

Inferring one- and two-point kinetic energy budgets from direct numerical simulations of turbulent multiphase flows

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Direct numerical simulations have become an extremely valuable tool for analysing turbulent multiphase flows. While such tools are now able to cover a wider range of flow situations, our fundamental understanding and predicting capabilities of such flows are still rather sparse.

For instance, it is still unclear to which extent the turbulent kinetic energy, defined for either all or one particular scale, for either both or one particular phase, is altered by the presence of interfacial forces and the jumps of fluid physical properties. It is also unclear how the cascade process in heterogeneous fluid turbulence differs from that of classical single fluid turbulence. This requires a handy theory of multiphase turbulence, somehow similar to its single-phase counterpart, to be elaborated.

Here we propose to use Direct Numerical Simulations and transport equations for the scale-dependent kinetic energy to provide insights into these processes. We extend the work by Dodd and Ferrante [1] who derived the conditional one-point kinetic energy budgets, and the work by Crialesi-Esposito et al [2] who focused on the spectral content of kinetic energy, and derive a transport equation for the velocity structure functions conditioned by a given phase. This allows us to probe the effect of the fluid and flow properties on the scale-dependent energy transfer, energy production and dissipation, in each phase separately.

We explore the peculiar case of forced homogeneous and isotropic turbulence which is simulated using the `archer` code covering various fluid and flow situations.

References

- [1] DODD, Michael S. et FERRANTE, Antonino. On the interaction of Taylor length scale size droplets and isotropic turbulence. *Journal of Fluid Mechanics*, 2016, vol. 806, p. 356-412.
- [2] CRIALESI-ESPOSITO, Marco, ROSTI, Marco Edoardo, CHIBBARO, Sergio, et al. Modulation of homogeneous and isotropic turbulence in emulsions. *Journal of Fluid Mechanics*, 2022, vol. 940, p. A19.

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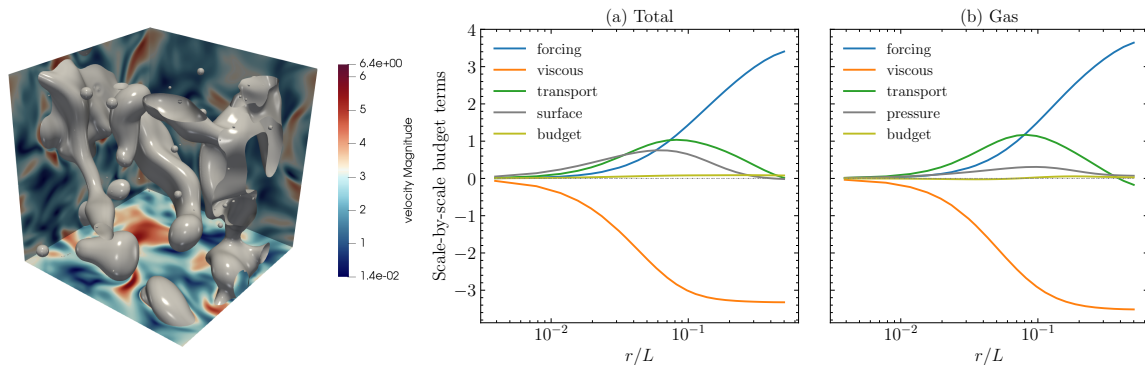


Figure 1: Total (a) and conditional (b) scale-by-scale energy budgets for homogeneous isotropic turbulence of heterogeneous fluids with 80% gas, 20% of liquid, equal densities and viscosity coefficients.