the change from laminar to turbulent states using highly efficient discretisations.

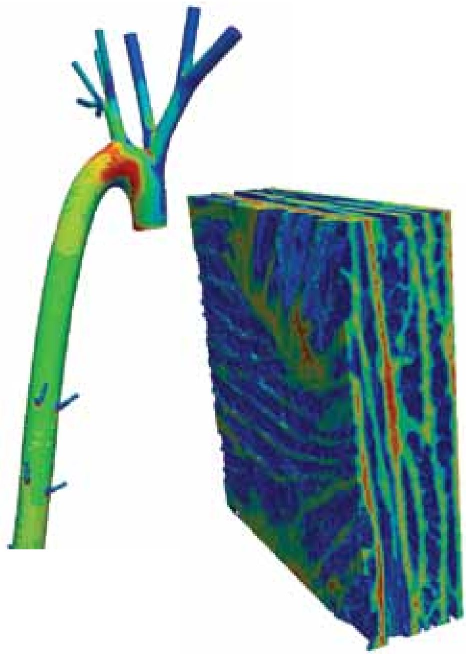


▲ **External compressible aerodynamics:** modelling flow separation over a turbine blade.



▲ **Cardiac electrophysiology:** patient-specific modelling of the electrical system of the heart, using a reaction-diffusion system on a manifold, to improve understanding of atrial fibrillation.

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



▲ **Biomedical flows:** calculating transverse wall shear stress in the aorta as a marker for atherosclerosis and investigating permeability of the arterial wall.

## Other applications

Linear and transient stability analysis, laminar flow control, acoustic perturbation modelling, shallow-water wave propagation, one-dimensional pulse wave propagation, vortex induced vibration.

## Vision

To maximise the performance of high-order methods we are exploring advanced numerical strategies such as spatial and temporal adaptivity. Nektar++ is constantly evolving and we are embracing the next generation of parallel computing, including many-core accelerators and cloud computing platforms. To harness the complexity inherent in both the methods and future technology would require detailed expertise from the user. We will therefore capture hardware and software metadata and leverage auto-tuning techniques, as well as providing accessible interfaces through scripting languages such as Python, to ensure high-order spectral/hp element technology remains accessible to users from across science and industry.

## Licence

Open-source GPL-compatible MIT licence.

## Contact

**Professor Spencer Sherwin**
Department of Aeronautics
**Tel:** +44 (0)20 7594 5052
**Email:** s.sherwin@imperial.ac.uk

**www.nektar.info**
**www.prism.ac.uk**