180-GHz Interferometric Imager

NASA's Jet Propulsion Laboratory, Pasadena, California

A 180-GHz interferometric imager uses compact receiver modules, combined high- and low-gain antennas, and ASIC (application specific integrated circuit) correlator technology, enabling continuous, all-weather observations of water vapor with 25-km resolution and 0.3-K noise in 15 minutes of observation for numerical weather forecasting and tropical storm prediction.

The GeoSTAR-II prototype instrument is broken down into four major subsystems: the compact, low-noise receivers; sub-array modules; IF signal distribution; and the digitizer/correlator. Instead of the single row of antennas adopted in GeoSTAR, this version has four rows of antennas on a coarser grid. This dramatically improves the sensitivity in the desired field of view.

The GeoSTAR-II instrument is a 48-element, synthetic, thinned aperture radiometer operating at 165–183 GHz. The instrument has compact receivers integrated into "tiles" of 16 elements in a 4×4 arrangement. These tiles become the building block of larger arrays. The tiles contain signal distribution for bias controls, IF signal, and local oscillator signals. The IF signals are digitized and correlated using an ASIC correlator to minimize power consumption.

Previous synthetic aperture imagers have used comparatively large multichip modules, whereas this approach uses chip-scale modules mounted on circuit boards, which are in turn mounted on the distribution manifolds. This minimizes the number of connectors and reduces system mass. The use of ASIC technology in the digitizers and correlators leads to a power reduction close to an order of magnitude.

This work was done by Pekka P. Kangaslahti, Boon H. Lim, Ian J. O'Dwyer, Mary M. Soria, Heather R. Owen, Todd C. Gaier, Bjorn H. Lambrigtsen, and Alan B. Tanner of Caltech, and Christopher Ruf of the University of Michigan for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47995

Maturation of Structural Health Management Systems for Solid Rocket Motors

Marshall Space Flight Center, Alabama

Concepts of an autonomous and automated space-compliant diagnostic system were developed for conditioned-based maintenance (CBM) of rocket motors for space exploration vehicles. The diagnostic system will provide real-time information on the integrity of critical structures on launch vehicles, improve their performance, and greatly increase crew safety while decreasing inspection costs. Using the SMART Layer technology as a basis, detailed procedures and calibration techniques for implementation of the diagnostic system were developed.

The diagnostic system is a distributed system, which consists of a sensor network, local data loggers, and a host central processor. The system detects external impact to the structure. The major functions of the system include an estimate of impact location, estimate of impact force at impacted location, and estimate of the structure damage at impacted location.

This system consists of a large-area sensor network, dedicated multiple local data loggers with signal processing and data analysis software to allow for real-time, *in situ* monitoring, and long-term tracking of structural integrity of solid rocket motors. Specifically, the system could provide easy installation of large sensor networks, onboard operation under harsh environments and loading, inspection of inaccessible areas without disassembly, detection of impact events and impact damage in real-time, and monitoring of a large area with local data processing to reduce wiring.

This work was done by Xinlin Qing, Shawn Beard, and Chang Zhang of Accellent Technologies, Inc for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32819-1.

Validating Phasing and Geometry of Large Focal Plane Arrays

CCD defects are used here to advantage.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Kepler Mission is designed to survey our region of the Milky Way galaxy to discover hundreds of Earth-sized and smaller planets in or near the habitable zone. The Kepler photometer is an array of 42 CCDs (charge-coupled devices) in the focal plane of a 95-cm Schmidt camera onboard the Kepler spacecraft. Each 50×25-mm CCD has 2,200×1,024 pixels. The CCDs accumulate photons and are read out every six seconds to prevent saturation. The data is integrated for 30 minutes, and then the pixel data is transferred to onboard storage. The data is subsequently encoded and transmitted to the ground.

During End-to-End Information System (EEIS) testing of the Kepler Mission System (KMS), there was a need to verify that the pixels requested by the science team operationally were correctly collected, encoded, compressed, stored, and transmitted by the FS, and subsequently received, decoded, uncompressed, and displayed by the Ground Segment (GS) without the outputs of any CCD modules being flipped, mirrored, or otherwise corrupted during the extensive FS and GS processing. This would normally be done by projecting an image on the focal plane array (FPA), collecting the data in a flight-like way, and making a comparison between the original data and the data reconstructed by the science data system.

