Chaotic flow and mixing with a dilute polymer solution in a regime of elastic turbulence.

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I present an experimental investigation of random flows of a dilute polymer solution above the onset of the elastic instability in both closed and open flow configurations [1]. Systematic investigation [2, 3] of micro flows of a dilute polymer solution has shown that, when elastic stresses overcome the viscous ones ($Wi > 1$), the micro flow becomes quite irregular and evolves (as Wi is further increased) rapidly towards a fully developed chaotic regime. Although the typical size of the elongated polymer molecules is likely to become comparable to the diameter of the micro channel , we show that the random micro flow of a dilute polymer solution surprisingly displays most of the features of elastic turbulence (Groisman and Steinberg, $Nature, 2000$) in geometrically similar macro flows: *fast growth of flow resistance, randomly varying and strongly fluctuating velocity fields, fast and monotonous decay of the Eulerian velocity correlations.*

The random microscopic flow turns out to be an ideal realization of the Batchelor regime of mixing. By studying the mixing efficiency at different Peclet numbers (Pe), we confirm a very recent theoretical prediction (Chertkov and Lebedev, 2003): the mixing efficiency scales algebraically with Pe. This difference with respect to the case of the Batchelor regime in an unbounded system is further clarified by systematic measurements of the width of the mixing boundary layer as a function of Pe.

Finally, we characterize the flow randomness in a regime of elastic turbulence by focusing on the statistics of particle pair separations [1, 4]. We compare the Finite Time Lyapunov Exponents ($FTLE$) with the statistical description in Eulerian frame, namely velocity correlation times and average velocity gradients.

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