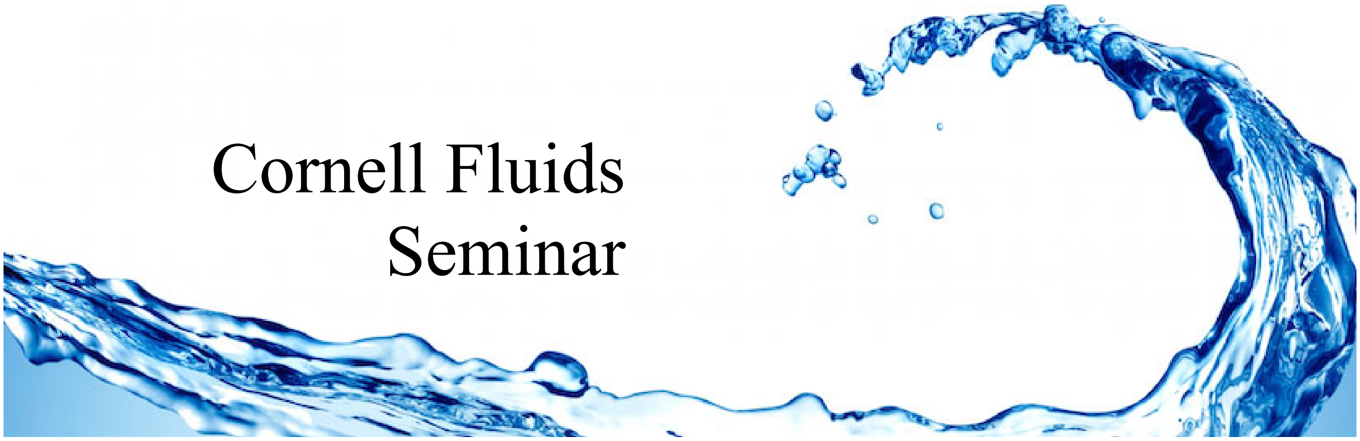

Cornell Fluids
Seminar

Tuesday, October 22, 2019, 12 pm
106 Upson Hall

Understanding micro-bubble generation in liquid-liquid impact events via numerical simulations

Shahab Mirjalili
Stanford University

Abstract: Micro-bubbles have been observed in various contexts such as in raindrops impacting liquid pools, boiling heat transfer, aerosol generation, breaking oceanic waves and ship wakes. Due to their long residence time under the free surface, micro-bubbles impact air-sea mass transport, formation of white caps and the signature of seafaring vessels. As such, understanding the mechanism involved in the formation of micro-bubbles is of significant interest. Based on evidence from drop-pool impact experiments, the leading hypothesis for the formation of micro-bubbles is that they are formed when liquid interfaces collide, entrapping a thin gas film and subsequently generating hundreds of micro-bubbles per impact. Due to the very small length and time scales involved, there is a lack of understanding of this mechanism, in addition to quantitative data regarding the generated micro-bubbles. This physical understanding has significant practical value, as one seeks to model micro-bubbles in large scale turbulent two-phase flow simulations.

In this talk, we first briefly introduce a novel diffuse interface method for simulation of incompressible, immiscible two-phase flows. For the remainder of the talk, we examine the impact of a drop on a deep liquid pool as an appropriate model problem for studying how collisions between two arbitrarily-curved interfaces may lead to microbubble entrainment. Using numerical simulations with a boundary integral method, we explain the physics of thin gas film entrapment and the stages of its evolution. These numerical simulations, in addition to theoretical arguments, lead to the discovery of a transition in the dynamics of the thin gas film that is necessary for entrapment of high aspect ratio films that can shed micro-bubbles. After presenting our study on thin gas film entrapment, we employ the introduced diffuse interface method to numerically simulate thin retracting gas films. A new scaling law for gas film retraction velocity is found. Moreover, using high-fidelity 3D simulations, we find that a transverse instability on the edge of the film is responsible for micro-bubble generation.

Bio: Shahab received his PhD in Mechanical Engineering under the supervision of Professor Ali Mani at Stanford University in June 2019. His dissertation focused on the development of numerical methods for simulation of two-phase flows and application to studying micro-bubble generation. Prior to that, he earned his MS from Stanford University and a BS from Sharif University of Technology, both in Mechanical Engineering. His research interests are primarily in the areas of two-phase flows and electro-kinetics in plasma regimes.

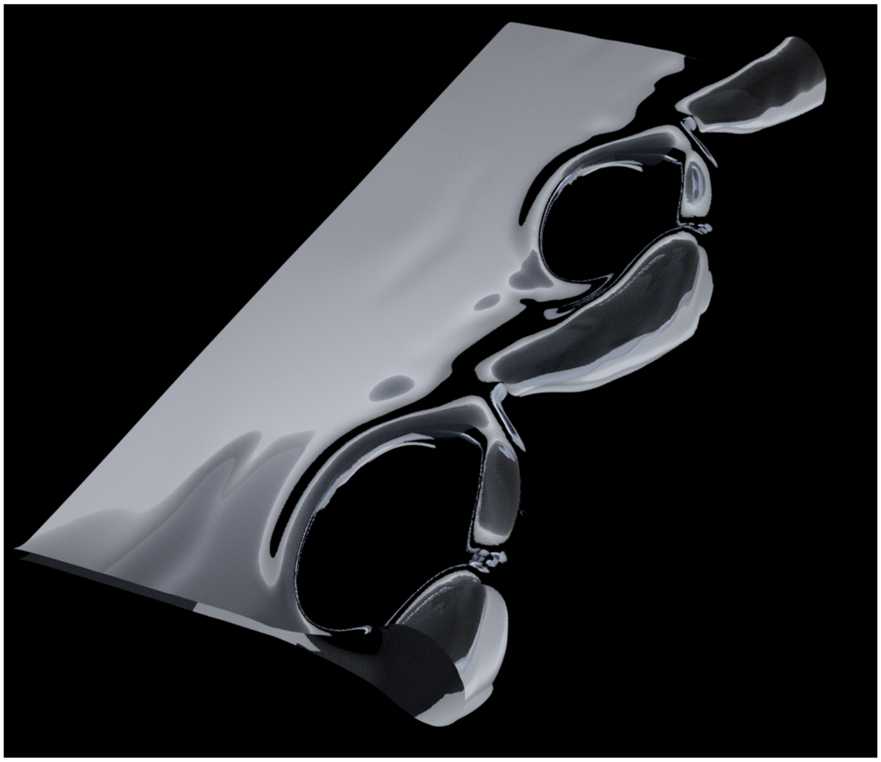

Figure 1: Retracting gas film