SETTLING OF PARTICLES IN HOMOGENEOUS SHEAR TURBULENCE

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Abstract The settling of (inertial) particles is studied in homogeneous shear turbulence. A drift velocity perpendicular to gravity is measured due to the interplay between the homogeneous shear turbulence and gravity acting on the particles. We introduce a model to predict and understand this phenomenon.

INTRODUCTION

Turbulent flows occur in various industrial and natural phenomena. In many of these cases, turbulent fluctuations are coupled to a large-scale flow. Homogeneous shear turbulence is the first step in understanding how the mean flow influences turbulent fluctuations. The flow are here homogeneous but anisotropic. To highlight the difference between homogeneous-isotropic and homogeneous-shear turbulence, we show the dispersion of particles from a line source. It is clear that the presence of shear introduces an additional dispersion mechanism in the system. More strikingly, Gualtieri *et al.* [1] have shown that for inertial particles anisotropic behaviour occurs even at scales where the carrier flow can already be isotropic. Thus to understand particle dynamics, the influence of both the small and the large scales of turbulence must be investigated.

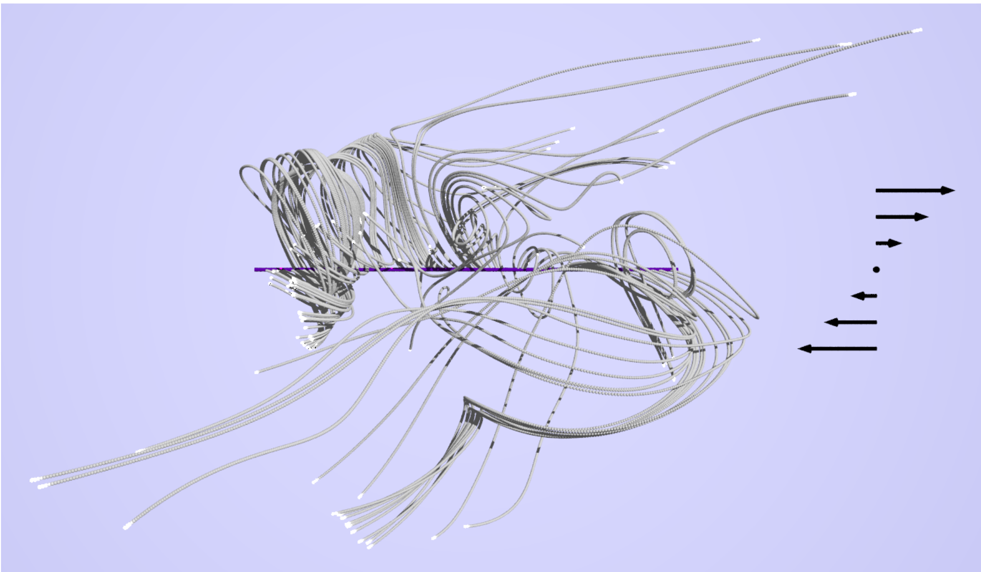

Figure 1. Trajectories of tracers in a homogeneous shear flow. All tracers started from the purple line and the mean flow is shown on the right hand side.

MODEL

We examine the dynamics of the system by an Eulerian-Lagrangian model. The flow is simulated by an Eulerian approach using a Pseudo-spectral code, while the particle trajectories are obtained by a Lagrangian approach. For homogeneous-isotropic turbulence these simulation are commonly used in many applications [4].In order to simulate homogeneous-shear turbulence, the classic Rogallo scheme [3] is implemented in the Pseudo-spectral code. Here, the frame of reference moves with the mean flow, which implicates that the frame of reference will keep straining over time. In order to keep the frame of reference from straining to much, a remap step of the flow field must be performed after every $\frac{1}{S\Delta t}$ simulation time steps. Here S is the dimensionless shear rate and Δt the length of the simulation time step.

The particles are modelled with the Maxey-Riley equations [2]. For the heavy particles we use a simplified version of these equations consisting of the Stokes drag and the gravity force. For the almost neutrally buoyant particles we use the full equations.

SETTLING VELOCITY

We started with investigating the settling velocity. For homogeneous isotropic turbulence it is well known that the settling velocity can increase due to the presence of turbulence [5]. We are interested in how shear will affect this behaviour and what the consequences are for real life applications. For heavy particles we found some interesting new phenomena. When the shear is directed like in Figure 1 and gravity is directed in the positive horizontal direction a vertical drift velocity of the particles is measured in downward direction. The magnitude of this drift velocity is shown in Figure 2. We introduced a model, starting from some basic assumptions to explain and predict this behaviour. The model is able to predict the trend of this behaviour correctly. Next we will investigate the settling velocity for the almost neutral buoyant particles.

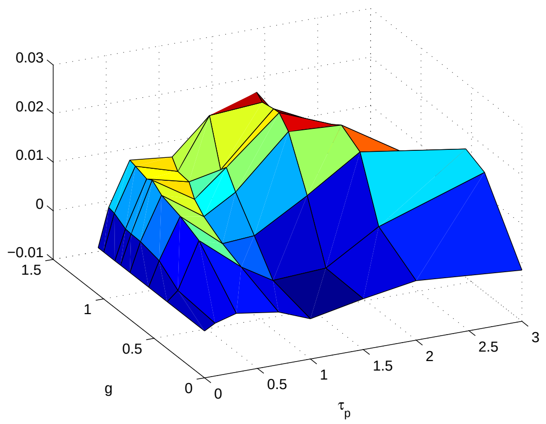

Figure 2. Drift velocity of particles in shear turbulence as a function of the gravitational force g and the particle response time τ_p.

References

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