OpenFOAM in Combustion Research

Quadrature-Based Moment Methods for Polydisperse Multiphase Flows

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Time: **April 22, 2022, 10:00 Singapore/Beijing | 03:00 London**
April 21, 2022, 22:00 New York

Register: https://nus-sg.zoom.us/webinar/register/WN_5KrJGGuwS5eO01Mwt9-bgg

Abstract

Quadrature-based moment methods (QBMM) are a computational approach to describe the spatio-temporal evolution of a distribution of properties of a particle population. In the simplest case, this distribution can be univariate, in flows where the particle population is made by small entities with negligible inertia but whose size changes due to phenomena such as aggregation, breakup, growth, and nucleation. In more complex flows, like gas-liquid and gas-solid flows, where the disperse entities have non-negligible inertia, the distribution is multivariate and depends at least on the particle size and the particle velocity, but may also be a function of more variables, as the system composition.

The evolution of the distribution function (or number density function, NDF, for brevity) is described by the generalized population balance equation (GPBE). Solving this equation is challenging because of the number of independent variables and the complexity of the physical phenomena that characterize these flows. In the context of QBMM, the GPBE is replaced by a set of partial differential equations for the moments of the NDF. This set of equations is unclosed because advection fluxes and source terms depend on the NDF, which is the unknown of the problem. QBMM provide closures to these terms by reconstructing the NDF with a Gaussian quadrature approximation and using the reconstructed NDF to calculate the unclosed terms.

The implementation of QBMM in a computational fluid dynamics code presents several challenges. It is of paramount importance that numerical methods preserve the realizability of the moments, ensuring that a distribution exists that has the moments for which the set of PDEs is solved. Inappropriate high-order advection schemes can compromise realizability, time integration schemes, and during the integration of non-linear source terms. Adequate numerical approaches to address these challenges while preserving accuracy and a reasonable computational time have been developed and will be the focus of this seminar. An overview of QBMM and the numerical methods used to solve moment conservation equations will be presented first using a univariate population balance model as a reference and then discussing example applications to gas-liquid and gas-particle systems.

About the Speaker

Professor Alberto Passalacqua is an associate professor of Mechanical Engineering at Iowa State University, with a courtesy appointment in Chemical and Biological Engineering. He received his Ph.D. in Chemical Engineering from Politecnico di Torino (Italy), in 2008. He is the associate director of the Center for Multiphase Flow Research and Education (CoMFRE) at Iowa State University and the lead developer of OpenQBMM, the first open-source implementation of quadrature-based moment methods into OpenFOAM. He was the recipient of the American Chemical Society – Petroleum Research Fund Doctoral New Investigator award in 2014. He has received the Jean d'Alembert junior research fellowship at Université Paris-Saclay (France) in the Summer of 2017 and 2018. His research, funded by the US National Science Foundation, the US Department of Energy, and several private companies, focuses on developing, implementing, and validating meso- and macro-scale computational models for reacting multiphase flows.