# The effects of variable viscosity on the decay of homogeneous isotropic turbulence

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We investigate the decay of incompressible homogeneous isotropic turbulence in a variable viscosity fluid. The viscosity coefficient is assumed to depend linearly on a scalar, representing either a temperature or a concentration, and obeying a simple advection-diffusion equation. At high Reynolds numbers, Direct Numerical Simulations (DNS) allow us to confirm the validity of Taylor's postulate that the dissipation is independent from the viscosity and its fluctuations. At low Reynolds numbers, we report the presence of extra energy at small scales due to these variable viscosity effects. This implies that the turbulent kinetic energy decreases less rapidly as a function of time in variable viscosity fluids. In order to explain this phenomenon and quantify its importance on the turbulent flow, we propose a statistical approach based on an eddy-damped quasi-normal markovian (EDQNM) spectral closure which takes into account the non linearity introduced by variable viscosity. It is shown that this latter additional term is of constant sign in the energy spectrum equation and reduces the dissipation of the flow as observed. Also, by assuming the dominance of distant interactions between wave numbers, we can propose a simple formula expressing that variable viscosity effects lead to an effective reduction of the mean viscosity proportional to the variance of viscosity fluctuations.

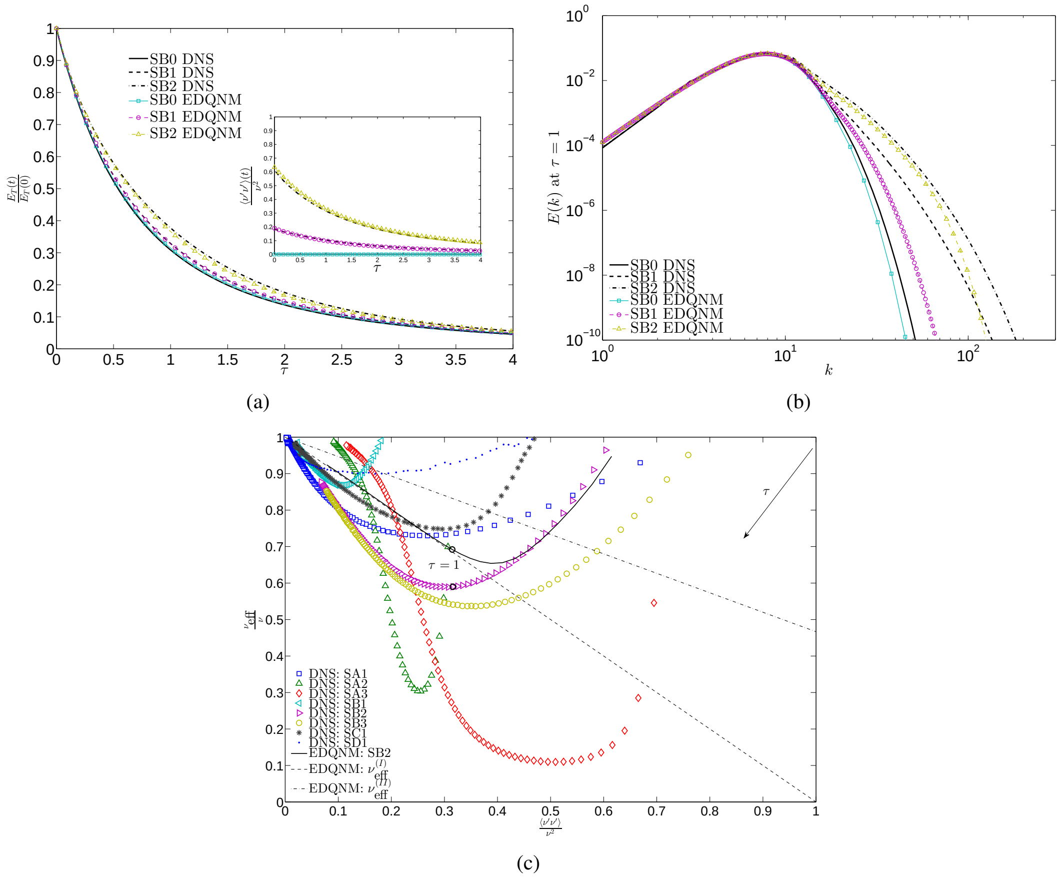


Figure 1: (a) Time-evolution of total kinetic energy in DNS and EDQNM. Comparison between constant (SB0) and variable viscosity (SB1-2) cases having the same mean viscosity. (b) Energy spectra function of the wavenumber $k$ at $\tau = 1$ for the same simulations. (c) Representation of the effective viscosity $\nu_{\text{eff}}$ function of the variance of fluctuating viscosity $\langle \nu' \nu' \rangle$ in the simulations.

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