LEMON FRUIT

Frequency comb based absolute frequency reference design for future spaceborne multi species differential absorption Lidar systems for green-house gases monitoring

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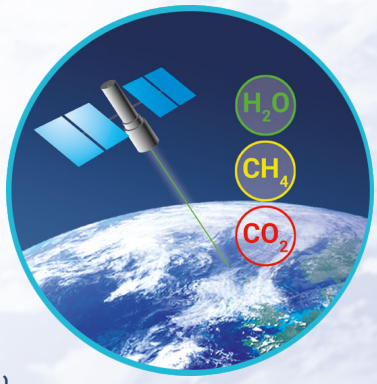
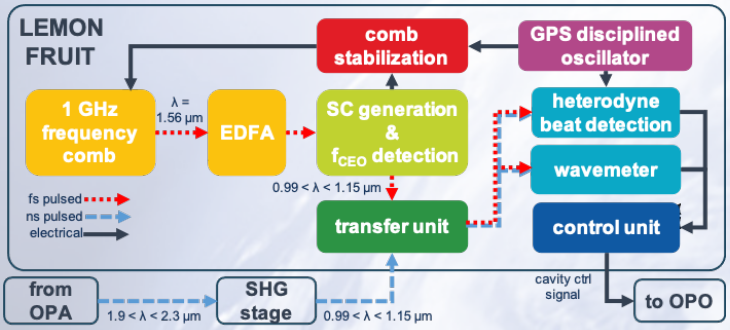
Introduction

The Lidar Emitter and Multi-species greenhouse gases Observation iNstrument (LEMON) [1,2] is a novel Differential Absorption Lidar (DIAL) sensor concept for greenhouse gases and water vapor measurements from space. It is based on a versatile transmitter allowing for addressing various absorption lines of different molecules. Here we present a concept employing a 1 GHz frequency comb, which allows the absolute referencing over the whole spectral range from 1.9 µm to 2.3 µm covered by the highly flexible emitter. The LEMON Frequency Reference UnIT (FRUIT) is designed to match the requirements of the vibration loads associated with airborne operation. In addition, the requirements for a future space development are considered in the design. This includes increased stability and accuracy requirements for DIAL measurements at high optical depth (e.g. CO_2).



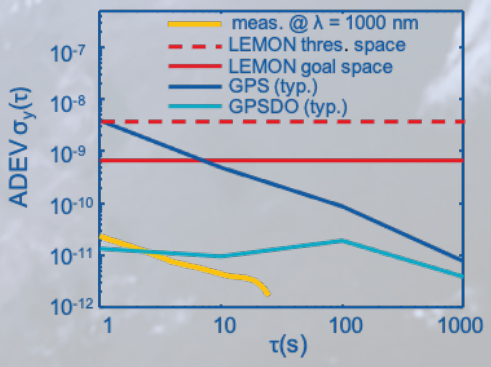


FRUIT Design

The frequency ruler which the FRUIT employs to measure the frequencies is based on a frequency comb acting as transfer oscillator to map the stability and accuracy of a GPS disciplined oscillator into the optical domain. A femtosecond laser with a repetition rate of 1 GHz operating at a wavelength of 1.5 µm provides the performance for nonlinear supercontinuum (SC) generation and frequency comb stabilization at a large comb mode spacing. It is constructed to withstand the loads associated with operation in an airplane. With the transfer unit a part of the comb spectrum is selected and heterodyned with the actual OPA pulse. Together with the comb parameters and a coarse wavemeter measurement, this allows to determine the absolute optical frequency of the emitted OPA pulses.

Results and Outlook

After the initial design phase, the concept has been implemented on breadboard level and preliminary tests with the stabilized comb have shown performance compliant with the requirements. The implementation of the airplane instrument is currently ongoing. In parallel, radiation tests on critical subunits, such as the nonlinear fiber have been performed successfully demonstrating the potential of the concept for a spaceborne instrument.



References

[1] https://lemon-dial-project.eu/
[2] A detailed description of the LEMON instrument is presented in ICSO 2020, Session 19, 050 - Design and pre-development of an airborne multi-species differential absorption Lidar system for water vapor and HDO isotope, carbon dioxide, and methane observation.

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