Pair dispersion of inertial particles in turbulent flows

Alessandra S. Lanotte[1]

[1] *CNR - Istituto di Scienze dell'Atmosfera e del Clima, Area Tor Vergata, 00133 Roma and INFN, Sezione di Lecce, 73100 Lecce, Italy.*

The statistical properties of small-scale Eulerian velocity increments is responsible for the way, initially close pairs of tracers separate in turbulent flows. As a result, depending on the values of time and space scales, we can observe different regimes for relative dispersion, see e.g. [1].
The application of similarity theory for Eulerian velocity statistics is at the base of the turbulent relative dispersion for inertial particle pairs also, i.e. of small, finite-size particles with a density contrast with respect to the advecting flow. However, inertia can significantly influence particles dynamics and dispersion: inducing strong inhomogeneities in their spatial distribution in the flow [2], and affecting small-scale velocity increment statistics, a phenomenon connected to the formation of *caustics* [3].
By means of direct numerical simulations at two values of the Taylor-scale Reynolds number $Re_\lambda \sim 200$ and $Re_\lambda \sim 400$, we report about the evolution of both heavy and light pairs [4].
For the former case, it is found that turbulent dispersion is schematically governed by two temporal regimes. The first is dominated by the presence, at large Stokes numbers, of small-scale caustics in the particle velocity statistics, and it lasts until heavy particle velocities have relaxed towards the underlying flow velocities. At such large times and large scales, a second regime starts where heavy particles separate as tracers particles would do.
In the case of light particles with vanising inertia with respect to the fluid one, strong small-scale clustering leads to a considerable fraction of pairs that do not separate at all, although the mean separation increases with time. This effect strongly alters the shape of the probability density function of light particle separations.

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