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Публікуються результати експериментальних та теоретичних досліджень у галузях фізичної електроніки, фізики плазми, фізики поверхні твердого тіла, емісійної електроніки, криогенної та мікроелектроніки, нанофізики та наноелектроніки, високотемпературної надпровідності, квантової радіофізики, функціональної електроніки, твердотільної електроніки, мобільного зв'язку, медичної радіофізики, методів отримання діагностичної інформації та її комп'ютерної обробки.

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CONTENTS

Bilonozhko V., Gurzhiy K., E. Lukyanetz Investigation of the death of hippocampal neurons under the influence of hypoxia by using a laser scanning confocal microscopy	8
Bychok A., Zorenko O., Hayday Yu. The research of the impedance characteristics of the impatt diodes in avalanche breakdown mode for use them as a solid source of noise in submillimeter range.....	10
Vasylets M., Udachyna A., Gryaznova V. Analysys of university students grading aimed to ECTS grading scale implementation	13
Vladymyrskiy A., Malyshev V., Goriachko A., Moiseienko V., Matviyenko A., Tovstolytkin A. Effect of irregular arrays of metallic nanostructures on transmission characteristics of microwave filters	17
Gnatenko A., Machekhin Yu., Vasko K. Providing control of the polarization inside the resonator fiber ring laser.....	20
Gorbachenko V., Chereda I., Kruchenko J., Lukyanetz E. Measurements of the time parameters of conditioned food reflex in rats under memantin treatment with using of automatic registration system	20
Grygoruk v., Kuzmych R., Oberemok O., Pavlyuk S. Abnormal unsteady heat conduction semiconductor diode structures	23
Dan'ko V., Koval I., Kisil O., Solovyov V. Development of measurement channels for gas analysis systemson modern radio components	26
Zelenyuk M., Susla A., Guyvan H., Slivka A., Kedyulich V. Uniaxial pressure effect on phase transition of Cr ³⁺ -doped TGS crystals	30
Ivanyuta O., Kratko S. Modernization systems of passive disguise.....	32
Ischchuk L., Pavlyuk S., Zubrikova O., Paltsev A. Film thickness determination from ito reflection spectra of infrared radiation.....	34
Karlash A. Luminescent nanocomposites based on nanosilicon in silica aerogel matrix	36
Koronovskyy V. Caused by external electric field the effect of the domain walls positions changes in epitaxial ferrite-garnet films.....	40
Kulyk P., Pavlenko B., Kulyk S., Strunets P., Goriachko A., Melnyk V. Surface properties of Ge(111) and Si(111) after Bi ion implantation.....	43
Kutovy D., Vernydub M., Gryaznov D., Boyko Yu. Reconstruction of database schema from wsdll	46
Maksimenko O., Khizhnyak S., Zaginaylov G. Efficient method for analysis of mode conversion and ohmic losses in terahertz gyrotrons	49
Machulansky A., Babych B. Dielectric-metal composites with dispersed inclusions of copper for microwave range devices	55
Melnyk I. Methodic of simulation of guiding of short-focus electron beam in the equipotential transporting channel of high voltage glow discharge electron guns	57
Miroshnichenko N., Melenevska N., Kulich E., Aslamova L., Miroshnichenko S., Hobta Yu. Research of the transmission coefficients during of the cone-beam tomography.....	62
Miroshnichnko S., Volkov E. Experimental 3D objects stereo x-ray measurement	65
Pidenko S., Kurashov V. Organization of space and ground segments of the transmission system INMARSAT BGAN.....	68

CONTENTS

Reschikoff S.

Basic relations for construction of adaptive system
for low-frequency noise measurement of semiconductor devices.....71

Sidorenko V., Semenets Yu., Skripka S., Gorovenko M., Kravchuk P.

The deeper investigation of subsurface inhomogeneities of dielectric objects
by controlling the local field diagram of the probe of a near-field microwave microscope.....73

Shaternik V., Prokopenko O., Shapovalov A., Suvorov O., Belogolovskii M.,

Novel functionality of josephson junctions with resonance-percolating charge transport.....76

Skarbuta A., Olszewski S.

