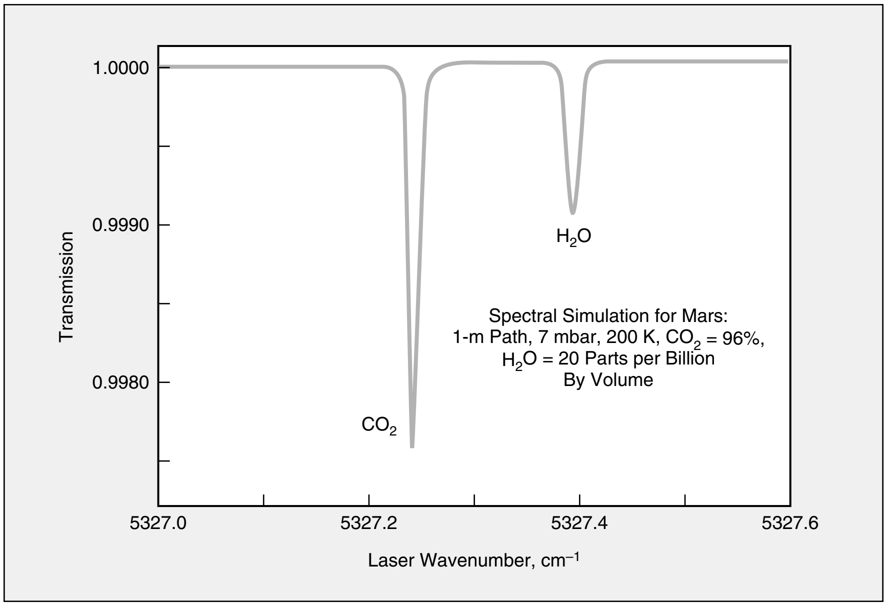


Figure 1. These **Simulated Spectral Transmission Measurements** illustrate the present method as applied to a wave-number range that contains absorption lines of N_2O and CO_2.

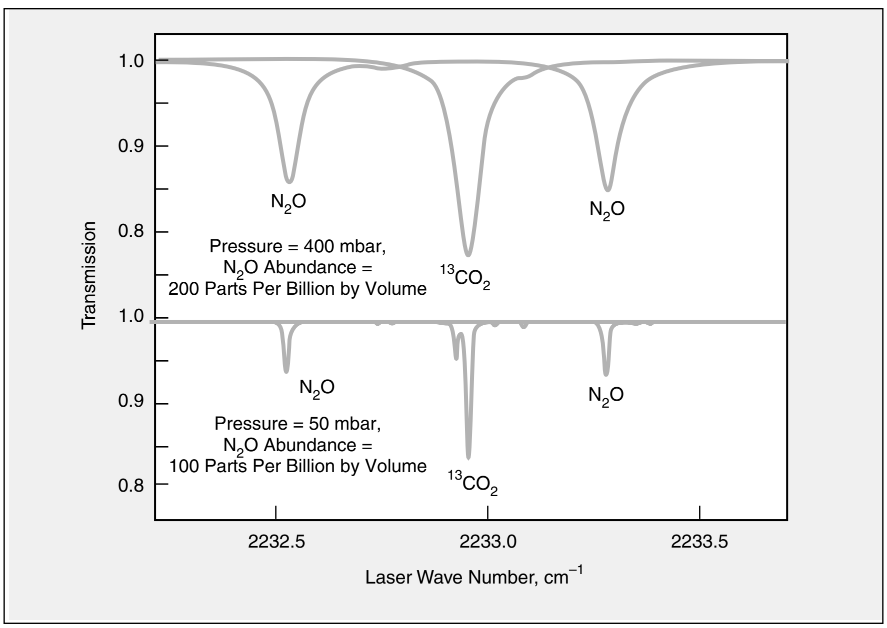


Figure 2. The **Spectral Region Near 1.88 µm** would be appropriate for measurements of water on both Mars and the Earth where suitable near-infrared laser devices would exist.

known and varies slowly and by a small enough amount to be considered constant for calibration in the present context. Hence, absorption-spectral measurements of the concentrations of gases of interest can be normalized to the concentrations of CO_2. Because at least one CO_2 calibration line is present in every spectral scan of the laser during absorption measurements, the atmospheric CO_2 serves continuously as a calibration standard for every measurement point.

Figure 1 depicts simulated spectral transmission measurements in a wave-number range that contains two absorption lines of N_2O and one of CO_2. The simulations were performed for two different upper-atmospheric pressures for an airborne instrument that has a path length of 80 m. The relative abundance of CO_2 in air was assumed to be 360 parts per million by volume (approximately its natural level in terrestrial air). In applying the present method to measurements like these, one could average the signals from the two N_2O absorption lines and normalize their magnitudes to that of the CO_2 absorption line. Other gases with which this calibration method can be used include H_2O, CH_4, CO, NO, NO_2, HOCl, C_2H_2, NH_3, O_3, and HCN.

One can also take advantage of this method to eliminate an atmospheric-pressure gauge and thereby reduce the mass of the instrument: The atmospheric pressure can be calculated from the temperature, the known relative abundance of CO_2, and the concentration of CO_2 as measured by spectral absorption.

Natural CO_2 levels on Mars provide an ideal calibration standard. Figure 2 shows a second example of the application of this method to Mars atmospheric gas measurements. For sticky gases like H_2O, the method is particularly powerful, since water is notoriously difficult to handle at low concentrations in pre-flight calibration procedures.

