Postdoctoral offer:

- **Title**: **Sonic boom propagation in the atmosphere: meteorological and ground effects**
- **Supervisors**: Didier Dragna (Assistant professor, didier.dragna@ec-lyon.fr)
  Sébastien Ollivier (Assistant professor, sebastien.ollivier@univ-lyon1.fr)
- **Laboratory**: Laboratoire de Mécanique des Fluides et d'Acoustique, UMR CNRS 5509,
  École Centrale de Lyon, 69134 Ecully Cedex
- **Duration**: 12 months

Context:

This postdoctoral position is within the framework of the European project RUMBLE.

Fifteen years after the retirement of the Concorde, there is a renewed interest for civilian supersonic flights and several companies are currently developing supersonic aircraft concepts with launches scheduled in mid-2020s. The main obstacle to the revival of civil supersonic transportation remains the issue of noise. More specifically, the inherent sonic boom generates at the ground a significant annoyance (large overpressure, induced vibrations, ...) and impacts the population located under the flight path. This has caused the ban of civilian supersonic flight over land in the United States and several other countries.

Novel technologies are developed to lower the sonic boom annoyance. In particular, tests at laboratory scale and then at full scale have shown that a reduction of the peak overpressure at the ground can be achieved by a thorough aircraft design. These reduced sonic booms have been referred to as "low booms". Such studies motivate the lifting of the overland flight ban and the need of regulations to define what is the acceptable annoyance threshold due to sonic booms for population.

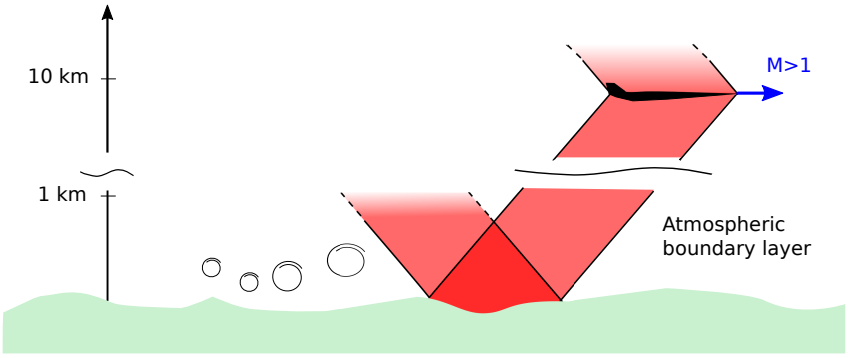

Figure 1: Sonic boom generated by a supersonic aircraft propagating in the atmosphere.

The European project RUMBLE (RegUlation and norM for low sonic Boom LEvels), which was launched in December 2017, contributes in this international effort to elaborate new regulations and norms for civililan supersonic flights. In particular, certification procedures have to be established and recommendations on the state of the atmosphere and on the measurement site for certification campaigns have to be provided. It is therefore required to know what are the parameters that influence the sonic boom signature and the perceived level at the ground. Currently, the prediction of far-field propagation of the sonic boom relies mostly on ray-tracing approaches, which can account for a slowly-varying inhomogeneous atmosphere. However, small scale inhomogeneities, such as turbulence appearing in the atmospheric boundary layer, are more difficult to tackle. Besides, the reflection of the sonic boom on the ground is modeled naively, by multiplying by two the pressure as it is for a flat perfectly reflecting ground in linear acoustics. There is no specific study in the literature on the variability induced by an irregular terrain.

Work:

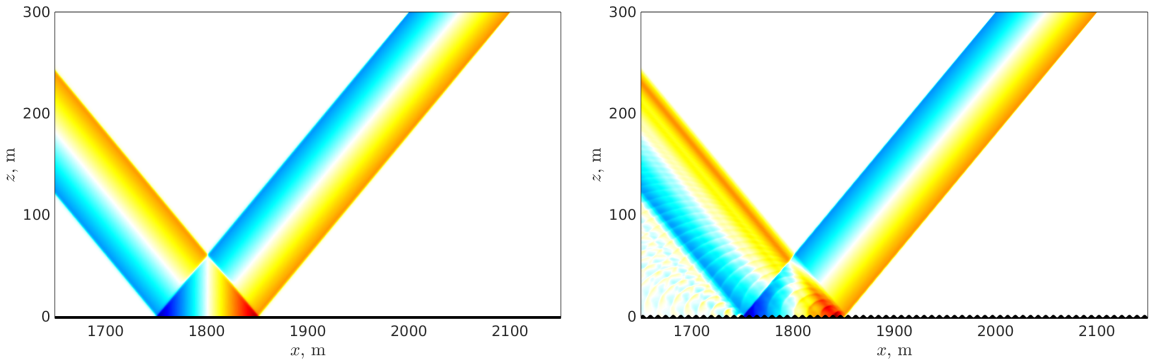

Figure 2: Preliminary numerical simulation of the propagation of a sonic boom in the atmosphere: snapshots of the acoustic pressure above (left) a flat ground and (right) a ground with a sinusoidal profile.

The aim of the proposed study is to improve the prediction of the sonic boom propagation in a complex environment. For this purpose, numerical simulations of sonic boom propagation in the atmosphere will be performed using a solver of the Euler equations, based on finite-difference time-domain techniques. The work will focus on two aspects. First, the influence of the topography on the pressure waveforms at the ground will be examined. In particular, a statistical study will be carried out to determine the variabilty of the waveform characteristics due to the terrain irregularity. Secondly, propagation of sonic boom in a inhomogenous atmosphere will be investigated. In particular, a realistic description of the atmospheric turbulence based either on data from a LES simulation or on anisotropic synthetic turbulence models will be accounted for. In both studies, typical N-wave and low-boom signatures will be considered.

Profile:

The candidate should have a PhD in acoustics or fluid mechanics. He or she should have previous experience in numerical simulation. Working knowledge of programming in Fortran 90 is a strong asset, but is not mandatory.