DUAL COMB GENERATION FROM A SINGLE FIBER LASER CAVITY VIA SPECTRAL SUBDIVISION

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Dual comb spectroscopy holds the promise of bringing the bandwidth, resolution and sensitivity advantages of direct frequency comb spectroscopy to the mainstream. Replacing complex Fourier transform interferometer (FTIR) or virtually imaged phased array (VIPA) detectors with a simple photo diode potentially leads to compact, robust, field-usable measurement setups. In exchange, some of that complexity is then shifted to the laser source, usually leading to the requirement of two identical mode-locked lasers, actively stabilized to each other. However, such a dual comb source can be significantly simplified by generating two pulse trains using a single laser cavity, with the advantage of passive mutual coherence due to common-mode noise cancellation in the down converted radio frequency (RF) comb.

We introduce a new, particularly flexible, method to generate a single-cavity dual comb, exploiting independent mode-locking within two isolated spectral regions of the gain profile, created by intra-cavity spectral filtering. By setting a non-zero cavity dispersion we generate stable pulse trains with different repetition rates. These are made to overlap spectrally via successive spectral broadening in a non-linear fiber, yielding a compact, fully useable dual comb source. The underlying concept is generally applicable to nearly all kinds of passively mode-locked lasers, including state-of-the-art all-fiber types.

We demonstrate its feasibility in a nonlinear polarization evolution (NPE) mode-locked Yb:fiber laser. Spectral filtering is introduced in the free-space section of the grating compressor by mechanically blocking a central frequency band using a needle-shaped object. Fine control over its position and thickness allows for easy tuneability of the spectral separation and dual-laser operation. The laser features two independently mode-locked pulse trains centered around 1015 nm and 1040 nm, respectively, with a spectral width of about 10 nm each. Their pump-power limited repetition rates are around 20 MHz with a difference tuneable from 10 kHz down to 750 Hz. In a proof-of-principle experiment the laser output was spectrally broadened and further amplified, producing a spectral overlap around 1030 nm with an average power of 40 mW over a bandwidth of 10 nm. Once properly stabilized and brought to higher repetition rates we expect to produce a stable downconverted RF comb. Even more robust implementations might for example involve the integration of spectral filtering in form of fiber Bragg gratings or dielectric filters into and all-fiber figure-9 laser. Nonlinear conversion schemes will further extend the spetral range into the Mid-IR or XUV regions.