CEMRACS 2017 Project

Statistical and probabilistic modeling of cloud of particles strongly coupled with a turbulent fluid (StochasticTurbulence)

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Many applications such as combustion involve the transport of a cloud of particles strongly coupled with a fluid [1,2]. In the standard case, fluid evolution can be described by deterministic evolution equations such as Navier-Stokes equations. However, in the coupled case, evolution equations are unclosed due to the exchange term with the particles [3,4]. Thus the proper level of modeling for the gas evolution equations, for the particle evolution equations and for the exchange terms needs to be stochastically designed in order to obtain a consistent coupled evolution model for particle transport in turbulent flows.

One of the difficulty in the derivation of this model is that uncertainty arises both for the chaotic behavior of the fluid [5,6,7] and from the initial properties of the particles such as position and velocity. Thus we need assumptions about the statistical and probabilistic properties of the stochastic processes driving the dynamics. Even if some advances have been made in the field [8], the field is far from being closed. A first approach consists in considering a Gaussian structure of the variables of interest [9,10].

The aim is to reproduce the time resolved fluctuations, in the evolution of the system, induced by the presence of particles in the fluid, whilst preserving statistical meaningfulness. In a first part, it will be necessary to understand the level of approximation of the original system, i.e. the scale or granularity at which we aim at resolving it. Next we have to propose a mathematical stochastic model for the evolution of the chosen variables, knowing that Gaussian structure is certainly not preserved. This model has to be coherent with physical properties (transport law, diffusion) and will be validated by dedicated simple numerical simulations in well-chosen configurations as well as eventually turbulence simulations of more realistic configurations such as in [1].

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