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A. Burbeau, Remi Abgrall

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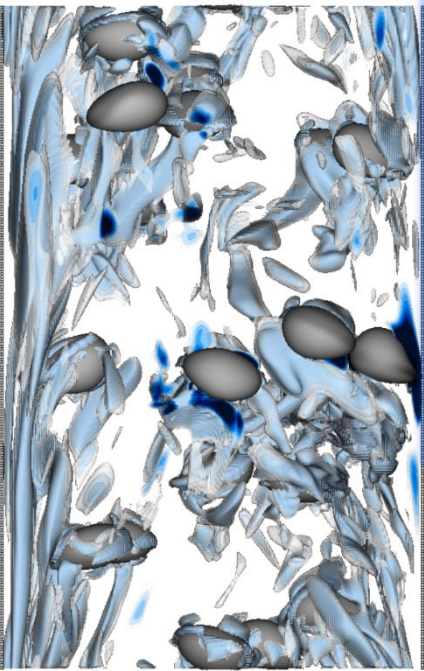
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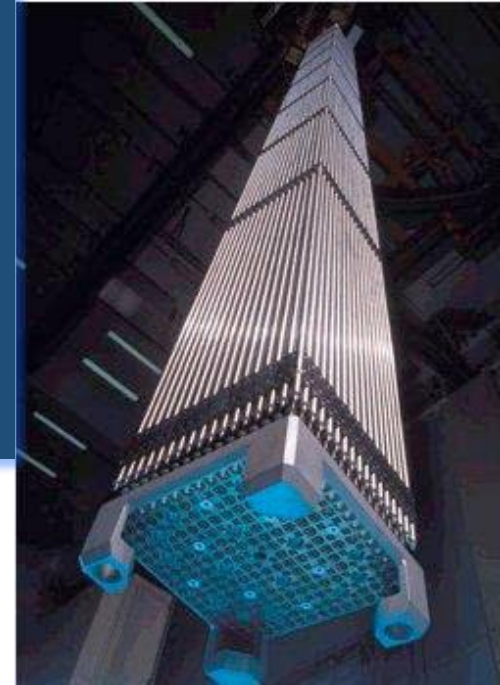


Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach

Feb 1 - 2, 2018 | Paris

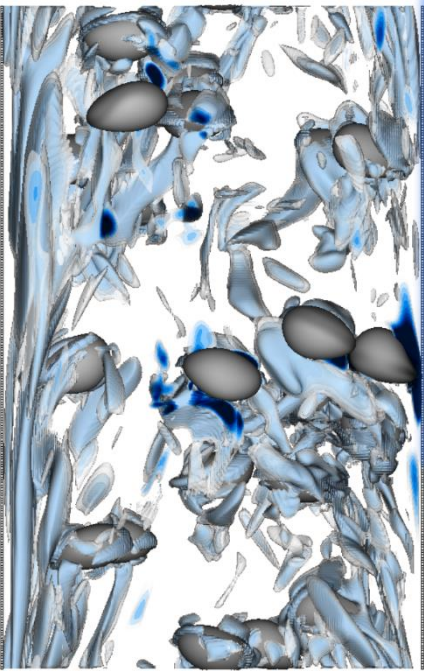


University of Zurich ^{UZH}



WITH PARTICIPATION



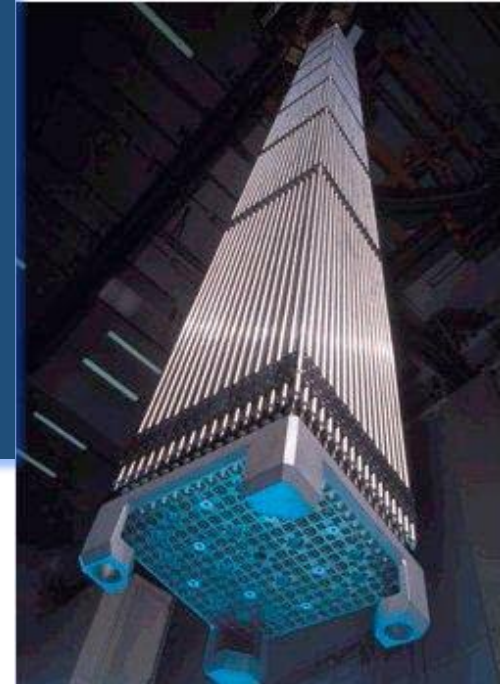


Workshop on numerical and physical modelling in multiphase flows: a “cross-fertilization” approach

Feb 1 - 2, 2018 | Paris



University of
Zurich^{UZH}



Introduction. Why This Workshop?

Anne Burbeau and Rémi Abgrall

A FACT (real in France and probably elsewhere)

There is a cut between the academic research and the industrial world



Well-posedness, stability, convergence, accuracy, ...

Academic research
→ Simplified physical models

Research in industry
→ « Real life » cases

Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach

Experimental programs

A FACT (real in France and probably elsewhere)

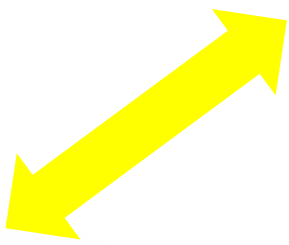
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Experimental programs

A FACT (real in France and probably elsewhere)

There is a cut between the academic research and the industrial world



- Improved/new numerical schemes, with a mastered theory

- Validation on real cases
- Proficiency in physics
- Expert advice on the validity of simulation results



Academic research
→ Simplified physical models

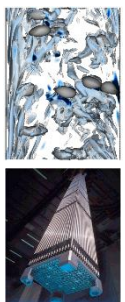
Research in industry .
→ « Real life » cases



Experimental programs

Workshop on numerical and physical modeling in multiphase flows: a "cross-fertilization" approach

WHO ARE WE?



Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach



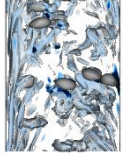
The first aim of this two-day workshop was "to gather researchers from different background: researchers that are motivated by more pragmatic considerations and those which aim is to design potentially more sound approaches but are less worried by validations on "real life" cases".



Participation of 70

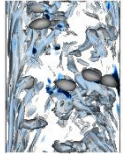
- researchers
- project manager
- managers

from more than 20 institutions



Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach

SHORT PRESENTATION OF CEA AND THERMAL-HYDRAULICS FOR NUCLEAR REACTORS



Established in October 1945 by General de Gaulle, CEA leads research programs, on behalf of the French government, aiming at increasing scientific knowledge and contributing to innovation and technology transfer in a limited number of areas.

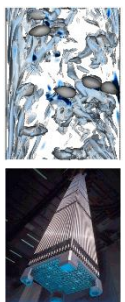
In 2010, CEA became the Alternative Energy and Atomic Energy Commission

CEA, by its scientific and technological research programs and by its ability to propose research formation, is committed to face major societal challenges :

- Support for the industry through innovation
- Energy transition to a low-carbon energy mix
- Health
- Defence and Global Security



FROM RESEARCH TO INDUSTRY



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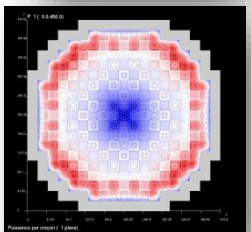
- Support for the industry through innovation
- **Energy transition to a low-carbon energy mix**
- Health
- Defence and Global Security



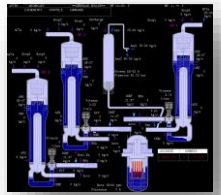
Nuclear energy

- Future industrial nuclear systems
- Optimization of present nuclear systems
- Large tools for the development of nuclear energy
- Clean up and dismantling

