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A fast, physically based method for mixing computations

PATRICE MEUNIER, CNRS-IRPHE, EMMANUEL VILLERMAUX, Universite de Provence — We introduce a new numerical method for the study of diffusing scalar filaments in a 2D advection field. The position of the advected filament is computed kinematically, and the associated convection-diffusion problem is solved using the computed local stretching rate, assuming that the diffusing filament thickness is smaller than its local radius of curvature. This assumption reduces the numerical problem to the computation of a single variable along the filament, thus making the method extremely fast and applicable to any Peclet number. This method is then used for the mixing of a scalar in the chaotic regime of a Sine Flow, for which we relate the global quantities (spectra, concentration PDF) to the distributed stretching of the convoluted filament. The numerical results indicate that the PDF of the filament elongation is log-normal, a signature of random multiplicative processes. This property leads to exact analytical predictions for the spectrum of the field and for the PDF of the scalar concentration, in good agreement with the numerical results. These are thought to be generic of the chaotic mixing of scalars in the Batchelor regime.

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