Compressibility effects on the return to isotropy of homogeneous anisotropic turbulence

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This study aims at shedding some light on the influence of the compressibility on the anisotropic turbulence decay with a numerical approach. We solve the full three-dimensional Navier-Stokes equations using a finite difference approach. The inviscid part is resolved using a fifth-order Weighted Essentially Non-Oscillatory scheme (WENO). Viscous terms contributions are computed with a sixth-order accurate compact scheme. A third-order Runge Kutta algorithm is used to advance in time.

The well known "return to isotropy" phenomenon consists in energy transfers among normal components of the Reynolds stress tensor. In the budget equations, the fluctuating pressure-deformation correlation term is responsible for the energy redistribution. Previous studies have analyzed compressibility effects regarding isotropic flows. They have shown that the root mean square value of pressure fluctuations is correlated with the turbulent mach number M_t and the parameter χ that controls the energy ratio between the compressible and solenoidal part of the velocity field. Moreover, they have shown that for $M_t > 0.4$, eddy shocklets may occur and imply a faster decrease of the turbulent kinetic energy.

A parametric study depending on the initial values of M_t , χ and the initial anisotropic state has been achieved. We have observed similar evolutions than in the compressible isotropic situation. For $M_t = 0.6$, we have found that eddy shocklets occur in our simulations as the turbulent kinetic energy decrease faster than for low M_t values. The probability density function of the local Mach number confirms that a non-negligible fraction of the flow field is locally supersonic. Concerning the return to isotropy trajectories, we have been confronted to a transient evolution in the early stage of our simulations. We were not able to determine a specific impact of compressibility for two-component initial anisotropic states on the return to isotropy trajectories. Nevertheless, the return to isotropy rate could be exploited. We could see that increasing M_t implies a faster return to isotropy while the opposite is true when increasing χ. Moreover, the return to isotropy rate is more affected by the variation of M_t than the changes in χ.