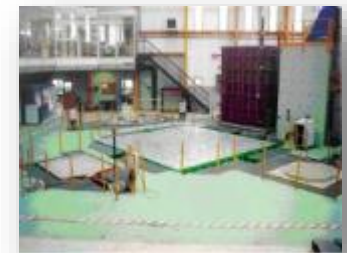
Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach



Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach



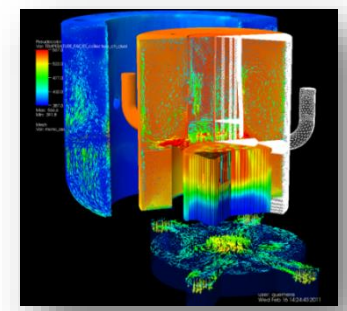
A **R&D UNIT** including 400 people
Which provides and increases several skills, covering EXPERIMENTAL and NUMERICAL SIMULATION:



- **Thermo-mechanical** analysis of structures
- Fluid mechanics and **thermal-hydraulics**
- **Neutronics** and radiation transport
- Adresses the multi-physics and multi-scale aspects: **crucial** with regard to our studies. In particular **core physics** and **nuclear reactor modelling**
- **Applied mathematics** and **Software engineering**.

To satisfy the needs of our main customers

- From **industry partners** (AREVA, EDF, ANDRA)
- From the French **TSO** (IRSN)
- Missions : **design and operation of the CEA nuclear facilities and experimental reactors. Advise the French Government**



The DM2S: 3 AREAS, 3 SERVICES



Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach

SEMT

Mechanical and thermal sciences, static and dynamic, Fluid-Structure Interaction, Welding, Earthquake analysis

SERMA

Nuclear Data, Core Physics, Radiation Protection and Shielding, Criticality-Safety, Fuel Cycle, Nuclear Instrumentation, Analysis of Nuclear Systems

STMF

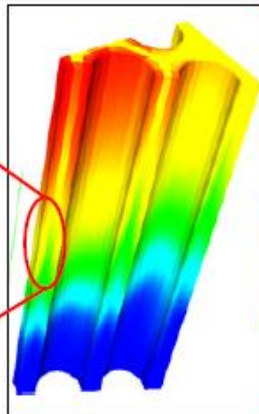
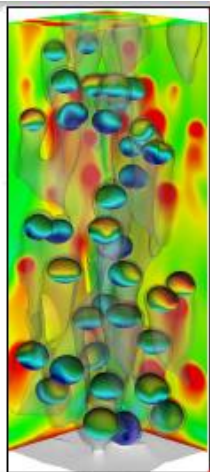
Fluid Mechanics and Thermal-hydraulics

- **Code development** : Multi-scale for all kind of reactors (modelization, applied mathematics, numerical methods, software engineering) ;
- **Applied studies** ;
- **Validation on analytical dedicated experimental devices** (instrumentation, conception and realization of experimental programmes)

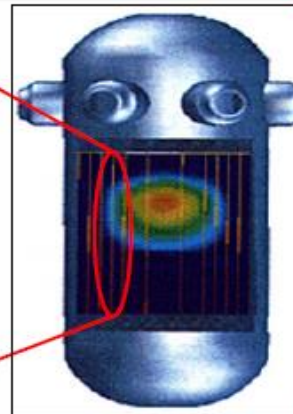


Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach

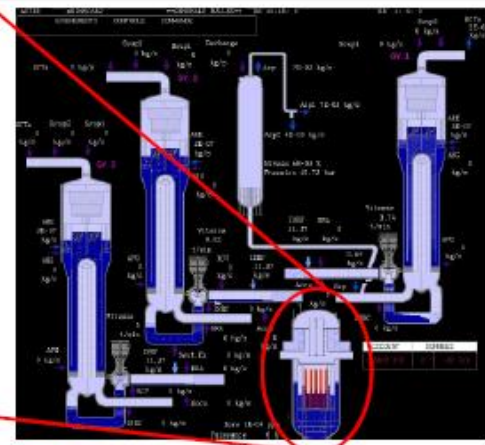
3D Local:
RANS, LES, DNS



« homogenized
3D»

