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First results from ground-based CO_2 remote sounding using high-resolution thermal IR laser heterodyne radiometry

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Over the course of the last decade, the Laser Spectroscopy Group at RAL Space has considerably furthered the passive remote sensing technique of thermal IR Laser Heterodyne Radiometry (LHR), and applied it successfully to the ground-based sounding of atmospheric profiles of a variety of trace gases, including methane. LHR is underpinned by coherent detection technology and ideally shot noise-limited, which can significantly enhance the signal-to-noise ratio of acquired atmospheric spectra over conventional direct detection spectrometers when high spectral (>500,000 resolving power) and high spatial resolutions are needed. These benefits allow probing optimized narrow spectral windows (1 cm-1) with full absorption lineshape information, useful for trace gas vertical profiling.

Furthermore, LHR has a high potential for miniaturization into a rugged, unprecedentedly compact package, through hollow waveguide optical integration, facilitating its deployment in ground-based observation networks, as well as on a variety of airborne and spaceborne platforms, whilst retaining its high specifications.

This makes LHR well-suited to the remote sounding of key greenhouse gases, in particular carbon dioxide, as observations with high precision and accuracy are crucial to discriminate trends and small variations over a substantial background concentration, and in order to contribute to flux estimations in top-down carbon cycle inversion approaches and anthropogenic emission monitoring.

Here, we present a new optical bench-based LHR prototype that has been specifically built to demonstrate CO_2 sounding in the thermal IR. The instrument has been coupled to a new permanently installed solar tracker to take a long-term measurement series in solar occultation mode, and to assess the performance of the instrument. We discuss its theoretical performance modelled using an Observation System Simulator, and showcase first results from a 6 months' archive, with observations undergoing gradual refinement as the retrieval method is improved.