DTU Electro

High energy ultrafast laser generation from a Tm-doped Mamyshev oscillator

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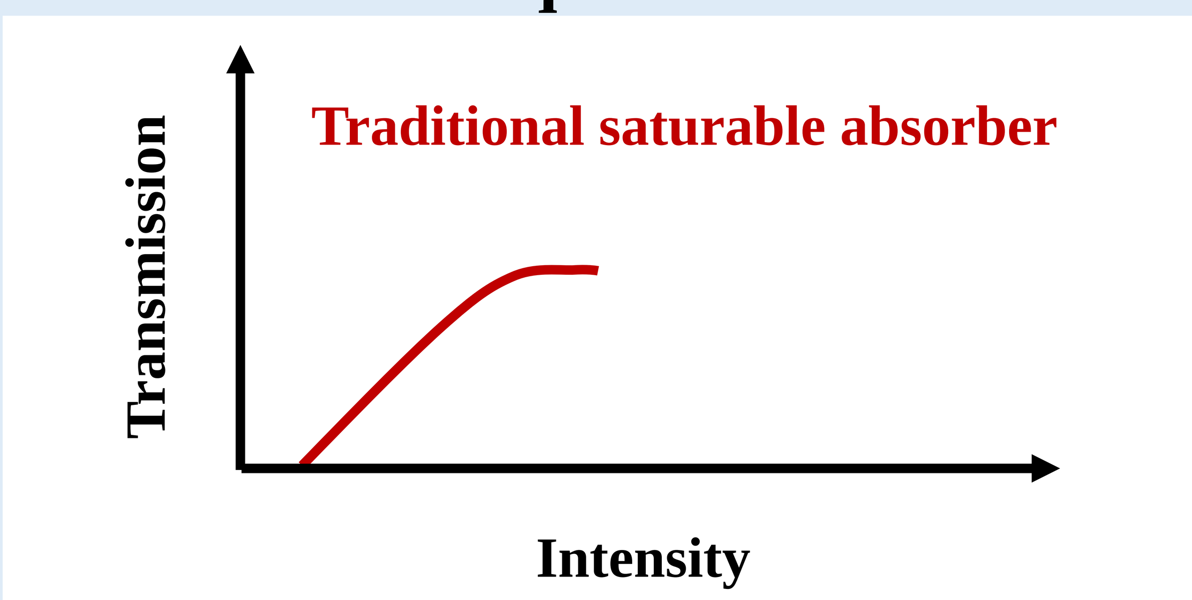
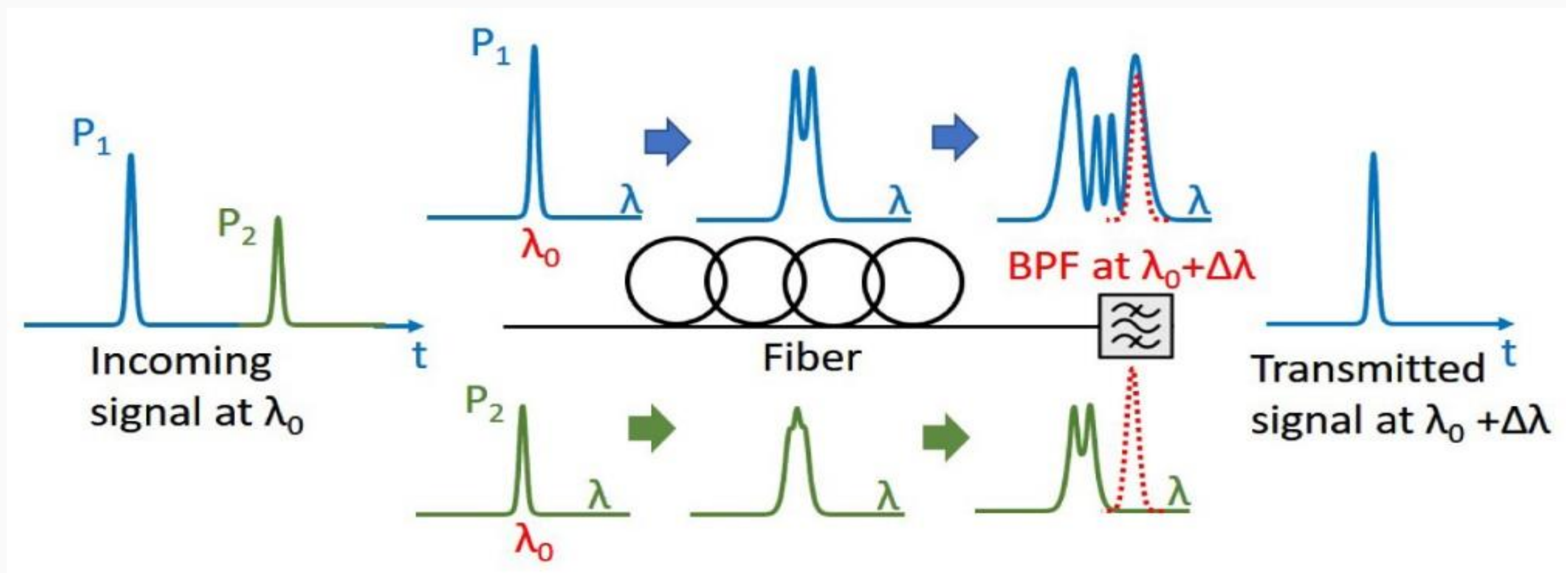
Introduction

