turns on a circular form, are mounted orthogonally inside the non-metallic housing. The fiber-optic conversion module comprises three interferometers, one for each search coil. Each interferometer has a high bandwidth optical phase modulator that impresses the signal received from its search coil onto its output. The output of each interferometer travels by fiber optic cable to the avionics unit, and the search coil signal is recovered by an optical phase demodulator. The output of each demodulator is fed to an analog-to-digital converter, whose sampling rate is determined by the maximum expected rate of rise and peak signal magnitude. The output of the digital processor is a faithful reproduction of the coil response to the incident magnetic field. This information is provided in a standard output format on a 50-ohm port that can be connected to any number of data collection and processing instruments and/or systems.

The measurement of magnetic fields using fiber-optic signal processing is novel because it eliminates limitations of a traditional B-dot system. These limitations include the distance from the sensor to the measurement device, the potential for the signal to degrade or be corrupted by EMI from lightning, and the size and weight of the sensor and associated plate.

*This work was done by Jay Gurecki of Kennedy Space Center; Bob Scully of Johnson Space Center; and Allen Davis, Clay Kirkendall, and Frank Bucholtz of the Naval Research Laboratory. Further information is contained in a TSP (see page 1). KSC-13221*

# Photocatalytic Active Radiation Measurements and Use

## This technology can be used to improve the ability to predict the performance of photocatalytic materials under different illumination conditions.

*Stennis Space Center, Mississippi*

Photocatalytic materials are being used to purify air, to kill microbes, and to keep surfaces clean. A wide variety of materials are being developed, many of which have different abilities to absorb various wavelengths of light. Material variability, combined with both spectral illumination intensity and spectral distribution variability, will produce a wide range of performance results. The proposed technology estimates photocatalytic active radiation (PcAR), a unit of radiation that normalizes the amount of light based on its spectral distribution and on the ability of the material to absorb that radiation.

Photocatalytic reactions depend upon the number of electron-hole pairs generated at the photocatalytic surface. The number of electron-hole pairs produced depends on the number of photons per unit area per second striking the surface that can be absorbed and whose energy exceeds the bandgap of the photocatalytic material. A convenient parameter to describe the number of useful photons is the number of moles of photons striking the surface per unit area per second. The unit of micro-einsteins (or micromoles) of photons per $m^2$ per sec is commonly used for photochemical and photoelectric-like phenomena. This type of parameter is used in photochemistry, such as in the conversion of light energy for photosynthesis.

Photosynthetic response correlates with the number of photons rather than by energy because, in this photochemical process, each molecule is activated by the absorption of one photon. In photosynthesis, the number of photons absorbed in the 400–700 nm spectral range is estimated and is referred to as photosynthetic active radiation (PAR). PAR is defined in terms of the photosynthetic photon flux density measured in micro-einsteins of photons per $m^2$ per sec. PcAR is an equivalent, similarly modeled parameter that has been defined for the photocatalytic processes.

Two methods to measure the PcAR level are being proposed. In the first method, a calibrated spectrometer with a cosine receptor is used to measure the spectral irradiance. This measurement, in conjunction with the photocatalytic response as a function of wavelength, is used to estimate the PcAR. The photocatalytic response function is determined by measuring photocatalytic reactivity as a function of wavelength. In the second method, simple shaped photocatalytic response functions can be simulated with a broad-band detector with a cosine receptor appropriately filtered to represent the spectral response of the photocatalytic material. This second method can be less expensive than using a calibrated spectrometer.

*This work was done by Bruce A. Davis of Stennis Space Center and Robert E. Ryan and Lauren W. Underwood of Science Systems and Applications, Inc. Inquiries concerning the technology should be addressed to the Intellectual Property Manager, Stennis Space Center, (228) 688-1929. Refer to SSC-00328.*

# Computer Generated Hologram System for Wavefront Measurement System Calibration

*NASA's Goddard Space Flight Center, Greenbelt, Maryland*

Computer Generated Holograms (CGHs) have been used for some time to calibrate interferometers that require nulling optics. A typical scenario is the testing of aspheric surfaces with an interferometer placed near the paraxial center of curvature. Existing CGH technology suffers from a reduced capacity to calibrate middle and high spatial frequencies. The root cause of this shortcoming is as follows: the CGH is not placed at an image conjugate of the asphere due to limitations imposed by the geometry of the test and the allowable size of the CGH.