Projecting a focused image onto the FPA through the telescope would normally involve using a collimator suspended over the telescope opening. There were several problems with this approach: the collimation equipment is elaborate and expensive; as conceived, it could only illuminate a limited section of the FPA (≈25 percent) during a given test; the telescope cover would have to be deployed during testing to allow the image to be projected into the telescope; the equipment was bulky and difficult to situate in temperature-controlled environments; and given all the above, test setup, execution, and repeatability were significant concerns. Instead of using this complicated approach of projecting an optical image on the FPA, the Kepler project developed a method using known defect features in the CCDs to verify proper collection and reassembly of the pixels, thereby avoiding the costs and risks of the optical projection approach.

The CCDs composing the Kepler FPA, as all CCDs, had minor defects. At ambient temperature, some pixels look far brighter than they should. These "hot" pixels have a higher rate of charge leakage than the others due to manufacturing variations. They are usually stable over time, and appear at temperatures above 5 °C. The hot pixels on the Kepler FPA were mapped before photometer assembly during module testing. Selected hot pixels were used as target "stars" for the purposes of EEIS testing. "Dead" pixels are permanently off, producing a permanently black pixel. These can also be used if there is some illumination of the FPA.

During EEIS testing, Dark Current Full Frame Images (FFIs) taken at room temperature were used to create the hot pixel maps for all 84 Kepler photometer CCD channels. Data from two separate nights were used to create two hot pixel maps per channel, which were cross-correlated to remove cosmic ray events which appear to be hot pixels. These hot pixel maps obtained during EEIS testing were compared to the maps made during module testing to verify that the end-to-end data flow was correct.

This work was done by Shaun P. Standley and Thomas N. Gautier of Caltech; Douglas A. Caldwell of SETI Institute; and Maura Rabbette of Ames Research Center for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46868

Transverse Pupil Shifts for Adaptive Optics Non-Common Path Calibration

NASA's Jet Propulsion Laboratory, Pasadena, California

A simple new way of obtaining absolute wavefront measurements with a laboratory Fizeau interferometer was recently devised. In that case, the observed wavefront map is the difference of two cavity surfaces, those of the mirror under test and of an unknown reference surface on the Fizeau's transmission flat. The absolute surface of each can be determined by applying standard wavefront reconstruction techniques to two grids of absolute surface height differences of the mirror under test, obtained from pairs of measurements made with slight transverse shifts in X and Y.

Adaptive optics systems typically provide an actuated periscope between wavefront sensor (WFS) and common-mode optics, used for lateral registration of deformable mirror (DM) to WFS. This periscope permits independent adjustment of either pupil or focal spot incident on the WFS. It would be used to give the required lateral pupil motion between common and non-common segments, analogous to the lateral shifts of the two phase contributions in the lab Fizeau.

The technique is based on a completely new approach to calibration of phase. It offers unusual flexibility with regard to the transverse spatial frequency scales probed, and will give results quite quickly, making use of no auxiliary equipment other than that built into the adaptive optics system. The new technique may be applied to provide novel calibration information about other optical systems in which the beam may be shifted transversely in a controlled way.

This work was done by Eric E. Bloemhof of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48060

Qualification of Fiber Optic Cables for Martian Extreme Temperature Environments

NASA's Jet Propulsion Laboratory, Pasadena, California

Means have been developed for enabling fiber optic cables of the Laser Induced Breakdown Spectrometer instrument to survive ground operations plus the nominal 670 Martian conditions that include Martian summer and winter seasons. The purpose of this development was to validate the use of the rover external fiber optic cabling of ChemCam for space applications under the extreme thermal environments to be encountered during the Mars Science Laboratory (MSL) mission.

Flight-representative fiber optic cables were subjected to extreme temperature thermal cycling of the same diurnal depth (or ΔT) as expected in flight, but for three times the expected number of in-flight thermal cycles. The survivability of fiber optic cables was tested for 600 cumulative thermal cycles from –130 to +15 °C to cover the winter season, and another 1,410 cumulative cycles from –105 to +40 °C to cover the