

in the dispersion plane. It is redirected in much the same way as with a flat mirror. However, in the sagittal plane light gets redirected in a manner similar to a cylindrical mirror. It exhibits focusing with the focal length only defined by the curvature of the grooves, the incident wavelength, and the grating period.

Because of this, one single diffraction grating can exhibit two dispersal patterns. It disperses light just like a regular flat diffraction grating, while at the same time focusing (or de-focusing) diffracted light onto a perpendicular plane. This focusing generates less aberrations than a mirror would. Non-trivial property of this device is

that its focal length for a fixed wavelength does not depend on the incident angle, even if the angle is extremely non-paraxial.

*This work was done by Dmitri Iazikov, Thomas W. Mossberg, and Christoph M. Greiner of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15680-1*

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## Universal Millimeter-Wave Radar Front End

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

A quasi-optical front end allows any arbitrary polarization to be transmitted by controlling the timing, amplitude, and phase of the two input ports. The front end consists of two independent channels — horizontal and vertical. Each channel has two ports — transmit and receive. The transmit signal is linearly polarized so as to pass through a periodic wire grid. It is then propagated through a ferrite Faraday rotator, which rotates the polarization state 45°. The received signal is propagated through the Faraday rotator in the opposite di-

rection, undergoing a further 45° of polarization rotation due to the non-reciprocal action of the ferrite under magnetic bias. The received signal is now polarized at 90° relative to the transmit signal. This signal is now reflected from the wire grid and propagated to the receive port.

The horizontal and vertical channels are propagated through, or reflected from, another wire grid. This design is an improvement on the state of the art in that any transmit signal polarization can be chosen in whatever sequence de-

sired. Prior systems require switching of the transmit signal from the amplifier, either mechanically or by using high-power millimeter-wave switches. This design can have higher reliability, lower mass, and more flexibility than mechanical switching systems, as well as higher reliability and lower losses than systems using high-power millimeter-wave switches.

*This work was done by Raul M. Perez of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov). NPO-46654*

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## Mode Selection for a Single-Frequency Fiber Laser

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

A superstructured fiber-grating-based mode selection filter for a single-frequency fiber laser eliminates all free-space components, and makes the laser truly all-fiber. A ring cavity provides for stable operations in both frequency and power. There is no alignment or realignment required. After the fibers and components are spliced together and packaged, there is no need for specially trained technicians for operation or maintenance. It can be integrated with

other modules, such as telescope systems, without extra optical alignment due to the flexibility of the optical fiber.

The filter features a narrow line width of 1 kHz and side mode suppression ratio of 65 dB. It provides a high-quality laser for lidar in terms of coherence length and signal-to-noise ratio, which is 20 dB higher than solid-state or microchip lasers.

This concept is useful in material processing, medical equipment, biomedical

instrumentation, and optical communications. The pulse-shaping fiber laser can be directly used in space, airborne, and satellite applications including lidar, remote sensing, illuminators, and phase-array antenna systems.

*This work was done by Jian Liu of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15600-1*

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## Qualification and Selection of Flight Diode Lasers for Space Applications

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

The reliability and lifetime of laser diodes is critical to space missions. The Nuclear Spectroscopic Telescope Array (NuSTAR) mission includes a metrology system that is based upon laser diodes. An operational test facility has

been developed to qualify and select, by mission standards, laser diodes that will survive the intended space environment and mission lifetime. The facility is situated in an electrostatic discharge (ESD) certified cleanroom and consist of an

enclosed temperature-controlled stage that can accommodate up to 20 laser diodes. The facility is designed to characterize a single laser diode, in addition to conducting laser lifetime testing on up to 20 laser diodes simultaneously.

A standard laser current driver is used to drive a single laser diode. Laser diode current, voltage, power, and wavelength are measured for each laser diode, and a method of selecting the most adequate laser diodes for space deployment is implemented. The method consists of creating histograms of laser threshold currents, powers at a designated current, and wavelengths at designated power. From these histograms, the laser diodes that illustrate a performance that is outside the normal are rejected and the re-

maining lasers are considered space-borne candidates.

