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## Cover design

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## Additional design

Stephan Friedman

## Editorial office

Premier Publishing s.r.o. Praha 8 – Karlín, Lyčkovo nám. 508/7, PSČ 18600

## E-mail:

pub@ppublishing.org

## Homepage

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## Section 1. Geology

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*Yarboboev Tulkin Nurboboevich,  
Associate Professor and Doctor of Natural Science of  
Karshi Engineering and Economic Institute*

*Sultanov Shukhrat Adhamovich,  
Senior teacher of Karshi Engineering-Economic Institute*

*Meylieva Kibriyo Oybekovna,  
Student of Karshi Engineering-Economic Institute  
E-mail: Sultonovshuxrat87@gmail.com*

### THE ROLE OF OIL AND GAS SECTORS IN THE SOCIO-ECONOMIC DEVELOPMENT OF SOUTHERN PARTS OF UZBEKISTAN

**Abstract.** The article gives an overview of the role of oil and gas sectors in the socio-economic development of Kashkadarya and Surkhandarya regions of Uzbekistan, as well as the key indicators of oil and gas sectors in the region currently.

**Keywords:** Oil, gas, backup, mining, resource, fuel and energy, hydrocarbon, refining.

The availability of oil and gas resources is a key instrument for any country to solve economic issues and even to reach political goals. In this regard, Uzbekistan is also no exception. After gaining independence in 1991, Uzbekistan sought ways to increase the production of natural resources and expand the consumer market. Today, significant progress has been made in this regard.

Nowadays, Uzbekistan is the second largest oil producer in Central Asia, fourth in the CIS, and 21<sup>st</sup> in the world, and second in the CIS in gas production. Significant changes have been made in the sector as a result of targeted programs and favourable investments implemented in a short period of time. On the basis of implemented structural changes and attraction of foreign investments, gradual implementation of the tasks set by the President of the Republic of Uzbekistan, the oil and gas industry as well

as new productive powers have also been created in geological and geophysical research, construction of deep oil and gas wells, extraction, processing and transportation of hydrocarbons, production capacities [1; 2; 3].

Currently, the primary fuel and energy resources of the Republic of Uzbekistan comprise 97% of oil and gas, 2.3% of coal, and 0.7% of hydropower. One of the largest companies in our country is UzTransGas.

Geological oil reserves – 5 bln. tons. Approved reserves – 100 mln. tons. Geological reserves of natural gas are more than 5 trln. cubic meters, and confirmed reserves – 1.1 trln. m<sup>3</sup>. According to the Center for Economic Research of Uzbekistan (CER), natural gas and coal reserves in Uzbekistan will last for the next 20–30 years, while oil and gas consumption is almost used up. However, it should be noted that in our country, as in other advanced oil and gas producing

countries, there are undiscovered very large deposits, non-traditional oil and gas fields as yet.

The capacity of manufacturing of Uzbekneftegaz is 60–70 billion cubic meters of natural gas a year and 8 mln. tons of liquid hydrocarbons. Uzbekneftegaz is the 11th largest natural gas producer in the world [4; 5].

As a result of exploration work carried out in accordance with the Decree of President Sh. M. Mirziyoyev dated November 3, 2017, PG-3372, it has been discovered 16 oil and gas fields and produced 171 million tons of fuel of underground hydrocarbon reserves for the period of 2017–2018 and 9 months of 2019.

For reference: 16 deposits, 4 in Ustyurt region (Beshkala, Lower Surgil, Kushkair, Oralik), 2 in Fergana region (Uchtepa, Chakar), 10 in Bukhara-Khiva region (Topichaksoy, Marvarid, Shortak, Chordarbaza, Tumaris, Andakli, South Kulbeshkak, Yarmak, Dultatepa, Shorkum).

By the end of 2019 it is planned to increase its hydrocarbon reserves by 53 million tons of fuel, which is currently under exploration in the central part of the Ustyurt region (Alpomish, Ultan, Arslan, etc.), west of the Bukhara-Khiva region (Tumaris, Andakli, South Kulbeshkak, Eastern Xatar and etc), in the southern part of the Fergana region (Uchtepa, Chakar, Lower Kashkarkir3 and others).

In particular, the regions of South Uzbekistan (Kashkadarya and Surkhandarya) differ from other regions in the country in terms of volume, structure, specialization and inclusion of industrial products.

Currently, the region supplies about 1/6 of the country's industrial output. The bulk of these products are oil, natural gas, gas condensate, sulfur, polyethylene, and building materials. These same industries, in particular, fuel products, represent the region's share in the national labor distribution. Most of the existing cities function as district centers, with light industry enterprises such as food processing, cotton cleaning and textile processing. In rural areas, industrial production is concentrated mainly in district centers – cities and towns.

Uzbekistan has a great potential for processing natural gas. In this regard, the Mubarek Gas Processing Plant (GRES) is one of the largest enterprises in the world with annual capacity of \$30 billion cubic meters of gas, the second is Shurtan Refinery. The plant's annual capacity is 20 billion cubic meters of gas. During the years of independence, large-scale projects on deep processing of gas and production of products meeting international standards have been implemented. Major enterprises such as Shurtan Gas Chemical Complex (GKM) and Kandym Gas Processing Complex have been established.

In April 2018, Kandym Gas Processing Complex was commissioned. The gas processing complex was built under the joint project of Uzbekneftegaz and Russian company, Lukoil. The Kandym group includes six gas condensate minefields – Kandym, Kuvachi-Alat, Akkum, Parsankul, Khodji and western Khodji.

Kandym JCC capacity is 8.1 billion cubic meters of gas a year, which produce 213.000 tonnes of stable condensate, 17.500 tonnes of compressed gas and over 191.000 tonnes of sulfur per year.

The project “Creation of synthetic liquid fuels (GTL) based on purified methane from the Shurtan Gas Chemical Complex” reflects advanced technological solutions in the gas and chemical industry. This project is one of the largest mega projects in the CIS.

Implementation of the project at Uzbekneftegaz is an evidence of the rapid development of the industry, along with the importance of ensuring the country's fuel and energy security.

The project will produce 1.5 million tonnes of high quality Euro-5 synthetic fuel by refining 3.6 billion cubic meters of natural gas a year. Of these, 743.000 tonnes of diesel fuel, 311.000 tonnes of jet fuel, 431.000 tonnes of naphtha and 21.000 tonnes of liquefied gas.

The launch of the new plant will allow saving foreign currency by developing real sectors of the economy, further increasing the transit potential of the country, meeting the major demand for oil products and reducing oil imports [8].

It is planned to complete construction and assembly works in the second half of 2020 and create 682 new jobs at the plant.

Based on the instructions of the head of our state, the Concept of Expansion of Production Capacities of Shurtan Gas Chemical Complex was revised and the issue of the involvement of synthetic naphtha in the production process was studied. When the project is launched, the plant's polymer production capacity will be increased from 125.000 to 450.000 tonnes, or 3.6 times. As a result, there will be more opportunities for the development of the petrochemical sector. In the first phase it is planned to process high-grade raw materials synthetic naphtha and produce pyrolysis distillate with new types of polyethylene and polypropylene. Access to pyrolysis distillates for the production of new products will create a technological cluster in the region, which will be an important factor in the further development of the chemical, automotive, pharmaceutical, construction and textile industries.

Uzbekneftgaz and Russian Gazprom are implementing a project to build a petrol station within the geological prospecting in Surkhandarya region. The total volume of investments in the framework of the agreements may reach up to 5.8 billion US dollars [3; 6].

The first phase for 2018–2022 there will be built a gas processing plant with a capacity of 5 billion cubic meters a year. In particular, as part of “the Early Gas” Program, by 2020, up to 1 billion cubic meters of natural gas will be extracted from the 2.800-meter-deep gas layer.

In 2023, another 15 wells will be put into operation, the second turn of the gas processing plant will be launched, which will increase gas production to 5 billion cubic meters per year.

In the second phase, 2023–2025, it will be constructed a gas and chemical complex with the capacity of 500.000 tonnes of polymer products per year through processing 1.5 billion m<sup>3</sup> of gas. After

the project's implementation, a total of 2.200 high-skilled jobs will be created.

Investments in industry of Uzbekistan make up 2704.8 billion sum, of this amount, Kashkadarya accounts for more than 80.0% and Surkhandarya region – 20.0% (2019 y). The analysis of the territorial structure of capital investments is important because it demonstrates which regions and cities of the zone are going to develop in the near future.

At present, the major part of capital investments in Kashkadarya region is spent on identifying and exploiting new oil and gas fields, the construction of industrial enterprises and reconstruction of transport infrastructure which all considered strategically important for our country. Therefore, investments in the region are dominated by oil and gas-rich districts like Mubarek (28.0%), Mirishkor (17.0%), Guzar (12.3%) and Dehkanabad (7.6%) due to the construction of the potash plant. However, Kasbi, Kitab, Chirakchi, Yakkabog, Kamashi and Koson districts accounted for only 9.0% of total investment. In fact, even in these areas there are large undeveloped hydrocarbon deposits.

The internal structure of the industry by the end of 2018 is as follows: fuel industry (by product value) – 75.9%, light industry – 7.4%, food industry – 4.8%, compound feed industry – 2.8%. For comparison: in 2008 these figures were 56.4; 18.1; 9.2; and 2.6 percent. Thus, it is possible to conclude that for the last 10 years, the industrial sector of the region has either intensified the development of production tools or heavy industries. This is also the result of industrialization of the regional economy [9].

Gas condensate in the region is produced by Mubarek Oil and Gas Production Department, Mubarek Gas Processing Plant, Shurtan Oil and Gas Production Department, Shurtan Gas Chemical Complex and Gissarneftgaz LLC (limited liability company). Among them Mubarek Oil and Gas Production Department and Shurtan Oil and Gas Production Department are leaders in oil and natural gas production. About half of liquefied gas is supplied by

Shurtangaz Chemical Complex. Almost 100% of sulfur is supplied by the Mubarek Gas Processing Plant.

There are such plants as Mubarek Oil and Gas Production Department, Mubarek Gas Processing Plant, Shurtan Oil and Gas Production Department and Shurtan Gas Chemical Complex. More than 30 thousand people are working at these enterprises.

More than 2,000 students are currently studying at the Oil and Gas Faculty of the Karshi Engineering-Economic Institute. 16 laboratory services are used for their training. Work is underway to establish new oil and gas labs, and supply qualified specialists for the field [10].

With the launch of a very powerful GTL project, not only diesel and aviation kerosene, but also

export-oriented products like naphtha, polyethylene, polypropylene will be produced. In addition to the creation of about 900 jobs at the plant, it was noted that in the related industries, such as processing, transportation and delivery, it would create 10 times more, which is about 10.000 new jobs.

The above data shows that the oil and gas industry is one of the most important sectors in the economy of Uzbekistan. Uzbekistan has significant potential for industrial development and further economic growth in the country. Completion of current projects and further attraction of foreign investments into new projects will serve as a solid basis for the development of Uzbekistan's fuel and energy complex.

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## Section 2. Mathematics

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*Tozhiev Tokhirjon Halimovich,*

*PhD, Associate Professor*

*E-mail: r\_rasulov51@mail.ru*

*Ibragimov Shavkat Mamirovich,*

*Senior Lecture,*

*Kayumov Akhror Muminovich,*

*teacher*

*Abdullaev Shokhboz Solizhonovich,*

*teacher*

*Solizhonov Zhasur Valerievich,*

*Bachelor*

*Ferghana State University*

### MONTE CARLO METHOD FOR CONSTRUCTING AN UNBELISED ASSESSMENT OF DIFFUSION PROBLEMS

**Abstract.** In this article is used the Monte Carlo method to solve Cauchy problems in a diffusion equation. A Markov chain is constructed with absorption on the trajectory of this chain, an unbiased estimate is constructed for solving problems. Examples of estimates of solution functionals are given and the behavior of their variances is discussed. The resulting integral equation is solved using branched Markov chains with absorption.

**Keywords:** diffusion, Monte Carlo method, approximate solutions, unbiased estimates, algorithm, algorithm efficiency.

**Introduction.** In the research of dynamic systems in computer modeling, Monte Carlo theories and methods are often used to solve linear boundary value problems of mathematical physics. This has been sufficiently researched in [1–9]. Tasks usually come down to solving equivalent integral equations.

Algorithms of the Monte Carlo method for problems with initial conditions have been little researched even in the case of ordinary differen-

tial equations. The only research with examples of Monte Carlo solutions for systems of ordinary differential equations was considered in [5]. In these cases, Monte Carlo methods may be more efficient than classical computational methods. If we keep in mind that the application of the Monte Carlo method, which has been shown to be effective in multidimensional problems, the development of numerical integration methods in a system with many noise is very relevant.