Abelization procedure for recovering of emission intensities' 3D distributions
for direct flow plasmatron torch from 2D images.....80

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ДОСЛІДЖЕННЯ ФІЗИЧНИХ ВЛАСТИВОСТЕЙ НЕРЕГУЛЯРНИХ МАСИВІВ МАГНІТНИХ НАНОСТРУКТУР

Наведено результати експериментальних досліджень фізичних властивостей нерегулярних масивів магнітних наноструктур та їх впливу на передавальні характеристики мікрохвильових фільтрів на базі плівок ЗІГ. Дослідження проводилися на плівках ЗІГ в шестисантиметровому діапазоні довжин хвиль. Досліджено вплив часткової металізації на форму кривої АЧХ та пропускну здатність плівок утвореної наноструктури. Визначено, яким чином часткова металізація впливає на ширину лінії ФМР та форму кривої АЧХ, що є важливою задачею для побудови НВЧ фільтрів на магнітостатичних хвилях. Результати досліджень перевірялись та аналізувались за допомогою атомної силової мікроскопії.

Ключові слова: спінові хвилі, залізо-ітрієвий гранат, магнітні наноструктури, дипольно-обмінні спінові хвилі, обернення хвильового фронту, НВЧ фільтр.

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ИССЛЕДОВАНИЕ ФИЗИЧЕСКИХ СВОЙСТВ НЕРЕГУЛЯРНЫХ МАССИВОВ МАГНИТНЫХ НАНОСТРУКТУР

Приведены результаты экспериментальных исследований физических свойств нерегулярных массивов магнитных наноструктур и их влияния на передаточные характеристики микроволновых фильтров на базе пленок ЖИГ. Исследования проводились на пленках ЖИГ в шестисантиметровом диапазоне длин волн. Исследовано влияние частичной металлизации на форму кривой АЧХ и пропускную способность пленок образованной наноструктуры. Определено, каким образом частичная металлизация влияет на ширину линии ФМР и форму кривой АЧХ, что является важной задачей для построения СВЧ фильтров на магнитостатических волнах. Результаты исследований проверялись и анализировались с помощью атомной силовой микроскопии.

Ключевые слова: спиновые волны, железо-иттриевый гранат, магнитные наноструктуры, дипольно-обменные спиновые волны, обращение волнового фронта, СВЧ фильтр.

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PROVIDING CONTROL OF THE POLARIZATION INSIDE THE RESONATOR FIBER RING LASER

This paper presents the implementation of the mode-locked fiber laser ring by nonlinear rotation polarization (NPR). This method is implemented using liquid crystal (LC) cells, which control the polarization of laser light by applying them an alternating signal. It was also conducted experiments of interaction of laser radiation (wavelength 1550 nm) from the LC cell. It was built and research diagrams the stability of the polarization in the fiber ring laser.

Key words: fiber laser, liquid crystal cells, femtosecond pulses, control voltage, wave plates, mode locking.

Introduction. At present there is a lot of fiber lasers that operate in the mode-locking. These lasers are used in metrology, spectroscopy, THz generation, micro processing, microscopy and other. Mode locking can be passive and active. The advantage of passive mode locking consists in availability of optical components. Fiber ring laser with passive mode locking can reach the shortest pulse durations – tens femtoseconds. Usually, passive mode locking of fiber lasers is achieved by nonlinear polarization rotation. Therefore, the main task for the creation of such lasers is to improve and implement a new approach to the establishment of mode locking.

Mode locking of laser. Generation of dissipative solitons and comprehensive study of the physics of the process of their formation, preceded the advent of lasers, preceded the appearance of lasers that operate in the mode-locked and generate ultrashort pulses. In a simple laser longitudinal modes propagate independently of one another in the cavity. It looks like a set of independent lasers that operate at different frequencies. The individual phases of the light waves in each mode are not fixed and

may change randomly, is the result of factors such as thermal vibrations of the laser design, mechanical vibration and others. The lasers are supported by only a few oscillating modes, the interference between the modes can cause the effect of beating on their outputs. This leads to random fluctuations of intensity. The lasers, which propagates thousands of modes, these interference effects are generally averaged out to a constant intensity. This mode of operation is called a continuous wave. The electric field of pulsed radiation in which the laser modes are not synchronized, can be written as:

$$E(t) = \sum_{m=1}^N A_m \cos(\omega_0 + m\Delta\omega t + \varphi_m) \quad (1)$$

where φ_m - phase of the laser mode, $\Delta\omega = 2\pi c / 2$ - the distance between modes (for ring resonator), $\Delta\omega = \pi c / 2$ - the distance between modes (for linear resonator). If $\varphi_1 = \varphi_2 = \varphi_N = 0$ and $A_1 = A_2 = A_N = E_0$, the formula that describes the electric field in the mode-locking is written as follows:

$$E(t) = \frac{E_0 \sin(N\Delta\omega t)}{2} \operatorname{cosec}\left(\frac{\Delta\omega t}{2}\right) \cos(\omega_0 t) \quad (2)$$

If each mode will oscillate with a fixed ratio between its phase and the phases of the other modes, the output of the cavity formed by a short pulse of high intensity. Modes laser will periodically interfere with each other, creating a burst of intensity, fig. 1. This type of laser will be called laser mode-locked.

