Designing Mamyshev oscillator cavity by particle swarm optimization algorithm

E. Kuprikov[1], A. Perepelov[1], A. Kokhanovskiy[1], I., A. Bednyakova[1,2], S. Turitysin[1,3].
[1]Division of Laser Physics and Innovative Technologies, Novosibirsk State University, Novosibirsk, 630090, Russia
[2]Institute of Computational Technologies SB RAS, Novosibirsk, 630090, Russia
[3]Aston Institute of Photonic Technologies, Aston University, B4 7ET, Birmingham, UK

e-mail evggamgam@gmail.com

***Abstract* — We apply particle swarm algorithm for numerical optimization of a Mamyshev oscillator. We demonstrate that our approach can be used for design of laser configuration with megawatt peak power scale.**

Keywords— Mamyshev oscillator, nonlinear Schrodinger equation, particle swarm optimization,

I. Introduction

Mamyshev oscillator is an attractive source of high-energy ultrashort pulses [1] that can be of interest in various applications including micromachining, metrology, spectroscopy and telecommunication. However, design and operation of this type of a fiber mode-locked laser is a complex scientific and technical problem. The main reason is the nonlinear dynamics of radiation resulting from the intrinsic nonlinearity of some elements of a fiber laser cavity and non-trivial interplay of the key underlying physical effects defining mode-locked regimes.

In this paper, we show how the particle swarm optimization (PSO) algorithm [2] can be used to numerically design the Mamyshev oscillator providing pulses with MW peak power after external compression.

II. Numerical model

The scheme of a Mamyshev oscillator is presented in Fig.1.

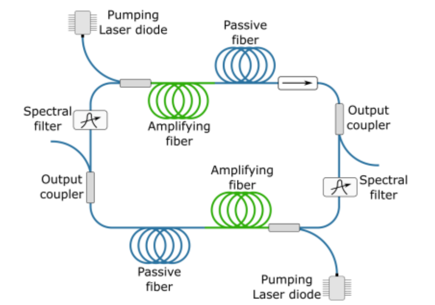

Fig.2. Schematics of the considered Mamyshev oscillator

Numerical modeling of light dynamics in the cavity was based on the nonlinear Schrödinger equation in the fibre spans. Spectral filters were located symmetrically around 1035 nm. As variable parameters to optimize we consider lengths of passive fibre spans in the range of 1–20 m, gain coefficients of the amplifying fibres (1 – 60 nJ), bandwidth of the spectral filters (1 – 10 nm), spectral distance between filters (1 – 20 nm), and the output couplers ratio in the range 0.1 – 0.9.

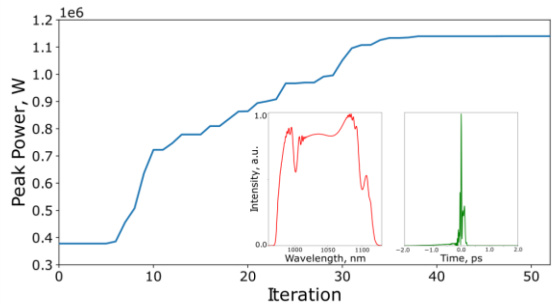

Fig.2. The peak power of the pulse after compression from the iteration of the algorithm and a pulse with an energy of 1.14 MW

The goal for PSO algorithm was to maximize the fitness function which was selected as a peak power of generated pulses after external compression. At the first stage of the algorithm, 80 particles are randomly initialized. Each particle corresponds to a different configuration of the laser resonator parameters. For each configuration, the resonator is calculated, and the formed pulse is estimated using the fitness function. Next, new positions of the particles are determined according to the PSO algorithm, and the procedure is repeated. Algorithm stops when a fitness function value stops changing within the selected accuracy.

III. Results

Figure 2 demonstrates the evolution of the optimal solution found by the PSO algorithm. After 40 iterations of the algorithm the fitness function was saturated. Corresponding pulses have duration 10 ps, energy 88.8 nJ and spectral width (before external compression) of 92.8 nm. After compression pulse has peak power 1.14 MW and duration 184 fs.

[1] Liu Z., Ziegler Z. M., Wright L. G., & Wise F. W, "Megawatt peak power from a Mamyshev oscillator," *Optica*, vol. 4, no. 6, pp. 649-654, 2017.

[2] A. Kokhanovskiy, E. Kuprikov, A. Bednyakova, I. Popkov, S. Smirnov, & S. Turitsyn, "Inverse design of mode-locked fiber laser by particle swarm optimization algorithm," Scientific Reports, vol. 11, no. 1, pp 1-9, 2021

This work was supported by Russian Science Foundation (17-72-30006).

2022 International Conference Laser Optics (ICLO) | 978-1-6654-6664-6/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICLO54117.2022.9840077