In-Cavity Pulse Shaping and Dissipative Parametric Instability Mode-Locking in Fibre Lasers

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At the level of fundamental research, fibre lasers provide convenient and reproducible experimental settings for the study of a variety of nonlinear dynamical processes, while at the applied research level, pulses with different and optimised features – e.g., in terms of pulse duration, temporal and/or spectral shape, energy, repetition rate and emission bandwidth – are sought with the general constraint of developing efficient cavity architectures.

In this work, we review our recent progress on the realisation of pulse shaping in passively-mode-locked fibre lasers by inclusion of an amplitude and phase spectral filter into the laser cavity. We present a fibre laser design in which pulse shaping occurs through filtering of a spectrally nonlinearly broadened pulse in the cavity. This strategy of pulse shaping is illustrated through the numerical demonstration of the laser operation in different pulse-generation regimes, including parabolic, flattop and triangular waveform generations, depending on the amplitude profile of the in-cavity spectral filter [1]. As an application of this general approach, we show that the use of an in-cavity flat-top spectral filter makes it possible to directly generate sinc-shaped Nyquist pulses of high quality and of a widely tunable bandwidth from the laser [2]. We also report on a recently-developed versatile erbium-doped fibre laser, in which conventional soliton, dispersion-managed soliton (stretched-pulse) and dissipative soliton mode-locking regimes can be selectively and reliably targeted by programming different group-velocity dispersion profiles and bandwidths on an in-cavity programmable filter [3].

Further, we report on our recent results on the passive mode locking of a Raman fibre laser by a recently predicted new type of parametric instability – the dissipative Faraday instability [4], where spatially periodic zig-zag modulation of spectrally dependent losses can lead to pattern formation in the temporal domain. High-order harmonic mode locking is achieved in a very simple experimental configuration, with the laser cavity including an optical fibre and two chirped fibre Bragg gratings, and no additional mode-locking elements. The results not only open up new possibilities for the design of mode-locked lasers, but extend beyond fibre optics to other fields of physics and engineering.

References

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