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Weakly-compressible approach for turbulent channel flow and the issue of initial conditions

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ABSTRACT

In recent years, the common availability of the parallel computing devices, like multi-core CPUs and graphic processing units (GPU), are making the weakly-compressible (WC) approaches to computational fluid dynamics in the low-speed limit more popular. Since such methods consist of solving hyperbolic and/or parabolic equations and no elliptic problems occur, the parallelisation is straightforward when explicit time integration is used, what results in high computational efficiency. We recently obtained a very good results for the case of turbulent channel flow, see [1], using the Entropically Damped Artificial Compressibility (EDAC) model, proposed in [2]. The EDAC governing equations are purely parabolic and thus very convinient in numerical handling, especially in turbulent flow regime where the diffusive terms are not dominating but stabilise the solution. On the other hand, the advection-diffusion equations inherently support the wave solutions [3]. This results in some numerical difficulties due to the disparity of the WC–based characteristic speeds.

In the present work we focus on the initial conditions (IC) for the channel flow. For example, the usual approach of setting the parabolic velocity profile with node-wise random perturbations leads to re-laminarisation or blow-up of the solution of the EDAC equations. Therefore, we set the velocity IC by adding some large-scale perturbations in the form of Fourier modes (FM). This, however, introduces long acoustic waves into the solution that dissipate slowly and delay the transition to the statistically steady state. The main aim of this work is to find a proper composition of the FM magnitudes and frequencies to shorten this transition time.

References

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