Pure-Rotational Molecular Spectroscopy with a Low-Power CMOS-Based W-Band Transmitter

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Abstract — The distinct rotational signatures of gas-phase molecular species in the millimeter (mm) and sub-millimeter (sub-mm) spectral regions have long assisted remote sensing communities in the interrogation of atmospheric and astrophysical media. *In situ* studies employing highly-mobile instrumentation have not been able to reproduce the success of their remote-based counterparts largely due to the unaccommodating size and power requirements of traditional mm and sub-mm wave hardware. The Laboratory Studies and Atmospheric Observations group at JPL has embraced the marriage of novel custom-designed CMOS source and heterodyne detection electronics, which often leverage advances in the mobile phone industry, and traditional cavity enhanced laboratory techniques to combat the issues that have plagued the deployment of *in situ* mm wave sensors.

One device emerging from these efforts is a freestanding CMOS-based transmitter tunable to sub-500 Hz resolution over the operational bandwidth of 90 – 105 GHz. For prototyping purposes this transmitter, the output of which can be both frequency and amplitude modulated, has been deployed as the radiation source in a high-resolution sub-Doppler (Lamb-dip) absorption spectrometer. The presented experimental findings have shown that this device, which effectively functions as a USB powered/controlled W-band source, has sufficient output power (~2 mW peak) to perform spectral-hole burning saturation experiments and a phase-noise floor low enough to determine spectral line positions with a precision of 1 part in 10^9 and accuracy within the error of measurements made with traditional millimeter-wave sources. These findings highlight the promise of exploiting CMOS architectures for use in gas specific, low-power, and potentially low-cost *in situ* sensors.