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On the effect of buoyancy on lateral migration of bubbles in turbulent flows: insights from Direct Numerical Simulations

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Abstract

Bubble migration is a key concern in turbulent bubbly flows as it dramatically affects momentum and mass transfers between phases. Its prediction in steam-water conditions relevant to PWR applications is difficult to assess because experiments are often conducted with air/water flows that present substantially different properties. The effect of the deformability of bubbles on the lift force has been extensively studied experimentally, or numerically, and characterized based on the Eötvös and Reynolds numbers. Nonetheless, the effect of buoyancy is not well understood. The strength of gravity and the resultant enhancement of turbulence can have a significant impact on bubble migration in the cross-flow direction.

In this work, we propose to use Direct Numerical Simulations (DNS) of turbulent bubbly flows to better understand the dominant physical mechanisms at play and cover ranges of conditions difficult to access experimentally. DNS offers a rich insight into the underlying physical phenomena and allows us to control the relative importance of different sub-physics. Starting from the flow conditions studied by Lu and Tryggvason [1], we perform four DNS of bubbly flows at a slightly higher Reynolds friction number, covering deformable and almost-spherical bubbles in weakly-buoyant or buoyant conditions. Separate effects of the Eötvös number and of an increasing gravitational force are assessed. Mean quantities, Reynolds stresses and higher-order statistics are computed to analyze the effect of bubbles on liquid turbulence levels, which influences the wall-normal void fraction profile.
New insights on the way bubbles alters liquid turbulence levels and influence the lateral migration of bubbles are presented. Further experimental and numerical studies are required to support and extend this analysis.

[1] J. Lu and G. Tryggvason. Effect of bubble deformability in turbulent bubbly upflow in a vertical channel. Physics of Fluids, 20(4), 2008,   10.1063/1.2911034.

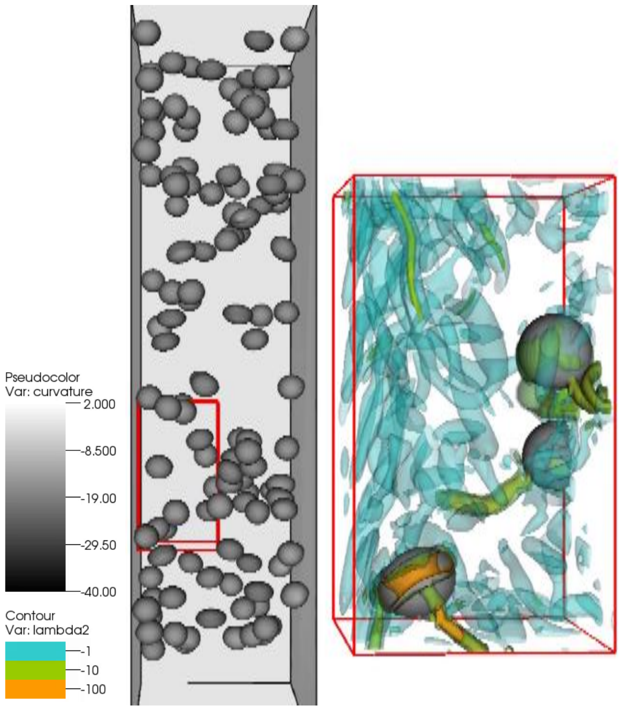

Figure 1: DNS of turbulent bubbly flow of almost-spherical bubbles in buoyant conditions.