**Statement of the problem.** Consider the Cauchy problem in the classical formulation in  $(n + 1)$  – dimensional space  $R^{n+1}$  in a layer  $\Omega = R^n \times [O, T]$ :

$$(L_1 u)(x, t) = \frac{\partial u(x, t)}{\partial t} - \sum_{j=1}^k a^{ij} \frac{\partial^2 u(x, t)}{\partial x^i \partial x^j} + \sum_{j=1}^k \sum_{m=1}^l \beta_j^m x^j \frac{\partial u(x, t)}{\partial x^m} = f(x, t), \quad (1)$$

$$u(x, 0) = \phi(x), \quad x \in R^n, \quad (2)$$

where  $\alpha^{ij}$  и  $\beta_j^m$  ( $i = 1, 2, \dots, k, j = 1, 2, \dots, k, m = 1, 2, \dots, l$ ) are constant coefficients,  $n = k + l$ . Let  $\alpha = (\alpha^{ij})$  is a matrix with dimension  $k \times k$ ,  $\beta = (\beta_j^m)$  is a matrix with dimension  $l \times k$ .

Further suppose that: 1.  $\alpha = (\alpha^{ij})$  – is a symmetric matrix and is positive definite. 2.  $\beta = (\beta_j^m)$  a matrix such that the Gram matrix ( $\omega = (\beta \alpha \beta^T)^{-1}$ ) with dimension  $l \times l$  is positive definite, i.e. she is non-degenerate.

The functions  $f(x, t)$  and  $\phi(x)$  will be considered continuous in  $R^n$ . Under the assumption of the existence and uniqueness of the solution of problems

$$Z(x, t; y, \tau) = \pi^{-\frac{n}{2}} \|a\|^{\frac{1}{2}} (t - \tau)^{-\frac{\gamma}{2}} \exp \left\{ -(y - Cx)^T d \left( \frac{1}{t - \tau} \right) a d \left( \frac{1}{t - \tau} \right) (y - Cx) \right\} \quad (3)$$

where  $\|a\| = \det(a)$ ,  $\gamma = k + 3l$ . Using the fundamental solution  $Z(x, t; y, \tau)$  in space  $R^{n+1}$ , we define areas (sharoid) as follows. Let the number (parameter) be positive, i.e.  $r > 0$ . Further area

$$B_r(x, t) = \left\{ (y, \tau) : (y - Cx)^T d \left( \frac{1}{t - \tau} \right) a d \left( \frac{1}{t - \tau} \right) (y - Cx) \leq \frac{\gamma}{2} \ln \frac{r^2}{t - \tau}, t > \tau \right\} \quad (4)$$

From (4) it is seen that  $\tau$  satisfies the following conditions:  $\tau < t, \tau > t - r^2$ . Each section of a spheroid with a horizontal plane  $\tau = const, t - r^2 < const < t$ , is an  $n$ -dimensional ellipsoid centered at a point  $e^{-(t-\tau)\beta} x, \tau$ . If  $r \rightarrow 0$ , then  $B_p(x, t) \subset B_r(x, t)$ . When  $B_r(x, t)$  and  $\partial B_r(x, t)$  monotonously contracted

$$(E_r, u)(x, t) = \left( \frac{\gamma}{\pi} \right)^{\frac{n}{2}} \int_0^1 \lambda^{\gamma-1} \left( \ln \left( \frac{1}{\lambda} \right) \right)^{\frac{n}{2}} \int_{s_1(0)} \int u(y(\lambda, \theta), \tau(\lambda)) H^T(\theta) 4b\alpha b^T H(\theta) ds d\lambda,$$

(1) – (2), we construct an algorithm for its numerical implementation.

To simplify the solutions of the problem, we introduce (in block notation) the following matrices

$$n \times n \text{ as } a = a(s) = \begin{pmatrix} m_1 m_2 \\ m_2^T m_3 \end{pmatrix}, \quad q = q(s) = a^{-1}(s),$$

$$C(s) = \begin{pmatrix} I_k & 0 \\ -s\beta_l & I_l \end{pmatrix} = \exp \begin{pmatrix} 0 & 0 \\ -s\beta & 0 \end{pmatrix},$$

$$d(\rho) = \begin{pmatrix} \rho^{1/2} I_k & 0 \\ 0 & \rho^{3/2} I_l \end{pmatrix}.$$

Here,  $m_1 = \frac{1}{4s} [\alpha^{-1} + 3\beta^T \omega \beta]$  is  $k \times k$  dimensional block,  $m_2 = \frac{3}{2s^2} \beta^T \omega$  a block with a size  $k \times l$ ,  $m_2^T$  a block with a size  $l \times k$ ,  $m_3 = \frac{3}{s^3} \omega$  a block with a size  $l \times l$ , matrices  $I_k, \omega, \beta, I_l$  also have similar dimensions. Here in after,  $I_r$  is the identity matrix with a size  $r \times r$ ,  $d(\rho)$  is the diagonal matrix,  $s = t - \tau$ .

The matrices  $a(s)$  and  $q(s)$  for  $s > 0$  are positive definite. Then the fundamental solution of equation (1) with a singularity at a point  $(y, \tau)$  has the form

$$B_r(x, t) = \left\{ (y, \tau) : Z(x, t; y, \tau) > \pi^{-\frac{n}{2}} \|a\|^{\frac{1}{2}} r^{-\gamma}, t > \tau \right\}$$

will be called a sharoid with radius  $r$  whose center is located at a point  $(x, t)$ . Then  $B_r(x, t)$  it can be rewritten as

toward the center  $(x, t)$ . Therefore, there is  $r > 0$  such that  $(x, t) \in \Omega \quad \overline{B_r(x, t)} \subset \overline{\Omega}$ .

Let  $r > 0$  such that  $B_r(x, t) \subset \overline{\Omega}$ . Then, to solve problem (1) – (2), the following relation holds:

$$u(x, t) = (E_r, u)(x, t) + \bar{f}(x, t), \quad (5)$$

where



$$\bar{f}(x,t) = \int_{B_r(x,t)} \int \left[ Z(x,t;y,\tau) - \pi^{-\frac{n}{2}} \|a\|^{\frac{1}{2}} r^{-\gamma} \right] f(y,\tau) dy d\tau.$$

Here  $S_1(0)$  is the  $(n-1)$  - dimensional unit sphere with the usual orthogonal coordinates:  $\theta = (\theta_2, \theta_3, \dots, \theta_n)$ ,  $0 \leq \theta_j \leq \pi$ , for  $2 \leq j \leq n-1$ ,  $0 \leq \theta_n \leq 2\pi$ .  $H(\theta) \in S_1(0)$  is unit  $n$  - dimensional vector

$$y(\lambda, \theta) = e^{-r^2 \lambda^2 \beta} x + \left( \gamma \ln \left( \frac{1}{\lambda} \right) \right)^{\frac{1}{2}} d(r^2 \lambda^2) b^{-1} H(\theta), \quad (6)$$

$$\tau(\lambda) = t - r^2 \lambda^2$$

It follows from (6) that if  $r(x,t) \leq t^{\frac{1}{2}}$ , then when  $(x,t) \in \Omega$  we have  $\bar{B}_r(x,t) \subset \bar{\Omega}$ .

We proceed to the construction of a Markov chain  $\{(x^j, t^j)\}_{j=0}^{\infty}$  on which we will construct an un-

$$(E_r u)(x,t) = \int_0^{\infty} P_1(\rho) d\rho \int_{S_1(0)} P_2(H) u \left( y \left( e^{-\frac{\rho}{\gamma}}, \theta \right), \tau \left( e^{-\frac{\rho}{\gamma}} \right) \right) dS$$

where  $P_1(\rho)$  is the density of the gamma-distributed random variable with the parameter  $1 + \frac{n}{2}$ , ...

$$P_2(H) = \frac{H^T 4b\alpha b^T H}{\gamma \sigma_n}.$$

In what follows, we will model a random vector with a distribution density

$$P_2(H) = P_2(H_1, H_2, \dots, H_n) = -\frac{1}{\gamma \sigma_n} \sum_{ij=1}^n K_{ij} H_i H_j \chi_{S_1(0)}(H) \quad (7)$$

where  $\chi_{S_1(0)}(H)$  is the indicator of the set  $S_1(0)$ ,  $\sigma_n$  is the surface of the unit sphere,  $K_{ij}$  are the elements of  $n \times n$  dimensional matrix  $K = 4bab^T$ . Since  $H_1, H_2, \dots, H_n$  are the coordinates of the unit vector,  $H_1^2 + H_2^2 + \dots + H_n^2 = 1$  we get that  $H^T K H \leq \mu_1$ , where  $\mu_1$  is the largest eigenvalue of the matrix  $K$ . Then we

biased estimate of the solution  $u(x,t)$  to problem (1) - (2).

For  $u(x,t) = 1$ , applying formula (5) we get

$$\left( \frac{\gamma}{\pi} \right)^{\frac{n}{2}} \int_0^1 \lambda^{\gamma-1} \left( \ln \left( \frac{1}{\lambda} \right) \right)^{\frac{n}{2}} d\lambda \int_{S_1(0)} H^T(\theta) 4b\alpha b^T H(\theta) ds = 1$$

It follows that the core of integral equation (5) can be considered as the distribution density. Consider the integral

$$J = \int_0^1 \lambda^{\gamma-1} \left( \ln \left( \frac{1}{\lambda} \right) \right)^{\frac{n}{2}} d\lambda.$$

Making a change of variables  $\lambda = e^{-\frac{\rho}{\gamma}}$ , we get

$$J = \frac{1}{\gamma^{\left(1+\frac{n}{2}\right)}} \int_0^{\infty} e^{-\rho} \rho^{\frac{n}{2}} d\rho = \frac{\Gamma\left(1+\frac{n}{2}\right)}{\gamma^{\left(1+\frac{n}{2}\right)}}$$

where  $\Gamma(n)$  is the gamma function. Now we can imagine  $(E_r u)(x,t)$  as follows

can model a random vector with a distribution density (7) by the Neumann method.

Below is shown the algorithm of modeling.

**Algorithm:** 1. An isotropic vector  $\omega = (\omega_1, \omega_2, \dots, \omega_n)$  and  $\gamma_2$  a random variable distributed uniformly in  $(0,1)$  are modeled. 2.  $E = \mu_1 \gamma_1$ . 3. If

$$\frac{\left( \sum_{ij=1}^n K_{ij} \omega_i \omega_j \right)}{\gamma} \geq E, \text{ then } \omega \text{ is accepted, otherwise}$$

paragraph (1) is repeated.

Let  $\{\xi_j\}_{j=1}^{\infty}$  is a sequence of independent gamma distributed random variables with a parameter  $\left(1 + \frac{n}{2}\right)$ ,  $\{\omega^j\}_{j=1}^{\infty}$  is a sequence of independent vectors with a distribution density  $P_2(H)$ . Now we define the Markov chain in  $\Omega$  the following recurrence relations:

$$x^0 = x, t^0 = t, t^j = t^{j-1} - \exp\left(\frac{-2\xi_j}{\gamma}\right), x_i^j = x_i^{j-1} + t_{j-1} \exp\left(-\frac{\xi_j}{\gamma}\right) \xi_j^{\frac{1}{2}} \sum_{m=1}^n b_{im} \omega_m^j,$$

$$x_{k+p}^j = x_{k+p}^{j-1} - t_{j-1} \exp\left(-\frac{2\xi_j}{\gamma}\right) \sum_{c=1}^k \beta_{pc} x_c^j + t_{j-1}^{\frac{3}{2}} \exp\left(-\frac{3\xi_j}{\gamma}\right) \xi_j^{\frac{1}{2}} \sum_{v=1}^n b_{k+p,v} \omega_v^j, \quad (8)$$

where  $i = 1, 2, \dots, k$ ,  $p = 1, 2, \dots, l$ ,  $j = 1, 2, \dots$ ,

$r(x^{j-1}, t^{j-1}) = (t_{j-1})^{\frac{1}{2}}$  and relation (8) is obtained from (6). Now (5) we can write in the form

$$u(x^{j-1}, t^{j-1}) = E_{(x^{j-1}, t^{j-1})} u(x^j, t^j) + \bar{f}(x^{j-1}, t^{j-1}). \quad (9)$$

We define a sequence of random variables  $\{\eta_l\}_{l=0}^\infty$  by the following equality,

$$\eta_l = \sum_{j=1}^{l-1} h(x^j, t^j) f(y^j, \tau^j) + u(x^l, t^l), \quad (10)$$

where  $(y^j, \tau^j)$  is a random point of a sharoid  $B_r(x, t)$  at fixed  $(x^j, t^j)$ , having a distribution density in it as

$$\frac{\left[ Z(x^j, t^j; y, \tau) - \pi^{-\frac{n}{2}} \|a\|^{\frac{1}{2}} r^{-\gamma} \right]}{h(x^j, t^j)},$$

where  $h(x, t) = \iint_{B_r(x, t)} \left[ Z(x, t; y, \tau) - \pi^{-\frac{n}{2}} \|a\|^{\frac{1}{2}} r^{-\gamma} \right] dy d\tau$ .

