The Local Wavenumber Model for Turbulent Mixing

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We present the recent status in the development of a turbulence closure model to study two–fluid mixing. The model under study is a two–point spectral closure model and is known as the local wavenumber (LWN) model. The LWN model is envisioned as a computationally efficient option in two–fluid mixing problems common in several multiphysics applications. Statistical hydrodynamical quantities such as the Reynolds stress, and mixing parameters such as density correlations and mix–width evolution are captured with high fidelity using the LWN model[1]. In addition to the mean quantities, the model is able to capture the spectral evolution of the statistical quantities like the kinetic energy and density correlations. We present two different fluid mixing scenarios with increasing complexity. The first scenario is a *homogeneous* variable density fluid mixing driven by buoyancy. The second scenario is fluid mixing in the typical Rayleigh Taylor configuration, in which there is *inhomogeneous* variable–density fluid mixing driven by buoyancy[2]. Our work points towards possible future improvements in analytical multiscale models of turbulence[3].

A validation of the LWN model against high–resolution numerical simulations is shown in Fig. 1. Figures 1(a) and (b) clearly show that the LWN model accurately captures the time evolution of the density correlation $b(t)$ and the mix–width W respectively.

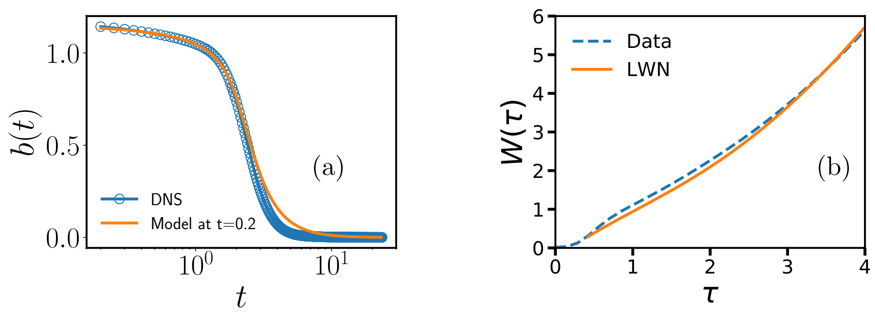

Figure 1: (a) Mix parameter b as a function of time; blue line with circles for Direct Numerical Simulation data and orange line for LWN model; this case is for the homogeneous variable–density turbulent mixing. (b) Mix–width W evolution as a function of time; blue dashed line for simulation data and orange line for LWN model; this case is for inhomogeneous variable–density turbulent mixing.

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[1] Pal et al., *Phys. Rev. Fluids* **3**(12), 124608 (2018)

[2] Pal et al., *Phys. Rev. E* **104**(2), 025105 (2021)

[3] Kurien and Pal, *Philos. Trans. Royal Soc. A* **380**(2219), (2022).