Bi-Component Droplet Combustion Experiment Designed

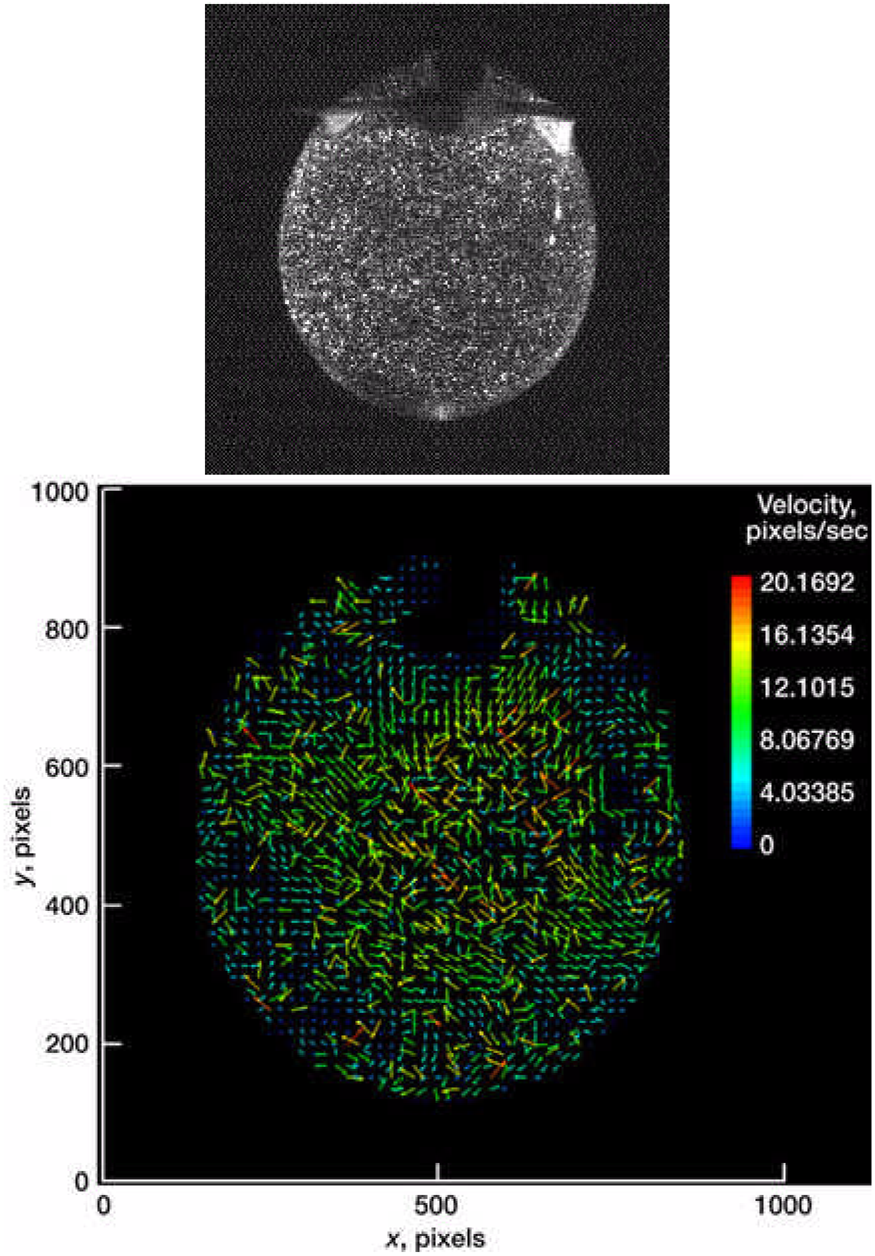
The combustion of liquid fuels is a major source of energy in the world today, and the majority of these fuels are burned in the form of a spray. The research at the NASA Glenn Research Center in droplet combustion has the overall goal of providing a better understanding of spray combustion by studying the smallest element in a spray, the single droplet. Practical fuels are multicomponent in nature; that is, they are composed of a large number of constituents. The Bi-Component Droplet Combustion Experiment (BCDCE) extends the work at Glenn from pure, or single-component, fuels to an idealized liquid fuel composed of two completely miscible components. The project is a collaborative effort between Glenn and Prof. B.D. Shaw of the University of California, Davis.

When a liquid droplet burns, fuel vaporizes from the droplet surface where it convects and diffuses to the flame front. A fuel component can only vaporize if it is present at the droplet surface. As a result, the combustion behavior of a multicomponent liquid fuel droplet is a strong function of the flow inside the droplet. These liquid flows can be caused by a number of factors, but the predominant force is a surface tension gradient along the surface of the droplet. These gradients can be relatively large and can cause significant motion throughout the droplet.

The BCDCE project is planned to fly onboard the International Space Station in the Multi-User Droplet Combustion Apparatus. The unique feature of this experiment is that it will be the first droplet combustion experiment to perform a detailed characterization of the flow inside a liquid fuel droplet.

The experiment will use a relatively new technique called Digital Particle Imaging Velocimetry (DPIV) to characterize the liquid flow. In this technique, very small (~5-μm-diameter) particles are dispersed throughout a liquid droplet. These particles are illuminated by a thin laser sheet. Images of the particle motion are recorded on a computer, which then tracks the motion of the particles to determine the flow characteristics.

These two images show some sample results from the DPIV apparatus. On the left is an image of the particles inside the droplet. On the right is a vector plot of the particles that results from the analysis of two consecutive images (i.e., the velocity of the particle is the distance traversed between consecutive frames divided by the time between frames).



Left: Particle image. Right: Vector plot.

These data, combined with images of the flame and droplet (and other diagnostics) obtained in the Multi-User Droplet Combustion Apparatus, will be analyzed to determine the combustion characteristics of the droplet. These results will then be compared with detailed numerical predictions performed by Prof. Shaw to yield a more complete fundamental understanding of the mechanisms governing the combustion of practical fuels. This improved understanding will lead to improved efficiency for future combustors.

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