Migration and deformation of droplets and bubbles rising in a wall bounded shear flow at small and finite Reynolds numbers

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Introduction

Determining how buoyant particles and bubbles migrate horizontally in a vertical pipe flow is of central importance to estimate the averaged characteristics of the corresponding widespread two-phase flow, including the local volume fraction of the dispersed phase, wall friction and heat exchange through the wall. This determination is made difficult by the fact that any particle moving in a wall-bounded shear flow experiences two different types of lift forces, one being due to the local shear while the other results directly from the presence of the wall. Things are even more complex with drops and bubbles which may deform in such a flow and undergo an additional deformation-induced lift force. These ingredients make it difficult to predict analytically the magnitude or even the direction of the resulting lift force.

Results

In the present study we investigate the migration and deformation of droplets and bubbles in a wall-bounded linear shear flow via, analytical predictions, experiments and computational solutions in the Stokes-flow limit. An apparatus in which a CCD camera and a microscope follow the rising bubble are used for Reynolds numbers less than 5; this apparatus allows us to determine accurately the bubble radius contour and rising speed, together with the distance between the bubble and the wall. The computational solutions are based on our three-dimensional fully-implicit interfacial spectral boundary element algorithm.

Conclusions

The interfacial deformation becomes significant when the viscosity of the suspending liquid is large enough. In this regime, we determine the shape of the drops/bubbles and the deformation-induced transverse force. Our experimental and computational findings are in good agreement while the theoretical prediction of Magnaudet, Takagi and Legendre (JFM, 2003) is found to predict accurately the deformation but to severely underpredict the deformation-induced lift force.