POSTDOC OFFER

Large scale plunging jets: impact, energy dissipation and air entrainment

Duration: 12 months, starting in Spring 2023.

Location: LEGI (http://www.legi.grenoble-inp.fr/) and CERG (http://www.cerg-fluides.com/) at Grenoble, France.

Candidate profile: engineering or physics background with strong formation in fluid mechanics. A PhD in a related topic is required. Experience in experimentation measuring techniques and modelling. Experience using Matlab and/or Python is recommended.

Context and how to apply: this postdoctoral contract is funded by the **JetPlume ANR** project, that involves LEGI (Grenoble, France), LMFA (Lyon, http://lmfa.ec-lyon.fr/), CORIA (Rouen, https://www.coria.fr/) and Electricité de France (EDF). Periodic meetings and discussions will be held periodically between all partners.

Interested candidates should send their CV and cover letter to Martin Obligado (Martin.Obligado@univ-grenoble-alpes.fr).

Topic: Large-scale plunging jets encountered in hydroelectric infrastructures directly influence turbine operation and performance through their ability to generate huge bubble clouds and thereby draw air into the pipelines under load. Nevertheless, despite the relevance of applications, something as fundamental as predicting the flow rate of air entrained in a pool by a plunging jet is still an open question.

This project consists on an **experimental** study that involves LEGI lab, the Studies and Research Centre from Grenoble (CERG) and Electricité de France (EDF), and aims at providing a better understanding of these flows within hydroelectric installations.

I this context, a key parameter for the modelling and scale-up of these flows is the ability of a jet to entrain air under the free surface that it impacts and the characterization of its sub-surface dynamics. Other important parameters are the size distribution of the bubbles generated, the entrained air flow rate and the spatial distribution of local quantities of interest (such as concentrations, phase velocities, flux, etc.).

Objectives and experimental work: the main objective is therefore to understand which parameters govern the amount of air entrained in the pool and the aeration of the free-falling jet. The postdoctoral researcher will perform experiments in the LEGI facility to characterise the two-phase jet below the free surface in terms of velocity, concentration and flux profiles using optical probes. The goal is to vary the jet parameters, such as its velocity and the initial turbulent intensity, and to analyse the results comparing them to the few measurements and/or modelling proposals available in the literature.

To accurately describe the phenomenon and propose a reliable model to predict the dynamics of plunging jets, the postdoctoral researcher will use a very large-scale experiment, the *'JetHigh'* experimental platform. This facility, located at the CERG test center nearby Grenoble, will be used to analyze plunging jets with injected velocities from 2 to 35 m/s with an injection diameter between 26 mm to 213 mm, along a 10-meter free fall height impacting a 23 m meter depth plunge pool. We will use this very large-scale facility to follow the jet all along its fall (figure 1).

For both facilities, several measurement techniques have been deployed including:

• Pressure sensors to evaluate the average speed and the level of turbulence of the jet,
• A set of high-speed cameras to analyze the position and the topology of the jet at impact as well as the speed of corrugation of its surface,
• A high frequency momentum sensor to determine the unsteady impact force of the jet,
• Underwater cameras to visualize the cloud of bubbles and measure the depth of penetration,
• Optical probes to measure the size, the speed of the bubbles formed, their concentration as well as the entrained air flow. This sensor also provides access to the penetration depth of the bubble cloud. It can also be used in the jet to characterize internal gas structures (void ratio, size, velocity) or surface structures.

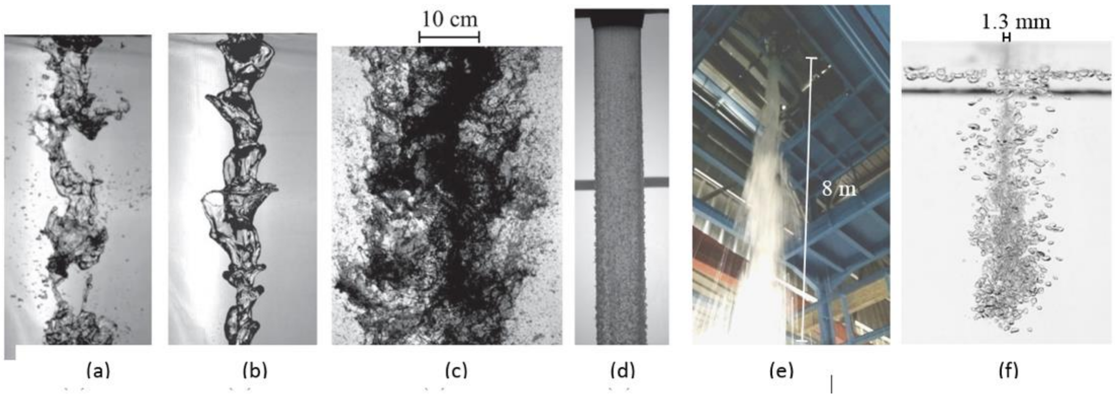

Figure 1: Visualization of falling jet in large-scale *JetHigh* experiment. (a) D_0=37 mm and V_0=11 m/s, (b) D_0=83 mm and V_0=3 m/s, (c) D_0=83 mm and V_0=5 m/s, (d) Same conditions as (c) but at the injection, (e) View of the *JetHigh* experimental facility D_0 = 213cm, V_0= 2 m/s. (f) View of a bubble cloud on a laboratory scale experiment D_0 = 1.3 mm and V_0 = 8 m/s. (a),(b),(c) are at the same scale.

The postdoctoral researcher will therefore perform experiments using all available experimental techniques at both LEGI and CERG facilities. He/she will be in charge of the data analysis and the comparison with data previously acquired. He/she will also be part of the development of a first-order model that can be used by engineers to evaluate the power of the jet at impact, the entrained airflow, the average size of the bubbles formed and the penetration depth of the bubble cloud.

References

- Kiger, Kenneth T., and James H. Duncan. "Air-entrainment mechanisms in plunging jets and breaking waves." *Annual Review of Fluid Mechanics* 44 (2012): 563-596.

- Guyot, Grégory, Alain Cartellier, and Jean-Philippe Matas. "Penetration depth of a plunging jet: from microjets to cascades." *Physical Review Letters* 124, no. 19 (2020): 194503.

- Guyot, Grégory, Alain Cartellier, and Jean-Philippe Matas. "Depth of penetration of bubbles entrained by an oscillated plunging water jet." *Chemical Engineering Science: X* 2 (2019): 100017.