Project Title: Particles in turbulence, what do they do?

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Project Description:

Atmospheric flows transporting aerosols or volcanic ashes, aircraft pneumatic lines in chemical processes, combustion systems and engine intakes in dusty environments are few instances of turbulent flows carrying solid particles. The disperse phase may give rise to agglomerates, deposition, may alter the flow dynamics, and may even lead to catastrophic system failures. When the particles are not light and small enough to follow all the fluid motions, nor they are heavy enough to be unaffected by the flow, predicting the collective particle behavior is extremely challenging for engineering relevant cases.

Fig.1. Experimental snapshot of inertial particles in the central plane of a turbulent channel flow. †

Part of the complexity of particle-laden flows arises from the large number of parameters at play, which does not allow to build predictions based on a particular numerical or experimental test case. High-fidelity simulations, tracking millions of particles and resolving down to the smallest flow scales, are now possible, but only in very simple flow configurations and at very large computational cost. On the other hand, there is a lack of well documented experimental data, which is key to improve our understanding of this type of flows and support simplified models that can be used for engineering design. Finally, new non-local metrices and innovative ways of characterizing the particle and fluid fields are needed, for the un-biased analysis of both experimental and numerical datasets.

Two projects are available as part of this research effort on particle-laden flows:

1) The first project will involve hands-on experimental work. The undergraduate researcher will assist in designing and developing a particle-laden flow experiment, including the test-rig and the set of measurement techniques. This is an excellent opportunity to learn the main principles of wind tunnel design, dive into experimental techniques with particular emphasis in optical techniques (PIV/PTV) and familiarize with multiphase flow systems.

2) The second project will focus on large data analysis. Large three-dimensional datasets will be analyzed from high-fidelity simulations of inertial particles in a fully-developed turbulent channel flow. The undergraduate researcher will assist in developing tools to postprocess the data and extract flow turbulence quantities, particle concentration fields and correlations between them. In this project, the undergraduate researcher will learn concepts of turbulence and multiphase flows, and will gain experience on complex data analysis using datasets from state-of-the-art high-fidelity simulations. †

Student Background: We are seeking two highly motivated students interested in turbulent flows and multiphase systems. For project 1, previous fluid dynamics and experimental lab course work is desirable. CAD experience is a plus. For project 2, the applicant is required to have some prior experience with Matlab. Previous fluid dynamics course work is desirable.

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