Passive scalar transport across 2D and 3D shearless mixing layers

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We present new results concerning the passive scalar turbulent transport in two and three dimensions in a shear-less mixing layer, see fig.1. We consider the system where one energetic turbulent isotropic field is left to convectively diffuse into a low energy one [3, 4]. In this system the region where the two turbulent flows interact is associated to a high intermittent thin layer that propagates into the low energy region. We have seen that the diffusion process in 2D is faster then in 3D. In 2D the time growth of the interaction width is super-diffusive, while in 3D is slightly sub-diffusive, as in the wind tunnel experiments by Veeravalli and Warhaft (JFM 1990). In both cases the passive scalar temporal spreading follows the spreading of corresponding kinetic energy field. The presence of the turbulent energy gradient is felt on the distribution of statistical quantities, as the skewness, kurtosis and spectra, across the layer. In two dimension, the passive scalar spectrum computed inside the mixing region presents an exponent in the inertial range which is half of the usually met exponent of the velocity fluctuation spectrum, typically close to - 3. In three dimension, we instead observed a mild difference between these two spectral exponents. The results are obtained from direct numerical simulations of the diffusion of the passive scalar across the interface which separates the two isotropic decaying turbulent fields with different kinetic energy. The size of the computational domain is $4\pi \times (2\pi)^2$ (discretized with 1200×600^2 grid points) in the 3D simulations and $(2\pi)^2$ (discretized with 1024^2 grid points) in the 2D simulations [5, 6]. For details on the numerical technique, see [3, 4].

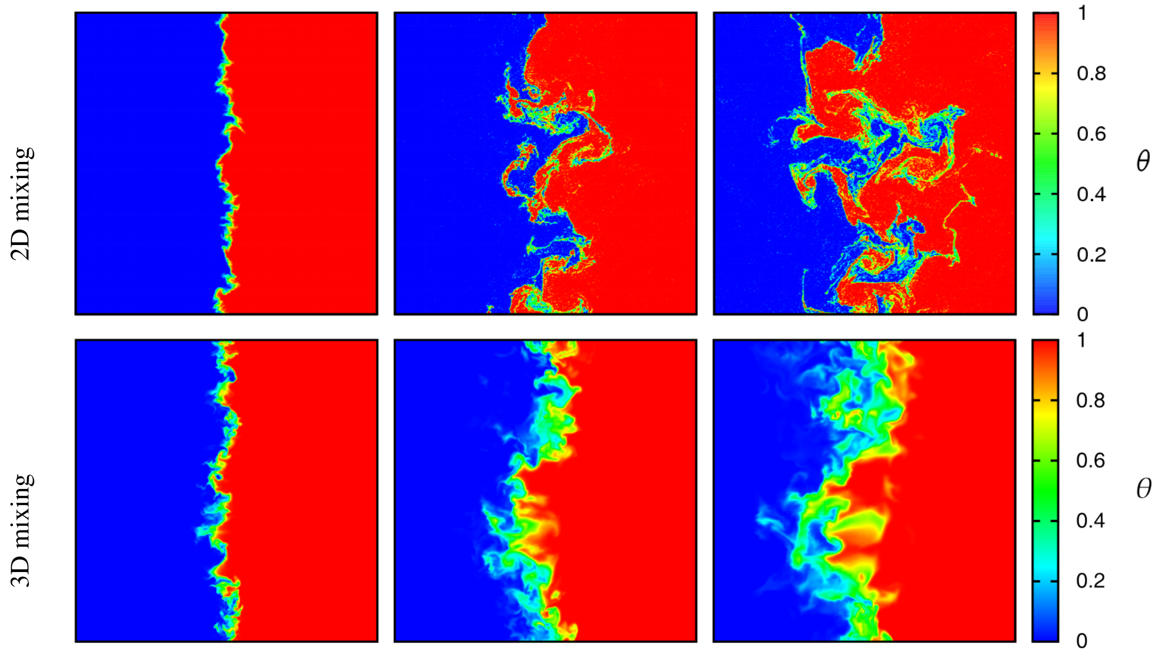

Figure 1: Visualization of the scalar field. The high turbulent energy velocity field is on the left of each image. The three different instants correspond from left to right to $t/\tau = 1, 5, 10$, respectively. The 3D simulation has an initial R_λ equal to 150 in the high energy isotropic region and 60 in the low energy region.

References

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