Dual-Wavelength Noise-Like Pulses in a Passively Mode-Locked Thulium-Doped Fiber Laser

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Mode-locked fiber lasers have been demonstrated as reliable optical sources to achieve solitons formation. Different regimes of soliton generation by means of mode-locked TDFLs at the 2 µm wavelength region have been demonstrated. Thulium-doped fibers lasers based on passive mode-locking techniques constitute a promising platform to manufacture ultrafast optical pulse sources around the eye-safe wavelength range of 2 µm and can generate high-energy optical pulses that have been studied over the past decades, owing to its great advantages of high stability, simple structure and compact size. To achieve passive mode-locking operation in a fiber laser, two types of mode-locked techniques based on artificial saturable absorbers (SAs) have been widely employed. The first approach is the nonlinear switching-based mode locking, including nonlinear polarization rotation (NPR) and nonlinear optical loop mirror (NOLM). Because these techniques either introduce polarization-dependent components or a polarization selection mechanism in the laser cavity, the output pulses usually possess fixed linear polarization. Theoretically, a scalar model is used to describe these output pulses, known as scalar solitons. The other approach is material SA-based mode-locking, where SA devices and materials as diverse as the semiconductor saturable absorber mirror (SESAM), graphene, carbon nanotube (CNT), or novel two-dimensional materials, such as MoS2, and topological insulator are used.

In this paper, we experimentally demonstrate in a simple way switchable single- and dual-wavelength TDFL NLP mode-locking based on an NPR effect in the anomalous dispersion regime. By finely adjusting the polarization controller, the fiber laser can generate either conventional soliton or NLPs, or even hybrid NLP-soliton regimes. When the launched pump power is 2.5 W, a 1.3 MHz, ∼66 nJ conventional soliton centered at 1996 nm is obtained. Further adjustments yield stable squared NLP operation at either 1994 or 2002 nm or synchronous operation at both wavelengths simultaneously.