The Royal Academy of Engineering

Global Research Award

The effect of phase change on dispersed turbulent multiphase flows

Host: National Technical University of Athens, Greece

Dr Ian Eames

Department of Mechanical Engineering, UCL

Introduction

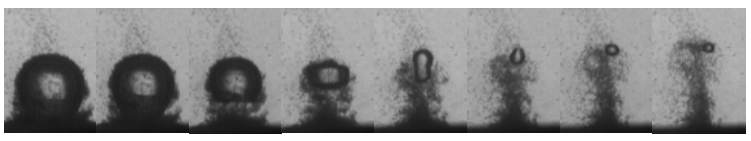
Phase change is important in a wide variety of engineering flows (nucleate boiling, evaporating fuel droplets, cavitation). Evaporation is even important in the spreading of disease by sneezing and in internal combustion engines. In these problems discrete elements move and ultimately disappear. As a consequence of momentum being globally conserved, the disappearance of these bubbles, droplets etc must lead to a vortex being generated. We develop new concepts, models and experiments to show the generation of this vortex.

Nucleate boiling

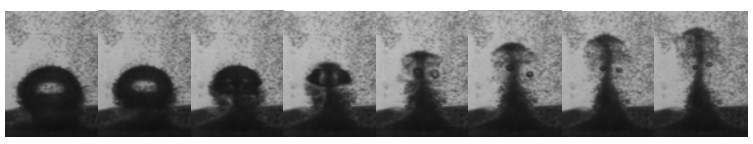
Our new experiments are the first to show the generation of a vortex as vapour bubble disappears. When the bubbles collapse in a time t_v longer than >5ms the vortex is generated by a viscous mechanism, while for rapid collapse (<5ms), a topological mechanism is important. The momentum of the vortex is

$$M_v = \lambda \rho V_o g t_c$$

where $\lambda \sim 1$, V_o is the maximum bubble volume, t_c is the collapse time and ρ is the density of water. These predictions of the vortex momentum are in agreement with



Bubble collapses slowly in 18ms



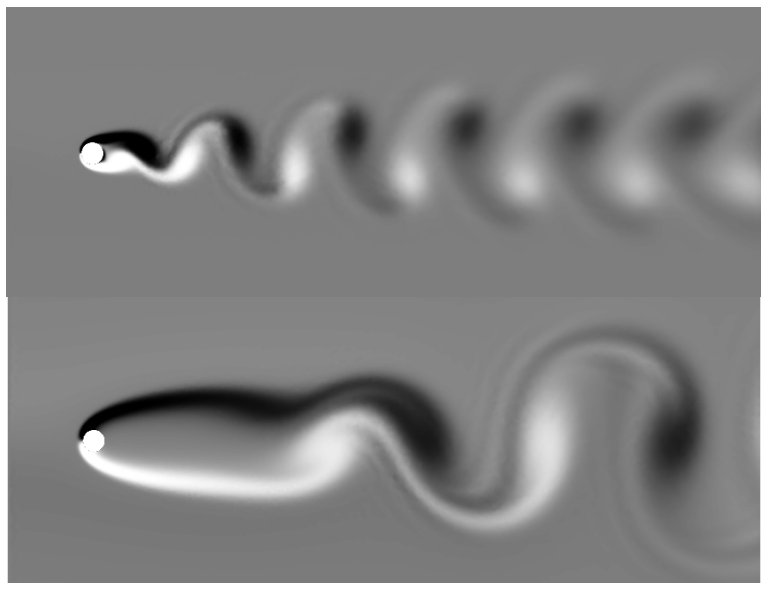
Bubble collapse quickly in 3ms

Droplet evaporation

Evaporating droplets generate a vortex whose momentum is equal to

$$M_v = m_o v_o,$$

the initial momentum of the droplet. On the right-hand side highly resolved numerical solutions for the flow past an evaporating droplet are shown. The effect of the evaporative flux leads to a substantial widening of the wake and is a key ingredient in momentum being globally conserved.



Achievements

The major achievement from the Global Research Award has been to substantially develop my expertise on large scale computations, which I am currently applying to the problems described above. Some of our new code has been completed, tested and is being applied to droplet evaporation.