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New Strategies and Results for Modeling Droplet-Laden Turbulent Flows

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Room 2540 GGB

ME Seminar Link
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Abstract:
A common situation in fluid dynamics is the flow of a gas with dispersed solid particles and/or liquid droplets. Such multiphase flows, i.e. flows with multiple immiscible phases, appear often in engineering situations involving heat and/or mass transfer. In aviation, liquid fuel is injected into

the engine as a spray of droplets which subsequently evaporate and combust. The rate of combustion, power output, and pollution production from the combustion are all limited by the process of droplet dispersion, evaporation, and vapor mixing in the combustor. This talk will discuss some results from our investigations into droplet dynamics in turbulent flows.

The main goal of this work has been improving the state-of-the-art in modeling droplets in turbulent flows. Standard modeling techniques using the classical Lagrangian Particle Technique (LPT) neglect many crucial details necessary to accurately model the trajectory, evaporation rate, and combustion properties of droplets as they appear in spray combustion. To fill in the gap, the work uses a combination of analytical theory and numerical simulation to develop next-generation models of droplets in sprays. Mathematical analysis is used to develop theories of droplet evolution in sprays. The theoretical results are extended through comparison to simulation data from our in-house high-fidelity interface-capturing direct numerical simulation code.

As a result of our investigations, we confirmed that droplet deformation due to the aerodynamic forces induces faster evaporation and combustion rates. And we proposed physical mechanisms to explain the phenomenon. Overall, an increase by as much as 20% was noted for the tested configuration. For trajectory, we've confirmed that the deformation of droplets and the aerodynamic shear-induced flow within droplets have strong affects the droplet drag. And we suggest corrections to standard models to account for this affect. Finally, we apply our results to make improved LPT models of droplet in turbulent flows. Our initial investigation suggests that traditional models underpredict the amount of droplet dispersion in turbulent flows, and therefore do not correctly predict the dynamics of droplet and spray combustion in aviation engines.

Bio:

John Palmore Jr is an Assistant Professor of Mechanical Engineering at the University of Washington where he leads the Combustion, Atomization, Multiphase & Particulate Physics Research & Education (CAMP-PhyRE) group. CAMP-PhyRE develops analytical and computational strategies to investigate multiphase fluid flows in areas such as aviation, biomedicine, energy, and the environment. CAMP-PhyRE has with worked numerous entities on multiphase flow research including NASA, the National Science Foundation, the US Army Corps of Engineers, and private industry.

Before joining the faculty of the University of Washington, Dr. Palmore was an Assistant Professor of Mechanical Engineering at Virginia Tech. He currently serves as the Chair-Elect of the American Physical Society (APS) Forum for Early Career Scientists.