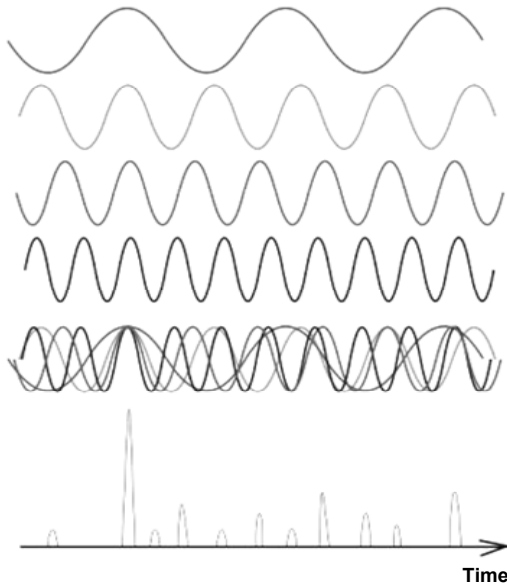


Fig. 1. Interference of longitudinal modes of the laser resonator

Pulse period T will be equal to the period bypass: for a ring resonator $T = Ln/c$, for linear resonator $T = 2Ln/c$, where L - cavity length, n - refractive index of the optical medium, c - speed of light. This time corresponds to the frequency interval between any two adjacent modes $\Delta\nu = 1/T$. The duration of each light pulses is determined by the amount of modes that oscillate with identical phase (but in reality do not always laser modes are synchronized in phase). If N of modes is synchronized with a frequency interval $\Delta\nu$, the total width of synchronized modes corresponds $\Delta\nu N$ and this value is the greater, the shorter the duration of the laser pulse. In practice, the actual pulse width is determined by the shape of each pulse, which in turn is determined by the exact ratio of the amplitude and phase of each longitudinal mode. Limiting the duration of the pulse τ is related to the spectral width ν of the generated radiation (3):

$$\nu\tau \geq k, \quad (3)$$

where k - correction coefficient associated with the pulse shape, for example a Gaussian pulse, $k = 0.441$, and for the pulse-shaped square hyperbolic secant $k = 0.315$.

This section has been described mode locking lasers.

Erbium fiber ring femtosecond laser. Figure 2 depicts diagram of a typical erbium-doped fiber femtosecond laser that operates in the mode-locked by the method of nonlinear polarization rotation.

Nonlinear rotation of the polarization is carried out by rotating the set of wave plates in space.. There are several schemes of erbium-doped fiber femtosecond laser using a different set of plates. Scheme shown in fig. 2 has a big disadvantage - it is the instability of work. Any movement of the fiber, temperature change or switch button pump can lead to loss of mode locking and loss of

generation. As a result, in practice, quarter- and half-wave plates inside the cavity need to be adjusted from time to time, either manually or automatically (e.g., using motorized holders). This is a significant drawback of NPR mode locking, since it requires continuous maintenance (manual plates adjustment) or increases overall laser cost (automatic plates adjustment). Passive mode locking using saturable absorber also require proper adjustment of the polarization inside the cavity to obtain mode-locking [2, 4]. Although, some configurations based on polarization maintaining (PM) fibres were demonstrated [3], high cost of PM optical elements is their significant drawback. However, the output characteristics of these lasers is worse than that of lasers with nonlinear polarization rotation. Therefore, we suggest using the method of nonlinear polarization rotation mode locking without the wave plates. Instead, we propose to apply the liquid crystal cells that are controlled by an electric signal.

