Modeling and Simulation of the physical world (SIM)

S. Labbé (UJF – LJK)
B. Penz (Grenoble INP – G–SCOP)
Physical world simulation: In-Silico to In-Vivo and return

- **Physical world**
  - Comparisons with the physical world
  - Amelioration of symbolic models

- **Virtual world**
  - Mathematical study of models
  - Mathematical validation

- **Numerical world**
  - Infinite to finite
  - Algorithms building

- **Simulation**
  - Optimization
  - High Performances Computing

- **Modeling**
  - Study of discrete models

- Examples:
  - Advection simulation using particle method with $256^3$ particles realized by (project PARMES, LJK)
  - An analogic model of spins (project HM-MAG, LJK)
  - A model for the Leidenfrost effect (project MIGAL, LJK)
Modeling and simulation: Key-points

Four work-packages

- Multi-scale, multi-physics modeling
- Uncertainties in modeling
- Numerical methods and H.P.C.
- Optimization and inverse problems

Application domains and tools

- Homogeneity
- Asymptotic analysis
- Sub-sonic turbulence
- Impact of structure on fluid flows
- Bio-mechanics for patients
- Monitoring and analysis of hydraulic structures
- HPC for uncertainty quantification
- HPC for complex materials simulation
- Operational research and combinatorial optimization
- Optimal transport for data image assimilation
- Shape optimization applied to plasmonic
- Tomography
- and much more...
**PERSYVAL–Lab main assets**

### An extended community

- **10 Laboratories**
  Laboratories linked to the Labex and networked to a large number of experimental laboratories.

- **Several Research Groups**
  Several national groups of research on themes compatible with Persyval–lab show the dynamism of the site.

- **Collaboration with experimental sciences**

### A coherent formation offer

- **Several Masters**
  A master of maths, applied maths and computer science.

- **Engineering schools**
  Several engineering school: Polytech, ENSIMAG...

- **PhD grants of Persyval–lab**
  one for SIM-action in 2012

### Strong links with industries

- **LSI Carnot Institute**
  Top level academic research from Grenoble in various fields such as embedded software, microelectronic components, surgical robots, sensor networks.

- **MaiMoSiNE**
  Portal for transverse modelization activities in Grenoble and link with local industries.

- **Several industries**
  Xerox, ST–Microelectronic, Schneider, hundreds of SME/SMI’s...

### Illustration through some examples
Complex systems and uncertainties

Computations must be validated through comparisons with the physical world. Tools are

- Uncertainties quantification
- Data assimilation

1. Image produced by the INRIA/LJK team MOISE, specialized in data assimilation and uncertainties quantification.
2. Image produced by the TIMC team BCM specialized in computational biology and mathematics.

(1) Visualization and identification of flood lowering of the Pearl River.

(2) Approximate Bayesian Computation (ABC) : tool for the calibration of simulation used for biology applications.
Tools for understanding the virtual world

1. Work realized by P.-O. Lamare, PhD student GIPSA-LAB/LJK recruited thanks to the previous year Persyval-lab PhD campaign.
2. Work realized by the VERIMAG Team, Timed and Hybrid Systems.

The study of the model’s behavior is a key-point of the convergence between the two worlds: physical and virtual

\[
\begin{align*}
\dot{m}(t) &= -am(t) + q_\text{vol}(t) - \int_0^t m(t) dt \\
m(t) &= 0, \quad t := \text{argmin}_{j \in \{1, \ldots, N\}} q_j(w(t)) \\
\text{Inv:} \quad m(t) &\leq 0
\end{align*}
\]


Exploring trajectories of open dynamical systems
Efficient simulations

Simulation creates links thanks to high performance computing optimizations

1. Image produced by the INRIA/LJK team MOISE, specialized in data assimilation and uncertainties quantification.
2. Image produced by the GIPSA-LAb team Gestes phonatoires, Analyse et Modélisation Acoustique.

(1) Numerical study of the fluid transfer from Atlantic Ocean to Indian Ocean.
(2) Computation used to illustrate the turbulence transition phenomena.
# The SIM action scientific committee

<table>
<thead>
<tr>
<th>Name, First Name</th>
<th>Laboratory</th>
<th>Name, First Name</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blaise, Philippe</td>
<td>LETI</td>
<td>Mars, Jérôme</td>
<td>GIPSA</td>
</tr>
<tr>
<td>Blayo, Éric</td>
<td>LJK</td>
<td>Méhaut, Jean-François</td>
<td>LIG</td>
</tr>
<tr>
<td>Blum, Michael</td>
<td>TIMC</td>
<td>Penz, Bernard</td>
<td>G–SCOP</td>
</tr>
<tr>
<td>Cung, Van Dat</td>
<td>G–SCOP</td>
<td>Piau, Didier</td>
<td>IF</td>
</tr>
<tr>
<td>Dang, Thao</td>
<td>VERIMAG</td>
<td>Picard, Christophe</td>
<td>LJK</td>
</tr>
<tr>
<td>Desbat, Laurent</td>
<td>TIMC</td>
<td>Prieur, Clémentine</td>
<td>LJK</td>
</tr>
<tr>
<td>Dumas, Éric</td>
<td>IF</td>
<td>Prieur, Christophe</td>
<td>GIPSA</td>
</tr>
<tr>
<td>Gallay, Thierry</td>
<td>IF</td>
<td>Sebo, Adras</td>
<td>G–SCOP</td>
</tr>
<tr>
<td>Gayon, Jean-Philippe</td>
<td>G–SCOP</td>
<td>Stéphanou, Angélique</td>
<td>TIMC</td>
</tr>
<tr>
<td>James, Guillaume</td>
<td>LJK</td>
<td>Trystam, Denis</td>
<td>LIG</td>
</tr>
<tr>
<td>Labbé, Stéphane</td>
<td>LJK</td>
<td>Van Hirtum, Annemie</td>
<td>GIPSA</td>
</tr>
<tr>
<td>Maler, Oded</td>
<td>VERIMAG</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>