would collect light into a multimode optical fiber, which would guide the light through a fiber-selection switch to a reflection/fluorescence spectrometer. The switch would have four positions, enabling selection of spectrometer input from the targeting lens, from either of one or two multimode optical fibers coming from a reflectance/fluorescence-microspectrometer optical head, or from a dark calibration position (no fiber). The switch would be the only moving part within the instrument.

For reflection spectroscopy, light from an incandescent lamp would be focused onto another multimode optical fiber, would pass through a mode scrambler, and would illuminate the specimen through a microscope head. Light reflected from the specimen would be collected through the same optical fiber and would be directed into the reflection/fluorescence spectrometer via beam splitter 1. To illuminate the specimen for fluorescence spectroscopy, light from an ultraviolet laser would be directed, via beam splitter 2, into the same optical fiber used to illuminate the specimen for reflectance spectroscopy. The fluorescent light from the specimen would be collected and sent to the reflection/fluorescence spectrometer in the same manner as that of the reflected light.

For Raman spectroscopy, light from a laser diode would be focused onto a single-mode optical fiber and would pass through fiber Bragg grating 1, which would lock the wavelength. This light would be guided through two directional couplers to the microscope head. Raman-shifted light captured by the lens would be collected through the same single-mode optical fiber, and would be guided to the Raman spectrometer through one of the directional couplers and fiber Bragg grating 2, which would reject the reflected (unshifted) light. The Raman spectrometer and its associated optical components were described in "Confocal Single-Mode-Fiber-Optic Raman Microspectrometer" (NPO-20932), *NASA Tech Briefs*, Vol. 25, No. 4 (April 2001), page 10a.

The imaging portion of the instrument would include a charge-coupled-device (CCD) color camera, which would be used to provide contextual information for the point-imaging (confocal) subsystems. The lens for this camera and the lens for confocal imaging would be different but integrated into a single unit in the microscope head, as depicted in the detail at the bottom of the figure. The aforementioned multimode optical fiber used for reflection and fluorescence spectroscopy and the aforementioned single-mode optical fiber used for Raman spectroscopy would also be used for confocal imaging at a lower and a higher resolution, respectively.

This work was done by Pantazis Mouroulis of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30650

Position-Finding Instrument Built Around a Magnetometer

A coarse indication of position is derived from a relatively inexpensive instrument.

Goddard Space Flight Center, Greenbelt, Maryland

A coarse-positioning instrument is built around a three-axis magnetometer. The magnetometer is of a type that is made of inexpensive hardware and is suitable for use aboard spacecraft orbiting no more than 1,000 km above the surface of the Earth. A data processor programmed with suitable software and equipped with a central processing unit, random-access memory, programmable read-only memory, and interface circuitry for communication with external equipment are added to the basic magnetometer to convert it into a coarse-positioning instrument. Although the instrument was conceived for use aboard spacecraft, it could be useful for navigation on Earth under some circumstances.

A major feature of the proposed instrument is an ability to generate a coarse estimate of its position in real time (that is, without start-up delay). Algorithms needed to solve the position equations have been developed. These include algorithms to work around gaps in measurement data that arise from a singularity near the minimum in the magnetic field of the Earth.

Some work has been done to develop a prototype of this instrument incorporating a standard three-axis flux-gate magnetometer and a Pentium P-5 (or equivalent) processor with a clock frequency of 120 MHz. Alternatively, the processor could be of the '486 class. A computer model of the instrument has been completed and tested.

This work was done by Eleanor Ketchum of **Goddard Space Flight Center**. *Further information is contained in a TSP (see page 1).*

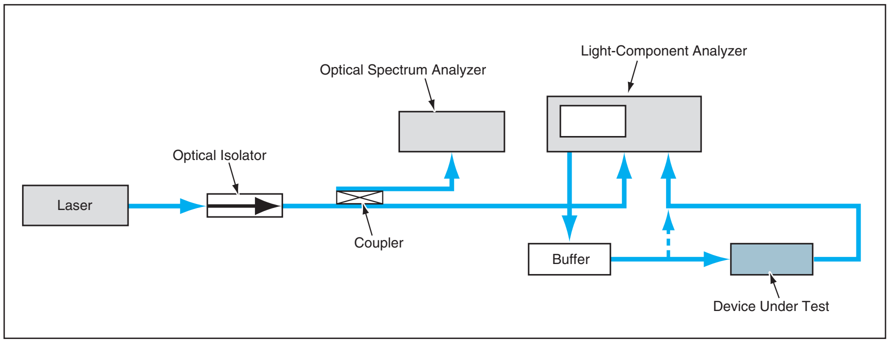
This invention has been patented by NASA (U.S. Patent No. 6,114,995). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13880.

