IOWA STATE UNIVERSITY

Center for Multiphase Flow Research and Education

Challenges and Opportunities in the Simulation of Bubbly, Cavitating Flows

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Abstract

Models and numerical methods for simulating bubbly, cavitating flows have benefitted from recent advances in sharp and diffuse interface-capturing schemes, but many challenges remain to be solved before they can be routinely used to predict the complex, multiscale flows associated with important applications in engineering and medicine. In particular, the complex phase boundary, small length scales, and fast time scales associated with the dynamics of bubbles and clouds of bubbles strain existing algorithms and computational resources. In this talk, I will review different formulations for multiphase/multicomponent flows that involve large changes in volume, including methods that explicitly resolve the material interface, and ones that model the mixture as either homogeneous, or as a dilute dispersion of spherical bubbles. These methods are demonstrated in applications involving the high-intensity ultrasound and shock waves used for medical imaging and intra- and extra-corporeal manipulation of cells, tissue, and urinary calculi. Such waves are currently used to treat kidney stone disease, plantar fasciitis, and bone nonunion, and they are being investigated as a technique to ablate cancer tumors and mediate drug delivery. In many applications, acoustic waves induce the expansion and collapse of preexisting or newly cavitating bubbles. The resulting bubble dynamics generate large, localized stresses and strains that can be beneficial or deleterious depending on how effectively they can be controlled. I will describe efforts aimed at simulating the collapse of bubbles, both individually and in clusters, in order to characterize these mechanical stresses and strains.

Biography

Tim Colonius is the Frank and Ora Lee Marble Professor of Mechanical Engineering at the California Institute of Technology. He received his B.S. from the University of Michigan in 1987 and M.S and Ph.D. in Mechanical Engineering from Stanford University in 1988 and 1994, respectively. He and his research team use numerical simulations to study a range of problems in fluid dynamics, including aeroacoustics, flow control, instabilities, shock waves, and bubble dynamics. Prof. Colonius also investigates medical applications of ultrasound, and is a member of the Medical Engineering faculty at Caltech. He is a Fellow of the American Physical Society and the Acoustical Society of America, and he is Editor-in-Chief of the journal Theoretical and Computational Fluid Dynamics. He was the recipient of the 2018 AIAA Aeroacoustics Award.

Refreshments will be provided.

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

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