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Bi-Pulse Fiber Laser Source Concept for Integrated-Path Differential Absorption Lidar from Space

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CO₂ monitoring over an atmospheric column provides crucial information for climate change monitoring. A possible implementation for this measurement is IPDA (Integrated-Path-Differential-Absorption) lidar on a satellite that measures the absorption difference between two close wavelengths (λ_{ON} , absorbed by CO₂ and λ_{OFF} , not absorbed). Distance to ground must be simultaneously measured. Pulses must be short enough for telemetry (<100ns), narrow-linewidth for spectrally resolved absorption measurement (<100MHz) and high-energy for signal-to-noise ratio (mJ-level).

All-fiber MOPA (master-oscillator-power-amplifier) laser sources present many advantages (robustness to vibrations, alignment-free, versatility, efficiency) but are limited in peak power. Having simultaneously short, narrow linewidth and mJ-level pulses is challenging because of stimulated Brillouin scattering (SBS) [1]. However, it is possible to decouple the spectral and time constraints, leading to a new “bi-pulse” strategy.

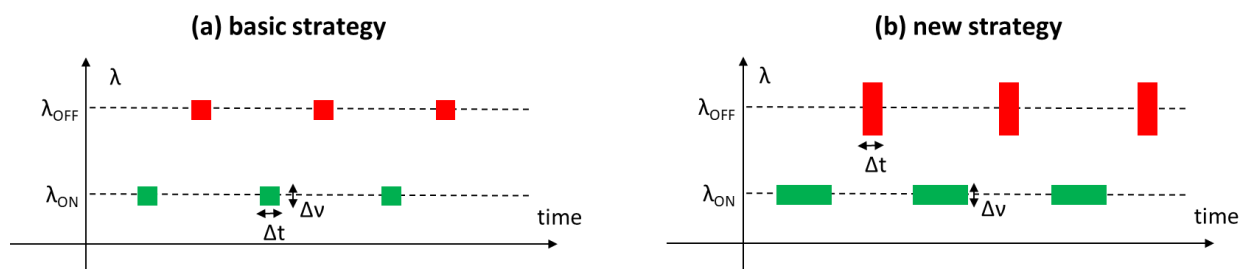


Fig. 1 (a) initial and (b) new strategies for laser pulses duration and linewidth. In both cases, Δt is constrained by telemetry and $\Delta \nu$ is constrained by absorption linewidth.

We propose and demonstrate an all-fiber bi-pulse source alternating short λ_{OFF} pulses with enlarged spectrum for offline and telemetry measurements and narrow linewidth, long λ_{ON} pulses for on-line measurement. This versatile source can be adapted to maximize precision of CO₂ measurements. Figure 1 illustrates the concept.

This new strategy has been implemented in Onera’s 1545nm high power amplifier BOFIX with 140ns- λ_{ON} and 1.3 μ s- λ_{OFF} pulses. The short pulses spectrum was broadened to ~2GHz with a phase modulator. Using the initial strategy, the energy of the two pulses were limited to 75 μ J by Δt and $\Delta \nu$ (see figure 1). Using the new strategy, the accessible energies are 450 μ J and 570 μ J for the short and long pulses, respectively. Figure 2 shows the improvement in terms of peak power and energy in the new strategy.

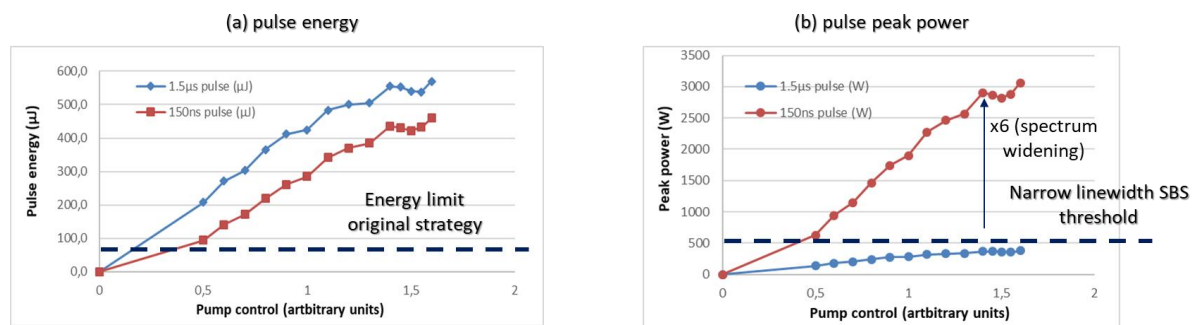


Fig. 2 Pump (a) energy and (b) peak power at BOFIX output. On (a), the dash lines show the energy limited in the original strategy. On (b), the dash line shows the narrow linewidth SBS threshold.

A new **all-fiber architecture** using a **bi-pulse strategy** is proposed for **IPDA lidar from space**. A 6x gain in energy for this particular IPDA lidar application has been demonstrated with this strategy. New limits are interpulse ASE and 500W SBS peak power threshold for long pulse. This is a promising laser source for IPDA lidar from space.

References

- [1] N. Cézard *et al.*, « 1579 NM Fiber Laser Source for Spaceborne Monitoring of Carbon Dioxide », in *EPJ Web of Conferences*, 2016, vol. 119, p. 17010. doi: 10.1051/epjconf/201611917010.