Euromech colloquium 512:
Small scales turnbulence and related gradients statistics

Clustering of inertial particles in free jets

C.M. Casciola, P. Gualtieri, F. Picano, G. Sardina
Dip. Mecc. Aeron., Università di Roma "La Sapienza", via Eudossiana 18, 00184 Roma, Italy

Recently, clustering of inertial particles in turbulence has been thoroughly analyzed for statistically homogeneous and isotropic flows. The most striking result concerns the singular behavior exhibited by the radial distribution function under proper resonance conditions, showing clustering below the Kolmogorov scale. Since anisotropy is strongly depleted through the inertial range, the advecting field anisotropy may be expected in-influential for the small scale features of particle configurations. By addressing direct numerical simulations (DNS) of a statistically steady particle-laden homogeneous shear flow, we find instead that the small scales of the particle distribution are strongly affected by the geometry of velocity fluctuations at large scales. The proper statistical tool is the angular distribution function of particle pairs (ADF). Its anisotropic component may develop a singularity whose strength quantifies the anisotropy of the small scale clustering. The data provide evidence that the process is essentially anisotropic, even in the range of scales where isotropization of velocity statistics already occurred.

In order to show the relevance of the results for a generic shear flow, several cases, ranging from turbophoresis in wall bounded shear flows to the segration process induced by turbulence in particle laden free jets, will be discussed focusing mainly on particle behavior in free jets, of special interest given the increase with axial distance of turbulent length and time scales occuring in this flow and its relevance for applications in combustion.

References

- J. Bec et al., "Heavy Particle Concentration in Turbulence at Dissipative and Inertial Scales", Phys. Rev. Lett. 98, 2007
- B. Jacob, C.M. Casciola, A. Talamelli, P.H. Alfredsson, "Scaling of mixed structure functions in turbulent boundary layers", Phys. Fluids, 20, 2008.
- P. Gualtieri, F. Picano, C.M. Casciola, "Anisotropic clustering of inertial particles in homoegenous shear flow", JFM in press 2009.
- F. Picano, C.M. Casciola, "Small scale anisotropy and universality of axisymmetric jets, Phys. Fluids 19, 2007.
- G. Troiani, M. Marrocco, S. Giammartini, C. M. Casciola, "Counter-gradient transport in the combustion of a premixed CH_4/Air annular jet by combined PIV/OH-LIF", Combustion and Flame 156, 2009.