Towards High Fidelity Multiscale and Multiphysics Modeling and Simulation of Multiphase Flows

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Abstract

Multiphase flows play an important role in aerospace, marine and biomedical applications with both beneficial (e.g. atomization of fuel, lithotripsy) and detrimental effects (e.g. erosion, loss of efficiency). The ability to accurately predict multiphase flow behavior is imperative to control its formation, exploit its benefits and reduce its detrimental effects. A major difficulty in accurately predicting multiphase flows lies in the complex multiple length scale nature of such flows. Applying a universal model to cater to all the length scales is prohibitive in terms of computational cost. Hence, the most practical way to solve the multiscale problem is to develop models separately at both micro and macro length scales and then develop appropriate bridging models that can transition smoothly between models at different length scales. In this talk, I will discuss my research on two important areas of multiphase flow modeling in the realms of macroscopic and microscopic length scales which are the building blocks of a multiscale model.

First, I will discuss my work in the area of cavitation, a physical phenomenon that leads to gas phase formation in a liquid due to a reduction in pressure. I will present the development and application of a Large Eddy Simulation (LES) methodology for cavitating flows and discuss the importance of non-dissipative numerical methods and turbulence modeling in the prediction of cavitation. The enhanced accuracy of LES compared to low fidelity methods in modeling complex cavitating flows will be demonstrated. Under the next topic, I will discuss my research on the development of a Euler-Lagrange based simulation methodology for modeling gaseous micro bubbles dispersed in a liquid/solid medium. An important biomedical application of this method is the modeling of High Intensity Focused Ultrasound (HIFU), a non-invasive therapy for cancer treatment. Finally, I will discuss my future research ideas focused on the development of a holistic multiscale model, improved turbulence models for multiphase flows and their applications in emerging areas of aerospace engineering, marine engineering and biomedicine.

Biography

Dr. Aswin Gnanaskandan is currently a Research Scientist at Dynaflow Inc., USA, where he primarily works on developing numerical models for multiphase flows for applications in aerospace engineering, marine engineering and bio-medicine. Dr. Gnanaskandan completed his bachelor's degree in Aeronautical Engineering from Madras Institute of Technology, India, where he was a University Gold Medal winner and also the recipient of "Academic Excellence Award" from the Ministry of Human Resources and Development in 2006. He graduated with a M.S (2012) and PhD (2015) in Aerospace Engineering and Mechanics from the University of Minnesota, where he was the recipient of the "John and Jane Dunning Copper" fellowship. During his PhD, he worked with Prof. Krishnan Mahesh on numerical modeling of multiphase cavitating flows and developed a low dissipative, unstructured-grid methodology to simulate multiphase flows. Subsequently he moved to California Institute of Technology as a post-doctoral researcher where he worked with Dr. Josette Bellan on physical and subgrid scale modeling of high-pressure multispecies flows for which he received a "NASA certificate of recognition" in 2018. At Dynaflow Inc., he currently works on a number of research projects including liquid droplet breakup, dispersed bubbly flows, cavitation erosion and sonoporation. He is an active reviewer for multiple international journals and also the recipient of a "Certificate for outstanding contribution in reviewing" from the International Journal of Multiphase flow.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.