Assuming that  $u(x, t) = t$  and applying formula (9) for  $j = 1$  from (8) we get

$$h(x, t) = r^2(x, t) (\gamma / (\gamma + 2))^{\left(1 + \frac{n}{2}\right)}. \quad (11)$$

Let  $\{\mathfrak{S}_l\}_{l=0}^\infty$  is a sequence of  $\sigma$  algebras generated by random variables  $\xi_1, \xi_2, \dots, \xi_l$  and a sequence of vectors  $\omega^0, \omega^1, \dots, \omega^l$  and random points  $(y^0, \tau^0), (y^1, \tau^1), \dots, (y^{l-1}, \tau^{l-1})$ . We denote the solutions to problem (1) – (2) corresponding to those given  $f, \varphi$  as  $u_{f, \varphi}(x, t)$ .

$$y(\xi, \zeta, \omega) = e^{-r^2 \exp\left(-\frac{2\xi}{\gamma+2}\right) \zeta^{\frac{2}{\gamma}}} \beta x + \left(\frac{\gamma}{\gamma+2} \xi\right)^{\frac{1}{2}} \alpha \left( r^2 \exp\left(-\frac{2\xi}{\gamma+2}\right) \zeta^{\frac{2}{\gamma}} b^{-1} \omega \right), \quad (12)$$

$$\tau(\xi, \zeta) = t - \exp\left(-\frac{2\xi}{\gamma+2}\right) \zeta^{2/\gamma}.$$

Here  $\xi$  is gamma when a distributed random variable with a parameter  $r\left(\frac{n}{2}\right)$ ,  $\zeta$  is beta distributed random variable with a parameter  $\left(\frac{2}{\gamma}, 2\right)$ ,  $\omega$  is a random unit vector.

**Theorem 1.** a) the sequence  $\{\eta_l\}_{l=0}^\infty$  forms a martingale with respect to the sequence of  $\sigma$  – algebras  $\{\mathfrak{S}_l\}_{l=0}^\infty$ ; b) if  $u_{f,0}(x, t) < +\infty$  and  $u_{|\varphi|,0}(x, t) < +\infty$ , then  $\eta_l$  it is quadratically integrable.

**Proof:** First, we prove that  $\{\eta_l\}_{l=0}^\infty$  it forms a martingale. From the definition  $\mathfrak{S}_l$  it is clear that  $\eta_l$  is measurable  $\mathfrak{S}_l$ , in then using the conditional expectation property and formulas (9, 11) we get

$$E_{(x,t)}[\eta_{l+1} / \zeta_l] = \sum_{j=0}^{l-1} h(x^j, t^j) f(y^j, \tau^j) + u(x^l, t^l) = \eta_l$$

It follows that  $\{\eta_l\}_{l=0}^\infty$  it forms a martingale relatively  $\{\mathfrak{S}_l\}_{l=0}^\infty$ . Let us prove that  $E_{(x,t)} \eta_l^2 \leq \infty$ . It is enough to show that

$$I = E_{(x,t)} \left( \sum_{j=0}^{l-1} h(x^j, t^j) f(y^j, \tau^j) \right)^2 < +\infty$$

Dividing  $I$  into two terms  $r^2(x, t) \leq t$ , we obtain from the final condition that  $h(x, t) \leq \left(\frac{\gamma}{\gamma+2}\right)^{1+n/2} t$ , this implies the proof of the theorem.

Now we show one of the methods for estimating a random node of a quantity

$$\bar{f}(x, t) = \iint_{B_r(x, t)} \left[ z(x, t; y, \tau) - \pi^{-\frac{n}{2}} \|a\|^{\frac{1}{2}} r^{-\gamma} \right] f(y, \tau) dy d\tau.$$

**Lemma 1.** For the function  $\bar{f}(x, t)$ , the relation

$$\bar{f}(x, t) = \left(\frac{\gamma}{\gamma+2}\right)^{\left(1 + \frac{n}{2}\right)} r^2 E f(y(\xi, \zeta, \omega), \tau(\xi, \zeta)),$$

where

$$B_r = \{(y, \tau) : y^T a(1/\tau) a d(1/\tau) y < \gamma / 2 \ln r^{2/\tau}, \tau > 0\},$$

The resulting mirror image of the spheroids  $B_r(o, o)$  relative to the plane  $\tau = 0$ . These areas will also be called sharoides (radius  $r$ ). Then we have

$$f(x, t) = \frac{\|a\|^{1/2}}{\pi^{n/2} r^\gamma} \iint_{B_r} \left[ r^\gamma \tau^{\gamma/2} \exp(-y^T d(1/\tau) a d(1/\tau) y) - 1 \right] \times$$

$$\times f(e^{-\tau\beta} x + y, t - \tau) dy d\tau$$

We make a change of variables and some integral transformation and obtain the proof of Lemma 1.

Consider the question of the computational realizability of estimate (10). Take  $\varepsilon$  small enough and consider  $(\partial\Omega)_\varepsilon = (R^n * [0, \varepsilon])$ . Let

$N_\varepsilon = \min\{l : (x^l, t^l) \in (\partial\Omega)_\varepsilon\}$  be the moment of the first hit of the process  $(x^l, t^l)$  in  $(\partial\Omega)_\varepsilon$ , i.e.  $N_\varepsilon$  is the moment the process stops (Markov moment).

**Lemma 2.** There is an inequality:

$$E_{(x,t)} N_\varepsilon \leq \left(\frac{\gamma + 2}{\gamma}\right)^{1+n/2} \frac{t}{\varepsilon}.$$

**Proof.** Having taken  $u(x, t) = t$  and applying formulas (10) and (11) we get

$$\begin{aligned} t = U_{1,0}(x, t) &\geq E_{(x,t)} \sum_{j=1}^{N_\varepsilon-1} h(x^j, t^j) = \\ &= \left(\frac{\gamma}{\gamma + 2}\right) E_{(x,t)} \sum_{j=1}^{N_\varepsilon-1} r^2(x^j, t^j) \end{aligned}$$

It follows  $r(x, t)$  from the definition that  $r^2(x^j, t^j) = \{t^j\} \geq \varepsilon$ . Hence we get that

$$t \geq \left(\frac{\gamma}{\gamma + 2}\right)^{1+n/2} \varepsilon E_{(x,t)} N_\varepsilon. \quad \text{Consequently}$$

$$E_{(x,t)} N_\varepsilon \leq \left(\frac{\gamma + 2}{\gamma}\right)^{1+n/2} \frac{t}{\varepsilon}. \quad \text{The lemma is proved.}$$

**Theorem 2.** Let the conditions of Theorem 1 be satisfied. Then  $\eta_{N_\varepsilon}$  is an unbiased estimate for  $u(x, t)$ . Its dispersion is finite.

**Proof.** It follows from Theorem 1 that  $\eta_i$  it is quadratically integrable and hence it is uniformly integrable and  $N_\varepsilon < +\infty$ . Further, the moment the process is stopped is a Markov moment. Therefore, according to the Doob theorem “On the transformation of free choice” [2] and formula (9)  $E\eta_{N_\varepsilon} = E\eta_i = u(x, t)$  i.e.  $\eta_{N_\varepsilon}$  is an unbiased estimate for  $u(x, t)$ . From  $\eta_{N_\varepsilon}$  and  $\eta_\infty$  the definition of random variables it can be seen that  $D\eta_{N_\varepsilon} \leq D\eta_\infty$ . From  $\eta_{N_\varepsilon}$  with the standard method, a mixed, but practically realizable estimate  $\eta_{N_\varepsilon}^*$ . Let  $\varphi_1(x, 0) = \phi(x)$   $x \in R^n$  and  $(x, t^*)$  be the point  $\partial\Omega$  closest to  $(x, t)$ . In the assessment

$$\begin{aligned} \eta_{N_\varepsilon} &= \sum_{j=0}^{N_\varepsilon-1} h(x^j, t^j) f(y^j, \tau^j) + u(x^{N_\varepsilon}, t^{N_\varepsilon}) \quad \text{replace} \\ u(x, t^{N_\varepsilon}) &\text{ and } u(x, t^{*N_\varepsilon}) \text{ with get} \\ \eta_{N_\varepsilon}^* &= \sum_{j=0}^{N_\varepsilon-1} h(x^j, t^j) f(y^j, \tau^j) + \varphi_1(x, t^{*N_\varepsilon}) \end{aligned}$$

**Theorem 3.** Let  $u(x, t)$  the Lipschitz condition and  $A(\varepsilon)$  the modulus of continuity be satisfied. Then the random variable is a biased estimate for  $u(x, t)$ .  $D\eta_{N_\varepsilon}^*$  is limited parameter  $\varepsilon$  function.

**Proof:** Since  $E_{(x,t)} \eta_{N_\varepsilon} = u(x, t)$  then

$$\begin{aligned} |u(x, t) - E_{(x,t)} \eta_{N_\varepsilon}^*| &= |E_{(x,t)} \eta_{N_\varepsilon} - E_{(x,t)} \eta_{N_\varepsilon}^*| = \\ &= |E_{(x,t)} u(x, t^{N_\varepsilon}) - E_{(x,t)} \varphi_1(x, t^{*N_\varepsilon})| \leq E_{(x,t)} |u(x, t^{N_\varepsilon}) - \\ &- u(x, t^{*N_\varepsilon})| = A(\varepsilon) \end{aligned}$$

The theorem is proved.

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Rui Yang,  
Emory University  
E-mail: yr159123@hotmail.com

## AMERICANS' WORRY ABOUT FINANCING RETIREMENT: COMPARING THREE PREDICTIVE MODELS

**Abstract.** This paper aims to build a predictive model about Americans' financial worry over retirement on the basis of demographic factors and subjective financial, physical, and mental health conditions. In this paper, a cross-sectional nationally representative data set based on the National Health Interview Survey 2018 was used. Missing values in the data set were first indicated by dummies features and then replaced using mean value imputation. Three machine learning models, random forest, logistic regression, and multilayer perceptron, were built, and their respective performances were compared. As a result, all three algorithms reported fairly similar results with approximately 0.9 true positive rate (TPR), 0.3 false positive rate (FPR), and 0.88 area under curve (AUC). We also found that financial condition is the most important factor relating to people's financial worry. As a result, policy-makers should put more weight on this factor when designing specific policies or deciding an individual's eligibility to receive necessary assistance.

**Keywords:** retirement, financial worry, random forest, logistic regression, multilayer perceptron

Despite recent rebounds in the economy, Americans today have become increasingly worried about financing their retirement since the Great Recession. A survey conducted by the Pew Research Center in 2012 has shown that people's worry about retirement finances has been on the rise recently, compared to 25% in 2009, about 38% adults expressed they are "not too" or "not at all" confident that they have enough money to support their retirement plans (Morin & Fry [18]). The same research has also shown that the proportion of people worry about financing their retirement varies greatly among different age groups and income groups, with the mid-age and mid to low-income level individuals being most worried.

While the subject of financial preparation for retirement has been extensively explored, most research has only focused on how different factors are associated with people's financial anxiety. Research by Owen and Wu in 2007 established the relationship between psychological factors as well as mari-

tal status and people's degree of concern about the adequacy of their retirement plans. The result of their study showed that compared to other groups, singles and those who have experienced negative financial shocks worry more about financing retirement. In 2004, Morgan and Eckert found that age, health, and income are significant predictors of financial preparation and anxiety.

Almost all of these studies, however, were done on the macro-level. There is a noticeable lack of studies that actually connect factors, such as age or marital status, to build a model that gives predictions on an individual level. This paper aims to fill this gap through developing, validating, and comparing several models based on these factors, and, at the same time, find the most significant predictor relating to people's financial worry after retirement. A more accurate predictive model might help policymakers to tailor specific policies on the micro-level to address such worries more effectively.

