Lagrangian Investigation of Coherent Structures in Two-dimensional Decaying Turbulence

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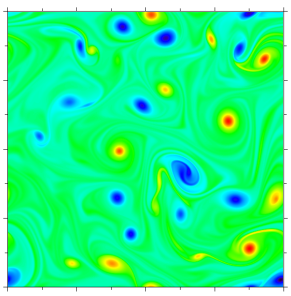

Eulerian investigation of decaying two-dimensional turbulence reveals that many flow properties show a self-similar behaviour [1]. However, literature on a description in the Lagrangian frame is sparse. We therefore present a numerical investigation of two-dimensional decaying turbulence in the Lagrangian picture. Focusing on single particle statistics, we investigate Lagrangian trajectories in a freely evolving turbulent velocity field. We find

that the time-resolved acceleration pdf has a highly non-Gaussian functional form with pronounced tails. When normalized to its standard deviation the functional form of this pdf shows no variation over a wide temporal range of the decay process, indicating that a self-similar scaling regime can also be found in the Lagrangian frame of reference. As a consequence the time-resolved moments of the acceleration pdf follow a power-law.

In two-dimensional decaying turbulence one can identify several basic flow structures [2] such as the Lamb-Oseen-vortex or Lundgren‘s famous two-dimensional spiral [3]. These structures are of major significance for the evolution of a Lagrangian tracer particle. In order to gain a deeper understanding of the described system we are led to investigate the evolution of a single particle or an ensemble of tracers in isolated coherent structures. We focus on the Lamb-Oseen-vortex and Lundgren's spiral. We find that averaging over an ensemble of Lagrangian particles is crucial for the emergence of fat-tail statistics. By the idealized concept of a point vortex we derive analytical solutions for the functional form of the pdf's.

References

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