

BULK VISCOSITY EFFECTS ON HOMOGENEOUS ISOTROPIC TURBULENCE

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ABSTRACT

Over the last 70 years, Computational Fluid Dynamics researchers have routinely invoked Stokes' hypothesis [1] to set the bulk viscosity equal to zero. In the case of incompressible fluids or monoatomic gases, this is true whether the volumetric viscosity is truly zero or the velocity divergence is null. However, for compressible polyatomic gases, in which the velocity divergence can be a non-negligible value, the second viscosity can be several orders of magnitude higher than the dynamic viscosity.

Previous works [2] have concluded that, indeed, including the volumetric viscosity increases the decay of turbulent kinetic energy. This effect is more noticeable in cases with a high bulk-to-kinematic viscosity ratio, such as CO_2 . In these cases, assuming Stokes' hypothesis can lead to inaccurate results. Nonetheless, these conclusions were only extracted in Decaying homogeneous isotropic turbulence simulations, where, in some cases, the dilatational velocity field dropped to zero almost immediately.

In this work, we analyze the effect of including the second viscosity in the Compressible Navier-Stokes equations. We perform a DNS of the Decay and Forcing of the homogeneous isotropic turbulence using the pseudospectral method and logarithmic variables [3] to enhance the overall stability. This method allows us to minimize the amount of numerical diffusion added, as the derivatives will be computed exactly rather than numerically. Therefore, all differences among the performed simulations should be linked to the presence and amount of the added second viscosity.

The work is divided into two main simulation blocks: the usual Decay of homogeneous isotropic turbulence and the Forced homogeneous isotropic turbulence. The authors believe that analyzing what occurs in a problem more similar to a real case scenario, where energy is injected via boundary conditions, could shed some light on the energy-transfer phenomena involving the usually omitted volumetric viscosity.

REFERENCES

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