## Method

### Data Set Description

The National Health Interview Survey (hereinafter referred to as NHIS) is a nationally representative cross-sectional household study which monitors trends of illness and the progress of current health objectives. The survey was initiated in 1957 by Centers for Disease Control and Prevention and has been conducted annually since then with an approximate 70% response rate (National Center for Health Statistics, [9]). Data from the survey conducted in

2018 was used in this analysis, which had a response rate of 83.9%, with 25,417 completed surveys out of 30,297 eligible adults (NHIS2018 Survey Description [11]). The dataset from the 2018 NHIS (NHIS2018 Sample Adult File [11]) was used to identify potential associations of financial worry after retirement among U.S. adults with factors including demographic features, health condition, smoking behavior, sleeping habits, and mental condition.

A list of 28 different indicator features used in the model can be found in (Table 1).

Table 1.– Description of the 28 Features

<b>Groups</b>	<b>Code</b>	<b>Description</b>
<b>1</b>	<b>2</b>	<b>3</b>
<b>Other</b>		
	SEX	Sex
	REGION	Region
	RACERPI2	Race group
	AGE_P	Age
	R_MARITL	Marital status
<b>Employment</b>		
	YRSWRKPA	Number of years on the job
	WRKLYR4	Whether have a job or business at any time in the past 12 months
<b>Health</b>		
	HYPEV	Ever been told having hypertension
	CHDEV	Ever been told having coronary heart disease
	CANEV	Ever been told having cancer
	LIVEV	Ever been told having chronic liver condition
	AMIGR	Had severe headache/migraine in the past 3 months
	AINLIL2W	Had stomach problem with vomit/diarrhea in the past 2 weeks
	DIBEV1	Ever been told having diabetes
	ARTH1	Ever been told having arthritis
<b>Smoking</b>		
	SMKSTAT2	Had smoked at least 100 cigarettes
<b>Financial</b>		
	ASISTLV	How worried about not being able to maintain the standard of living
	ASINBILL	... pay monthly bills
	ASIHCS	... pay rent/mortgage/housing costs
	ASICCMP	... make credit card payments
	ASICNHC	... afford medical costs of healthcare

<b>1</b>	<b>2</b>	<b>3</b>
<b>Mental</b>		
	ASISLEEP	Hours of sleep on average
	ASISLPFL	Number of times having trouble falling asleep in the past week
	ASISAD	How often did you feel so sad that nothing cheers you up in the past month
	ASINERV	How often did you nervous in the past month
	ASIRSTLS	How often did you restless in the past month
	ASIHOPLS	How often did you hopeless in the past month
	ASIWTHLS	How often did you worthless in the past month

### Data Pre-processing

#### Recodin

Currently, the U.S. full retirement age is 66 years and 2 months (U. S. Social Security Administration [19]). For the purpose of this study, sample points with an age greater than 67 years were excluded from the data set. The final sample size is  $N = 19,090$ . The outcome variable is coded as “ASIRETR”, corresponding to the question in the survey “How worried are you right now about not having enough money for retirement?” The effective responses consist of four levels, indicating the respondents are “very,” “moderately,” “not too,” or “not” worried about their financial condition after retirement. Then this variable was recoded into a binary variable where the first three levels were combined and coded as 1, while the last level was coded as 0. In this way, one indicates a respondent has financial worry over retirement while zero indicates the respondent does not have such feeling.

The explanatory variable representing race (coded as “RACERPI2”) was recoded into three groups: white, black/African American, and other, where the third group is a combination of other races as well as multiple races.

The nominal variable is one kind of categorical variables whose levels are simply labels and thus does not contain any meaning of order. For example, in the variable “REGION”, “Northeast” is encoded as 1, and “Midwest” is encoded as 2. Even though we want these two levels to be equally weighted, it is

usually problematic if we feed the feature directly into the model, as most algorithms will mistakenly assume that Midwest is greater than Northeast. Thus the results produced in this way may not be optimal. A way to solve this is to use the one-hot encoding (Raschka [16]). The idea behind this approach is to create a dummy feature for each unique value in the nominal variables. Here, for each region in the “REGION” variable, a new binary feature was created whose values were used to indicate the particular region of a sample.

#### Missing value

It is common in real-world applications that the samples contain missing values for variable reasons. In the NHIS data set, a missing value is introduced when the respondent either refused to answer the question or did not understand the answer. Most machine learning algorithms become problematic when missing values are present within the data set. A convenient yet defective approach to handle this is simply removing data that contains a missing value. However, depending on the size of missing values, we may end up removing too many sample points, which introduces a significant new selection bias, and, at the same time, we take the risk of losing valuable information that the classifier needs to learn model parameters. An alternative approach is to use mean value imputation, where the missing values are replaced by the mean of that feature.

As can be seen in (Figure 1), the frequency of missing values is relatively low in both classes: most features

have less than 5% missing values with only one exception that contains about 7% missing values. As a result, using mean value imputation is unlikely to have a significant impact on the overall reliability of the data set.

In this research, two steps were taken to treat the missing values. First, a dichotomous dummy feature was created aside each feature, using one to

indicate sample points containing a missing value in the corresponding feature and zero otherwise. Then the mean imputation method was utilized to fill the blank. This two-step method had the advantage of not only keeping all the original information, but also making the whole data set useable by nearly all algorithms.

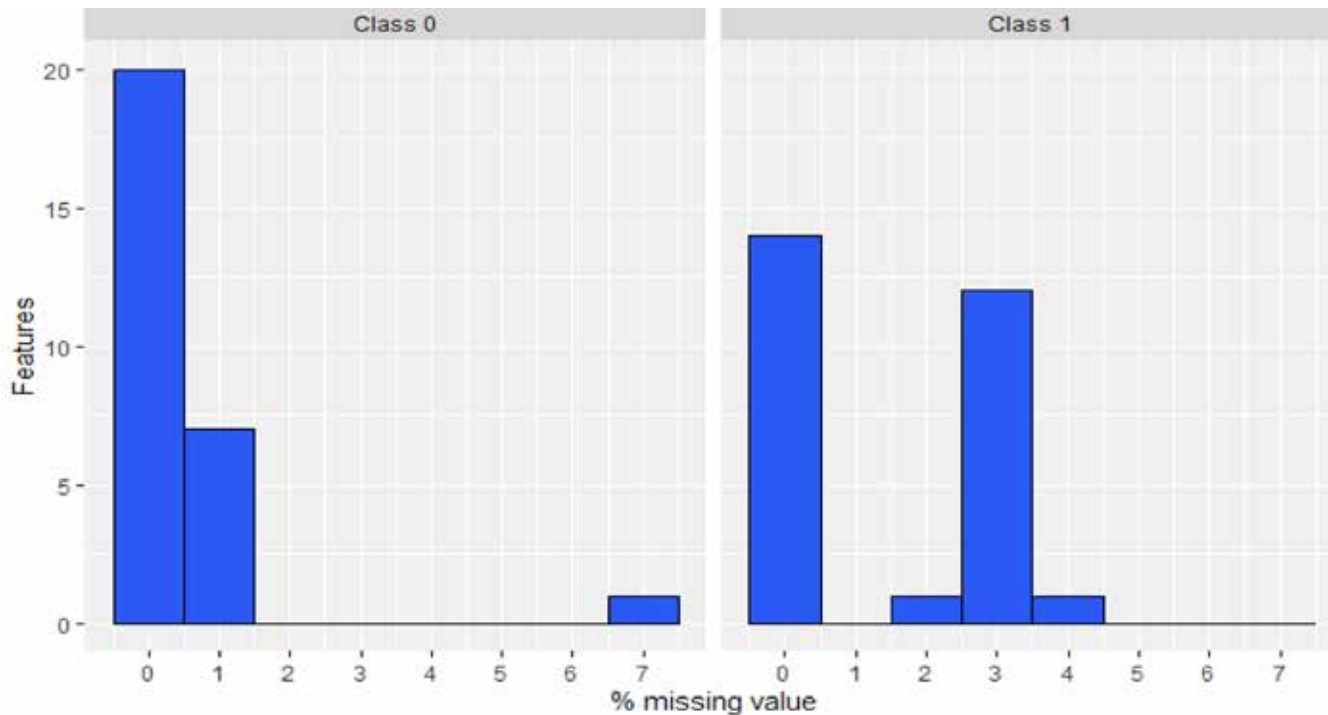


Figure 1. The distribution of missing values for each class

### Standardization

Some machine learning algorithms, such as neural networks, require a specific technique called feature standardization for better training speed and accuracy. Feature standardization transforms different features into comparable scales and ensures all features weigh equally in the training process.

For each feature, its mean and standard deviation were first computed as  $\bar{x}$  and  $s$ . Then each data point  $x_i$  with respect to that feature was replaced by  $y_i$  calculated as:

$$y_i = \frac{x_i - \bar{x}}{s}$$

After standardization, all features follow a standard normal distribution with mean zero and unit standard deviation.

### Splitting up the data

For most machine learning algorithms, the data set typically needs to be randomly split into one training set and one test set. The training set is first fed into the model to learn parameters, while the test set is held untouched. Then the test set is used to give unbiased performance measure of how well the model fits on the training set. In this model, the training set has 70% of data and the test set has the remaining 30%.

### Machine Learning Models

#### Logistic regression

Logistic regression is one of the most well-known algorithms for classification that performs very well on linearly separable classes. In logistic regression, each feature has its specific weight  $w_i$ . The net input



$z$  is calculated as a linear combination of input and feature weights, which is derived by:

$$z = w^T x = w_0 + w_1 x_1 + \dots + w_m x_m$$

Where  $m$  is the number of features. Given  $z$  in the entire real number range, it then can be transformed into the probability that a sample belongs to a certain class through the logistic function:

$$\varphi(z) = \frac{1}{1 + e^{-z}}$$

The goal of logistic regression is to find the optimal weights that maximize the likelihood of overall classification, which then becomes to minimize the cost function over the entire data set given below:

$$C(w) = -\frac{1}{n} \sum_{i=1}^n y^i \log(\varphi(z^i)) + (1 - y^i) \log(1 - \varphi(z^i))$$

A typical problem during the training process is overfitting. Overfitting occurs when the model is more complex than the data. Overfitting can be identified when the model has much better performance on the training set than test set. A possible way to reduce high variance is to introduce regularization into the model. The concept behind regularization is to add an extra term to the cost function which gives penalties to the extreme parameter weights. A common form of regularization is called L2 regularization, which can be written as follows:

$$L = \frac{1}{C} \sum_{j=1}^m w_j^2$$

This paper used L2 regularization and 5-fold cross validation in the model. The regularization parameter  $C$  was set to be 100, which was found via grid search. The model was built using the scikit-learn package with other options set by default. Raschka's book provides more details about logistic regression and regularization [15].

### Artificial neural network

An artificial neural network is a computational model inspired by biological neural networks. Unlike linear models such as logistic regression, neural networks are able to capture non-linear relations within data, which makes the algorithm stand out from linear models when the relationship between the input and output is highly complicated.

A multilayer network is an artificial neural network that consists of one input layer, one or multiple hidden layers, and one output layer. The input layer is the first layer, the output layer is the last layer, and any layers between them are hidden layers. The data are passed into the input layer, processed by the hidden layers, and finally transformed into predicted labels in the output layer.

An activation function in neural networks brings in the much desired non-linearity property that enables the model to capture almost any relationship. The three most common activation functions are logistic function, hyperbolic tangent function, and rectified linear unit (ReLU) given below:

$$f(x) = \max(0, x)$$

This paper used ReLU as the activation function for the neural network. One advantage of ReLU over the other two functions in this model is the reduced computational cost (Arora et al. [2]). In this model, the network has two hidden layers, with 16 nodes in the first layer and 8 nodes in the second layer. The network was trained via a technique called back propagation. More detail about this technique and general neural networks can be found in Raschka's book [17]. Like logistic regression, this paper used L2 regularization in the training process, and the regularization parameter  $\alpha$  was set to be 0.0572, which was found via grid search.

### Random forest

Random Forest is an ensemble learner where multiple weak learners (decision trees) are trained independently on a random sample of the training data with replacement. Usually, a single decision tree has a high chance of overfitting the data when it grows deeper. However, the high variance can be reduced when we introduce various uncorrelated decision trees into the same data set. Generally, a random forest outperforms a decision tree and can achieve a better balance between variance and bias. A more detailed description of random forest can be found in Breiman's article [3].

