TLB
Technologie-Lizenz-Büro
der Baden-Württembergischen
Hochschulen GmbH

Fully optical high-frequency modulation of laser pulse trains

Background

Laser pulses are often provided with mode-locked oscillators. Modulation is then carried out, for example, by mechanical choppers, electro-optical modulators or a direct modulation of the diode amperage. The common modulation methods are limited in terms of modulation frequency and pulse length, especially for the modulation of pulsed lasers with high average power and short pulse duration.

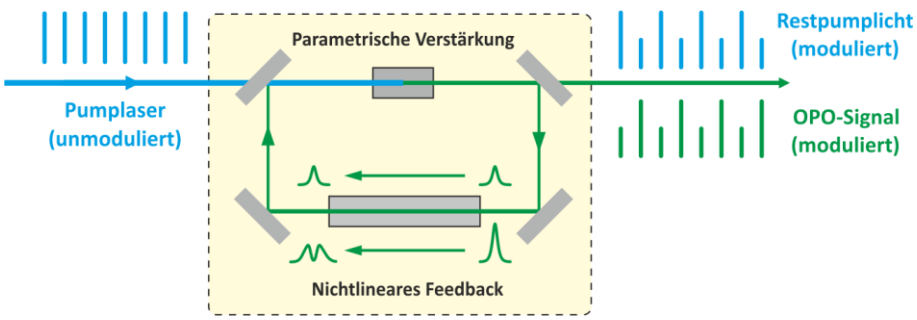
Problem

All known methods for modulating laser pulse trains are actively controlled, i.e. the modulation is performed with the aid of expensive control electronics.

Solution

Scientists at the University of Stuttgart have now developed a fully optical, passive method for amplitude modulation of high-frequency pulse trains, with which the maximum modulation frequency can also be applied to a pulse train of ultrashort pulses. In that case, the modulation is done by a passive element.

A synchronously pumped optical parametric oscillator (OPO) is used as the modulating element, which has a gain medium in the resonator arm and a nonlinear medium in the feedback arm. In the OPO the incoming laser pulses are converted into three pulses: the signal pulse, the idler pulse and an unchanged residual pump pulse. At the OPO's decoupling element, idler pulse and residual pump pulse are completely decoupled and part of the signal pulse is directed back into the feedback arm. The interplay of gain and losses in the nonlinear medium generates the modulation. Modulation depth and modulation frequency can be selected.



Schematic illustration of the method for amplitude modulation of a pulsed pump laser via a passive optical element. Modulation depth and frequency are freely selectable [Image: University of Stuttgart].

Contact
Dr.-Ing. Michael Ott
TLB GmbH
Ettlinger Straße 25
76137 Karlsruhe | Germany
Phone +49 721-79004-0
ott@tlb.de | www.tlb.de

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US 9,735,536 B2 granted
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Service
Technologie-Lizenz-Büro GmbH has been entrusted with the exploitation of this technology and assists companies in obtaining licenses.

Advantages

- Modulation of light pulses with very high modulation frequencies
  Modulation of pulsed lasers with high average power (>500 mW) and short pulse duration (<2 ps)
- Stable system, fully automated use
- Cost-effective, as no control electronics required
- Extreme improvement of signal-to-noise ratio in modulation-based measurements
- No electronic noise artifacts
- Simplified Raman microscope design

Fields of application

This novel method makes it possible to modulate the pulse amplitudes of an unmodulated laser pulse train at high frequency, even in the MHz range, using a fully optical modulation method. In contrast to conventional methods, the maximum modulation frequency (namely half the repetition rate) can even be applied to pulse trains of an ultrashort pulse laser, with pulse durations in the femto or picosecond range. Pump-probe measurements as well as microscopy methods such as stimulated Raman microscopy or CARS microscopy can thus use an intrinsically extremely low-noise frequency range.

In addition to the modulated pulse train, the optical system can provide two synchronized pulse trains with tunable wavelengths. This is particularly interesting for spectroscopy applications where two synchronized pulse trains with different wavelengths are required to use lock-in techniques.