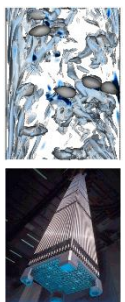


0D, 1D, « 3D »



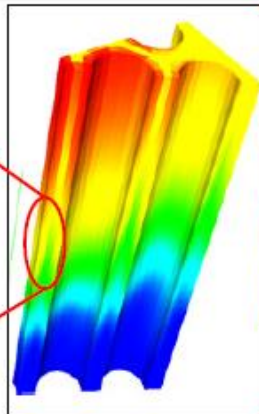
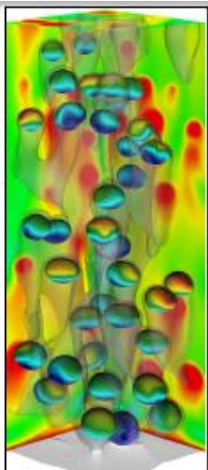
Component ⇔
« 3D » component
modeling,
especially of the
bundles zone

System ⇔ unsteady
approach with simplified
modeling of all circuit items

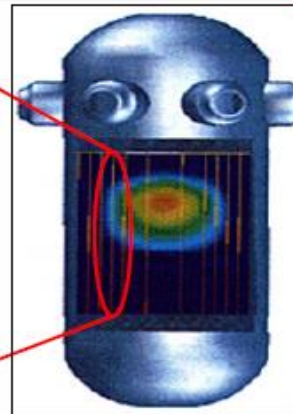


Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach

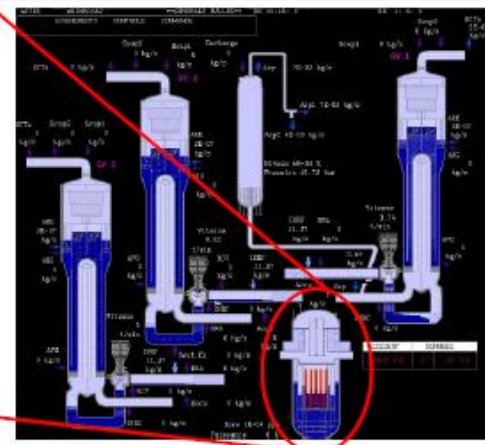
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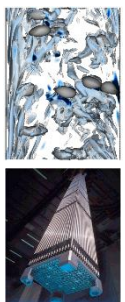
System ⇔ unsteady
approach with simplified
modeling of all circuit items

- CPU NEEDS
- STUDIED PHYSICAL DOMAIN REDUCTION



- FILTERING
- MODELING EFFORT
- STUDIED PHYSICAL DOMAIN EXTENSION

HOW TO ASSESS THE PREDICTION CAPABILITIES OF A CODE?

