Erbium-Raman noise-like pulses from a figure-eight fibre laser

O. Pottiez
Centro de Investigaciones en Óptica, Loma del Bosque 115, Col. Lomas del Campestre, Leon, Gto. 37150, Mexico, pottiez@cio.mx, tel +52 477 4414200ext288, fax +52 477 4414209

B. Ibarra-Escamilla, E. A. Kuzin
Instituto Nacional de Astrofísica Óptica y Electrónica, Departamento de Óptica, L. E. Erro 1, Puebla, Pue. 72000 Mexico, baldemar@inaoep.mx, ekuz@inaoep.mx, tel/fax +52 222 2472940

Passively mode-locked fibre lasers are versatile, low-cost sources of pulsed radiation that are attractive for many applications. Although initially developed for the generation of soliton-like fs pulses, these lasers are now also used for the production of longer, strongly chirped pulses with very high energies, in the normal dispersion regime. All-normal-dispersion fibre lasers, which allow producing dissipative solitons with energies up to several tens of nJ and sub-ps durations after dechirping [1], deserve a particular mention.

The noise-like pulses [2-6] constitute a different category of pulses. They are typically observed in long and very long laser cavities, in both anomalous and normal dispersion regimes. Noise-like pulses are ~ns packets of thousands of ultrashort (sub-ps) pulses. Although their global properties (total duration, average bandwidth, etc.) are remarkably stable, their inner details are widely variable, justifying the term of partial mode locking. Although this regime is sometimes viewed as an undesirable operation in fiber lasers, their high energy [4], wide spectrum [3] and low coherence time [2] justify their interest for some applications. Besides, studying noise-like pulses is interesting as it may help understand the mechanisms that destabilize more conventional pulses at high energies in a fiber cavity, eventually leading to their formation [5].

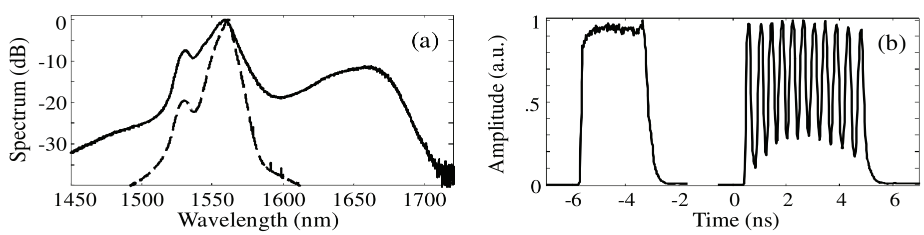

Fig. 1 (a) Two optical spectra and (b) two sampling scope traces of the noise-like pulses for different WR adjustments.

In this work we report on the experimental observation of erbium-Raman dual-wavelength noise-like pulses in an erbium-doped figure-eight fibre laser. The scheme is similar to [6], except that the dispersion compensating fibre (DCF) segment includes 100 m of DCF1 and 55 m of DCF2 (dispersion = -3 and -38 ps/nm/km, respectively). The Nonlinear Optical Loop Mirror (NOLM) is a power-symmetric, polarization-imbalanced device, whose switching characteristic can be tuned through wave retarder (WR) adjustments [7]. The net dispersion is estimated to - 0.58 ps/nm for a total cavity length of ~290 m.

For some WR adjustments, non-self-starting mode locking is observed, and one pulse circulates in the cavity (fundamental mode locking). Its nature of noise-like pulse is evidenced by the wide, smooth optical spectrum and double-scaled autocorrelation (a sub-ps spur on top of a wide pedestal). Besides the signal at 1560 nm, the spectrum also contains a strong Raman component around 1660 nm [Fig. 1(a), solid]. In the time domain, the pulse is several ns long. The shape of its envelope is variable depending on adjustments; in particular, it can appear roughly rectangular or carry a deep, regular amplitude modulation with ~ns period, making it look like a packet of bound pulses [Fig. 1(b)]. WR adjustments also allow removing the Raman peak [Fig. 1(a), dashed], without affecting the noise-like nature of the pulses. This indicates that, contrary to [5], the Raman component cannot be taken as the only responsible for noise-like pulse formation in our setup.

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