Liquid Spray Fuel Injection Studies using Planar Imaging Velocimetry (PIV)

Advisor: John Daily
Co-advisor: Olivier Desjardins

Liquid fuels are vaporized by atomizing the liquid into small droplets that more rapidly evaporate. Spray fuel injectors are found in internal combustion engines, aircraft and power generation gas turbines, rocket engines and liquid fuel stationary power plants. Understanding and controlling atomization is critical to making improvements in system performance, efficiency and pollutant control. In this project a diagnostic technique call Planar Imaging Velocimetry or PIV will be used to carry out experimental studies on several atomizers for varying flow conditions and fuel types. The results will be used for validation of Direct Numerical Simulations (DNS) of the sprays. The student will gain experience in laser diagnostics, experimental design and advanced image data reduction and analysis.

Expected accomplishments:

1. Extensive review of literature on multiphase flow experimental techniques.
2. Familiarization with PIV system and software.
3. Investigation of several fuel injectors under varying flow conditions.
4. Close collaboration with second project aiming at simulating these flows.
5. Develop strategies for comparing experimental measurements and simulations.

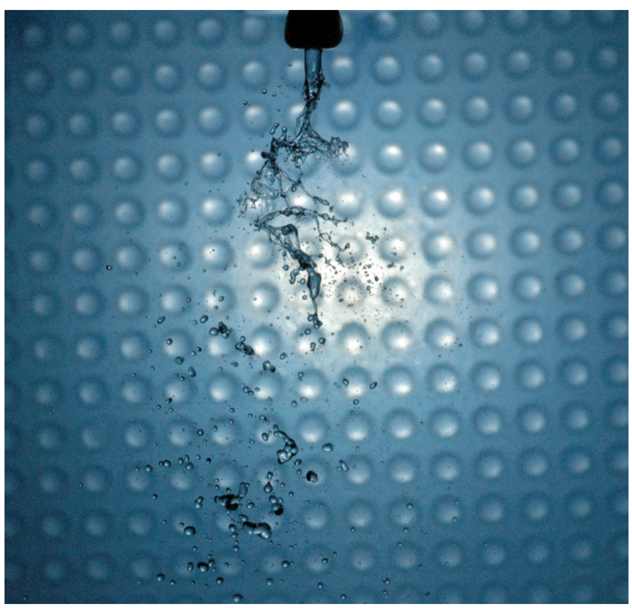

Figure 1: Experimental visualization of a dodecane co-annular injector.

Liquid Spray Fuel Injection Studies using Direct Numerical Simulation (DNS)

Advisor: Olivier Desjardins
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Most energy conversion devices today burn fuel that is stored in liquid form. However, combustion takes place in the gas phase, meaning that the liquid has to be evaporated before it can burn. Therefore, to maximize efficiency, the fuel is first atomized into a fine spray.

Because of the complexity of the physics behind liquid atomization, the current modeling paradigm is to rely on phenomenological models that require fine-tuning with the aid of experimental data. As a consequence, these over-simplified models are not predictive, and this limitation currently represents one of the main hurdles in advanced computational modeling of combustion engines. Therefore, there is a need for new atomization models based on first principles that capture the complex physical processes associated with turbulent liquid break-up and accurately predict spray droplet size and velocity distributions.

Toward this goal, this project aims at conducting Direct Numerical Simulation (DNS) of turbulent atomization in order to understand in more details the physics of atomization. This DNS study will be complemented by the experimental work described in the previous project.

Expected accomplishments:

1. Extensive review of literature on multiphase flow modeling.
2. Familiarization with an advanced research code and high performance computing environment.
3. Simulation of several injectors under various flow conditions.
4. Close collaboration with first project aiming at experimentally investigating these flows.
5. Develop strategies for comparing experimental measurements and simulations.

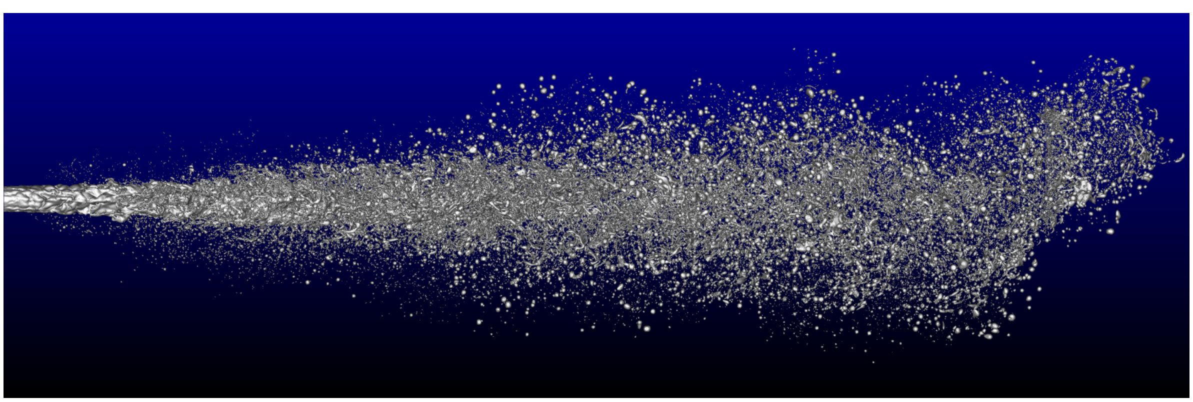

Figure 2: DNS of Diesel fuel injection on 1.2 billion grid points.