CCP – NTH
Nuclear Thermal Hydraulics

Background

Role of Nuclear Thermal Hydraulics (NTH) analysis:

- NTH analyses the behavior of fluids (such as water, gases, or liquid metals) and the transfer of heat within nuclear systems. It combines principles of fluid dynamics and heat transfer to ensure the safe and efficient operation of nuclear reactors and related technologies.
- NTH is the foundation for reactor design, safety analysis, operational stability, licensing and regulation, and advanced reactor development.

Challenges in NTH:

- Multi-scale, multi-physics nature of reactors.
- Innovative coolants (e.g., molten salt, supercritical water, liquid metal) introduce unique challenges in understanding flow and heat transfer.
- High-fidelity experimental data for validating simulations is often limited, especially for extreme conditions in nuclear reactors.

Objectives

Objective 1 (WP1): Community, network and training

- Organising technical meetings, workshops, user group meetings and training courses
- Fostering collaboration and supporting personal development.

Objective 2 (WP2): Software and methods development and maintenance

- Developing and maintaining the community high-fidelity codes and methods, such as CHAPSim.
- Maintaining and improving robust (reliable, affordable and user-friendly) CFD methodologies, and tools for the analysis of reactor systems, such as coarse grid CFD.
- Exploring and investigating heterogenous accelerator-based approaches, including solvers GPU porting and performance optimisation
- Exploring and investigating AI and machine learning (ML) applications in robust CFD modelling for nuclear thermal hydraulics
- Data management and NTH community catalogue

CHAPSIM code_saturne

Organisational Structure

- CCP-NTH community has over 40 named working group members from universities and main organisations in the nuclear industry in UK.
- CCP-NTH is managed by an Executive Committee (EC) consisting of the project Lead and Co-Leads, which is supported by an Advisory Committee (AC) consisting of members from universities and the industry.

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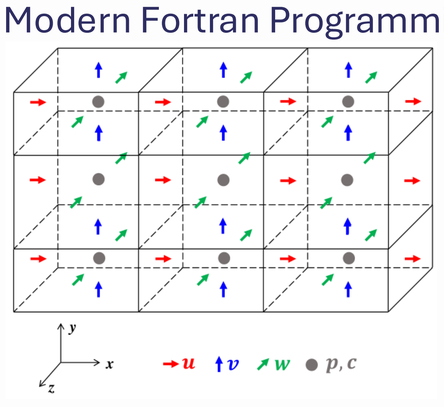
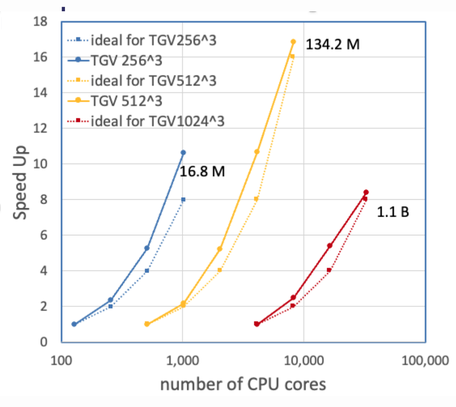
CFD solvers

CHAPSim: A CHannel And Pipe flow simulation solver, CHAPSim (v2), is an Open-Source, Highly Scalable, High-Accuracy Finite Difference DNS Code with MPI parallelization.

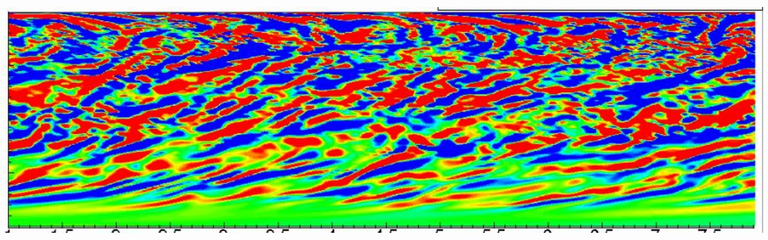
- **Developed Key Features:**
  - Applications in fluids with extreme property variations, rough surfaces, and conjugate heat transfer under a broad range of Prandtl numbers
  - Utilizes fully staggered structured grids with 2D domain decomposition.
  - Exhibits excellent scalability, tested on ARCHER2
  - Multiple numerical accuracy options up to 6th order.
  - Efficient FFT Integration:
  - Modern Fortran Programming Appr

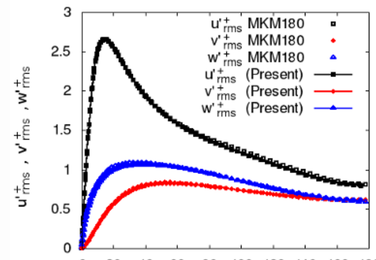


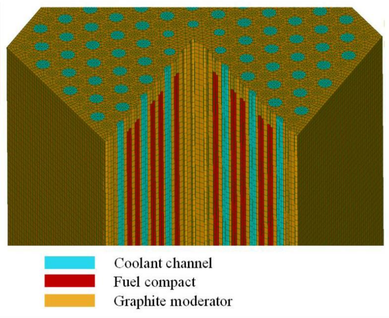


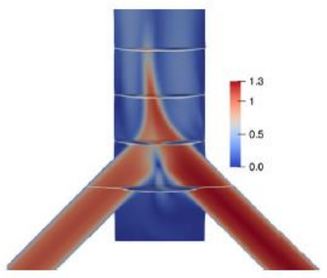
High-impact Case Study

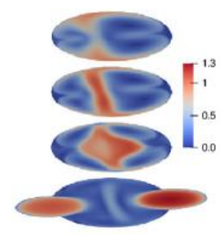
- **High Fidelity CFD**
  - DNS study of non-conventional coolant, such as supercritical water and liquid metal, to investigate turbulence and heat transfer characteristics for supporting advanced nuclear reactor design.
- **Robust CFD**
  - RANS/LES simulation of essential reactor components, for example, T and Y junctions, and rod bundles.
  - Cost-effective coarse-grid CFD (sub channel CFD) simulation of rod bundle assembly
- **Benchmark case**
  - Assessment of CFD solvers and turbulence models in modelling a Reactor Vessel Auxiliary Cooling System (RVACS)

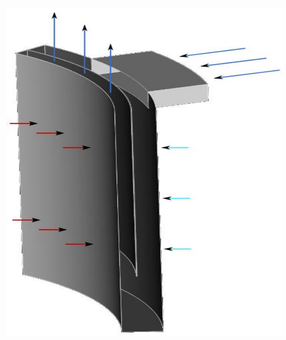


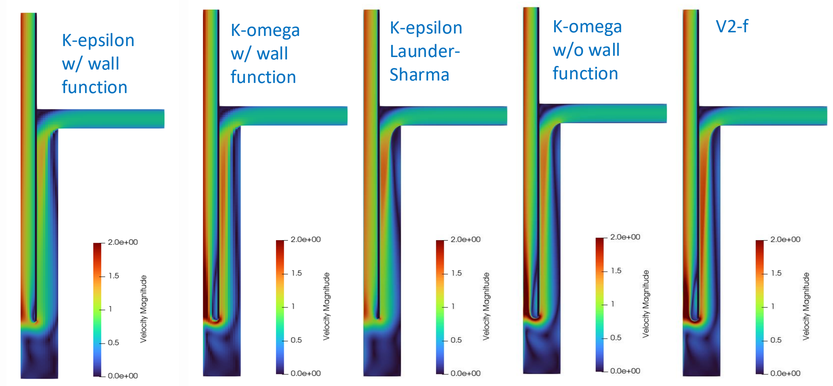












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