Improved Measurement of Dispersion in an Optical Fiber

The lower limit of measurability is extended.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved method of measuring chromatic dispersion in an optical fiber or other device affords a lower (relative to prior such methods) limit of measurable dispersion. This method is a modified version of the amplitude-modulation (AM) method, which is one of the prior methods. In comparison with the other prior methods, the AM method is less complex. However, the AM method is limited to dispersion levels ≥ 160 ps/nm and cannot be used to measure the symbol of the dispersion. In contrast, the present modified version of the AM method can be used to measure the symbol of the symbol of the



This **Apparatus for Measuring Dispersion** in the device under test is the same as that used in the unmodified AM method, except for the inclusion of the buffer.

dispersion and affords a measurement range from about 2 ps/nm to several thousand ps/nm with a resolution of 0.27 ps/nm or finer.

The figure schematically depicts the measurement apparatus. The source of light for the measurement is a laser, the wavelength of which is monitored by an optical spectrum analyzer. A light-component analyzer amplitude-modulates the light with a scanning radio-frequency signal. The modulated light is passed through a buffer (described below) and through the device under test (e.g., an optical fiber, the dispersion of which one seeks to measure), then back to the light-component analyzer for spectrum analysis.

Dispersion in the device under test gives rise to phase shifts among the carrier and the upper and lower sideband components of the modulated signal. These phase shifts affect the modulation-frequency component of the output of a photodetector exposed to the signal that emerges from the device under test. One of the effects is that this component goes to zero periodically as the modulation frequency is varied. From the basic equations for dispersion of the modulated signal and the amplitude of the modulation-frequency output of the photodetector, the following equation has been derived:

$$D_T = \frac{(2n-1)c}{2\lambda^2 f_n^2},$$

where D_T is the total dispersion, n is an integer, c is the speed of light, λ is the laser wavelength, and f_n is the nth modulation frequency for which the photodetector output vanishes.

One of the conclusions that one can draw from the foregoing equation is that the lower limit of measurability in the AM method is set by the highest modulation frequency. For example, in the case of an apparatus that lacks a buffer but is otherwise identical to that shown in the figure and that has a maximum modulation frequency of 20 GHz and a laser wavelength of 1,550 nm, the minimum measurable dispersion is about 160 ps/nm.

What distinguishes the present method is the inclusion of the buffer, which can be an optical fiber, a fiber-optic grating or a combination of the two. The buffer must have a known dispersion, D_B, approximately equal to or larger than the minimum measurable dispersion. One can determine D_B from a measurement performed without the device under test (that is, the buffer only) in the optical train. When both the buffer and the device under test are present, the total dispersion is given by

$$D_T = D_B + D_{DUT} = \frac{(2n-1)c}{2\lambda^2 f_n^2},$$

where D_{DUT} is the dispersion of the device under test. Then

$$D_{DUT} = D_T - D_B = \frac{(2n-1)c}{2\lambda^2 f_n^2} - D_B.$$

By virtue of the subtraction of D_B, the lower limit of measurability of D_{DUT} is lower than that of D_T. If the symbol of the dispersion is small, one can obtain it by measuring the change in f_n (df_n) and then calculating it approximately as the differential of the immediately preceding equation:

$$dD_T = -2D_T\, df_n / f_n.$$

This work was done by Shouhua Huang, Thanh Le, and Lute Maleki of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-30406, volume and number of this NASA Tech Briefs *issue, and the page number.*

Probe for Sampling of Interstitial Fluid From Bone

Lyndon B. Johnson Space Center, Houston, Texas

An apparatus characterized as both a membrane probe and a bone ultrafiltration probe has been developed to enable *in vivo* sampling of interstitial fluid in bone. The probe makes it possible to measure the concentration of calcium and other constituents of the fluid that may be relevant to bone physiology. The probe could be especially helpful in experimental studies of microgravitational bone loss and of terrestrial bone-loss disease states, including osteoporosis.

The probe can be implanted in the bone tissue of a living animal and can be used to extract samples of the interstitial bone fluid from time to time during a long-term study. The probe includes three 12-cm-long polyacrylonitrile fibers configured in a loop form and attached to polyurethane tubing [inside diameter 0.025 in. (0.64 mm), outside diameter 0.040 in. (1 mm)]; the attachment is made by use of a 1-cm-long connecting piece of polyurethane tubing [inside diameter 0.035±0.003 in. (0.89±0.08 mm), outside diameter 0.060±0.003 in. (1.52±0.08 mm)]. At the distal end, a 2-cm-long piece of polyurethane tubing of the same inner and outer diameters serves as a connector to a hub. A 1-cm-long piece of expanded poly (tetrafluoroethylene) tubing over the joint between the fibers and the connecting tubing serves as a tissue-ingrowth site.

This work was done by Elsa M. Janle of Bioanalytical Systems, Inc., for **Johnson Space Center**. *For further information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-23044*