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Particle pair diffusion of inertial particles such as dust in the atmosphere

Nadeem Malik, Yoseph Tereda, and Syed Usama
King Fahd University of Petroleum and Minerals, Mathematics, Saudi Arabia (namalik@kfupm.edu.sa)

The transport of particles in turbulent flows is ubiquitous in industrial applications and also in nature such as in dust storms and pollens. The mathematical equations that describe the motion of individual inertial particles (i.e. particles with weight and friction) is not fully developed yet, although simplified descriptions in specific contexts have been proposed, such as by Maxey and Riley [1].

The relative motion of groups of particles is equally important to understand, and this can usually be related to the relative motion of two particles, or pair diffusion. In 1926 Richardson [2] proposed a pioneering theory of pair diffusion of fluid particles based upon the idea of a separation dependent pair diffusivity, $K(l)$, where l is the distance between two particles. Richardson advanced the theory based on a locality hypothesis in which only energy in the turbulent scales similar to the pair separation l is effective in further increasing the pair separation, leading to the famous 4/3-scaling, $K \sim l^{4/3}$. Recent studies in turbulent particle pair diffusion [3] has suggested that both local and non-local effects govern the pair diffusion process inside the inertial subrange in high Reynolds number turbulence containing generalised power-law energy spectra, $E(k) \sim k^{-p}$ with $1 < p \leq 3$. This leads to a scaling like, $K \sim \sigma_l^{\gamma_p}$, where γ_p is intermediate between the purely local and the pure no-local scalings. $\sigma_l = \langle l^2 \rangle$ is the ensemble average pair separation.

Here, we investigate numerically turbulent pair diffusion of inertial particles [6] in high Reynolds number turbulence containing generalised power-law energy spectra, $E(k) \sim k^{-p}$ with $1 < p \leq 3$, over a extended inertial subranges, in the Stokes drag limit,and neglecting the added mass effect. We use a Lagrangian diffusion model [4,5] in this investigation. A particle trajectory is then obtained from the coupled equations,

$$\frac{dx}{dt} = v(t) \quad \text{and} \quad \frac{dv}{dt} = -\frac{1}{\tau}(v-u). \tag{1}$$

where, x is the particle position at time t, $v(t)$ is the particle Lagrangian velocity, $u(x,t)$ is the Eulerian velocity field generated by the diffusion model, τ is the particle response time. The Stokes number is, $St = \tau/t_\eta$, where t_η is the Kolmogorov time scale. Results and analysis from this investigation will be presented at the time of the conference.

References

[1] Maxey, M. R. and Riley, J. J. Equation of motion for a small rigid sphere in a nonuniform flow, *Phys. Fluids* 26, 883–889. 1983.

[2] Richardson L. F., Atmospheric diffusion shown on a distance-neighbour graph. *Proc. Roy. Soc. Lond. A* 100, 709-737. 1926.

[3] Malik, N. A. On Turbulent Particle Pair Diffusion. *Submitted to JFM* 2016. http://arxiv.org/abs/1405.3625v3

[4] Kraichnan, R. H. Diffusion by a random velocity field. *Phys. Fluids* 13, 22–31. 1970.

[5] Fung J. C. H., Hunt J. C. R., Malik N. A. & Perkins R. J. Kinematic simulation of homogeneous turbulence by unsteady random Fourier modes. *J. Fluid Mech.* 236, 281-318. 1992.

[6] Bec, J., Biferale, L., Lanotte, A., Scagliarini, A. and F., Toschi, Turbulent pair dispersion of inertial particles, *J. Fluid Mech.* 645, 497. (2010).