This innovation provides a calibration system where the imaging properties in calibration can be made comparable to the test configuration. Thus, if the test is designed to have good imaging properties, then middle and high spatial frequency errors in the test system can be well calibrated. The improved imaging properties are provided by a rudimentary auxiliary optic as part of the calibration system. The auxiliary optic is simple to characterize and align to the CGH. Use of the auxiliary optic also reduces the size of the CGH required for calibration and the density of the lines required for the CGH. The resulting CGH is less expensive than the existing technology and has reduced write error and alignment error sensitivities.

This CGH system is suitable for any kind of calibration using an interferometer when high spatial resolution is required. It is especially well suited for tests that include segmented optical components or large apertures.

*This work was done by Gene Olczak of ITT Geospatial Systems for Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15676-1*

# Non-Contact Thermal Properties Measurement With Low-Power Laser and IR Camera System

**Photons both excite and are used to measure the thermal response of any surface material.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

As shown by the Phoenix Mars Lander's Thermal and Electrical Conductivity Probe (TECP), contact measurements of thermal conductivity and diffusivity (using a modified flux-plate or line-source heat-pulse method) are constrained by a number of factors. Robotic resources must be used to place the probe, making them unavailable for other operations for the duration of the measurement. The range of placement is also limited by mobility, particularly in the case of a lander. Placement is also subject to irregularities in contact quality, resulting in non-repeatable heat transfer to the material under test. Most important from a scientific perspective, the varieties of materials which can be measured are limited to unconsolidated or weakly-cohesive regolith materials, rocks, and ices being too hard for nominal insertion strengths.

Accurately measuring thermal properties in the laboratory requires significant experimental finesse, involving sample preparation, controlled and repeatable procedures, and, practically, instrumentation much more voluminous than the sample being tested (heater plates, insulation, temperature sensors). Remote measurements (infrared images from orbiting spacecraft) can reveal composite properties like thermal inertia, but suffer both from a large footprint (low spatial resolution) and convolution of the thermal properties of a potentially layered medium. *In situ* measurement techniques (the Phoenix TECP is the only robotic measurement of thermal properties to date) suffer from problems of placement range, placement quality, occupation of robotic resources, and the ability to only measure materials of low mechanical strength.

A spacecraft needs the ability to perform a non-contact thermal properties measurement *in situ*. Essential components include low power consumption, leveraging of existing or highly-developed flight technologies, and mechanical simplicity.

This new *in situ* method, by virtue of its being non-contact, bypasses all of these problems. The use of photons to both excite and measure the thermal response of any surface material to a high resolution (estimated footprint ≈ 10 $cm^2$) is a generational leap in physical properties measurements.

The proposed method consists of spot-heating the surface of a material with a low (<1 W) power laser. This produces a moderate (5-10 K) temperature increase in the material. As the heat propagates in a hemisphere from the point of heating, it raises the temperature of the surrounding surface. The temperature of the heating spot itself, and that of the surrounding material, is monitored remotely with an infrared camera system. Monitoring is done during both the heating and cooling (after the laser is turned off) phases. Temperature evolution as a function of distance from the heating point contains information about the material's thermal properties, and can be extracted through curve-fitting to analytical models of heat transport.

*In situ* measurement of thermal properties of planetary surface materials provides ground-truth for remote sensing observations and high-resolution, site-specific data for any landed spacecraft environment. Thermal properties are necessary parameters for modeling and understanding thermal evolution of the surface and subsurface, climate state and history, and predicting the presence of subsurface water/ice. The applications extend to all solid bodies in the solar system, but with greatest applicability to bodies with thin or tenuous atmospheres where conduction and radiation are the dominant heat-transport properties.

*This work was done by Troy L. Hudson and Michael H. Hecht of Caltech for NASA's Jet Propulsion Laboratory. FFurther information is contained in a TSP (see page 1). NPO-47390*