The random forest in this model was built using scikit-learn with bootstrap samples, 100 decision

trees, and 50 minimum sample leaves. The cross-entropy function given below was applied as the cost function to maximize the information gain for each decision tree:

$$I_t(t) = \rho \log_2 \rho + (1 - \rho) \log_2 (1 - \rho),$$

Where  $\rho$  is the proportion of the samples that belongs to class zero for a particular node  $t$  (Witten et al. [24]). Unlike in some other random forest models that use the majority vote, the predicted labels of each sample point in this model are decided by averaging their probabilistic predictions of decision trees involved.

### Environment

The data pre-processing process was mainly conducted in R3.6.1 (R Core Team [14]). The missing value visualization was produced using the package `ggplot2` (Wickham [21]), the data cleaning process was done with packages `dplyr` (Wickham et al. [22]) and `tidyr` (Wickham & Henry [23]), and dummy features were created using `dummies` (Brown [4]). The data set read-in, partition, model training, and model validation process were done using `scikit-learn` (Pedregosa et al. [13]), `SciPy` (Virtanen et al. [20]), `NumPy` (Oliphant [12]), and `pandas` package (McKinney [7]). Other graphs were produced using `Matplotlib` (Hunter [5]).

### Model Validation

The most common metrics measuring the performance of binary classification models are confusion matrix, receiver operating characteristic (ROC), and area under curve (AUC). A confusion matrix is simply a matrix that lays out the counts of true positive, true negative, false positive, and false negative predictions of a classifier. Figure 2 displays the meaning of these terms.

		Predicted Label	
		0	1
Actual Label	0	True Negative	False Positive
	1	False Negative	True Positive

Figure 2. An illustration of confusion matrix

ROC graphs are useful in comparing the performance of different models. The x-axis of a ROC graph is the false positive rate, and the y-axis is the true positive rate. When giving prediction to a particular test case, most machine learning algorithms return a probability rather than a binary label. The classification is made when we set a decision threshold to dichotomize the result. When we shift the decision threshold from 0 to 100%, the false positive rate and the true positive rate will also change accordingly, which becomes the ROC curve if we connect those points together. The diagonal of a ROC graph can be interpreted as random guessing, while a curve that falls below the diagonal is said to perform worse than guessing. A curve at the top-left corner with a true positive rate 100% represents the performance of a perfect classifier that gives correct predictions under any decision threshold. In general, a classifier has better performance if its ROC is closer to the top-left corner.

It might be hard to identify which algorithm performs better by looking directly at ROC curves, especially when one curve is not totally enclosed in another. AUC overcomes this by finding the area under the ROC curve. A theoretically perfect classifier will have an AUC of 1, while a classifier that guesses randomly will have a value of 0.5. Generally, a higher value indicates better classification performance.

### Results and Discussion

The confusion matrix of three algorithms can be found in (Figure 3). All three algorithms have about 90% true positive rate and 30% false positive rate. In the diagnosis of worry about financing retirement, we are more concerned about providing potential financial and mental assistance to those who are truly anxious. The models have 90% accuracy in identifying those people. At the same time, it is also important to decrease the potential waste of resources on those who are incorrectly identified as positive samples. In contrast to the true positive rate, the false positive rate provides insights about the fraction of incorrect positive samples out of total negative samples.

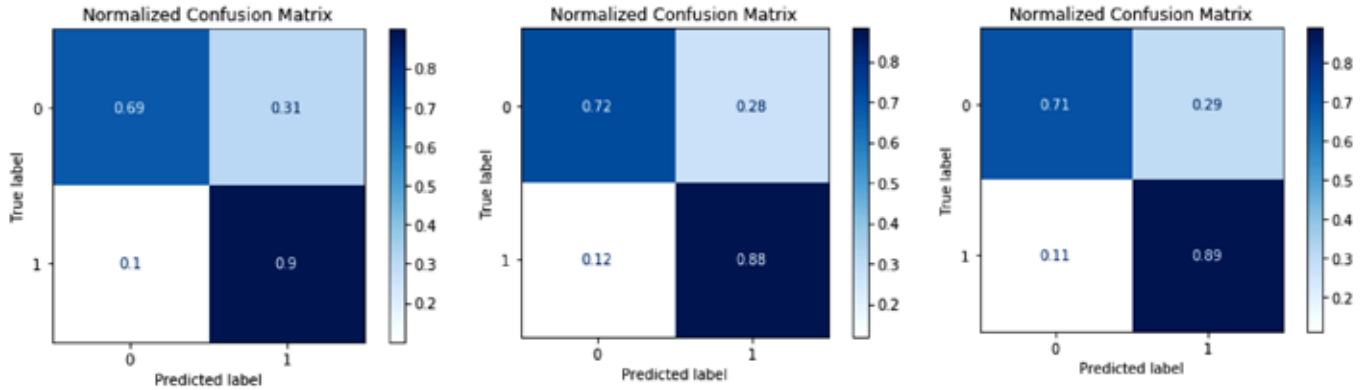


Figure 3. Confusion matrix: random forest (left), logistic regression (middle), multilayer perceptron (right)

Table 2 shows a comparison of three algorithms used in this study. Each algorithm was run 10 times, and the values shown are mean and standard deviation of the AUC score. As can be seen from the table as well as Figure 4, all algorithms report fairly similar results, with the multilayer perceptron having a slightly better score than the other two. However, considering the influence created by different partitions of the data set as well as other random disturbance in the training process, such difference can

safely be ignored. As a result, all algorithms demonstrate the same performance on this data set.

Table 2. – AUC results generated from three classification algorithms

Algorithm	Mean	Std
Random Forest	0.884	0.0032
Logistic Regression	0.883	0.0034
Multilayer Perceptron	0.886	0.0042

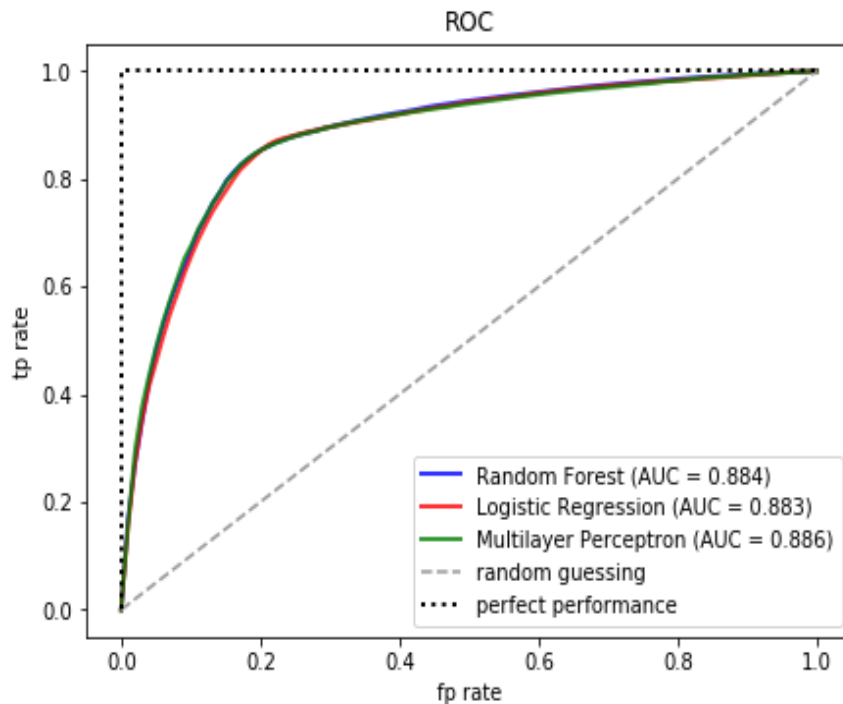


Figure 4. The mean ROC curves for three classifiers trained on the data set

When a model has high training accuracy but low test accuracy, the model is said to have high variance, and when both training and test accuracy are low, the model is suffering from high bias. Random forest is a pretty robust algorithm that is unlikely to overfit data, as long as the number of

decision trees are large enough. To further diagnose the existence of variance and bias issues within the other two models and whether increasing the number of training samples will help, a learning curve was plotted for each algorithm in (Figure 5).

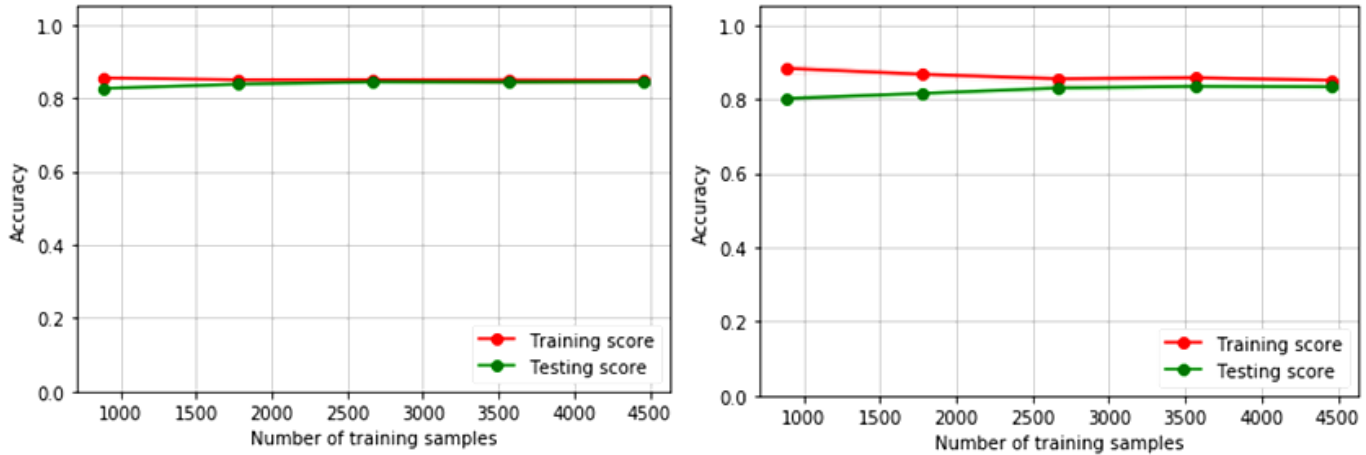


Figure 5. Learning Curves of two models: logistic regression (left), multilayer perceptron (right)

For both models, the testing score comes closer to the training score when the sample size increases from 1 000 to 2 500. Then both remain at approximately the same accuracy and stop improving with further enlargements of the sample. As a result, to further improve the classification accuracy, it would be of little help to collect more data, but it is possible to introduce new features to build a more complex model. In addition, as a linear model, the regular logistic regression might perform poorly in capturing the non-linear relationships within data. To remedy this, future research can focus on including higher-order combinations of original features in the model in order to achieve a better trade-off between bias and variance.

When building a predictive model for situations such as worry about financing retirement, most researchers care not only about the performance of their model, but also whether the model is able to provide a way that enables human users to interpret the results. However, most machine learning

algorithms do not offer a straight-forward explanation about the relationship. In neural networks, for example, an input is passed through many layers of transformations with thousands or even millions of mathematical operations involved. Such processes make the algorithm difficult to interpret. Random forest does better for this purpose, as it is able to calculate feature importance via a technique called mean decrease in impurity (MDI). Louppe et al. in [6] provided a description about the technical details involved in this technique used in scikit-learn package. Figure 6 shows ten of the most important features and their respective importance in random forest.

It is worthwhile to note that the importance of all features adds up to 1. Referring to Table 1, it is not difficult to see that the top five features are in the financial group, which accounts for about 0.85 of total importance. Based on this result, the financial group is the most informative group and plays the most essential role in this model.

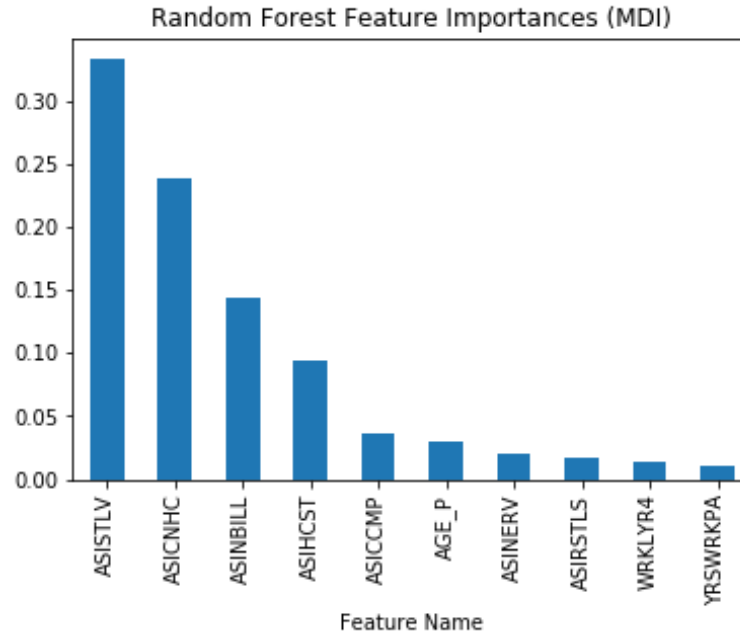


Figure 6. Ten most important features in random forest

Therefore, upon proposing policies to address financial worry after retirement in a more specific way, legislators should focus more on improving people's current financial condition or overall economy rather than tailoring specific policies for different races, ages, or other demographic groups. The results have also demonstrated that mental health, even though some factors are among the top ten features, actually plays a minor role in people's thinking process, and thus should be less emphasized.

