Brighter comb lasers on a chip mean new applications

August 29 2023

Researchers have shown that dissipative Kerr solitons (DKSs) can be used to create chip-based optical frequency combs with enough output power for use in optical atomic clocks and other practical applications. The advance could lead to chip-based instruments that can make precision measurements that were previously possible only in a few specialized laboratories. Credit: Grégory Moille, Joint Quantum Institute, NIST/University of Maryland

Researchers have shown that dissipative Kerr solitons (DKSs) can be used to create chip-based optical frequency combs with enough output power for use in optical atomic clocks and other practical applications. The advance could lead to chip-based instruments that can make precision measurements that were previously possible only in a few specialized laboratories.

Grégory Moille from the Joint Quantum Institute, NIST/University of Maryland, will present this research at Frontiers in Optics + Laser Science (FiO LS), which will be held 9–12 October 2023 at the Greater Tacoma Convention Center in Tacoma (Greater Seattle Area), Washington.

"Frequency combs are ubiquitous in metrology—just like a ruler measures length, they let us measure optical frequency with great precision," said Moille.

"Making them on chip helps us reduce greatly their power consumption, but also reduces the power in each comb tooth. This makes it hard to interface on-chip combs with other system like atomic frequency standards. We show that by simply carefully injecting another weak laser in the comb device, it lets us tune the system and therefore optimize the power in several comb teeth power by more than an order of magnitude."

Optical frequency combs emit a continuous train of short, closely spaced pulses of light containing millions of colors, which can be used to measure light waves as if they were radio waves. This allows technologies such as atomic clocks, computers and communications to be connected with optical waves that oscillate at 10,000 times higher frequencies than those found in electronics.

While conventional optical frequency combs are generated using mode-locked lasers that tend to be constrained to high-end scientific laboratories, there has been recent work to develop optical frequency combs using compact, chip-scale microresonators based on DKSs. DKSs are packets of light that rely on a double balance of nonlinearity and dispersion as well as dissipation and gain. Although DKS-based combs consume very little energy, they also do not produce enough output power to be useful.

In the new work, researchers harness the newly proposed Kerr-induced synchronization of Kerr solitons to an external stable laser reference to produce optical frequency combs with higher levels of power. This creates a substantial increase of power on the other side of the comb spectrum from the reference laser.

The researchers demonstrate, both theoretically and experimentally, that an external reference pump at 193 THz allows for the repetition rate tuning of an octave-spanning comb. This enables tuning of the phase-matching condition of the comb tooth at the dispersive wave in a way that optimizes its power. Alongside a self-balancing effect, directly related to the core robustness property of the DKS, they demonstrate a more than 15-fold power increase at the 388 THz comb tooth.

"We are just scratching the surface of what optimization can be performed," explains Moille. "We have not reached the power limit of this optimization and hope to reach power level compatible with interfacing our comb directly with other systems"

Provided by Optica

Citation: Brighter comb lasers on a chip mean new applications (2023, August 29) retrieved 29 April 2024 from https://phys.org/news/2023-08-brighter-lasers-chip-applications.html