Influence of polymer additives on small scale dynamics of a turbulent/non-turbulent interface in shearless flows

Hugo Abreu[1,*], Fernando T. Pinho[2] and Carlos B. da Silva[1]

[1,*] IDMEC, IST, University of Lisboa, Avenida Rovisco País, 1,1049-001 Lisboa, Portugal (hugo.abreu, carlos.silva)@tecnico.ulisboa.pt (Presenter)
[2] CEFT, FEUP, University of Porto, Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal, fpinho@fe.up.pt

Many flows are characterised by the coexistence of turbulent (T) and irrotational (or non-turbulent - NT) flow regions *e.g.* wakes, where the two flow regions are separated by a very sharp interface layer: the turbulent/non-turbulent interface (TNTI) [1]. When very long chains of molecules (polymers) are dissolved into a Newtonian solvent the resulting medium exhibits complex viscoelastic properties that substantially affect the flow, and present substantially less entrainment than Newtonian fluids [2].

New direct numerical simulations (DNS) of turbulent fronts bounded by irrotational regions in viscoelastic fluids are carried out in order to investigate the characteristics of the turbulent/non-turbulent interface (TNTI) layer. The viscoelastic fluid analysed here consists of a Newtonian solvent carrying a very small fraction of long chained polymer molecules, which is described using the finitely extensible nonlinear elastic constitutive equation closed with the Peterlin approximation (FENE-P), and the new simulations attain the highest Reynolds numbers yet observed for this fluid, in simulations or experiments. The work focusses on the small scale aspects associated with the entrainment mechanism that exists at the edges of wakes, jets, mixing layers and boundary layers. Specifically, we analyse the enstrophy and kinetic energy dynamics and their role in the turbulent entrainment mechanism in TNTI layers from viscoelastic fluids. A detailed analysis of the energy transfer shows that at these scales energy is injected into the fluid flow through polymer relaxation.

References:

[1] da Silva C. B., Hunt J. C. R., Eames I. and Westerwell J., (2014), Interfacial layers between regions of different turbulence intensity, *Annual Review of Fluid Mechanics, vol. 46, pp. 567-590.*

[2] G. Cocconi, G., De Angelis, E., Frohnapfel, B., Baevsky, M. and Liberzon, A., (2017), Small scale dynamics of a shearless turbulent/non-turbulent interface in dilute polymer solutions, *Physics of Fluids, vol. 29, pp. 075-102.*