### Conclusion

The intention of this study was to build a predictive model with the best performance and to investigate the factors most related to Americans' worry about financing retirement. Three different models were built, and all of them have achieved a similar and superb performance. The study finds that current financial condition is the key group involved in this process.

One limitation of the study is that it only establishes the importance of financial factors in predicting worry, but has not actually quantitatively discussed their relationships. A potential direction in this area could be to analyze how they are correlated. In addition, the mean value imputation method used in this paper to complete missing values is a very simple and rough approach: all samples with a missing value in a feature will be replaced by the same value. This method does not consider the potential feature correlations and is likely to reduce data variance. For future studies, more advanced imputation methods like k-nearest neighbors (kNN), which replaces missing elements with the mean of  $k$  nearest neighbors of that particular sample, can be used to obtain better performance.

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## Section 3. Medical science

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*Badashkeev Mikhail Valeryevich,  
candidate of pedagogical sciences, psychologist  
OGBUZ "Bokhansky RB"*

*E-mail: badashkeevm@mail.ru*

*Shoboev Andrey Eduardovich,  
neurologist, OGBUZ "Bokhansky RB"*

*E-mail: shoboev.87@mail.ru*

### MULTIDISCIPLINARY APPROACH IN THE TREATMENT OF COGNITIVE DYSFUNCTIONS FOLLOWING STROKE

**Abstract.** This research work examines the effectiveness of a multidisciplinary approach in the restorative treatment of stroke patients. Features of restoration of cognitive functions of patients, increase of their level of household adaptation, achievement of independence in performance of individual household skills, as well as normalization of psychological and sensual-emotional state. The degree of recovery of cognitive functions was determined using the Montreal Cognitive Assessment Scale (MoCA).

**Keywords:** stroke, psychological rehabilitation, neuroprotection, multidisciplinary team.

To date, cerebrovascular pathology has continued to be one of the most pressing and significant problems of modern Russian medicine for many years, largely due to the constant increase in the number of patients, as well as the severity of the medical, economic and social consequences of the disease, both for patients and their relatives and for society as a whole.

In our opinion, the most severe manifestation of cerebrovascular pathology is stroke. At present, many complex issues of diagnosis and treatment of cerebral stroke have been solved, which has significantly reduced the level of fatality, but other indicators characterizing the outcome of the disease remain very disappointing. So, in the Russian Federation among all reasons of primary disability, disability owing to a cerebral stroke with firmness is high on the list. To-

day more than one million people who had a stroke live in our country, at the same time about a third make faces of working-age of them, however less than 15% of patients continue the work [1, 2–7].

Clinical practice shows that the possibilities of recovery of functions lost in patients due to stroke are very variable, and are largely determined by the nature and severity of the stroke suffered, the age of the patient, the presence of concomitant diseases and the severity of complications of the main disease. Along with it, the volume, adequacy and correctness of the choice of tactics of performing treatment, coordination coherence of activity of doctors of various specialties participating in medical process [2, 26–31] also in no small measure have an impact on final result of rehabilitation.

There is evidence in the scientific literature that demonstrates the high impact of the multidisciplinary approach in the management and early rehabilitation of patients in the acute period of cerebral stroke. At the same time, it has been proved that the termination or suspension of specialized medical care at the subsequent stages of treatment is a direct factor causing an unfavourable prognosis for the restoration of lost functions of the post-insult patient [4; 5; 6].

Thus, in our view, there is no single generally accepted, scientifically sound system of measures for carrying out a multidisciplinary team of rehabilitation and treatment of patients who have suffered a stroke in relation to the subsequent stages of medical rehabilitation – in particular at the stage of the primary vascular department of the hospital. Neither foreign nor Russian theory and practice rank rehabilitation and treatment activities, which initially complicates the task at the initial stage. In turn, we focus on the systemic approach of neuroprotection and hypnotherapy, which for our clinical study is a hypothetical moment to increase the effectiveness of rehabilitation and treatment of stroke patients [7, 29–32].

To study the effectiveness and portability of drugs (“Citicoline” and “Cortexin”), patients who had undergone psychological diagnosis were selected, as well as informed in detail about the tactics and strategies of the process of recovery of cognitive functions. In strict compliance with the criteria, 70 patients were examined and treated for treatment in the neurological department. The blind randomization method divided the patients into 2 groups.

The first group – 30 patients who received basic therapy in combination with the preparation “Cortexin” 20 mg/m.

The second group – 40 patients who were treated with basic therapy, combination therapy with preparations “Cortexin” 20 mg v/m and “Citicoline” at a dose of 1000 mg v/kap per day, as well as additional work of the multidisciplinary team including hypnotherapy.

The diagnosis and evaluation of the patient’s cognition functions included the study of language

functions, short-term and working memory, attention, abstract thinking. The Montreal Cognitive Assessment Scale (MoSA) was used for this purpose. Non-parametric methods were used to determine differences between groups: U-test Mann-Whitney for two independent samples and Wilcoxon signed-rank test for two dependent samples. The differences between the compared groups were considered statistically significant at  $p < 0.05$ . Statistical analysis was done by SPSS10, Excel.

In the analysis of the assessment of intellectual impairment evaluated by the Montreal Scale of Cognitive Functions on the day of arrival, no reliable differences between the groups were identified. The duration of hospital treatment was 12 days.

Age list of patients: 30–39 years – 1.8%, 40–49 years – 12.7%, 50–59 years – 38.18%, 60 years are also more senior – 47.2%.

Clinical studies conducted in Group 1, patients who were treated with cortexin in combination, showed that the average results of the MoCA scale, although statistically significant after treatment, remained below the standard of 26 points (Wilcoxon Z-criterion = 2.73;  $p < 0.006$ . In the experimental group, the averages reached the norm (Wilcoxon Z-criterion = 5.12;  $p < 0.00001$ ).

Thus, the results of the differences in the distribution of scales between groups of patients treated with different approaches showed that the criteria for recovery of cognitive impairment after treatment by the multidisciplinary team were significantly higher than in the standard method (U-criterion = 194.5;  $p$ -level = 0.01).

Thus, our study fully confirms the effectiveness of the multidisciplinary approach in restoring cognitive functions in the rehabilitation period of stroke. The findings indicate the effectiveness of the complex therapy of these drugs in conjunction with hypnotherapy, which may be recommended for introduction into clinical practice of the treatment of cognitive disorders in patients who have suffered a stroke in the rehabilitation period.



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*Deinichenko Olena,  
postgraduate student, Department of Obstetrics  
and Gynecology, Zaporizhzhia State Medical University  
E-mail: agol0309@gmail.com.*

*Krut Yuriy,  
MD, Professor, Head of the Department of Obstetrics  
and Gynecology, Zaporizhzhia State Medical University  
E-mail: yuriy.krut@ukr.net.*

## **PROGNOSTIC SIGNIFICANCE OF RISK FACTORS FOR FETAL GROWTH RETARDATION IN PREGNANT WOMEN WITH CHRONIC HYPERTENSION**

**Abstract.** The role of risk factors for fetal growth retardation during pregnancy in patients with hypertension has not been sufficiently studied and their interaction in such patients has not yet been fully understood. To determine the prognostic significance of risk factors for fetal growth retardation in pregnant women with chronic arterial hypertension, depending on their number, is the primary purpose of this work. Analyzing the results of the clinical course of pregnancy and childbirth and treatment of pregnant women with chronic arterial hypertension 1 and 2, we can draw the following conclusions: in the presence of both risk factors together (chronic arterial hypertension 2 degrees and the presence disorders of uterine placental circulation) fetal growth retardation will develop.

**Keywords:** fetal growth retardation, pregnancy, arterial hypertension.

Arterial hypertension (AH) is a leading among cardiovascular diseases. AH promotes the development of long-term vascular and metabolic disorders [1, 2]. Arterial hypertension causes a number of pathological changes in the body of a pregnant woman, in particular, increases the risk of developing fetal growth retardation (FGR) [4–6].

Nowadays, different fetal developmental criteria do not allow the diagnosis of FGR in early pregnancy. This leads to late medical and preventative measures. Thus, there is a need to improve the methods of diagnosis of FGR.

There is also ambiguity in the assessment of prognostic criteria for FGR in pregnant women. Thus, in [7], the risk factors for FGR were determined by arterial hypertension, nicotine dependence during pregnancy, acute respiratory infection, anemia, fetoplacental insufficiency, and chronic fetal hypoxia.

According to the case-control study [8], the following risk factors for FGR are identified: the mother's age is less than 18 years and the father's age is over 40; the birth of a mother in the autumn; poor socio-economic conditions; carrier of TORCH infections; presence of extragenital pathology; stillbirths in history; gestational complications and congenital malformations of the fetus.

In pregnant women with FGR have identified increases in blood markers of protein peroxidation, lipids, and decreased activity of synthesis of nitric oxide, L-arginine and thiol compounds, indicating that the FGR is accompanied by a disorder of regulatory and adaptive processes [3].

It should be noted that the increase in blood pressure during pregnancy in most cases is accompanied by a normal course of pregnancy, and moderate pressure increase can be considered as an element of the

general process of adaptation of a woman's body to pregnancy and preparation for childbirth, as well as a physiological mechanism for maintaining the required level of feto-placental blood [10].

The incidence of hypertension of pregnant women ranges from 5–30% [10]. AH is a condition in which systolic blood pressure (SBP) rises above 140 mm Hg and diastolic blood pressure (DBP) exceeds 90 mm Hg as a result of repeated blood pressure measurements. According to the classification of AH there are the following types: AH that existed before pregnancy, or during the first 20 weeks; gestational hypertension, which is induced by pregnancy and is not accompanied by proteinuria; gestational hypertension, which is accompanied by significant proteinuria (more than 300 mg / l), considered as preeclampsia; Hypertension diagnosed before pregnancy in conjunction with gestational hypertension and proteinuria; unclassified hypertension with or without systemic manifestations, which is diagnosed after 20 weeks of pregnancy, if previous values of blood pressure were unknown [10; 11].

Even moderate chronic or gestational hypertension presents an increased risk of cerebrovascular and normal pregnancy [10].

The literature proposes models for prediction of occurrence FGR and preeclampsia in pregnant women with mild hypertension. Thus, in order to predict such complications in the first trimester of pregnancy, it is necessary to determine the degree of nocturnal reduction in DBT, left ventricular myocardial mass, time index of day DBT and malonic dialdehyde concentration; in order to predict them in the second trimester, it is necessary to determine the degree of nocturnal decrease in DBT and concentration of malondialdehyde [11].

In pregnant women with hypertension due to changes in the functioning of the cardiovascular system, there is a decrease in placental circulation. This includes a number of compensatory mechanisms aimed at restoring placental perfusion. The placenta begins to produce a number of pressor factors that

can damage it. These factors include vasoactive hormones of the endothelium: nitric oxide and prostacyclin (vasodilators) and endothelin, thromboxane, fibronectin (vasoconstrictors). Disruption of the normal relationship between these factors in hypertension is accompanied by dysregulation of vascular tone and leads to placental insufficiency.

Changes in fetal and uterine-placental complexes with violation of the adaptive-compensatory mechanisms at the molecular, cellular and tissue levels are at the heart of the feto-placental insufficiency. Which leads to disorders of transport, trophic, endocrine, metabolic and antitoxic function of the placenta, and subsequently – to the pathology of the fetus and newborn.

As a prognostic factor for possible FGR in pregnant women with hypertension, it is suggested to determine in the blood plasma the intermediate metabolite of methionine – homocysteine [9]. Hyperhomocysteinemia promotes the development of oxidative stress and the prothrombotic state of hemostasis. Thus, in women with hypertension, the levels of this metabolite were increased compared to pregnant women without hypertension. And the highest levels of homocysteine reached in pregnant women, who were subsequently defined by the FGR.

