Miniaturized Gas Correlation Radiometer for the Detection of Trace Gases in the Martian Atmosphere

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We present a miniaturized and simplified version of a gas correlation radiometer (GCR) capable of simultaneously mapping multiple trace gases and identifying active regions on the Mars surface.[1] Gas correlation radiometry (GCR) has been shown to be a sensitive and versatile method for detecting trace gases in Earth's atmosphere.[2,3] Reduction of the size and mass of the GCR was achieved by implementing compact, light-weight 1 mm inner diameter hollow-core optical fibers (hollow waveguides) as the gas correlation cells. In a comparison with an Earth orbiting CO_2 GCR instrument, exchanging the 10 m multipass cells with hollow waveguide gas correlation cells of equivalent pathlength reduces the mass from ~150 kg to ~0.5 kg, and reduces the volume from 1.9 m x 1.3 m x 0.86 m to a small bundle of fiber coils approximately 1 meter in diameter by 0.05 m in height (mass and volume reductions of >99%)[4,5].

A unique feature of this instrument is its stackable module design, with a single module for each trace gas. Each of the modules is self-contained, and fundamentally identical; differing by the bandpass filter wavelength range and gas mixtures inside the hollow-waveguide absorption cells. The current configuration contains four stacked modules for simultaneous measurements of methane (CH_4), formaldehyde (H_2CO), water vapor (H_2O), and deuterated water vapor (HDO) but could easily be expanded to include measurements of additional species of interest including nitrous oxide (N_2O), hydrogen sulfide (H_2S), methanol (CH_3OH), and sulfur dioxide (SO_2), as well as carbon dioxide (CO_2) for a simultaneous measure of mass balance.

Preliminary results indicate that a 1 ppb detection limit is possible for both formaldehyde and methane with one second of averaging. Using non-optimized components, we have demonstrated an instrument sensitivity equivalent to ~30 ppb for formaldehyde, and ~500 ppb for methane. We expect custom bandpass filters and 6 m long waveguides to significantly improve these promising results. Ongoing testing is being conducted on water vapor and deuterated water vapor.

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3 Pfister, G. *et al.* Effects of a Spectral Surface Reflectance on Measurements of Backscattered Solar Radiation: Application to the MOPITT Methane Retrieval. *Journal of Atmospheric and Oceanic Technology* **22**, 566-574 (2005).

4 Tolton, B. T., Hackett, J., Caldwell, D. & Miller, D. Strawman design for a gas-filter correlation radiometer satellite instrument to measure the atmospheric CO2 column. *Proc. of SPIE* **5543**, 332-337 (2004).

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