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Temporal cavity soliton formation in an anomalous dispersion cavity fiber laser: comment

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A recent paper [J. Opt. Soc. Am. B 31, 3050 (2014)] reports the experimental observation of the generation of stable pulse trains in a ring fiber laser. Contrary to what is stated, the theory published in that paper does not support the claim that the generation mechanism of the pulse train is the cavity-induced modulation instability effect. © 2015 Optical Society of America

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In a recent paper [1], Tang *et al.* describe a fiber ring laser comprising an erbium-doped fiber pumped by a 1480 nm, high-power Raman fiber laser source, a span of standard single mode fiber, a polarization controller (PC), and a polarization-independent isolator. The average cavity dispersion is anomalous and equal to about 2.8 ps/nm/km. By increasing the pump power above 500 mW and suitably adjusting the intracavity PC so that a low net cavity birefringence was obtained, the CW mode of operation of the laser became unstable, and a breakup into a train of optical pulses was observed. Given the 13 m cavity length (65 ns cavity round-trip time), the reported pulse train (see Fig. 7 of [1]) indicates that harmonic mode locking at 370 MHz, or about 24 times the cavity fundamental repetition rate, was obtained. The repetition rates of the pulse train could be varied, depending on the PC waveplates orientation. As the pump power was further increased, significant spectral broadening was observed, and the pulse train was destabilized into an irregular soliton bunch (see Fig. 8 of [1]). On the other hand, for a PC configuration leading to a relatively large cavity birefringence, by increasing the pump power, a breakup of the CW emission into a periodic train of polarization domains with alternating state of polarization was obtained. Moreover, each polarization domain involved a composite structure of subpulse bunches (see Figs. 9 and 10 of [1]).

In order to explain their observed breakup of CW lasing into pulse structures, Tang *et al.* invoke the mechanism of the cavity modulation instability (CMI) effect, which was originally described in [2,3]. In fact, the "Theoretical model" part of Section 2 of [1] derives a cavity-averaged propagation equation (Eq. (8) of [1]), by following the procedure that was outlined in [2]. Note that similar experimental results and conclusions for their interpretation have also been reported by the same group in [4].

However, the laser cavity that was described in [2,3] is fundamentally different from the fiber ring laser presented in [1]. Actually, [2,3] describe a passive fiber ring cavity, coherently pumped by an external CW laser beam. In that situation, the CW field builds up in the cavity (of length L and with linear refractive index n, possibly including an intensity dependent contribution) at the same frequency of the external pump laser, say, ω_0, until a steady intracavity power level is reached. Remarkably, the pump laser frequency ω_0 does not need to exactly match a particular resonance or longitudinal mode of the passive fiber cavity, say, ω_R [2,3]. This leads to a possibly nonzero *cavity detuning* $\delta = (\omega_R - \omega_0)t_R$ between the linear phase delay at the pump laser frequency $\omega_0 t_R = \omega_0 nL/c$ [equal to ϕ in the notation of [1]; see Eq. (2)] and the linear phase delay at a nearby cavity resonance frequency ω_R, namely, $\omega_R t_R = 2m\pi$, with integer m. To the contrary, in a fiber ring laser with no externally injected pump beam, such as the laser that is discussed in [1], the CW field is necessarily locked at a given frequency value, say, ω_L (which coincides with the cavity frequency ω_R, by supposing for simplicity that the resonance frequency of the gain medium $\omega_a = \omega_R$), as is well known from basic laser theory [5,6].

Therefore, the linear phase delay ϕ in the case of the laser described in [1] is a fixed quantity and not a free parameter that can be arbitrarily varied. Indeed, its value is irrelevant since an active fiber laser without a coherently injected pump has a trivial phase rotation symmetry. Indeed, the last term in the left-hand side of Eq. (8) can be trivially eliminated from the equation, which also formally proves that there is no CMI in the laser that is considered in [1].

As far as the possible explanation of the observed self-pulsing behavior, we may suggest the dissipative four-wave mixing effect, which does not rely on modulation instability and which leads to mode locking both in the normal and in the anomalous dispersion regime [7].

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