IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Direct van der Waals Simulation (DVS): Towards Predictive Simulations of Cavitation and Boiling

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Abstract

Cavitating flows are ubiquitous in engineering and science. Despite their significance, a number of fundamental problems remain open; and our ability to make quantitative predictions is very limited. The Navier-Stokes-Korteweg equations constitute a fundamental model of cavitation, which has potential for predictive computations of liquid-vapor flows, including cavitation inception – one of the most elusive aspects of cavitation. However, numerical simulation of the Navier-Stokes-Korteweg equations is very challenging, and state of the art simulations are limited to very small Reynolds numbers, open flows (no walls), and in most cases, micrometer length scales. The computational challenges emerge from, at least, (a) the dispersive nature of the solutions to the equations, (b) a complicated eigenstructure of the isentropic form of the equations, which limits the use of standard CFD techniques, and (c) the need to resolve the liquid-vapor interface, which without special treatment, has a thickness in the order of nanometers. Here, we present Direct van der Waals simulation (DVS), a new approach that permits, for the first time as far as we are aware, large-scale simulations of wall-bounded flows with large Reynolds numbers. The proposed discretization scheme is a residual-based approach that emanates from the dispersive nature of the equations and outperforms standard stabilization schemes for advection-dominated problems. We feel that this work opens possibilities for predictive simulations of cavitation.

Dr. Hector Gomez is a Professor in the School of Mechanical Engineering, the Weldon School of Biomedical Engineering (by courtesy), the Purdue Institute for Cancer Research, and a Faculty University Scholar at Purdue University. Gomez specializes in computational mechanics with particular emphasis in simulation at the interface of engineering and medicine, isogeometric modeling and analysis, and multiphysics systems. Prof. Gomez's research has been recognized with multiple awards including the Juan C. Simo Award from the Spanish Society of Computational Mechanics, the MIT Innovators Under 35, the Young Investigator Award from the Royal Academy of Engineering of Spain, the Gallagher Young Investigator Award from the US Association for Computational Mechanics and the Princess of Girona Scientific Research Award (presented by the King of Spain; all fields of science, engineering and humanities). He has also received the Fellow Award from the US Association for Computational Mechanics. Prof. Gomez has published over 100 journal papers and made over 180 contributions to conferences.

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

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