Mathematical Foundations of CFD

by Aleix Baez, Nicolás Valle, Xavi Trias

«Computer science is not about computers, in the same way that astronomy is not about telescopes. There is an essential unity of mathematics and computer science»

— Edsger Dijkstra

Main objectives

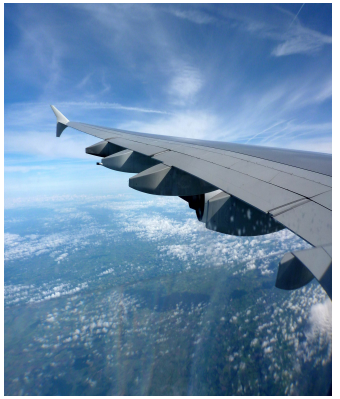
By the end of the seminar attendees are expected to gain understanding in:

- State-of-the-art CFD capabilities.
- Feasibility of research simulations.
- Link between continuum and discretized equations.
- Stability conditions.
- Types of errors and its consequences.

«Measuring programming progress by lines of code is like measuring aircraft building progress by weight.»

— Bill Gates

Outline



1.Technology ***Aleix Baez***

State-of-the-art CFD capabilities and cost.
Questions that can and cannot be answered.

2.Physics Formulation **Nicolás Valle/*Aleix Baez***

$$\frac{\partial \phi}{\partial t} + \Gamma \frac{\partial^2 \phi}{\partial x^2} = f$$

PDEs: qualitative and analytical perspective
Eigenvectors - solution spaces

3.Mathematical Resolution ***Xavi Trias/Aleix Baez***

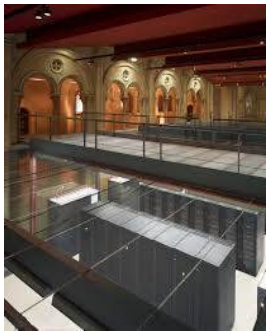
$$\frac{d\boldsymbol{\phi}_h}{dt} + \mathsf{D}\boldsymbol{\phi}_h = \boldsymbol{f}$$

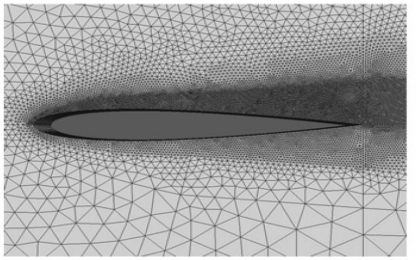
Discrete operators
Error analysis
Stability

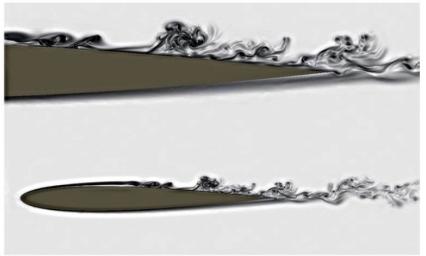
$$\boldsymbol{y} \leftarrow \mathsf{A}\boldsymbol{x}; \quad \alpha \leftarrow \boldsymbol{x} \cdot \boldsymbol{y}; \quad \boldsymbol{y} \leftarrow \alpha \boldsymbol{x} + \boldsymbol{y}$$

4.Computation ***Xavi Trias/Aleix Baez***

Kernels,
Solvers
Mesh estimations
Postprocess







“Programming is thinking, not typing.”—Casey Patton