Lattice Boltzmann and Pseudo-Spectral Methods for Decaying Turbulence

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We conduct a comparison of the lattice Boltzmann (LB) and the pseudo-spectral (PS) methods for DNS of decaying turbulence in a three dimensional periodic cube. We use a mesh size of 128^3 and the Taylor micro-scale Reynolds number $24.35 \leq \mathrm{Re}_\lambda \leq 72.37$. All simulations are carried out to $t \approx 30\tau_0$, where τ_0 is the turbulence turnover time. We compare instantaneous velocity u and vorticity ω fields, the energy $K(t)$, the energy spectrum $E(k, t)$, the dissipation rate $\varepsilon(t)$, the rms pressure fluctuation $\delta p(t)$, the pressure spectrum $P(k, t)$, the skewness, and flatness. Our results show that the LB method compares well with the PS method in terms of accuracy and efficiency: the flow fields and all the statistical quantities — except $\delta p(t)$ and $P(k, t)$ — obtained from the two methods agree well with each other when the initial flow field is adequately resolved by both methods. Our results indicate that the LB method resolution requirement is $\eta_0/\delta x \geq 1.0$, where η_0 and δx are the initial Kolmogorov length and the grid spacing, respectively.