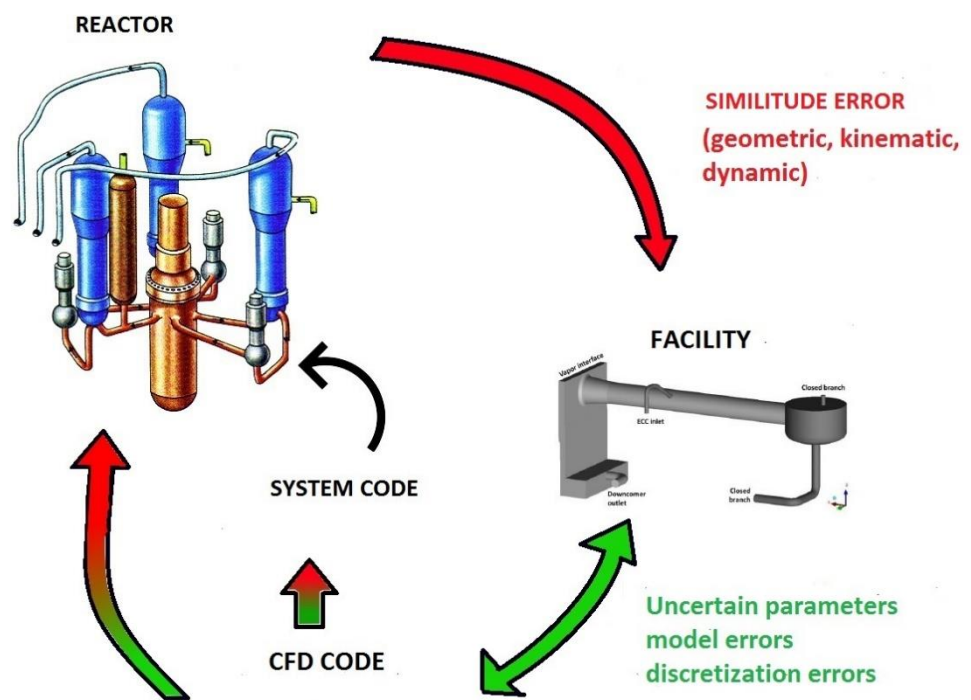


Workshop on numerical and physical modelling in multiphase flows: a "cross-fertilization" approach

The code validation and the calibration of the mathematical models rely on experimental data measured on devices that are scale models of a real design

- Controlling the different sources of errors that affect the numerical simulations
- Establishing a complete physical similarity

Long-term objective: to perform an up-scaling approach, integrating simulations from both CFD and system codes, with experiments in scaled and real design if available



$$\frac{\partial}{\partial t}(\alpha_k \rho_k) + \frac{\partial}{\partial x_j}(\alpha_k \rho_k U_{k,i}) = \Gamma_k$$

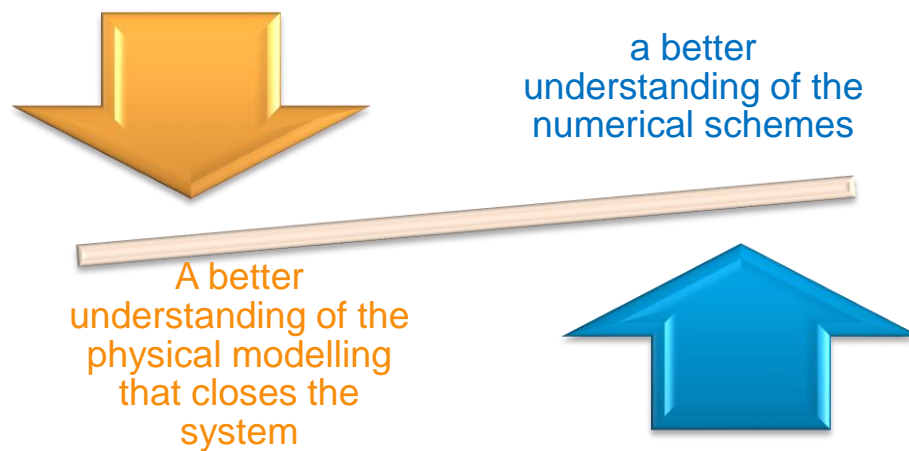
$$\frac{\partial}{\partial t}(\alpha_k \rho_k U_{k,i}) + \frac{\partial}{\partial x_j}(\alpha_k \rho_k U_{k,i} U_{k,j}) = \frac{\partial}{\partial x_j}(\alpha_k \tau_{k,ij}) - \alpha_k \frac{\partial P}{\partial x_i} + \alpha_k \rho_k g_i + \alpha_{kj} J'_{q \rightarrow k,i}$$

$$\frac{\partial}{\partial t}(\alpha_k \rho_k H_k) + \frac{\partial}{\partial x_j}(\alpha_k \rho_k U_{k,j} H_k) = \frac{\partial}{\partial x_j}(\alpha_k U_{k,i} \tau_{k,ij}) - \alpha_k \frac{\partial P}{\partial t} + \alpha_k \rho_k U_{k,i} g_i + \alpha_{kj} J'_{q \rightarrow k,i} U_{k,i} + \frac{\partial}{\partial x_j}(\alpha_k Q_{k,j}) + \Pi_k$$

Improved computer performances → industries and research organizations involved in nuclear reactor safety focus on the development of modelling at local scales.

