ANALYSIS OF LAGRANGIAN PARTICLE DYNAMICS

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Abstract Although there is a long history to study turbulence from the viewpoint of Lagrangian statistics, it is still hardly to claim available results as well founded. One of the prevailing considerations is that due to the finite Reynolds number effect, statistical behaviors, such as the scaling relations, can not be largely separated at different scales, which prevents further understanding of the implicit physics of turbulence dynamics.

Enlightened by streamline segment anayss (J. Fluid Mech. (2010), 648:183-203) in the Eulerian frame, in this work we introduce a similar method to investigate the turbulent Lagrangian trajectory statistics. In principle the unclosed trajectories of Lagrangian fluid particles can be partitioned into separate segments, according to the extrema of the magnitude of the velocity difference. Each segment can be characterized by the time difference Δt and the magnitude of velocity difference Δu. From the direct numerical simulation (DNS) data, the joint PDF (probability density function) of Δt and Δu can be extracted and the conditional mean $\langle \Delta u \mid \Delta t \rangle$ shows in a broad range a scaling relation $\Delta u \sim \Delta t^{1/2}$, which conforms with the dimensional analysis result. In comparison the conventional sample average fails to see this property and the physical mechanism behind such difference has been analyzed. This outcome can be attributed to the fact that different regions of the flow field have different local correlations. Furthermore the PDF of Δt has also been studied using a Poisson-like random cutting-reconnection model with the drift influence.