Single laser produces high-power dual comb femtosecond pulses

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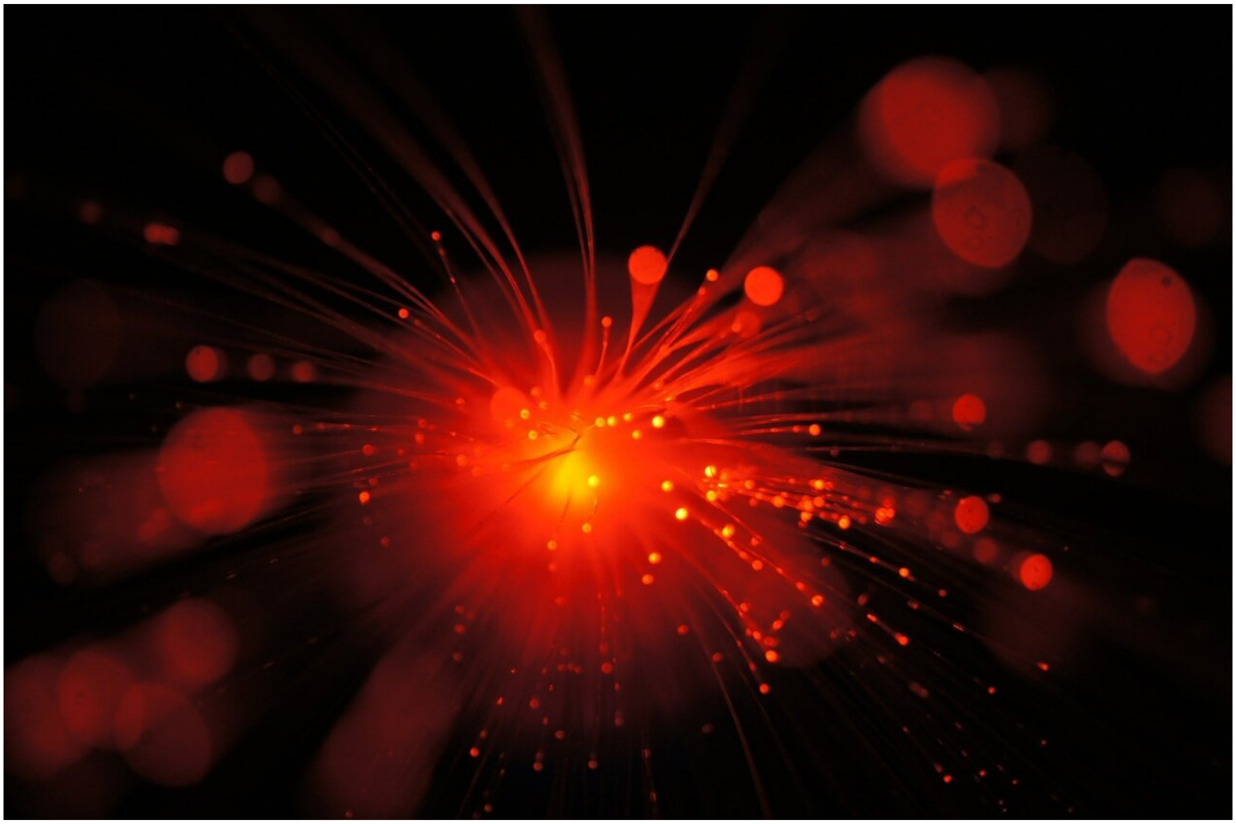

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Researchers have developed a new approach that uses a single laser cavity to create two high-power optical frequency combs emitting high-power femtosecond pulses. The new development paves the way for portable dual-comb light sources for applications such as spectroscopy and precision distance measurement.

Optical frequency combs emit a spectrum of colors—or frequencies—that are perfectly spaced like the teeth on a comb. Two such frequency combs with slightly different pulse repetition rates are often combined to create a dual-comb setup emitting a stream of short pulses.

Benjamin Willenberg from ETH Zurich in Switzerland will present the new approach at the all-virtual 2020 OSA Laser Congress, 13—16 October. The presentation will take place Friday, 16 October at 08:30 EDT.

"Our approach allows us to generate a pair of frequency combs with a small and passively stable offset in their repetition rate," said Willenberg. "This resolves the long-standing problem of the high complexity of dual comb systems without compromising on laser performance. Potential sensing applications include time-domain spectroscopy for non-destructive testing, trace-gas detection for industrial and environmental monitoring, and laser ranging for machine vision applications."Combining combs

The train of pulses available from dual comb lasers are particularly useful for extremely sensitive and fast spectroscopy measurements and precisely measuring distances via laser ranging. However, the need for two stabilized combs plus complex synchronization electronics has restricted these measurements to the laboratory.

In the new work, the researchers replaced these complex systems with a simpler passively stable optical approach. To achieve dual-comb operation, they used a single laser cavity multiplexed with birefringent calcite crystals to allow for lasing in the two polarization states. The researchers, for the first time, combined this birefringent crystal polarization multiplexing technique with a diode-pumped solid-state laser crystal. The Yb:CaF2 gain crystal used enables high-power femtosecond pulse generation due to its excellent thermal properties and broad emission spectrum.

Because the new design creates two frequency comb lasers using a single optical cavity, it could enable the development of more compact dual combs that offer flexibility in power, wavelength, bandwidth, and pulse repetition rates.

With the new setup, the researchers achieved pulses with a 175-femtosecond duration and 440 mW of power in two 1050-nm beams with a repetition rate difference of 1 kHz. They demonstrated the stability of the repetition rate difference by using the laser to perform low-noise measurements on semiconductor materials using asynchronous optical sampling. This involved using an ultrafast pulse to trigger a reaction, and a second pulse to measure the induced change.

Next steps for this technology include developing prototype systems in a robust and portable package, demonstrating scientific and industrial applications, scaling to higher powers and higher repetition rates for faster measurements, and setting up channels to offer the laser commercially.

More information: Benjamin Willenberg et al. Femtosecond dual-comb Yb:CaF2 laser from a single free-running polarization-multiplexed cavity for optical sampling applications, *Optics Express* (2020). DOI: 10.1364/OE.403072

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