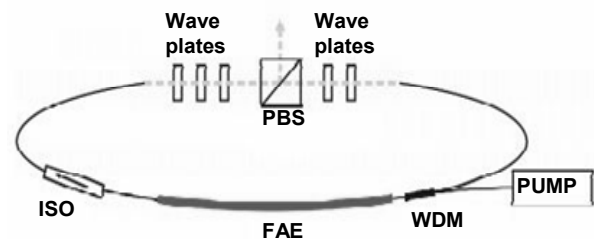


Fig. 2. Scheme of a typical erbium-doped fiber ring femtosecond laser: PBS – polarizing beam splitter; EDF – erbium-doped fiber; WDM – device for input radiation into the resonator; ISO – optical isolator; PUMP – diode pumping at 980 nm

Application of liquid crystal cells in the scheme with nonlinear rotation polarization. Scheme with the liquid crystal cell shown in figure 3.

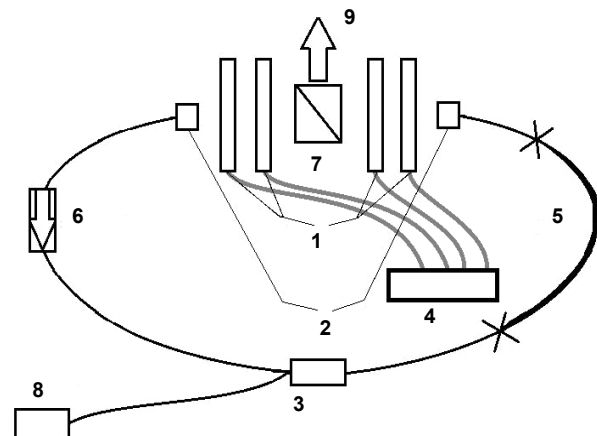


Fig. 3. Scheme fiber laser with LC cells: 1 – LC cells; 2 – collimators; 3 – device for input radiation into the resonator; 4 – control system for LC cells; 5 – one meter of erbium doped fiber.; 6 – optical isolator; 7 – polarizing beam splitter; 8 – diode pumping at 980 nm; 9 – radiation with a wavelength of 1550 nm.

In contrast to the wave plates LC cell are immune to many types of interference. Therefore, using a liquid crystal cells does not require constant adjustment of synchronization modes as is the case with wave plates. Liquid crystal cells operate in the wavelength range 1530–

1560 nm and a manipulated variable signal with a frequency of 1 kHz. The amplitude of the signal is adjusted in the range from 0 to 10 V. When we provide the electric field on the LC cell, it is deformed. That is, it changed at the angle of inclination of the internal elements. Figure 4 shows the variation in the intensity of the transmitted light through the LC cell. That is an effect of polarization rotation. Study transmittance LC cells was performed using the stand shown in Figure 5. By means of this experiment, we verified the proper operation of the cell, i.e. they can rotate the polarization. In our scheme, we use the four LC cells to fine tune the mode locking.

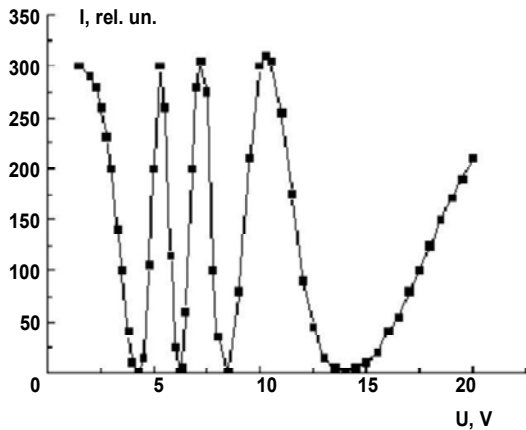


Fig. 4. The light transmittance of the LC cell depending on the applied AC voltage

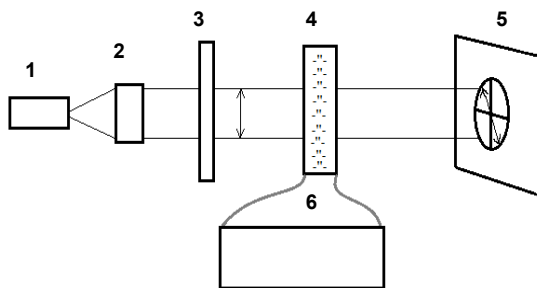


Fig. 5. The stand for investigation of the influence of the LC cell to laser radiation : 1 – source of radiation at a wavelength of 1550 nm; 2 – collimator; 3 – polarizing plate; 4 – LC cell; 5 – recording unit; 6 – control block for LC cell

Diagrams stability. However, studies conducted in the previous section insufficiently. In this section, we present stability diagrams [1] of polarization for the schema of the laser with nonlinear polarization rotation. Figures 6–9 show the area of stability depending on the angles of rotation of polarization at each of the controllers, where $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ – the angles of rotation of the polarization in the first, second, third and fourth polarization controllers. But also in these graphs, you can see the local maximums, this is the best area of stability. They are achieved in a very small range of angles of rotation of the polarization. It is easy to notice that when applying the wave plates, setting mode locking the laser will be carried out with great difficulty and great expense of time.