Given the established value of factors of angiogenesis and hormones of the placenta in the pathogenesis of FGR, it is promising to establish disturbances of their balance in combination with Doppler data of blood flow of the functional system of mother-placenta-fetus (circulation in uterine arteries, umbilical cord arteries) factors in early pregnancy in women with hypertension. To date, only isolated works have been found in the literature to study these indices in complex and / or in women with hypertension.

**Aim.** To determine the prognostic significance of risk factors for fetal growth retardation in pregnant women with chronic hypertension.

**Materials and methods.** A retrospective analysis of 117 case histories of pregnant patients with hypertension undergoing treatment at the Zaporizhzhia

Perinatal Center in 2017–2018 was conducted. A case-control study was performed. Criteria for inclusion in the study: pregnancy, chronic arterial hypertension (CAH) 1–2 stages. Exclusion criteria: stage 3 CAH, diabetes mellitus, multiple pregnancy, chromosomal and genetic disorders, thrombophilia, perinatal infections, systemic connective tissue diseases. Women were observed at 26–36 weeks of gestation. Pregnant women were divided into 2 groups. Group 1 included 14 pregnant women with hypertension who were diagnosed with fetal growth retardation. Group 2 (comparison group) included 103 women with arterial hypertension who did not determine fetal growth retardation. The CAH and the FGR were diagnosed according to current clinical protocols. Disturbances of uterine-placental circulation were established by means of the ultrasonic device “MyLabClassC-Esaote”. Pregnant women were treated according to current clinical protocols. Statistical analysis was performed using the pro-

gram “STATISTICA® for Windows 6.0” (Stat Soft Inc., No. AXXR712D833214FAN5). The statistical significance of the differences between the groups was determined using qualitative Fischer criteria and quantitatively using the Student’s T-test.

**Results and Discussion.** Risk factors of fetal developmental delay: 2 degree CAH, excess of blood pressure exceeding 140 and 90 mmHg, presence of disorders of uterine placental circulation of 2 and 3 stages were analyzed using anamnestic and standard clinical and instrumental indicators. There were no statistically significant differences between the groups according to the structure of comorbidities,  $p > 0.05$

Thus, analyzing the risk factors for fetal growth retardation revealed the prognostic significance of the risk factors for FGR (grade 2 CAH, grade 2–3 disorders of uterine placental circulation (DUPC)) in pregnant women with CAH depending on their number (Table 1).

Table 1. – Analysis of the prognostic significance of the risk factors for FGR in pregnant women with CAH

Number of risk factors	1 group, n=14		2 group, n=103		p
	Abs.	%	Abs.	%	
no factor	0	0	50	48.5	< 0.01
only one factor	4	28.6	43	41.7	> 0.05
2 factors together	10	71.4	8	7.8	< 0.001

In the absence of risk factors, no cases of FGR in pregnant women with CAH were reported,  $p < 0.01$ . While about half of CAH patients who did not have a FGR had at least 1 risk factor (51.5%), only 1/3 of pregnant 1 group had 1 factor (28.6%),  $p > 0.05$ .

Only 8 women in group 2 had both risk factors, whereas 71.4% of pregnant women in group 1 had stage 2 CAH and 2–3 stage DUPC,  $p < 0.001$ .

**Conclusions.** Thus, analyzing the results of the clinical course of pregnancy and childbirth and treatment of pregnant women with CAH 1 and 2 stages, we can draw the following conclusions: in the absence of risk factors (in women with CAH1 degree and in the absence of stage 1 or stage 1), it is most

likely that pregnant women will not develop FGR. In the presence of both risk factors together (grade 2 CAH and 2–3 grade DUPC), the most likely will be a FGR. In the presence of at least one risk factor (either HAG 2 degree and the absence of DUPC or DUPC1 degree, or CAH 1 degree and the presence of DUPC2–3 stages), it is impossible to predict the development of FGR in pregnant women.

**Prospects for further research.** In-depth study of methods of prognosis and prevention of FGR in pregnant women with CAH. We plane to find features of angiogenesis factors and placental hormones changes in patients with arterial hypertension with fetal growth retardation and detect

early indicators of such complication of placental insufficiency.

**Conflict of interests.** The authors declare no conflict of interest.

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*Samohvalov S.,  
PhD, M.D, CSL Hepatosurgery, Department of Surgery No. 2,  
Stare Medical and Pharmaceutical University  
“Nicolae Testemițanu”, Chisinau, Republic of Moldova  
MSPI State Government Hospital, Chisinau,  
Republic of Moldova, department of endoscopy  
and minimally invasive surgery, department of radiology*

*Danci A.,  
PhD, M.D, MSPI State Government Hospital, Chisinau,  
Republic of Moldova, department of endoscopy  
and minimally invasive surgery, department of radiology*

*Donscaia A.,  
PhD, M.D, MSPI Oncologic Institute, gastrology department,  
Chishinau, Republic of Moldova*

*Antoch L.,  
M.D, MSPI Oncologic Institute, gastrology department,  
Chishinau, Republic of Moldova*

*Cernat M.,  
M.D. MSPI Oncologic Institute, gastrology department,  
Chishinau, Republic of Moldova  
E-mail: adonscaia@mail.ru.*

## **MANAGEMENT OF MINIMALLY INVASIVE SURGERY IN THE TREATMENT OF PROXIMAL BILE DUCT TUMOR OBSTRUCTION**

**Abstract.** Obstructive jaundice induces catastrophic homeostatic disturbances that threaten the patient's life. The material of the study consisted from 42 patients with proximal biliary obstruction tumor treated in the Unit of Endoscopy and Miniinvasive Surgery of the Republican Government Hospital and MSPI Oncologic Institute, gastrology department, in the period between 2010–2018 years. There was carried out percutanattranshepatic decompression (PTHD) in 32 cases (76.2%) The success of the percutanattranshepatic approach in hilar tumors is in the limits of 90%.

**Keywords:** tumoral obstructive jaundice, percutanattranshepatic external decompression.

**Background.** Obstructive jaundice is a result of the serious complication of the biliary tract or pancreatic pathology, that during it's evolution modifies natural biliary flow from liver to the duoden. The obstructive jaundice is manifested by skin and mucous

jaundice, skin prurit, modifications of urine and stool color. The pain and fever are also characteristic for this syndrome [1; 2; 5; 6].

The main causes of the obstructive jaundice in patients after 50 years are malignant tumors. (67.3%

cases) [5; 6]. The proximal extrahepatic bile duct tumors make 10–26% from whole malignant lesions of the bile duct [2; 3; 9; 10]. About 54.4% from these patients consists males.

The metabolic disturbances induced by obstructive jaundice, threaten the patient's life if the obstruction isn't rezolved as quickly as posible. From surgical point of view these patients present a serious problem, because of low degree rezectibility of these tumors, while the obstruction has to be solved in a short time [2; 5; 6; 11].

As a solution, percutaneous biliary drainage for obstructive jaundice was introduced in 1970. It may be helpful in relieving obstructive symptoms, in special, those due to unresectable malignant tumors [3; 4; 7; 8; 9; 12; 13].

Implemented endoscopic ultrasonography-guided biliary interventions are of great and increasing interest in patients with unresectable biliary malignant obstruction [3; 7; 9; 12; 13].

Percutaneous biliary drainage starts with the performance of percutaneous transhepatic cholangiog-

raphy for the delineation of obstruction level. When the obstruction is high-degree, the external drainage is recomended [12; 13].

As a contraindication for percutaneous biliary drainage are mentioned presence of bleeging disorders and massive ascities [3; 4; 10].

Endoscopic ultrasound-guided biliary drainage is an effective alternative for rezolution of a biliary obstructive jaundice in cases of unresectable tumor lesions [1; 3; 9].

**The aim** of our study was to decrease the severity of metabolic manifestations in obstructive jaundice syndrome in patients with proximal bile duct tumor obstruction by minimal invasive methods for the patients life quality improving in unresectable tumors or as a first step for surgical radical treatment.

**Materials and methods.** The study is based on data of 42 patients with proximal bile duct tumor obstruction treated in our institutions from 2010 to 2018.

Data on obstructive jaundice causes are presented in (table 1).

Table 1. – The patients disturbation by pathology, gender and age

Pathology	Nr. cases	Age	Ratio M/F
Tumor Klatskin	19	52–67	1.2/1
Extrahepatic Colangiocarcinoma	12	45–78	1.2/1
Hilar metastatic tumors	5	47–68	1.2/1
Gall bladder tumor	6	51–75	1/5

Resulting from table, the patient's age varies from 50 till 78 years old, middle age being  $61.5 \pm 1.4$  years. Male/female ratio being 1.2:1.0, excepting the gall bladder tumors with ratio 1.0: 5.0.

All the patients have fulfilled the following main steps:

1. Clinical-analytic step – determination of metabolic disturbances;
2. Noninvasive step: ultrasound investigation, CT, MNR in cholangiography rejim;
3. Invasive step: endoscopic cholangiopancreatography (ECPG), percutaneotranshepatic punction (PTHP).

In about 80% cases there was an opportunity to make an accurate diagnosis of malign tumor as a cause of obstructive jaundice by fulfilled diagnostic methods.

The extra- and intrahepatic ducts enlarging have been observed by echography investigation in all cases. The maximum attension during the investigation has been attended to hepatic sizes, the biliary duct obstruction level, comon biliary duct implication, presence of ascities and metastatic lesions. Fig. 1 demonstrates enlargement of comon biliary duct (CBD), lack of ascities and hepatic metastatic lesions. These data presented the direct indications for biliary duct percutaneotranshepatic decompression.



Figure 1. Ultrasonography. Extend common bile hepatic duct

To estimate the possibility of endoscopic drainage the retrograde endoscopy cholangiopancreatography (RECPG) has been fulfilled.

The endoscopic bile ducts drainage is more physiological and comfortable for patients, producing good quality of life. Unfortunately, in 95% of our

cases the RECPG results have been demonstrated a full common bile duct obstruction, that didn't permit to make an endoscopic stent introducing. There is a case of principal bile duct obstruction demonstrated in (fig. 2). Fig. 3 demonstrates the results of percutanattanshepatic cholangiography.



Figure 2. Comon biliary hepatic duct obstuction



Figure 3. Percutanattanshepatic cholangiography



Figure 4. Percutanattanshepatic drainage



Figure 5. Percutanattanshepatic extern drainage



The obtained data on tumoral proximal bile duct obstruction was considered a direct indication for percutanattranshepatic external decompression. The fulfilled procedure is demonstrated in (fig. 4, 5).

If the monitoring of bile quantity and quality effected during 5–10 days, demonstrates good drainage function without any complications the second

minimally invasive step is fulfilling. The jejunostomy after Witzel is carrying out by minimally laparotomy for bile – intestinal passage recovery.

In (figure 6) the jejunostomy technique is presented.

Figure 7 demonstrates the bile extern passage recovery.

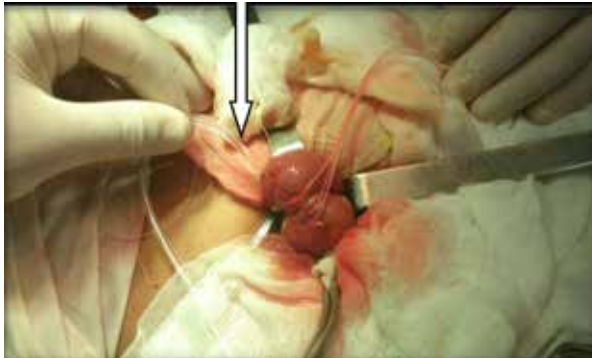


Figure 6. Jejunostomie



Figure 7. Extern bile drainage

The main serious complication after such intervention could be nonfunctionality of bile drainage. The drainage has to be disconnected to avoid the complication as a cholangitis. In these cases the antibiotics using and bile quantity and quality monitoring are of great importance.

**Results and discussion**

In our study from 42 patients with proximal biliary tumoral obstruction the percutaneoustranshe-

patic decompression has been carried out in 32 cases (76.2% (fig. 8). Two cases (4.8%) were successfully resolved by external-internal drainage (fig. 9), that is more physiological and comfortable for patients. In four cases of cholangiocarcinoma with Bismuth I obstruction (9.5%) the endoscopic decompression of biliary ducts was successful (fig. 10).



