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A Lagrangian view of vorticity-strain alignment in turbulent flows

EBERHARD BODENSCHATZ, MPI-DS, Goettingen, ALAIN PUMIR, ENS Lyon, HAITAO XU, MPI-DS, Goettingen — Vortex stretching is arguably the most important aspect of dynamics in 3- dimensional fluid turbulence. Intuitively, one would expect that the vorticity vector is aligned to the direction of the strongest stretching. It is therefore puzzling when numerical simulations and experiments showed that, at any instantaneous time, vorticity preferentially aligns to the intermediate eigenvalues of the rate of strain tensor, corresponding to much weak stretching. Here we show that the dynamics is simplified when the alignment process is studied in a Lagrangian frame, i.e, following a fluid element. Using data from particle tracking experiments and direct numerical simulations, we studied the evolution of 4 fluid tracers that initially form isotropic tetrahedra. The evolution dynamics can be revealed in terms of the velocity gradient tensor perceived by the tetrads. For tetrads with size spanning from the dissipative scale to well in the inertial range, we observed the alignment of the vorticity to the direction of the strongest stretching *at earlier time*, i.e., a demonstration of the expected vortex-stretching in turbulence. For tetrads of sizes within the inertial range, the alignment process occurs at time scales given by the tetrad size and the energy dissipation rate.

Eberhard Bodenschatz
MPI-DS, Goettingen

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