Quasi-coherent aspects in turbulent transport

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We present a statistical study of tracer transport in two-dimensional incompressible turbulence. It is well known that the turbulence has in these conditions a self-organizing character that consists of the generation of quasi-coherent structure (vortices). The tendency to self-organization appears at the basic level of tracer trajectories [1,2]. They can include both random and coherent aspects, which appear as random sequences of large jumps and trapping or eddying events. This complex behaviour is determined by the Hamiltonian structure of the equation of motion.

The aim of this study is to understand how the stochastic and quasi-coherent characteristics of the trajectories influence the transport. The paper is focused on determining the statistical properties of the distance between neighbour trajectories, which account for the degree of coherence of the motion. The results are obtained with the decorrelation trajectory method [3] and the nested subensemble approach [4], which provide a semi-analytical mathematical description that goes beyond the quasi-linear regime that corresponds to quasi-Gaussian transport. They describe the statistical effects of trajectory trapping. The statistical characteristics of trapped and free trajectories are separately studied and the average, the dispersion, and the probability distribution for the trajectories and for the distance between two neighbour trajectories are determined.

The statistical characteristics of the trapped trajectories are completely different from those of the free trajectories. The trapped trajectories have a quasi-coherent behaviour. The average, dispersion, and probability distribution function for these trajectories and for the distance between two trajectories saturate. Neighbour trapped trajectories have clump lifetime much longer than the time of flight. This shows that trapped trajectories form structures similar to fluid vortices. The statistical parameters of these structures (size, build-up time, statistical weight) are determined. The large jumps between the trapping events are random. They have negligible clump lifetime. The small-time probability (at time of the order of the decorrelation time) is non-Gaussian for both types of trajectories.

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