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Precision Heterodyne Oxygen-Calibration Spectrometry: Initial Deployment and Data Retrieval

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We describe the development and initial tests of a new laser heterodyne radiometry (LHR) technique: *Precision Heterodyne Oxygen-Calibration Spectrometry*, or PHOCS. Atmospheric gas analysis using solar occultation with heterodyne detection was pioneered at the Jet Propulsion Laboratory (JPL) beginning in the 1970s. Incoming light is combined with light from a narrow-band laser source (the local oscillator or LO) on a photodetector. The detector output will contain AC electronic signals at the (optical) difference frequencies. PHOCS heterodyne signals are proportional to the solar spectrum at the LO wavelength. When the LO coincides with an optical absorbance, the heterodyne signal intensity will drop by an amount proportional to the absorbance. PHOCS complements results from the Orbiting Carbon Observatory (OCO-2), Active Sensing of CO_2 Emissions over Nights, Days, and Seasons (ASCENDS), and ground-based Fourier transform spectrometers.

PHOCS builds on earlier work by using continuously tunable, near-infrared diode lasers as heterodyne local oscillators, conventional fiber optics, and low-noise room temperature detectors. In addition, PHOCS includes recently developed *rf* power sensors that have -70 dBm noise floors and that are USB-powered and readout directly through a USB interface. The prototype instrument is equipped with two active laser channels for oxygen (measured in the a $^1\Delta_g$ band near 1.27 μm) and carbon dioxide (a portion of the 30012 $\leftarrow$ 00001 vibrational transition near 1.57 μm) determinations. Because the oxygen mixing ratio is constant throughout the lower atmosphere, only variation in pressure and temperature profiles will affect the "fit" of modelled and observed oxygen features. By establishing "control points" within each layer, the initial (MERRA) pressure and temperature profiles can be iterated to reduce residuals in the fit of the oxygen features. With these improved T and P profiles, carbon dioxide concentrations within each tropospheric layer can be adjusted to reduce residuals in the fit of the water features.

The presentation will describe the development of the instrument by Mesa Photonics and will present the results of initial field tests the vicinity of Washington, DC during 2018-2019.