Ultrafast fiber lasers, owing to their high peak power and perfect beam quality, have been widely applied in many fields, such as laser sensing, laser processing, optical communication, and so on. As a result, how to generate stable ultrashort laser pulses is a hot topic. Traditional ultrashort laser pulses are usually obtained through a passive mode-locking technique that exploits an artificial or real saturable absorber, such as nonlinear polarization rotation or SESAM. However, these methods have some obvious drawbacks, such as environmental sensitivity or a low damaging threshold. What's more, the laser pulse generated through these methods cannot stand up with high nonlinear effects and split. Thus, it is desirable to develop some new techniques to overcome them.



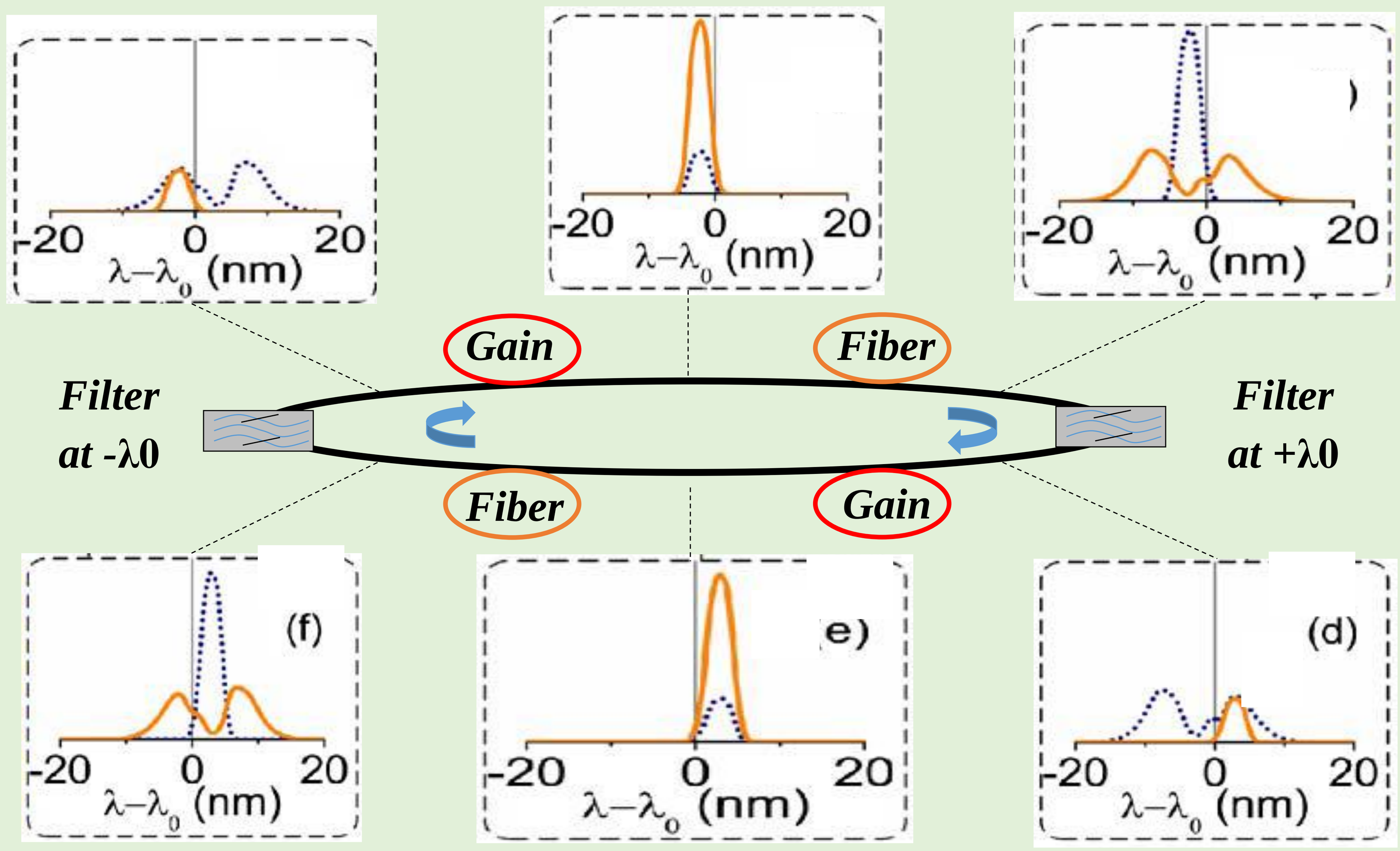
Mamyshev regenerator

The Mamyshev regenerator consists of a segment of high nonlinear fiber and a spectral filter. When the launched pulse with a central wavelength of λ_0 propagates through a nonlinear medium, it will experience self-phase modulation (SPM), leading to spectral broadening. After that, it will encounter a bandpass filter with a central wavelength of $\lambda_0+\Delta\lambda$ that is offset from the pulse's central wavelength λ_0. Crucially, the offset means the filter has little overlap with the initially launched spectrum, restricting the passed light to only that which is newly generated with a central frequency of $\lambda_0+\Delta\lambda$ through SPM.