This work was done by Chris Webster of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com***.

NPO-30401

Laser Ranging Simulation Program

Laser Ranging Simulation Program (LRSP) is a computer program that predicts selected aspects of the performances of a laser altimeter or other laser ranging or remote-sensing systems and is especially applicable to a laser-based system used to map terrain from a distance of several kilometers. Designed to run in a more recent version (5 or higher) of the MATLAB programming language, LRSP exploits the numerical and graphical capabilities of MATLAB. LRSP generates a graphical user interface that includes a pop-up menu that prompts the user for the input of data that determine the performance of a laser ranging system. Examples of input data include duration and energy of the laser pulse, the laser wavelength, the width of the laser beam, and several parameters that characterize the transmitting and receiving optics, the receiving electronic circuitry, and the optical properties of the atmosphere and the terrain. When the input data have been entered, LRSP computes the signal-to-noise ratio as a function of range, signal and noise currents, and ranging and pointing errors.

This program was written by Sabino Piazzolla of USC and Hamid Hemmati and David Tratt of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com***.

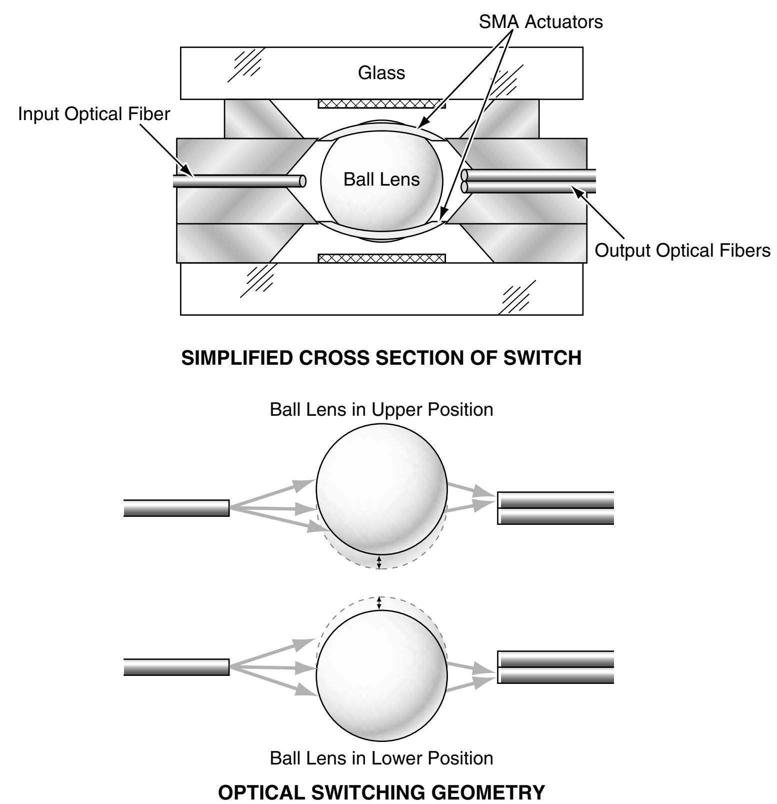
This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30549.

Micro-Ball-Lens Optical Switch Driven by SMA Actuator

This could be a prototype of low-loss, mass-producible optical switches.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure is a simplified cross section of a microscopic optical switch that was partially developed at the time of reporting the information for this article. In a fully developed version, light would be coupled from an input optical fiber to one of two side-by-side output optical fibers. The optical connection between the input and the selected output fiber would be made via a microscopic ball lens. Switching of the optical connection from one output fiber to another would be effected by using a pair of thin-film shape-memory-alloy (SMA) actuators to toggle the lens between two resting switch positions.



The **SMA Actuators** would move the ball lens between its two resting positions. Light would be coupled to one or the other output optical fiber, depending on which position was selected.

There are many optical switches — some made of macroscopic parts by conventional fabrication techniques and some that are microfabricated and, hence, belong to the class of microelectromechanical systems (MEMS). Conventionally fabricated optical switches tend to be expensive. MEMS switches can be mass-produced at relatively low cost, but their attractiveness has been diminished by the fact that, heretofore, MEMS switches have usually been found to exhibit high insertion losses. The present switch is intended to serve as a prototype of low-loss MEMS switches. In addition, this is the first reported SMA-based optical switch.

The optical fibers would be held in V grooves in a silicon frame. The lens would have a diameter of 1 μm; it would be held by, and positioned between, the SMA actuators, which would be made of thin films of TiNi alloy. Although the SMA actuators are depicted here as having simple shapes for the sake of clarity of illustration, the real actuators would have complex, partly netlike shapes. With the exception of the lens and the optical fibers, the SMA actuators and other components of the switch would be made by microfabrication techniques. The components would be assembled into a sandwich structure to complete the fabrication of the switch.

To effect switching, an electric current would be passed through one of the SMA actuators to heat it above its transition temperature, thereby causing it to deform to a different "remembered" shape. The two SMA actuators would be stiff enough that once switching had taken place and the electrical current was turned off, the lens would remain latched in the most recently selected position.

In a test, the partially developed switch exhibited an insertion loss of only –1.9 dB and a switching contrast of 70 dB. One the basis of prior research on SMA actuators and assuming a lens displacement of 125 μm between extreme positions, it has been estimated that the fully developed switch would be capable of operating at a frequency as high as 10 Hz.

This work was done by Eui-Hyeok Yang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com***.

NPO-30434