DYNAMICS AND INFLUENCE OF THE BUOYANCY FREQUENCY IN UNSTABLY STRATIFIED HOMOGENEOUS TURBULENCE

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Abstract We investigate unstably stratified homogeneous turbulence through direct numerical simulation and a spectral model based on a eddy-damped quasi-normal Markovian closure. In this study, we take into account and evaluate the importance of an unsteady buoyancy frequency expressing the evolution of a mixing zone submitted to Rayleigh-Taylor instability.

CONTEXT

Unstably stratified homogeneous turbulence (USHT) is an idealized framework introduced to study the dynamics of variable density mixtures when the acceleration of gravity is opposed to the mean density gradient. This approach is aimed at analysing some properties of turbulent fluctuating quantities in Rayleigh-Taylor mixing zones such as unsteadiness and anisotropy while getting rid of inhomogeneity effects. USHT has been explored extensively through numerical simulations [3] and theoretical studies [4] which focus particularly on the self-similar aspects of this flow. These works have shown the fundamental importance of large scales in the time evolution of turbulent quantities. They also have shed light on the limitations of direct numerical simulations, due to confinement effects induced by the growth of energetics scales. In order to overcome this difficulty, we have recently developed a spectral model based on an Eddy-Damped Quasi-Normal Markovian method which takes into account energy production by buoyancy terms [1]. This two-point statistical model describes axisymmetric turbulence through a set of velocity-density correlation spectra. It has been validated with comparison against direct numerical simulations. Some results are presented on Fig. 1: a comparison between the linear solution (RDT), EDQNM and DNS (Fig. 1(a)). Also results about the final self-similar regime at high Reynolds number (Fig. 1(b)) as well as kinetic energy spectra (Fig. 1(c)) are presented.

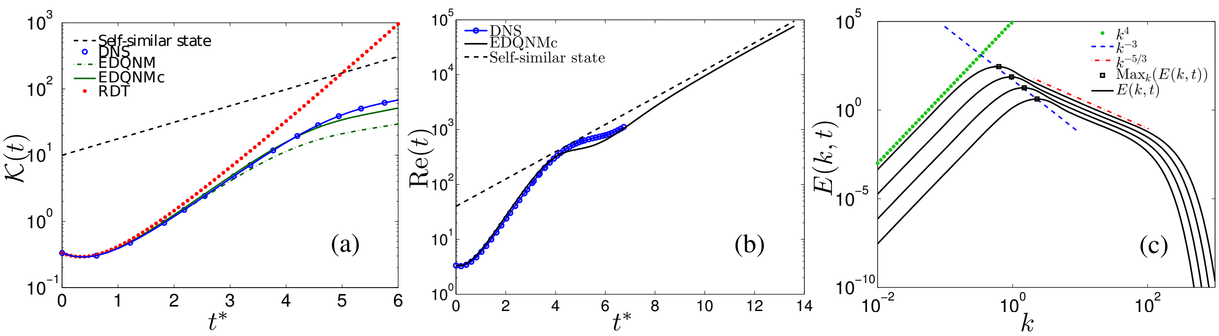

Figure 1. (a) Comparison between linear solution (red), DNS (blue) and EDQNM (green). (b) Reynolds number evolution with self-similar regime. (c) Self-similar evolution of the kinetic energy spectra.

OBJECTIVE

In the results shown above, the buoyancy frequency N defined from the mixing zone length and the gravity g as $N \sim \sqrt{g/L}$ was considered as constant. However, this hypothesis is unrealistic because the mixing zone evolves due to the vertical mass flux. In this work, we propose to extend the model by introducing an equation expressing the evolution of the buoyancy frequency as proposed by [2]. Different comparisons between direct numerical simulations and the extension of the previous EDQNM method will be presented.

References

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