モード同期全偏波保持ファイバーレーザーの自己始動特性に対する初期条件の影響

Impact of initial conditions on the self-starting property of an all-PM NPR mode-locked fiber laser

東京大学 [1], ○葉 貫宇 [1], 金 磊 [1], 山下 真司 [1], セット ジイヨン [1]

The University of Tokyo [1], ○ Guanyu Ye[1], Lei Jin[1], Shinji Yamashita[1], Sze Y. Set[1]

E-mail: ye@cntp.t.u-tokyo.ac.jp

Ultrashort laser source generated by mode-locked fiber laser has flourished in various fields. The laser mode-locked by all polarization-maintaining nonlinear polarization rotation (all-PM NPR) has gained interest due to the advantages of high damage threshold and alignment-free configuration [1]. But it has the difficulty to self-start. In this paper, we have numerically investigated the influence of different initial conditions on the self-starting probability of an all-PM NPR mode-locked fiber laser.

The schematic model of the stimulated all-PM NPR mode-locked fiber laser is shown in Fig. 1, and the total net dispersion is -0.081 ps^2 at 1550 nm. The coupled-mode nonlinear Schrödinger equations [2] are used and solved by the split-step Fourier method (SSFM). The Gaussian noise with an average power of several nW is used as initial conditions. The splicing angle at fused points A and B is firstly set as 15° and 40° respectively. 40 calculations have been done while the initial condition is different for each calculation. 22 calculations are found to realize steady mode-locking, indicating the self-starting probability of 0.55. Then the splicing angles are set as 25° and 25°, 4 out of 40 calculations have achieved mode-locking, indicating the self-starting probability of 0.1. To make a comparison, a different initial condition is used, which is the sum of a weak pulse and white Gaussian noise. The pulse has a Gaussian profile and a fixed duration of 0.8 ps. The variable is the peak power of the pulse, which varies from 2 nW to 0.02 nW on a logarithmic scale. Table 1 shows the self-starting probability with different initial conditions. The probability has been improved to 1 even though the peak power of the pulse is only around 10% of the average power of the white Gaussian noise. But there is no improvement if the pulse peak power is around 1% of the white Gaussian noise.

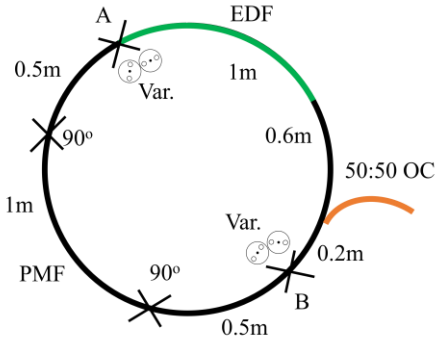

Fig. 1. Schematic model

Splicing angles at A and B / Initial condition	15° and 40°	25° and 25°
White Gaussian noise (nW)	0.55	0.1
2nW pulse + white noise (nW)	1	1
0.2nW pulse + white noise (nW)	1	1
0.02nW pulse + white noise (nW)	Not improved	Not improved

Tab. 1. Self-starting probability with different initial conditions

[1]. J. Szczepanek, et al., Opt. Express. 26(10), 13590-13604 (2018).　[2]. G. P. Agrawal, Nonlinear Fiber Optics, 4th (Elsevier, 2009).