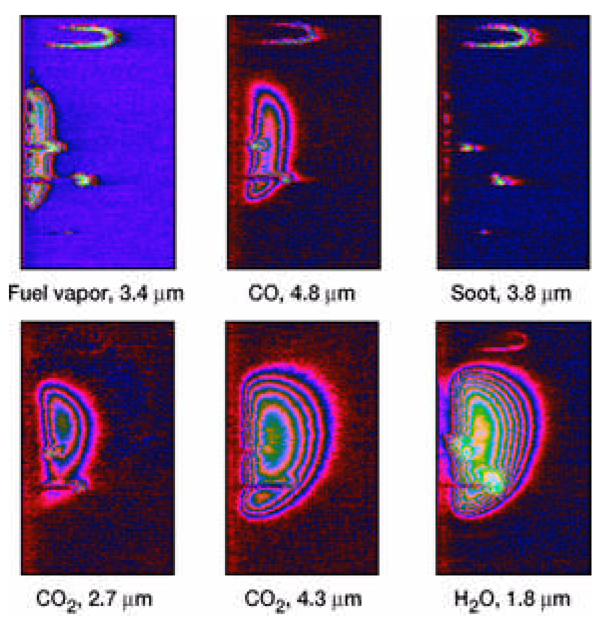
DARTFire Sees Microgravity Fires in a New Light--Large Data Base of Images Obtained

The recently completed DARTFire sounding rocket microgravity combustion experiment launched a new era in the imaging of flames in microgravity. DARTFire stands for "Diffusive and Radiative Transport in Fires," which perfectly describes the two primary variables--diffusive flow and radiation effects--that were studied in the four launches of this program (June 1996 to September 1997). During each launch, two experiments, which were conducted simultaneously during the 6 min of microgravity, obtained results as the rocket briefly exited the Earth’s atmosphere.

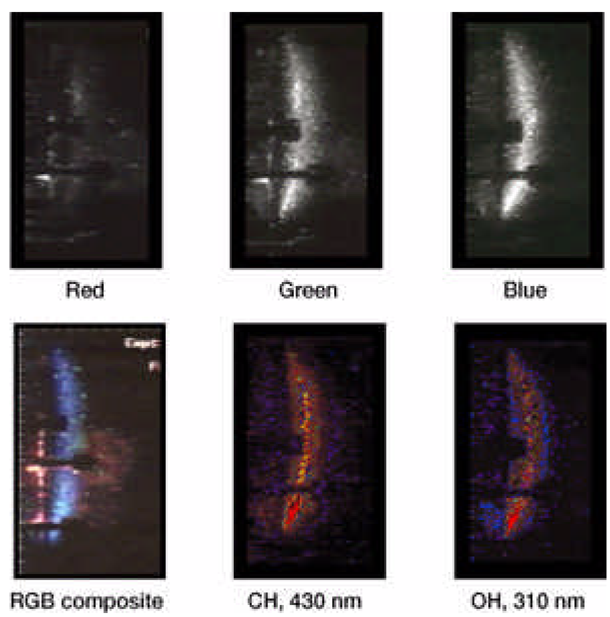
Within the rocket, mirror-image flow tunnels supported low-speed oxidizer flow through each tunnel. An infrared laser diode was mounted in the ceiling of one of the two tunnels to provide external radiant heating onto the black polymethylmethacrylate (PMMA, an acrylic plastic) fuel surface. Controlled external radiant heating compensated for inherent heat losses such as those from surface radiation. The walls of the tunnels had windows for ultraviolet-visible and infrared imaging of the flame. DARTFire was the first combustion experiment to image flames in these wavelengths, producing unique images of microgravity flames as they have never been seen before.



Filtered infrared multispectral images of a microgravity flame were obtained during a DARTFire sounding rocket experiment.

Infrared emissions from the gaseous combustion products were monitored in real time during the DARTFire experiment. An infrared camera was modified to include an internal rotating filter wheel that holds six different filters so that it can look at radiant emissions from six different infrared bands as the filter wheel rotates in front of the camera. The images in the preceding figure were obtained simultaneously with six different infrared filters, including a fuel vapor image, a carbon monoxide (CO) image, a soot image, two different wavelengths of carbon dioxide (CO_2), and a water vapor (H_2O) image. This infrared imaging provided immense quantities of data regarding the species fields in the experiment. A blackbody calibration of each filter provided effective blackbody temperature distributions for each image, and numerical predictions of the temperature and species fields were used to calculate the radiation distribution. The radiation distribution could then be compared directly with these calibrated images to test our understanding of the experiment.

A multispectral intensified array video camera was also used to image the flame in the ultraviolet and visible wavelength ranges. As with the infrared camera, six filters were used to obtain intensified images of the dim flames in different wavelengths, as shown in the following figure. Color images were obtained by combining red, green, and blue filtered images to obtain a 24-bit RGB color composite image of the flame. So that the combustion intermediate (free radical) species could be imaged directly, filters were used to capture the ultraviolet chemiluminescence of the methyl (CH*) and hydroxyl (OH*) excited-state free radicals in the reaction zone of the flames. The color images are what astronauts would see with their eyes. The size, shape, and color of the visible flame can be compared with the large normal-gravity flame data base. The chemilumiscent images allow an extended view into the heart of the reaction zone, where detailed chemistry models of the combustion process are sorely lacking experimental data.



Ultraviolet and visible light (intensified) multispectral images of a microgravity flame obtained during a DARTFire sounding rocket experiment.

The DARTFire experiment provided the first comprehensive spectral imaging of microgravity combustion flames. The effects of the flow and external radiant heating on the flame are well captured by this nonintrusive imaging. This large database of information is a wealth of information for researchers interested in the spectral emissions of microgravity flames. The DARTFire hardware was built by the NASA Lewis Research Center, and the image analysis was supported by Lewis' Graphics Visualization Laboratory.

Find out more about this research:
Glenn's Microgravity Division--http://exploration.grc.nasa.gov/
University site about DARTFire--
http://thermal.sdsu.edu/combustion/OFFS/pmma/flat/microgravity/devchannel/dartfire/dartfire.html

Bibliography

Olson, S.L., et al.: Diffusive and Radiative Transport in Fires Experiment: DARTFire. Proceedings of the Fourth International Microgravity Combustion Workshop. NASA CP-10194, 1997.

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