Multi-Segment Radius Measurement Using an Absolute Distance Meter Through a Null Assembly

This system can be used by fabricators or optics integrators for telescopes or other imaging systems.

NASA's Goddard Space Flight Center, Greenbelt, MD

This system was one of the test methods considered for measuring the radius of curvature of one or more of the 18 segmented mirrors that form the 6.5 m diameter primary mirror (PM) of the James Webb Space Telescope (JWST). The assembled telescope will be tested at cryogenic temperatures in a 17-m diameter by 27-m high vacuum chamber at the Johnson Space Center. This system uses a Leica Absolute Distance Meter (ADM), at a wavelength of 780 nm, combined with beam-steering and beam-shaping optics to make a differential distance measurement between a ring mirror on the reflective null assembly and individual PM segments. The ADM is located inside the same Pressure-Tight Enclosure (PTE) that houses the test interferometer. The PTE maintains the ADM and interferometer at ambient temperature and pressure so that they are not directly exposed to the telescope's harsh cryogenic and vacuum environment.

This system takes advantage of the existing achromatic objective and reflective null assembly used by the test interferometer to direct four ADM beamlets to four PM segments through an optical path that is coincident with the interferometer beam. A mask, positioned on a linear slide, contains an array of 1.25 mm diameter circular subapertures that map to each of the 18 PM segments as well as six positions around the ring mirror. A down-collimated 4 mm ADM beam simultaneously covers 4 adjacent PM segment beamlets and one ring mirror beamlet. The radius, or spacing, of all 18 segments can be measured with the addition of two orthogonally-oriented scanning pentaprisms used to steer the ADM beam to any one of six different sub-aperture configurations at the plane of the ring mirror.

The interferometer beam, at a wavelength of 687 nm, and the ADM beamlets, at a wavelength of 780 nm, pass through the objective and null so that the rays are normally incident on the parabolic PM surface. After reflecting off the PM, both the ADM and interferometer beams return to their respective instruments on nearly the same path. A fifth beamlet, acting as a differential reference, reflects off a ring mirror attached to the objective and null and returns to the ADM. The spacings between the ring mirror, objective, and null are known through manufacturing tolerances as well as through an *in situ* null wavefront alignment of the interferometer test beam with a reflective hologram located near the caustic of the null. Since total path length between the ring mirror and PM segments is highly deterministic, any ADM-measured departures from the predicted path length can be attributed to either spacing error or radius error in the PM. It is estimated that the path length measurement between the ring mirror and a PM segment is accurate to better than 100 µm.

The unique features of this invention include the differential distance measuring capability and its integration into an existing cryogenic and vacuum compatible interferometric optical test.

This work was done by Cormic Merle, Eric Wick, and Joseph Hayden of ITT Corp. for Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15674-1

Fiber-Optic Magnetic-Field-Strength Measurement System for Lightning Detection

Fiber optics used for signal paths provide enhanced immunity from electromagnetic radiation incident in the vicinity of the measurements.

John F. Kennedy Space Center, Florida

A fiber-optic sensor system is designed to measure magnetic fields associated with a lightning stroke. Field vector magnitudes are detected and processed for multiple locations. Since physical limitations prevent the sensor elements from being located in close proximity to highly conductive materials such as aluminum, the copper wire sensor elements (3) are located inside a 4-cubic-in. (≈66-cubic-cm) plastic housing sensor head and connected to a fiber-optic conversion module by shielded cabling, which is limited to the shortest length feasible. The signal path between the conversion module and the avionics unit which processes the signals are fiber optic, providing enhanced immunity from electromagnetic radiation incident in the vicinity of the measurements. The sensors are passive, lightweight, and much smaller than commercial B-dot sensors in the configuration which measures a three-dimensional magnetic field. The system is expandable, and provides a standard-format output signal for downstream processing.

Inside of the sensor head, three small search coils, each having a few 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.