Therefore, we propose to replace a number of wave plates in the LC cells by which to manage the polarization by an applied electric field to them. The voltage can be changed to several decimal places, provides the best stability polarization for mode locking.

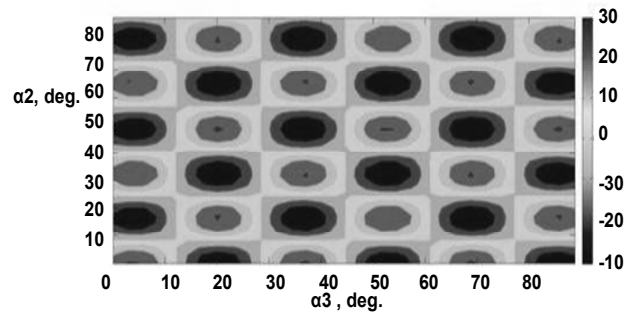


Fig. 6. Diagram stability when $\alpha_1 = \alpha_4 = 0$ deg

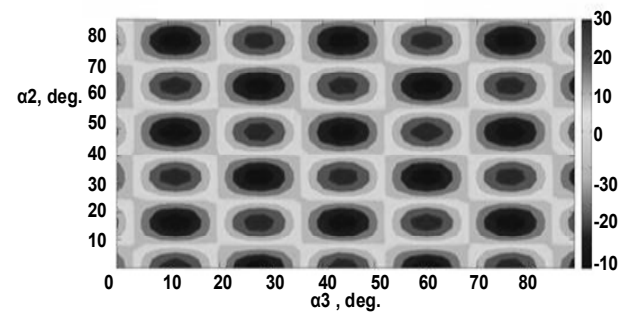


Fig. 7. Diagram stability when $\alpha_1 = 30$ deg, $\alpha_4 = 0$ deg

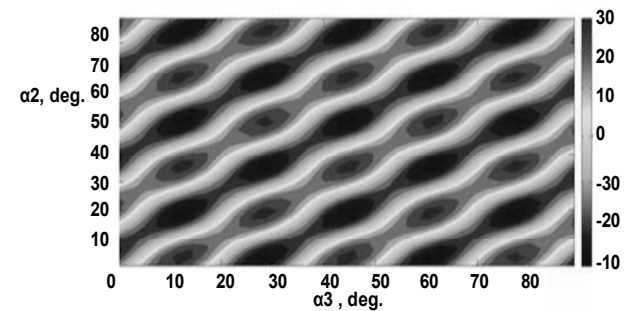


Fig. 8. Diagram stability when $\alpha_1 = 0$ deg, $\alpha_4 = 45$ deg

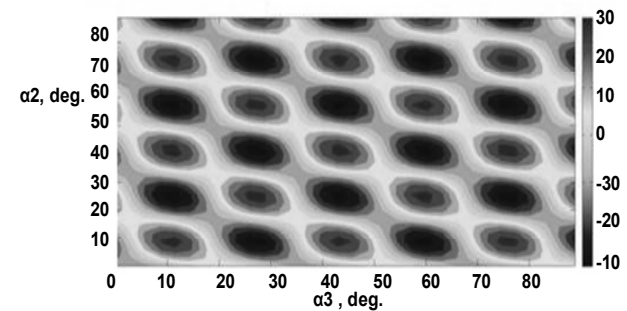


Fig. 9. Diagram stability when $\alpha_1 = 45$ deg, $\alpha_4 = 45$ deg

Conclusions. In this paper we were investigated the LC cell to control the polarization of the laser emission. These results serve to create an annular femtosecond fiber laser with passive mode locking, which is adjusted by applying an electrical signal of the LC cell. It is assumed that such a laser is easy to set up and stable work, regardless of external influences, such as micro-vibration, temperature drift diode pumping or simply pressing the power of the laser. Also, we calculated and analyzed the stability diagram of the polarization. Due to effect of the nonlinear rotation polarization can be achieved to mode lock in a ring fiber laser with a pulse duration of femtosecond order.

