Toward LES simulations of a disperse phase: a hierarchy of models and adapted numerical schemes

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The solutions of the turbulent dynamics of sprays generally present two features known to be hard to handle numerically: very stiff accumulations of particles/droplets in the quiet regions and absence (void) of particles/droplets within vortices, from which the spray is inertially ejected, see Figure 1. These features drive the need for a both high-order accurate and robust numerical method, which would correctly get the steep gradients of the solution in the particle-clustering zones, while preventing any non-physical behavior in the nearby empty zones.

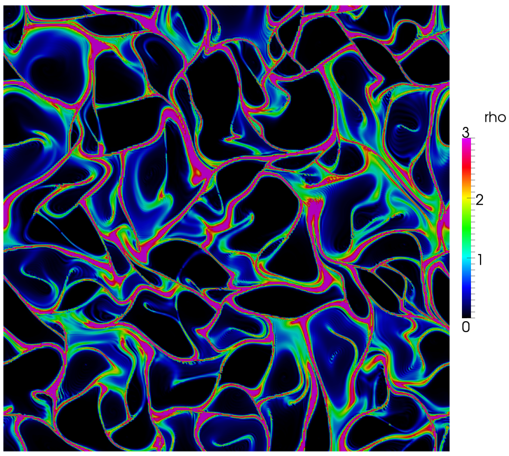

Figure 1: Density of droplets in a frozen Homogenous Istropic Turbulence velocity field after significant enough relaxation time invervals.

Keeping this in mind, this talk will first build a hierarchy of Eulerian models based on the evolution of the moments in velocity of a Boltzmann-like equation for the Number Density Function (NDF) describing statistically the particles/droplets cloud. From these models, the physically valuable solutions are those, called **realizable**, which are the sets of moments of at least one NDF. For example, since the density is the 0th-order moment of the NDF

$$\rho(t,\vec{x}) = \int_{\mathbb{R}^3} f(t,\vec{x},\vec{v})d\vec{v},$$

and the NDF is everywhere positive, a realizable state must have a positive density. Same with the pressure, energy, granular temperature, etc. Fortunately, it can be shown that the space of realizable states is convex and a convex state preserving numerical method therefore guarantees the physicality of the obtained solution. This is what we gain with an arbitrary high-order convex state preserving discontinuous Galerkin procedure, which will be presented in detail.

Next, the talk will focus on the system of equations considering all the three first moments of the NDF. Since the equation of energy is tensorial, so is the pressure and this is why this system is called the **Anisotropic Gaussian Model**. By comparison with Lagrangian reference solutions, we will show that this model statistically captures small scale Particles Trajectory Crossings (PTC), what simpler models do not achieve. Therefore, we do believe the Anisotropic Gaussian model is a good candidate to extend our current studies to the LES simulation of turbulent disperse flows and the end of the talk will present preliminary result in this research direction.