Internship on particle growth in complex environments

Keywords	Physics (particle-laden flows, turbulence, transport, agglomeration) Modelling (reduced-order models, spatial and temporal correlations) Scientific computing (numerical simulation, data analysis)

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Hosting Team	EPC CaliSto, Inria Centre at Université Côte d'Azur

Context

Solid particles suspended in a flow are omnipresent in our daily life and in the environment. To name a few examples, particles are present in atmospheric sciences (dispersion of pollutants, aerosols and/or pollens) or in marine sciences (plastic contamination in rivers or oceans). These particles are transported by turbulent flows; they can interact with each other to form aggregates which can fragment later on; they can accumulate on surfaces and form complex deposits which can clog flow passage sections. All these intricate phenomena form the field of dispersed two-phase flows, which is concerned with fluids that contain inclusions (bubbles, droplets, particles).

Objectives

We offer you to focus on the agglomeration phenomena, whereby aggregates grow in size due to inter-particle collisions and adhesion. The objective is to develop a more advanced model for agglomeration. More precisely, the new approach should reproduce the effect of correlated inter-particle collisions in turbulent flows that has been recently measured in some simulations [2] (see Figure 1).

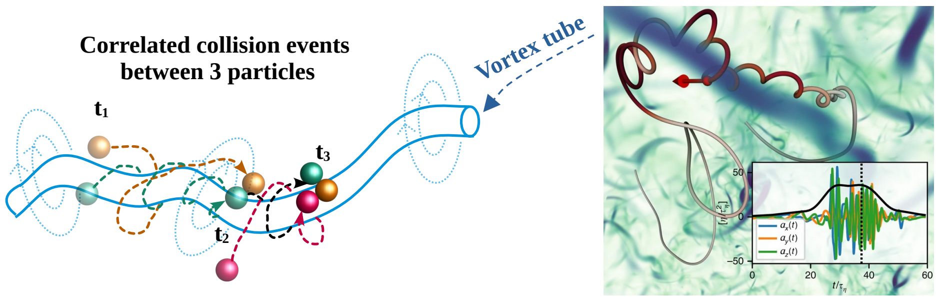

Figure 1: Sketch illustrating how correlated collisions between multiple particles can occur in a highly turbulent region, here around vortex filaments (image taken from DNS simulations with tracer particles on the right [3]).

Proposed methodology

To reach these objectives, we foresee the following steps:

1. Perform fine-scale numerical simulations of the dynamics of particles with various inertia suspended in a fluid flow with well-defined spatial correlations (e.g. a Kraichnan flow);
2. Analyze the results of fine-scale simulations to see how the spatial correlations in the fluid affect correlations between inter-particle collisions involving multiple particles;

3. Develop new macroscopic models that account for such correlated collisions between multiple particles. The idea will be to extent existing mean-field approaches (like population balance models) that reproduce the effect of agglomeration using a probability of collisions.
4. Assess the accuracy and efficiency of this new macroscopic model (e.g. through validations with fine-scale statistical data).

This internship is at the frontier between various scientific fields (physics, mathematics and scientific computing). It relies on a multi-scale approach that combines both microscopic simulations and macroscopic models.

The student will be encouraged to write a publication in an international journal at the end of the internship. Motivated students will be encouraged to pursue their work on this topic with a PhD thesis.

Applicant profile

We are looking for Master 2 students with a strong background in at least one of the following fields:

- Physics (Statistical Physics, Fluid dynamics, Modelling)
- Scientific computing and Applied mathematics (Numerical methods, Numerical simulations, Statistics)

Applicants should be fluent in English, have a good experience in programming (preferably C, C++).

We are looking for applicants who are rigorous, who demonstrate independent and creative thinking. Applicants interested in environmental problems are encouraged to apply.

Duration and period

The internship will cover a period of 5-6 months, between February and September 2024. The exact starting/end dates are quite flexible and can be adapted to the constraints of the student.

Host institution

The internship will take place within Team CaliSto at Inria Centre at Université Côte d'Azur, located in Sophia Antipolis near Nice (France). The student will be in contact with researchers that collaborate with the team members across France and Europe.

To apply

Interested applicants are welcome to send the following documents to christophe.henry@inria.fr and jeremie.bec@univ-cotedazur.fr:

1. a Curriculum Vitae;
2. a motivation letter;
3. a transcript of their grades from their Master studies;
4. at least one recommendation letter.

References

[1] Vallée R., Henry C., Hachem E., & Bec J. (2018): Physical Review Fluids, 3, 024303.
[2] Bec J., Ray S.S., Saw E.W. & Homann H. (2016): Physical Review E, 93, 031102(R).
[3] Bentkamp L., Lalescu C.C. & Wilczek M. (2019): Nature Communications, 10(1), 3550.