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The role of coherent structures in particle dispersion in turbulent flows

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Turbulent mixing of liquids and gases is ubiquitous in nature; it is the basis of all industrial fluid mixing processes, and it determines the spread of pollutants or bioagents in the atmosphere and oceans. The understanding of statistical properties of Lagrangian trajectories in turbulence is crucial for problems such as spreading of plankton in the ocean, transport of pollutants in the atmosphere, or rain initiation in clouds. Oceanic data on trajectories of free-drifting instruments indicate that the trajectory statistics can often be described by a Lagrangian integral scale. Turbulence however is a state of a flow dominated by a hierarchy of scales, and it is not clear which of these scales mostly affect particle dispersion. Moreover, coherent structures, often coexist with turbulence, such as the small scale forcing in laboratory experiments, or the self-generated spectral condensation [1]. How those coherent structures affect particle dispersion is not well understood. Recently developments in scientific imaging and computational power make it possible to tackle this problem experimentally. In this talk, we report analysis of higher order Lagrangian statistics in laboratory two-dimensional turbulence. Our results show that fluid particle dispersion is diffusive and is determined by a single measurable Lagrangian scale related to the forcing scale [2]. The higher order moments of the particle dispersion shows strong self-similarity in fully developed turbulence [3]. The role of the self-generated condensation structure to the higher order statistics of particle dispersion will be discussed. These experiments offer a new way of predicting dispersion in turbulent flows in which one of the low energy scales possesses temporal coherency. It may help better understanding of floater measurements in some areas of the ocean, where small scale but coherent eddies are present [4].

Reference:

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