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Large- and small-scale developments in thermophysics

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*The **Thermophysics Technical Committee** promotes the study and application of mechanisms involved in thermal energy transfer and storage in gases, liquids and solids, or combinations.*

This year brought both large- and small-scale developments in the field of thermophysics. In July, the **sunshield** for NASA's **James Webb Space Telescope** completed its first deployment test at a Northrop Grumman facility in Redondo Beach, California. The five-layer sunshield, unfolded to a final size of 12-by-18 meters, protects the telescope from solar heating and passively cools infrared science instruments to 45 kelvins. It also separates the warm and cold sides of the telescope to provide a thermally stable environment for precise alignment of the telescope's 18 primary mirrors.

To support development of the Webb telescope, NASA Goddard Space Flight Center's Cryogenics and Fluids Branch implemented a new approach for measuring total hemispheric emissivity of **thermal coatings** at cryogenic temperatures. The technique, carried out in a 10-kelvin cryostat, simulates radiative heat exchange between parallel plates and provides an emissivity measurement with better than 1 percent precision for temperatures between 300 and 20 kelvins. Using this approach, engineers characterized several candidate surface treatments for radiator surfaces and for absorbers to reduce stray thermal radiation in the region of the telescope's detectors. Once launched, the Webb telescope will be the most powerful sent to space and will provide scientists an unprecedented ability to detect distant objects and to look back in time at the origins of the universe.

On a much smaller scale, **oscillating heat pipes**, or OHPs, an emerging passive thermal control technology, took a major step forward to commercialization. ThermAvant Technologies, in collaboration with the Air Force Research Laboratory Space Vehicles Directorate, developed and tested a rapid, lower-cost manufacturing method for a high thermal conductivity OHP heat spreader. Costing a fraction to produce compared with traditional technologies, the measured thermal conductivity for the 0.08-inch-thick heat spreader was greater than 1,500 watts per meter kelvin, which is nine times greater than aluminum.

An OHP consists of a capillary-sized serpentine channel partially filled with a working fluid, such as the refrigerant R-134a. Evaporation and condensation of the fluid between hot and cold sections of the device create a pressure imbalance that causes fluid oscillations through the length of the channels. Rapid oscillation quickly and efficiently transports heat away from hot components, such as high power processors and power amplifiers. Because OHPs consist of millimeter-size channels, they are easily scaled to a wide range of patterns and device sizes.

Also in the area of two-phase thermal transport, researchers at UCLA recently developed and tested an inorganic aqueous solution that is compatible with aluminum and steel phase change heat-transfer devices. Bench-top lifetime testing showed minimal gas generation after 10 weeks for devices filled with the solution. Conversely, similar devices filled with water failed within minutes of start-up.

Water is one of the best heat-transfer fluids for phase change devices, but it has limited use in aerospace systems because it reacts with some metals to create non-condensable gases, which cause performance degradation and eventual device failure in phase change heat transfer devices. UCLA's novel solution simultaneously inhibited the creation of NCGs and significantly increased heat-transfer performance by creating a hydrophilic microstructure on the metallic surface.

Finally, this year AFRL's **Active Thermal Tile** experiment completed operation aboard the International Space Station. ATTs are variable conductance thermal interface gaskets that use thermoelectric devices to modulate heat transfer between a component and a spacecraft structure. Developed by AFRL/RV in conjunction with the Department of Defense Space Test Program and Infoscitex Corp., the devices control component temperatures within 0.1 kelvin despite spacecraft temperature fluctuations. This is especially useful for components with tight temperature requirements such as batteries, sensors and clocks.

Northrop Grumman engineers stack and unfurl a full-sized test unit of the sunshield for NASA's James Webb Space Telescope.

NASA