Self-starting fiber mode-locked laser assisted with DDQN algorithm

A. Kokhanovskiy[1], K. Serebrennikov[1], A. Shevelev[1], E. Kuprikov[1]
[1]Division of Laser Physics and Innovative Technologies, Novosibirsk State University, Novosibirsk, 630090, Russia

e-mail alexey.kokhanovskiy@gmail.ru

Abstract **— Here, we investigate the performance of Double-Deep Q-learning (DDQL) algorithm for designing self-starting fiber laser. Fiber mode-locked laser based on nonlinear polarization effect was chosen as an experimental platform. We show that the proposed algorithm is capable to learn non-trivial hysteresis dynamics inside the laser in order to achieve stable soliton generation.**

Keywords— mode-locked fiber laser, solitons, machine learning algorithms, reinforcement learning algorithms.

I. INTRODUCTION

Today machine learning algorithms attract significant attention in the field of ultrafast optics. Particularly, implementation of the algorithms allows efficient control and design of mode-locked fiber lasers [1]. Reinforcement learning algorithms [2] are special class of machine learning algorithms that are capable to learn complex dynamics of the controlled system. Therefore, such algorithms are perspective for controlling mode-locked fiber laser for which different types of hysteresis and bifurcation phenomena are essential.

Following work is devoted to implementation of DDQL algorithm to design self-starting fiber mode-locked laser based on nonlinear evolution of polarization.

II. EXPERIMENTAL SETUP

The scheme of fiber mode-locked laser, controlling and measuring systems is presented at Fig.1.

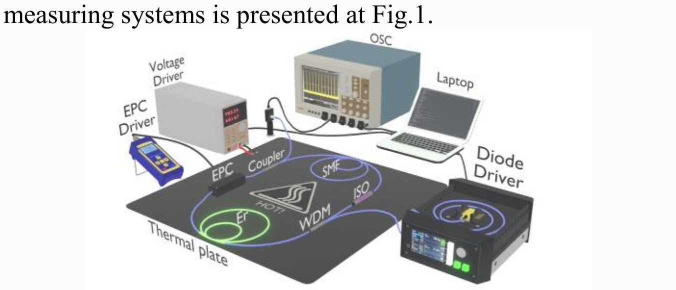

Fig.1. The scheme of experimental setup.

Laser composes stretch of active Erbium fiber, electronically - driven polarization controller (EPC), output coupler, stretch of passive SMF-28 fiber, optical isolator with blocked fast axis.

III. DDQN ALGORITHM

In terms of the DDQL algorithm, the problem is formulated as follows: the laser is an environment where an agent is acting by changing the parameters of the cavity. Fixed parameters of the cavity determine the parameters of the output optical radiation which are denoted as a state of the environment. The goal for the agent is to maximize the reward gained for the appropriate actions. Reward is a function that is designed to have maximum at desired mode-locked regime.

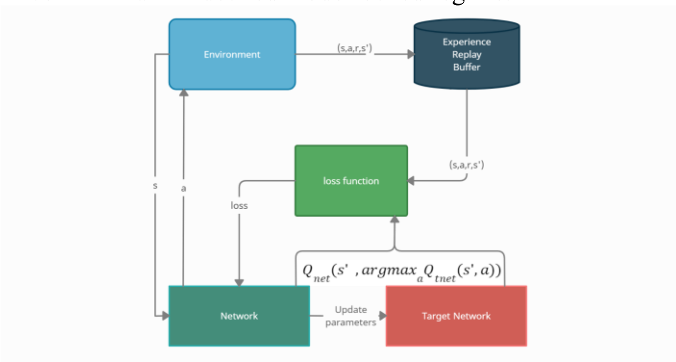

Fig.1. The scheme of DDQN algorithm

IV. RESULTS

Figure 3 demonstrates trajectory of pumping power by the trained DDQL algorithm

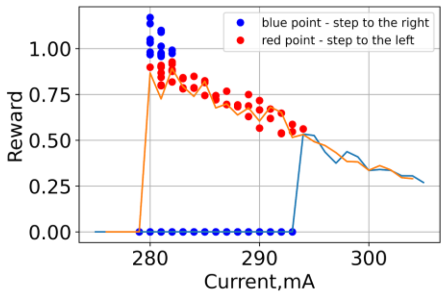

Fig.3. Laser current adjustment by DDQL algorithm.

The algorithm learns the hysteresis phenomena inside the laser cavity which consists in different pumping power thresholds for mode-locked regimes depending on adjusting pumping power trajectory.

[1] Genty, G., Salmela, L., Dudley, J. M., Brunner, D., Kokhanovskiy, A., Kobtsev, S., & Turitsyn, S. K. (2021). Machine learning and applications in ultrafast photonics. Nature Photonics, 15(2), 91-101.

[2] Yan, Q., Deng, Q., Zhang, J., Zhu, Y., Yin, K., Li, T., ... & Jiang, T. (2021). Low-latency deep-reinforcement learning algorithm for ultrafast fiber lasers. Photonics Research, 9(8), 1493-1501.

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/ICLO54117.2022.9839918