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

N Tarasov[1], S Boscolo[1], J Peng[1], C Finot[2], A M Perego[1], D V Churkin[3], S K Turitsyn[1], and K Staliunas[4]

[1]*Aston Institute of Photonic Technologies, Aston University, Aston Triangle, Birmingham, UK. Contact Phone: +441212043495*
[2]*Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6303 UBFC-CNRS, Dijon, France*
[3]*Novosibirsk State University, Novosibirsk, Russia*
[4]*Universitat Politècnica de Catalunya, Barcelona, Spain*
Contact Email: s.a.boscolo@aston.ac.uk

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

[1] S Boscolo, C Finot, H Karakuzu and P Petropoulos, Opt. Lett. **39**, 438 (2014)

[2] S Boscolo, C Finot and S K Turitsyn, IEEE Photon. J. **7**, 7802008 (2015)

[3] J Peng and S Boscolo, Sci. Rep. (2016), in press

[4] A M Perego, N Tarasov, D V Churkin, S K Turitsyn and K Staliunas, Phys. Rev. Lett. **116**, 028701 (2016)