Objectives :

- progressing in the small scale flow process modelling to get more confidence in the results obtained with system or component codes ;
- a better understanding physical situations of interest.



It is a long way before CFD becomes an integral part of the safety demonstration



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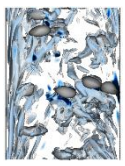


To gather researchers from different background

- a better understanding of different approaches?
- new collaborations?
- better software

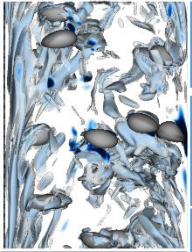
Subjects to be discussed (not exhaustive)

- **the different choices for the basic model**, typically one-fluid model, two-fluids model or multi-fluids models;
- **treatment of interfaces**: deterministic treatment or statistical description ?
- **Numerics versus physical modeling**? Is the better, more realistic or enough to achieve hyperbolicity thanks to a kind of mathematical regularization or to treat ill-posedness issue with numerical regularization?
- **Feedback on the use of the single-pressure two-fluid model**;
- **The 7 equations model for an interface diffuse method**: what are the issues for real configurations? Is this model really more difficult to discretize than a 6 equations model with pressure equilibrium? Why?
- **Comparison with experimental results**: role of data bases, how to interpret experimental result versus numerical ones?



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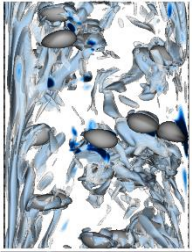
PRACTICAL INFORMATIONS



Workshop on numerical and physical modelling in
multiphase flows:
a "cross-fertilization" approach

Thursday (February 1)

9:30-9:50	Introduction: why this workshop. A. Burbeau, CEA.
9:50-10:40	Experimental Aspects in Multi-Phase Flows - Some insights from researches at CEA-DEN. L. Rossi and F. François, CEA.
10:40-11:10	Break
11:10-12:00	Modelling choices for two-phase flow - Feedback from the use of the single-pressure two-fluid model. D. Bestion, CEA.
12:00-13:30	Lunch
13:30-14:20	A Robust and Efficient Finite Volume Method for Two-phase Flows at All-Speeds on hybrid grids. Hong Luo, North Carolina State University.
14:20-15:10	Recent progresses and open issues in compressible two-phase flow modelling. R. Saurel, Aix-Marseille University.
15:10-16:00	Consistent and efficient BVD reconstructions for interfacial multiphase compressible flows. F. Xiao, Tokyo Institute of Technology.
16:00-16:20	Break
16:20-17:10	Multifield CFD calculations of industrial geometries in NEPTUNE_CFD. S. Mimouni, EDF.
17:10-18:00	Low Mach flows and multiphase flows. H. Guillard, INRIA.
18:45	Aperif/Happy hour
20:00	Dinner



Workshop on numerical and physical modelling in
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Friday (February 2nd)

9:00-9:25

Two Phase Flow industrial applications in TechnicAtome
P. Monier. TechnicAtome.

9 :25-9 :50

Examples of industrial applications : experimental program and numerical approach.
N. Goreaud and A. Mourgues. Framatome.

9:50-10:40

A biased point of view on multiphase flows modeling. Opening on the discussions.
R. Abgrall, University of Zurich.

10:40-11:10

Break

11:10-12:00

Short Talks for discussions

12:00-13:30

Lunch

13:30-15:00

Short Talks for discussions

15:00-15:20

Break

16:20-16:30

Round Table.

16 :30

End of the workshop.