Dimensionality influence of the passive scalar transport observed through experiments on the turbulence shearless mixing

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Dimensionality influence of the passive scalar transport observed through experiments on the turbulence shearless mixing / S. Di Savino; M. Iovieno; L. Ducasse; D. Tordella. - STAMPA. - 5(2011), pp. 105-105. ((Intervento presentato al convegno 5th European Postgraduate Fluid Dynamics Conference tenutosi a Gottingen, Germany nel August, 9-12, 2011.

Availability:
This version is available at: 11583/2447777 since:

Publisher:
DLR Institute of Aerodynamics and Flow Technology

Published
DOI:

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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 $1200 \times 600^2$ 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].