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Direct Numerical Simulations of bubbles in turbulent flows

Two-phase flows and in particular bubbly flows are an essential part of many industrial applications, occurring in nuclear power generation, chemical industry, in food-processing industry and many other installations. As soon as a flow contains a second phase, complex phenomena regarding the interaction of the two phases take place and in general need to be accounted for. One of the most fascinating aspects is the mutual interaction between the bubbles and the surrounding fluid turbulence in a configuration as simple as a vertical bubble-laden pipe flow. Here, the bubbles modify the turbulence and thus the behaviour of the fluid, which, in turn, influences the behaviour of the bubbles themselves, resulting in a problem of substantial complexity still not fully understood. To address such phenomena, Direct Numerical Simulations are performed in a vertical channel laden with spherical bubbles and the focus is on the interaction between fluid turbulence and bubble dynamics. Several simulations are conducted to assess the impact of different parameters on the flow features by varying, for example, the bubble size, the swarm composition, the void fraction and the direction of the mean fluid velocity. For each of the simulations a detailed analysis is undertaken, addressing instantaneous flow features as well as statistical quantities of both phases. The results of such simulations and the meticulous comparison among them provide a deep insight into the interaction between bubbles and fluid turbulence under several conditions. Furthermore, trustworthy statistical data are generated and employed for the assessment and improvement of existing models for the simulation of Euler-Euler turbulent bubbly flows and constitute a unique reference for further analysis and modelling as well.