Combustion Module-2 Achieved Scientific Success on Shuttle Mission STS-107

The familiar teardrop shape of a candle is caused by hot, spent air rising and cool fresh air flowing behind it. This type of airflow obscures many of the fundamental processes of combustion and is an impediment to our understanding and modeling of key combustion controls used for manufacturing, transportation, fire safety, and pollution. Conducting experiments in the microgravity environment onboard the space shuttles eliminates these impediments. NASA Glenn Research Center's Combustion Module-2 (CM-2) and its three experiments successfully flew on STS-107/*Columbia* in the SPACEHAB module and provided the answers for many research questions. However, this research also opened up new questions.

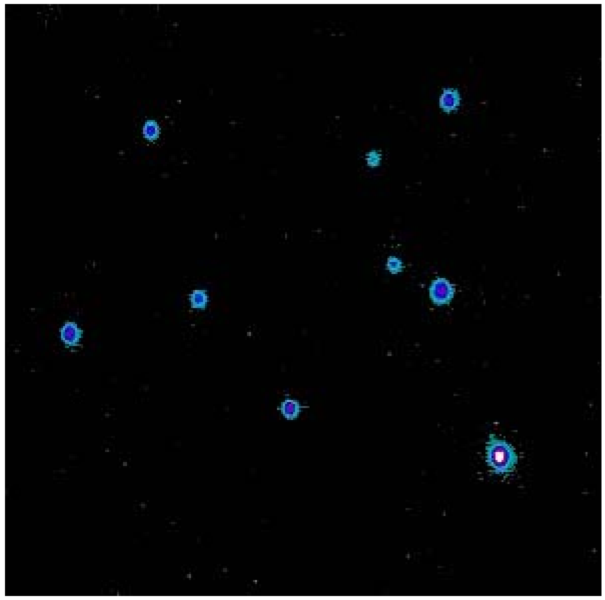
The CM-2 facility was the largest and most complex pressurized system ever flown by NASA and was a precursor to the Glenn Fluids and Combustion Facility planned to fly on the International Space Station. CM-2 operated three combustion experiments: Laminar Soot Processes (LSP), Structure of Flame Balls at Low Lewis-Number (SOFBALL), and Water Mist Fire Suppression Experiment (Mist). Although *Columbia's* mission ended in tragedy with the loss of her crew and much data, most of the CM-2 results were sent to the ground team during the mission.

CM-2 systems and software engineers conduct final inspections of the CM-2 flight hardware at Glenn before it is shipped to the launch site.

The LSP experiment studied the formation of soot in flames so that methods for controlling soot can be devised to eliminate or mitigate significant public health problems caused by emissions of pollutant soot (e.g., soot causes 60,000 premature deaths per year). Observations of the LSP flames made during the *Columbia* flight were very successful, and the LSP results have already suggested new ways to reduce, and possibly even eliminate, emissions of pollutant soot from flames.

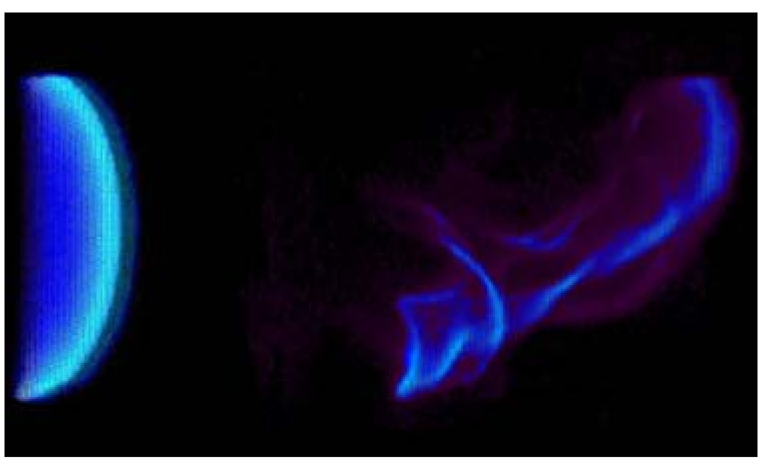
This LSP flame, which is an ethylene fuel burning in air at atmospheric pressure, is the longest laminar flame ever burned in microgravity.

The objective of the SOFBALL experiment was to study weakly burning hydrogen and methane flames in oxygen-inert mixtures, resulting in "flame balls." Because flame balls are steady, symmetric, and occur in fuels with simple chemistry, they represent the simplest possible interaction of chemistry and transport in flames. The accomplishments of the experiment included (1) the weakest and leanest flames ever burned (0.5 W of thermal power and only 8 percent of the fuel usually needed for chemical balance) and (2) the longest-lived flame ever burned in space (81 min). Several totally new and unexpected results were found, including oscillating flame balls and flame balls drifting in a spiral or corkscrew pattern. The data obtained during the mission will help lead to the development of cleaner, more fuel-efficient engines as well as improved methods for assuring spacecraft fire safety.



One of these nine color-enhanced SOFBALL flame balls burned for 81 min and set a new record for combustion in space.

The Mist experiment was motivated by the need to find a fire-extinguishing agent that would replace traditional chemical fire suppressants (halons), which have been banned because of their harmful effects to the ozone layer. Water mist, very small droplets like a fine fog, is a nontoxic, inexpensive, and efficient technology to replace halons while minimizing property damage. The results from the Mist experiment have provided crucial understanding of the physical and chemical mechanisms of how fine water droplets interact with and suppress flames. For example, small droplet sizes are consistently more effective for lean flame suppression than larger droplets. The results will be provided to manufacturers of fire suppression equipment to design the next generation of fire extinguishers that will be used in enclosed spaces such as airplanes, ships, libraries, museums, and residential homes. Water mist may also become a viable fire suppression system onboard orbiting spacecraft, such as the International Space Station.



The sequence of two color-enhanced Mist propane flames shows a smooth, hemispherical *flame in dry air, followed by a multilobed broken flame resulting from the interaction with the fine water mist.*

Find out more about this research at http://microgravity.grc.nasa.gov/combustion/

Glenn contacts: Ann P. Over, 216-433-6535, Ann.P.Over@nasa.gov; David T. Frate, 216-433-8329, David.T.Frate@nasa.gov; and Dr. David L. Urban, 216-433-2835, David.L.Urban@nasa.gov
Author: Ann P. Over
Headquarters program office: OBPR
Programs/Projects: Microgravity Combustion Science, Chemically Reacting Systems, Combustion Module-2