Long-standing problem for ultrafast solid-state lasers solved

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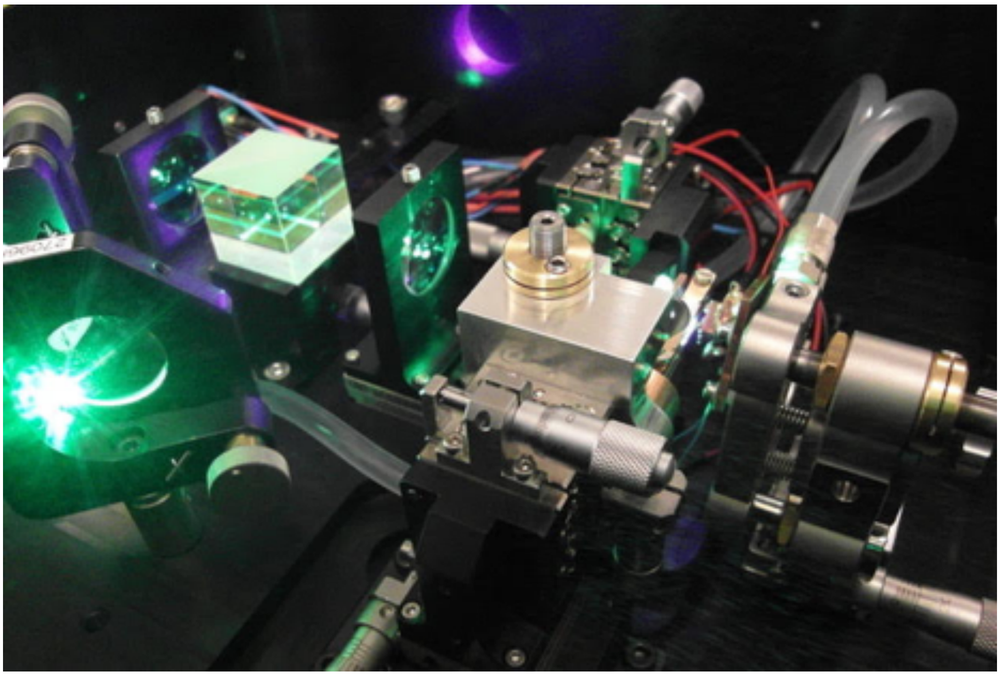
Ultrafast lasers with multi-gigahertz pulse-repetition rates are desirable for applications requiring high sampling rates or resolvable frequency-comb lines. ETH researchers have now solved one of the long-standing problems that has hindered progress towards gigahertz diode-pumped ultrafast solid-state lasers.



Prototype of the modelocked 10 GHz Yb:CALGO laser developed in the Ultrafast Laser Physics (ULP) group at ETH Zurich. (Photo: Aline Mayer, ETH Zurich)

So-called optical frequency combs (OFCs) have become key tools for a broad range of applications in metrology and spectroscopy, where the group of **Prof. Ursula Keller** at the Institute for Quantum Electronics has made key **pioneering contributions.** To produce OFCs with comb lines that can be easily resolved and at the same time have low noise levels, dedicated laser systems are required. In recent years, the photonics community has made major progress in the development and improvement of OFCs — nowadays there exists a broad variety of systems, from electro-optic and microresonator combs to Kerr-lens modelocked (KLM) Ti:sapphire lasers. All of these current gigahertz OFCs have, however, drawbacks that require compromises in terms of in system complexity, cost, stability, repetition rate and/or average power.

Directly diode-pumped ultrafast solid-state lasers modelocked with a semiconductor saturable absorber mirror (SESAM) have already proven to be stable and reliable OFC sources in the past. However, they have so far never been able to provide high power (Watt-level) and short (that is, femtosecond) pulses at repetition rates > 10 GHz. Such levels are difficult to reach because of inherent pulse-energy fluctuations that are increasingly difficult to suppress at high repetition rates and tend to damage the laser components.

Aline Mayer and **Dr Christopher Phillips** in the Keller group (Institute for Quantum Electronics) have now introduced a new class of modelocked lasers that can overcome these trade-offs. Writing in the journal *Nature Communications*, they recently introduced the first femtosecond Watt-level operation of a continuous-wave modelocked solid-state laser at repetition rate beyond 10 GHz.

The key to their success is the use of a SESAM in combination with a microstructured nonlinear device that exhibits a large, tunable and low-loss self-defocusing Kerr-like nonlinearity. This passive intracavity device, which they implemented through a new type of two-dimensionally patterned quasi-phase-matching crystal, protects the laser elements and enables stable short-pulse operation at 10-GHz repetition rate with a very simple linear laser cavity.

The approach makes it possible to use the ideal cavity format as well as direct pumping with a low-cost multi-mode diode, without compromising in performance or repetition rate. As such, this innovative design represents a new class of high-repetition-rate lasers that no longer suffer from the trade-offs of previous systems. As a result, numerous applications that so far have been possible only in a laboratory environment with expensive Ti:sapphire laser systems should now become more accessible.

Reference

Mayer AS, Phillips CR, Keller U: Watt-level 10-gigahertz solid-state laser enabled by self-defocusing nonlinearities in an aperiodically poled crystal. *Nature Communications* doi: **10.1038/s41467-017-01999-y** (2017).

Link

Website Ultrafast Laser Physics group

Page URL: https://www.phys.ethz.ch/news-and-events/d-phys-news/2018/01/long-standing-problem-for-ultrafast-solid-state-lasers-solved.html
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