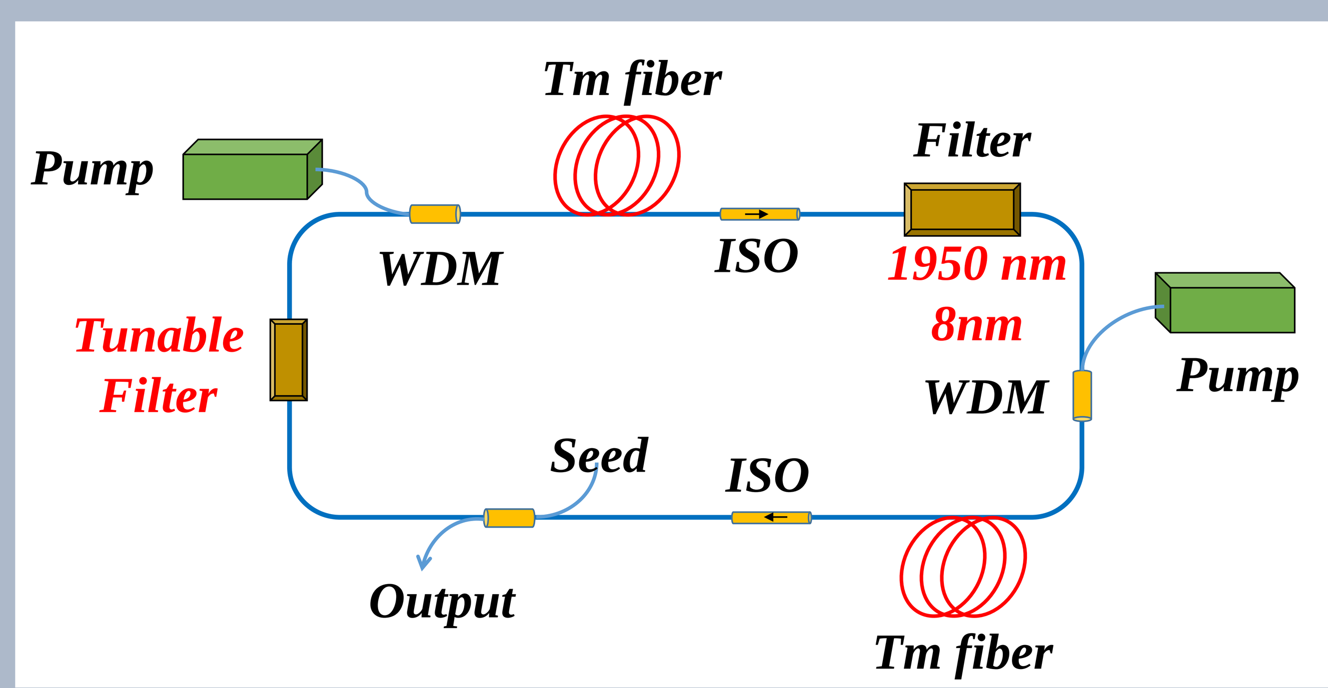
Mamyshev oscillator

In the Mamyshev oscillator, two filters with different center wavelengths are separated by a piece of nonlinear fiber. The transmission curves of the two filters are offset and do not overlap, which means that only pulses with a wide enough spectrum can pass through the filters. Since the spectrum broadening depends on the peak power of the pulse, the low-power continuous wave is negligible. Thus, only the high-peak power laser pulse will be amplified, filtered, and returned to its initial status.



Experimental setup

Mamyshev oscillators, which depend on high nonlinear effects, can usually generate stable and ultrashort laser pulses. After extra compression, the laser pulse duration can reach a few-cycle level. Up until now, most of the work has focused on the Yb- or Er-doped Mamyshev oscillator. Thus, our main work is to build a high-power and stable ultrafast Tm-doped Mamyshev oscillator at 2 μm wavelength. The expected repetition, pulse duration after external compression, and single pulse energy are 5 MHz, 50 fs, and 10 nJ.



Applications

Based on this advanced fiber laser, we will use it to pump some specific fibers and obtain a supercontinuum optical source for OCT and other applications.

References

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[2] J. Zheng, S. Yang, et al., Low mode-locking threshold and sub-90 fs Er-doped Mamyshev oscillator, Opt. Commun., 508, 127711 (2022).

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