Another important point is that the use of LC cells are cheaper than the use of high-precision motorized rotating systems. It is also a great advantage our design before others, that are used in various fields of science and technology, in particular optical information technology, that operate in the telecommunications C-band.

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ЗАБЕЗПЕЧЕННЯ КОНТРОЛЮ ПОЛЯРИЗАЦІЇ ВСЕРЕДИНІ РЕЗОНАТОРА ВОЛОКОННОГО КІЛЬЦЕВОГО ЛАЗЕРА

У цій статті представлена реалізація синхронізації мод кільцевого волоконного лазера методом нелінійного обертання поляризації. Цей метод реалізований за допомогою рідкокристалічних (РК) комірок, які управляють поляризацією лазерного випромінювання шляхом подачі на них змінного сигналу. Також був проведений експеримент по взаємодії лазерного випромінювання (довжиною хвилі 1550 нм) з РК коміркою. Були побудовані та досліджені діаграми стабільності поляризації в волоконному кільцевому лазері.

Ключові слова: волоконний лазер, рідкокристалічні комірки, фемтосекундні імпульси, керування напругою, хвильові пластини, синхронізація мод.

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ОБЕСПЕЧЕНИЕ КОНТРОЛЯ ПОЛЯРИЗАЦИИ ВНУТРИ РЕЗОНАТОРА ВОЛОКОННОГО КОЛЬЦЕВОГО ЛАЗЕРА

В этой статье представлена реализация синхронизации мод кольцевого волоконного лазера методом нелинейного вращения поляризации. Этот метод реализован с помощью жидкокристаллических (ЖК) ячеек, которые управляют поляризацией лазерного излучения путем подачи на них переменного сигнала. Также был проведен эксперимент по взаимодействию лазерного излучения (длиной волны 1550 нм) с ЖК ячейкой. Были построены и исследованы диаграммы стабильности поляризации в волоконном кольцевом лазере.

Ключевые слова: волоконный лазер, жидкокристаллические ячейки, фемтосекундные импульсы, управление напряжением, волновые пластины, синхронизация мод.

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MEASUREMENTS OF THE TIME PARAMETERS OF CONDITIONED FOOD REFLEX IN RATS UNDER MEMANTINE TREATMENT WITH USING OF AUTOMATIC REGISTRATION SYSTEM

Temporal features of motor phenomena of rats in the performance of food operant conditioned reflex obtaining food from feeders to response on a short beep were studied. Using device and software developed by us to register individual components of sensorimotor motor reaction the latent period, motor response time obtaining food, the amount needed for this and other attempts timing were analyzed. These indicators characterize the speed of information processing in the central nervous system and the overall level of excitability and motivation of animals. Temporal characteristics of individual units of sensorimotor responses are informative indicators of the functional state of the central nervous system, able to ensure the effectiveness of its monitoring and correction. The aim of our studies was to determine the effect of the drug memantine on these parameters, which is used in the treatment of Alzheimer's disease. We found that memantine increased the performance of old rats and slowed down their motor responses.

Key words: cognitive abilities, food reflex, rat, photoelectric registration, memantine.

Introduction. Alzheimer's disease (AD) is caused by progressive loss of cognitive abilities and is characterized by the formation of senile plaques of beta-amyloid and neurofibrillary glomeruli in neurons of the brain. AD is a neurological disease that is the most common cause of dementia, it is more than 65% of dementia in the elderly. Alzheimer's disease affects about 4% of people aged 65 to 74 years and more than 30% – over the age of 85 years. Therefore, it is important to study the mechanisms of AD and to develop new effective drugs to treat the disease. With this aim in biomedical research simulation diseases in animals is used, particularly in the study of neurodegenerative diseases to study of changes in the functioning of the central nervous system (CNS) on laboratory animals [1].

The most widely used marker of functional state of the CNS is to assess the characteristics of sensory-motor response (SMR). In most cases, establishment of dynamics or other differences in SMR accomplished through analysis of changes in reaction time (RT). To explain most of the neurophysiologic processes that lead to RT, often the term "latent period" (LP) is used – the time between the start of the stimulus and the occurrence of motor response. Value of LP is due to the implementation of physical-chemical process in the receptor, the passage of nerve impulses along pathways, analytical and synthetic activity in brain structures and operation of muscles. The dependence of speed and accuracy of performance of SMR on stability of attention, anxiety, age, pathological factors was found. In this regard, these are widely used as an objective and

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