

## Waveguide Harmonic Generator for the SIM

NASA's Jet Propulsion Laboratory, Pasadena, California

A second-harmonic generator (SHG) serves as the source of the visible laser beam in an onboard calibration scheme for NASA's planned Space Interferometry Mission (SIM), which requires an infrared laser beam and a visible laser beam coherent with the infrared laser beam. The SHG includes quasi-phase-matched waveguides made of MgO-doped, periodically poled lithium niobate, pigtailed with polarization-maintaining optical fibers. Frequency doubling by use of such waveguides affords

the required combination of coherence and sufficient conversion efficiency for the intended application. The spatial period of the poling is designed to obtain quasi-phase-matching at a nominal middle excitation wavelength of 1,319.28 nm.

The SHG is designed to operate at a warm bias (ambient temperature between 20 and 25 °C) that would be maintained in its cooler environment by use of electric heaters; the heater power would be adjusted to regulate

the temperature precisely and thereby maintain the required precision of the spatial period. At the state of development at the time of this reporting, the SHG had been packaged and subjected to most of its planned space-qualification tests.

*This work was done by Daniel Chang, Ilya Poberezhskiy, and Jerry Mulder of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45253*

## Whispering Gallery Mode Resonator With Orthogonally Reconfigurable Filter Function

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An optical resonator has been developed with reconfigurable filter function that has resonant lines that can be shifted precisely and independently from each other, creating any desirable combination of resonant lines. This is achieved by changing the axial distribution of the effective refractive index of the resonator, which shifts the resonant frequency of particular optical modes, leaving all the rest unchanged. A reconfigurable optical filter is part of

the remote chemical detector proposed for the Mars mission (Planetary Instrument Definition and Development Program — PIDDP), but it is also useful for photonic communications devices.

*This work was done by Lute Maleki, Andrey Matsko, Dmitry Strelakov, and Anatoliy Savchenkov of Caltech for NASA's Jet Propulsion Laboratory.*

*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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## Stable Calibration of Raman Lidar Water-Vapor Measurements

Data from occasional radiosonde campaigns and routine laboratory lamp measurements are utilized.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method has been devised to ensure stable, long-term calibration of Raman lidar measurements that are used to determine the altitude-dependent mixing ratio of water vapor in the upper troposphere and lower stratosphere. Because the lidar measurements yield a quantity proportional to the mixing ratio, rather than the mixing ratio itself, calibration is necessary to obtain the factor of proportionality. The present method involves the use of calibration data from two sources: (1) absolute calibration data from *in situ* radiosonde measurements made during occasional campaigns and (2) partial calibration data obtained by use, on a regular schedule, of a lamp that emits in a known spectrum de-

termined in laboratory calibration measurements.

In this method, data from the first radiosonde campaign are used to calculate a campaign-averaged absolute lidar calibration factor ( $t_l$ ) and the corresponding campaign-averaged ratio ( $L_1$ ) between lamp irradiances at the water-vapor and nitrogen channel wavelengths. Depending on the scenario considered, this ratio can be assumed to be either constant over a long time ( $L = L_1$ ) or drifting slowly with time.

The absolutely calibrated water-vapor mixing ratio ( $q$ ) obtained from the  $i$ th routine off-campaign lidar measurement run is given by

$$q_i = P_i / t_i = LP_i / P'_i$$

where  $P_i$  is water-vapor/nitrogen measurement signal ratio,  $t_i$  is the unknown and unneeded overall efficiency ratio of the lidar receiver during the  $i$ th routine off-campaign measurement run, and  $P'_i$  is the water-vapor/nitrogen signal ratio obtained during the lamp run associated with the  $i$ th routine off-campaign measurement run. If  $L$  is assumed constant, then the lidar calibration is routinely obtained without the need for new radiosonde data. In this case, one uses  $L = L_1 = P'_1 / t_1$ , where  $P'_1$  is the water-vapor/nitrogen signal ratio obtained during the lamp run associated with the first radiosonde campaign.