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Numerical simulation of heat transfer in homogeneous bubbly flows with interfacial resolution and discontinuous properties

A. Sonolet¹, G. Bois¹ and A. Toutant²

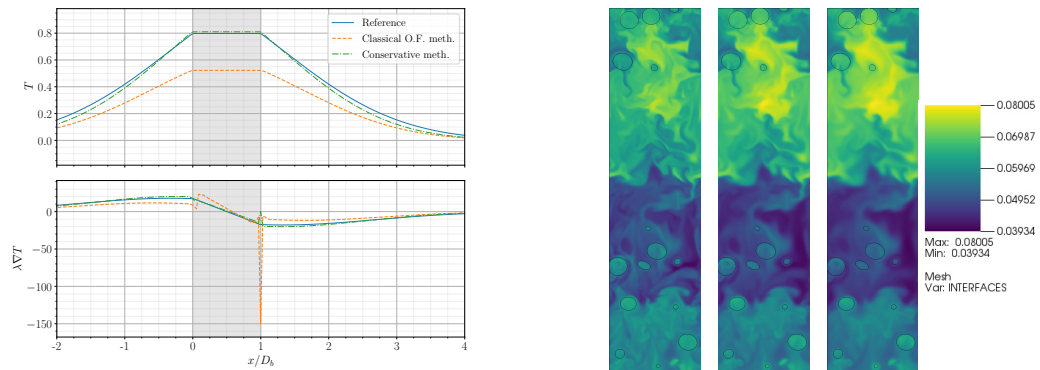
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This work aims to analyse various DNS results of heat transfer in turbulent bubbly flows without phase change.

In the simulation of such flows with sharp interfaces and discontinuous properties, energy conservation is difficult to achieve and is the object of the first part of this presentation. An innovative formulation in the finite volume and front-tracking frameworks is proposed to tackle this issue. The conservation of the formulation to model multiphase flow depends on several choices: the way the temperature equation is written and integrated, the hypothesis on the fluxes due to the discontinuity of the physical properties, and the space and time discretisations, with the interpolation methods chosen for the various fluxes near the interface. After a presentation of the classical one-fluid (O.F.) method and its drawbacks, a new set of coherent choices named ‘‘energy formulation with single phase interpolated fluxes’’ is proposed. It gives a genuinely conservative formulation with good abilities to predict the temperature. This formulation is tested in a representative one dimensional case first, and then in a full three-dimensional case.

This three-dimensional simulation set-up is original and is discussed in the second part of the presentation. It gives the opportunity to evaluate the energy conservation and to compute a Nusselt number. The informations extracted from this simulation are highlighted.



(a) Comparison of the numerical methods with discontinuous properties : $\rho_l c_{p_l} / \rho_v c_{p_v} = 0.1$, $\lambda_l / \lambda_v = 0.0035$

(b) Temperature profile with different Prandtl numbers: 2.62, 0.89, 0.5

Figure 1: Temperature evolution in a swarm simulated in (1a) one/(1b) three dimensions

References

Antoine du Cluzeau, Guillaume Bois, Adrien Toutant, and Nicolas Leoni. Analysis and modelling of bubble-induced turbulence from DNS of swarms. *Physical Review Fluids*, 2022. under review.