To perform laser lifetime testing, the facility is equipped with 20 custom laser drivers that were designed and built by California Institute of Technology specifically to drive NuSTAR metrology lasers. The laser drivers can be operated in constant-current mode or alternating-current mode. Situated inside the enclosure, in front of the laser diodes, are 20 power-meter heads to record laser power throughout the duration of lifetime testing.

Prior to connecting a laser diode to the current source for characterization and lifetime testing, a background program is initiated to collect current, voltage, and resistance. This backstage data collection enables the operational test facility to have full laser diode traceability.

*This work was done by Carl C. Liebe, Robert P. Dillon, Ivair Gontijo, Siamak Forouhar, Andrew A. Shapiro, Mark S. Cooper, and Patrick L. Meras of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47164*

## Plenoptic Imager for Automated Surface Navigation

*John H. Glenn Research Center, Cleveland, Ohio*

An electro-optical imaging device is capable of autonomously determining the range to objects in a scene without the use of active emitters or multiple apertures. The novel, automated, low-power imaging system is based on a plenoptic camera design that was constructed as a breadboard system. Nanohmics proved feasibility of the concept by designing an optical system for a prototype plenoptic camera, developing simulated plenoptic images and range-calculation algorithms, constructing a breadboard proto-

type plenoptic camera, and processing images (including range calculations) from the prototype system.

The breadboard demonstration included an optical subsystem comprised of a main aperture lens, a mechanical structure that holds an array of micro lenses at the focal distance from the main lens, and a structure that mates a CMOS imaging sensor the correct distance from the micro lenses. The demonstrator also featured embedded electronics for camera readout, and a post-processor executing

image-processing algorithms to provide ranging information.

*This work was done by Byron Zollars, Andrew Milder, and Michael Mayo of Nanohmics, Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18525-1.*

## Maglev Facility for Simulating Variable Gravity

**Effects of gravity on thermal fluid systems and small living things can be tested.**

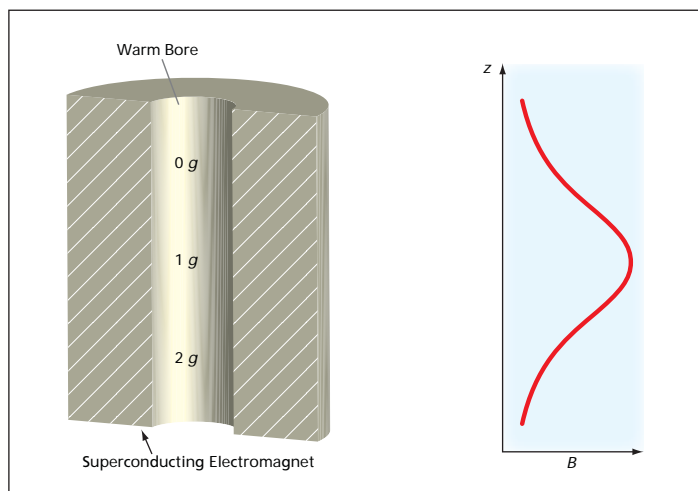
*NASA's Jet Propulsion Laboratory, Pasadena, California*

An improved magnetic levitation apparatus ("Maglev Facility") has been built for use in experiments in which there are requirements to impose variable gravity (including zero gravity) in order to assess the effects of gravity or the absence thereof on physical and physiological processes. The apparatus is expected to be especially useful for experiments on the effects of gravity on convection, boiling, and heat transfer in fluids and for experiments on mice to gain understanding of bone loss induced in human astronauts by prolonged exposure to reduced gravity in space flight.

The maglev principle employed by the apparatus is well established. The basic equation for equilibrium levitation of a diamagnetic object is

$$|\chi BV_z B / \mu_0| = \rho g,$$

where  $\chi$  is the magnetic susceptibility of the object,  $B$  is the magnitude of the magnetic-flux density,  $\mu_0$  is the magnetic permeability of the vacuum,  $\rho$  is the mass density of the object,  $g$  is the local gravitational acceleration, and  $\nabla_z B$  is the vertical gradient of the magnetic field. Diamagnetic cryogenic fluids such as liquid helium have been magnetically levitated for studying their phase transitions and critical



The Superconducting Electromagnet generates a static magnetic field with a vertical gradient. For water or other substances of diamagnetism, the gradient magnetic field opposes or aids the gravitational body force by an amount that varies with position along the bore.