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FRANCE 2030 PROGRAMME DE RECHERCHE NUMÉRIQUE POUR L'EXASCALE

Multiphysics coupling algorithms for black box solvers in a HPC framework

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Brief CV

- 2021-2024: Engineering school **SeaTech** (Toulon).
  - Applied mathematics;
  - Computational Mechanics: solids and fluids.
- 2024 (mar-sept): **CEA internship:** Evaluate the consequences of a Severe Accident on a Sodium-cooled Fast Reactor.

  Chaining two Scientific Calculation Tools.
  - *SIMMER*: Melting of the core.
  - *EuroPleXus*: Mechanical response of the structure.

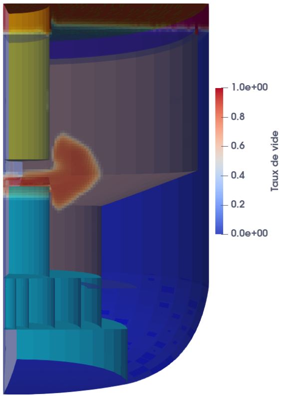

Figure 1: EuroPleXus calculation with SIMMER input (gaz bubble) data.

Multiphysics problems: context and challenges

PhD subject: Multiphysics coupling algorithms for black-box solvers in a HPC framework.

- **Directors:** Hélène Barucq (INRIA Makutu) and Isabelle Ramière (CEA).
- **Co-supervisor:** Raphaël Prat (CEA).
- **Beginning:** 4rth November 2024.

Multiphysics problems:

- Characterized by the interdependence of different physical phenomena.
- Requiring robust mathematical formulations and numerical methods

Numerical methods for multiphysics:

- **Monolithic methods:**
  - Use an unique solver to deal with the global system incorporating all physics.
  - Accurate when converging (often physical simplification).
  - Inherently instrusive.
  - Scalability often limited (cf. direct solvers).
- **Partitioned methods:**
  - Use independent solvers for each physical model.
  - Requiring efficient coupling algorithms for convergence.
  - Seems suited for HPC (asynchronous call of solvers).

PhD thesis objectives

Objective of the thesis

- Develop a **generic method** for solving multiphysics problems using black-box solvers.

⇒ Focus on **partitioned approaches** to maximize performance and scalability in a **HPC framework.**

⇒ **MFEM** software environment (natively HPC-optimized, hybrid CPU + GPU) to solve the multiphysics problem of interest
  - Thermo-mechanical (CEA);
  - Electromagnetic-acoustic (INRIA).

Main steps

1. Develop efficient, robust, and scalable **fixed-point convergence acceleration methods.**
2. Propose a proof of concept:
   - Coupling convergence and verification;
   - Compare the proposed strategy with
     - **Jacobian-Free Newton Krylov approach** (MOOSE);
     - **Monolithic approaches** (INRIA).
   - Scabality (if time ...).

Thank you for your attention