

– Postdoctoral Fellowship –
Prediction of Bistable Flows and Extreme Events through High-Fidelity
Simulations and Dynamic Mesh Adaptation
(MOST Team, LEGI, Grenoble)
Duration: 18 months, renewable.

Scientific Background

Many turbulent flows exhibit complex behaviors characterized by regime transitions, bifurcations, bistable dynamics, and rare high-amplitude events. These phenomena often play a critical role in the performance and safety of engineering and natural systems, including hydraulic turbomachinery, aerodynamic devices, and geophysical flows. These flows raise fundamental questions in fluid mechanics: what physical mechanisms govern transitions between distinct flow states? Are there precursor signatures that announce an impending regime shift or the occurrence of an extreme event?

Addressing these questions may require high-fidelity simulations capable of accurately capturing the spatio-temporal dynamics of the flow. In this context, mesh quality is a key ingredient. Over the past several years, the MOST (Modeling and Simulation of Turbulence) team at LEGI has developed automatic mesh adaptation strategies within the YALES2 code for DNS and LES simulations. These approaches are currently based mainly on statistical quantities and have demonstrated their ability to significantly reduce computational cost while limiting user bias in mesh generation.

For bistable flows or flows dominated by rare events, however, such strategies may fail to detect essential transient structures because they rely on averaged information. Developing truly predictive simulations of these phenomena therefore requires a better understanding of the physical mechanisms underlying the observed transitions and the design of new dynamic mesh adaptation criteria capable of tracking these mechanisms in real time.

Objectives of the Postdoctoral Project

The objective of this postdoctoral project is to improve our understanding of the physical mechanisms responsible for regime transitions and extreme events in turbulent flows, and to leverage this understanding to develop predictive simulation strategies based on dynamic mesh adaptation.

The work will focus on the detailed analysis of high-fidelity simulations to identify coherent structures, multiscale interactions, and precursor signatures associated with bifurcations and rare events. This analysis will aim to reveal the dominant mechanisms controlling the onset of these phenomena and to identify the regions of the flow that require enhanced resolution.

A second objective will be to develop new dynamic mesh adaptation criteria based on instantaneous flow quantities rather than converged statistical fields. The ultimate goal is to build a methodology that automatically concentrates computational resources in the critical regions and at the critical times, making predictive simulations of bistable flows and extreme events feasible at controlled computational cost.

Working Environment

The successful candidate will benefit from a highly recognized scientific environment, access to high-performance computing resources, and strong interactions with both academic and industrial partners. The project will be carried out within the framework of the ALEAS project, dedicated to identifying precursor mechanisms of extreme events in turbulent flows, in collaboration with Bérengère Dubrulle (SPEC) and Mickaël Bourgoïn (LPENSL).

Candidate Profile

- PhD in fluid mechanics, physics, applied mathematics, or a related field,
- Experience in numerical simulation and/or modeling of turbulent flows,
- Strong interest in collaborative research.

Application Procedure

Applicants should send the following documents by email (guillaume.balarac@univ-grenoble-alpes.fr): CV, list of publications, Cover letter, Contact information for references.

Contact

For any questions or informal discussion, candidates are encouraged to contact Thomas Berthelon at guillaume.balarac@univ-grenoble-alpes.fr.