Figure 8. PTHD

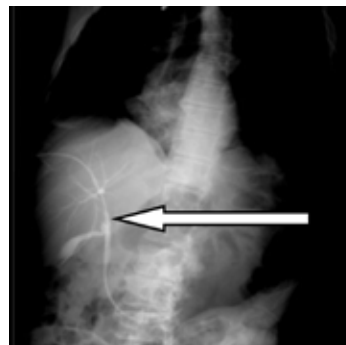


Figure 9. Extern-intern drainage

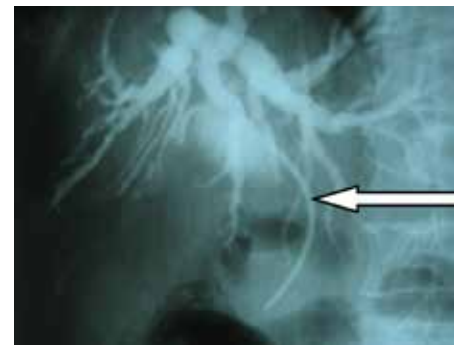


Figure 10. Endoscopic decompression

As a result of bile ducts decompression the patients general state has been improved in 48–72 hours, manifesting by skin prurit diminuation and bilirubin level decreasing with 50% during 5–10 days. There were registered the early complications

as a bile peritonitis after endoscopy stentation in 2 cases and intestinal hemorrhages in 2 cases. The complication's indexes in our study consisted 9.8% cases.

The mortality in early postprocedure's period was not inregistered. The survival period varied from two till 20 months. The data on patients survival are presented in tab. 2.

Table 2. – Patients' survival level

Pathology	Survival level in months
Tumor Klatskin	6–20
Extrahepatic colangiocarcinom	5–8
Hilar metastatic tumors	2–5
Gall bladder tumor	4–8

The uncleared problem remained, is it rationally to fulfill percutaneotranshepatic decompression in patients with multiple hepatic metastasis.

### Conclusions

1. Minimally invasive surgery in proximale bile duct obstruction has a great importance in diagnostic stages and as a first or final stage of treatment.

2. Percutaneotranshepatic external decompression in tumor proximal bile duct obstruction was successful in about 90% cases, and it's preferable in comparisson with endoscopic one.

3. Contraindications for the percutaneotranshepatic external decompression fulfilling are the massive ascities and bleeding disorders.

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*Suleymanov Suleyman Fayzullaevich,  
PhD, Senior Researcher, Associate Professor  
of the Chair of Microbiology, Virusology and  
Immunology of the Bukhara State Medical Institute,  
Bukhara, Uzbekistan  
E-mail: ss-1961@mail.ru*

## **CHARACTERISTICS OF THE IMMUNE SYSTEM PARAMETERS IN CHILDREN WITH COMORBIDE PATHOLOGY HIV AND CHRONIC TONSILLITIS**

**Abstract.** We studied 39 children with comorbid pathology-chronic tonsillitis (CT) and human immunodeficiency virus (HIV). The 1st group included 21 perinatal patients, and the 2<sup>nd</sup> group included 18 children with HIV with a vertical route of infection. In both groups of children with CT, significant suppression of cellular parameters was observed against the background of HIV infection. You can also identify a disorder of the functioning of the B(CD19)-link of the immune system. If the 2<sup>nd</sup> group had more intense disorders of immunological parameters, then the 1st group of patients had more pronounced clinical symptoms.

**Keywords:** chronic tonsillitis, children, HIV infection, cellular immunity, humoral immunity, immunoglobulins, inversion, immunodeficiency.

It is known that chronic tonsillitis (CT) is a common pathology – 4–15% of cases from all diseases of ENT organs. CT refers to multifactorial diseases, and the inflammatory process in the tonsils leads to pathological changes in them and the tonsils themselves become a source of infection [1; 2].

CT is also the most common bacterial infection in children with a normal immune system, but the features of the course of chemotherapy are still poorly understood. It has been demonstrated that with any form of chemotherapy, certain immune genetic functions of the tonsils are preserved. Damage to the immune system during HIV infection is systemic, manifested by deep suppression of the T- and B-units of cellular immunity, shifts in humoral immunity and non-specific defense factors, and the functional activity of lymphocytes and monocytes [3–5].

In the past two decades, the determining cause of secondary immunodeficiency in children has be-

come HIV infection, the pandemic of which continues to increase. HIV/AIDS is a kind of viral infection, the first acquired immunodeficiency in the history of medicine associated with a specific pathogen and characterized by an epidemic spread. The first human epidemic disease caused by retroviruses that exclusively infect T-helpers [6–9].

It has been shown that chemotherapy in acute, chronic and recurrent forms is often found in HIV-infected children. And although in most cases the etiology, symptoms and course of chemotherapy for both HIV-infected children and children with a normal immune system are the same, the protracted, severe or unusual course of this pathology with frequent relapses or the release of atypical pathogens (including opportunistic infections) should alert the doctor about possible HIV infection [10–12].

**Purpose of research:** to study the immunological parameters in HIV-infected children with CT.

**Material and methods.** For the period from 2017 to 2019 we observed 39 children with CT and HIV from the age of 10 months to 15 years who were registered with the Bukhara Regional AIDS Center. Of these, the 1st group consisted of 21 patients infected prenatally (IPW). In the 2<sup>nd</sup> group there were 18 patients with a vertical path of infection (VPI). In the control group there were 19 practically healthy children of a similar age who did not have a history of CT and HIV.

HIV diagnosis was based on the detection of specific antibodies in standard serological tests (ELISA analysis, Western-blot modification immunoblotting) and a comparison of epidemiological and serological data.

Immunological studies were carried out jointly with the Research Institute of Immunology of the Academy of Sciences of the Republic of Uzbekistan. (Tashkent). The study included patients with HIV infection and CT whose parents gave informed consent to participate in this study (the work was carried out in accordance with the Helsinki Declaration of the World Medical Association (World Medical Association Declaracion of Helsinki, 1964) and approved by the Ethics Committee of the Bukhara State Medical Institute).

Phenotyping of lymphocytic cells was carried out by an indirect immunofluorescence method using monoclonal antibodies to CD receptors manufactured by Sorbent-Servis Ltd, FSBI State Research Center "Immunology" FMBA of Russia (Moscow) using a Luminal R-8 microscope. T cells were determined (general population – CD3); T-helpers (subpopulation of Th – CD4); T-suppressors (sub-

population of Ts – CD8); T-killers (subpopulation of Tk – CD16), B-lymphocytes (subpopulation of CD19). The immunoregulatory index (IRI), the ratio of CD4/D8, was calculated.

The concentration of serum immunoglobulin (Ig) A, M and G was determined by radial gel immune diffusion according to G. Mancini et al. (1965) using mono specific serums against human immunoglobulin and standard blood serum.

The data obtained were subjected to statistical processing using the Microsoft Excel 2003 computer program on an LG-Pentium IV computer. The significance of differences when comparing average values was determined by the criterion t of student. Data are presented as  $M \pm m$ . Differences were considered significant at  $p < 0.05$ .

**Results and discussion.** It should be emphasized that in the Bukhara region and in Bukhara city, there has been a steady increase in both the rate of HIV-infected children and the number of pregnant women infected with HIV, as well as children born to HIV-positive mothers.

In approximately 70% of children with HIV infection, clinical symptoms of CT are identified after the diagnosis of HIV infection in the form of severe lymphadenopathy, hepatomegaly, recurrent acute respiratory infections complicated by sinusitis, bronchopneumonia. In 14 of them, AIDS-related diseases were recorded. Approximately 30% of patients had asymptomatic infection.

During the research, 8 children died. It is important to note that, as the disease lasted, a lesion of the tonsils occurred in the spectrum of clinical manifestations in our patients.

Table 1. – Clinical manifestations of CT in HIV-infected children, taking into account the pathways of infection

Symptoms of the disease	1 <sup>st</sup> group (n = 21)	2 <sup>nd</sup> group (n = 18)
<i>1</i>	<i>2</i>	<i>3</i>
Sore throat	21 (100%)	2 (11%)
Difficulty swallowing	21 (100%)	8 (53,3%)
Fever	21 (100%)	12 (80%)

<b>1</b>	<b>2</b>	<b>3</b>
Symptom of Giza	21 (100%)	18 (100%)
Symptom of Zack	21 (100%)	18 (100%)
Symptom of Preobrajensky	21 (100%)	18 (100%)
Sepsis	17 (81%)	2 (11%)
Cramps	18 (86%)	9 (50%)
Vomiting	18 (86%)	3 (17%)
Vomiting	13 (62%)	2 (11%)
Swollen lymph nodes	12 (57%)	10 (56%)
Chills	9 (43%)	1 (6,7%)
Nasal discharge	7 (33%)	2 (11%)
Burning throat	4 (19%)	3 (17%)
Sore throat	4 (19%)	3 (17%)
Malaise	2 (10%)	2 (11%)

In children with mixed pathology of CT and HIV of the first group, such pathologies as generalized lymphadenopathy, hepatosplenomegaly, bacterial pneumonia occurred with a frequency of 100%. In the same category of patients, the presence of herpes simplex virus and cytomegalovirus infection was significantly more often observed in 41% and 16% of cases, respectively. A specific lesion of the parotid glands of a non-inflammatory etiology in the form of sialadenitis, which was also characteristic of HIV infection, was rarely observed in only 3 (14%) children.

In addition, in the 1st group, 6 symptoms were met with an absolute frequency of 100%, and symptoms of CT in the form of pain when swallowing were determined in 100% of cases, sepsis in 81% of cases, and lymph nodes in 12 patients (57%), chills – in 9 (43%) (Table 1).

Children of the 2<sup>nd</sup> group infected with VPI, in addition to CT, the following symptoms were noted: delayed psychomotor development (100%), protruding frontal part, flattening of the nose (70%), elongated palpebral fissures and bluish sclera (60%) against a background of deep prematurity, microcephaly – in 50% of cases. In this group, 3 clinical symptoms were encountered with absolute frequency, and the severity of other symptoms was lower than in the 1<sup>st</sup> group.

The parameters of the cellular component of the immune status in HIV-infected children with chemotherapy are presented in (table 2). Our data indicate that patients of both groups show significant shifts in the functioning of their immune system, namely, patients of the 2 groups have a deep immunodeficiency of most parameters of the cellular component of the immune system.

Table 2. – Cellular parameters of the immune system in HIV-infected children with CT

<b>Indicator</b>	<b>Healthy (n = 19)</b>	<b>1<sup>st</sup> group (n = 21)</b>	<b>2<sup>nd</sup> group (n = 18)</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
White blood cells, cells/ $\mu$ l	6100 $\pm$ 187	3446 $\pm$ 283***	3261 $\pm$ 247***
Lymphocytes,%	30.9 $\pm$ 1.4	21.4 $\pm$ 3.5*	18.8 $\pm$ 3.1**
Lymphocytes, abs.	1884 $\pm$ 41.3	712 $\pm$ 84***	612 $\pm$ 63***
T(CD3),%	58.6 $\pm$ 2.1	33.1 $\pm$ 3.2***	30.5 $\pm$ 3.8***
T(CD3), abs.	1071.5 $\pm$ 53	243 $\pm$ 36.4***	176 $\pm$ 24.7***
Th(CD4),%	32.6 $\pm$ 1.7	14.6 $\pm$ 2.7***	12.4 $\pm$ 2.1***
Ts(CD8),%	20.3 $\pm$ 1.2	24.8 $\pm$ 2.3*	23.1 $\pm$ 2.9

<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
IRI (CD4/CD8)	1.6 ± 0.13	0.57 ± 0.26***	0.51 ± 0.21***
Tk(CD16),%	16.5 ± 1.4	18.1 ± 2.3	18.8 ± 3.1
B(CD19),%	26.3 ± 3.2	20.4 ± 2.9	22.7 ± 2.3
B(CD19), abs.	485.7 ± 31.6	147.3 ± 33.5***	132.7 ± 31.7***

Note: in the numerator data before treatment, in the denominator – after treatment; \* –  $p < 0.05$ ; \*\* –  $p < 0.01$ ; \*\*\* –  $p < 0.001$  – compared with the control group

They revealed significant suppression of the total pool of T(CD3)-lymphocytes and its subpopulation – Th with the CD4 marker in relative and absolute terms with a high level of confidence –  $p < 0.001$ . In patients of the 2<sup>nd</sup> group with VPI, these two parameters were even lower compared to the 1st group (Table 2).

It is also possible to distinguish the inversion of the IRI parameter in the downward direction in both groups, which was associated with a significant decrease in cells with the Th(CD4) phenotype and a parallel increase in the relative proportion of Ts(CD8)-cells with suppressor function, and this, in turn, indicates on the adverse course of immune processes in the immune system in HIV-infected children with CT. An increase in Ts(CD8) cells and inversion of IRI can be attributed to negative immune predictors that have a definite effect on the immune system of patients with this mixed pathology in children. Our data are completely consistent and confirmed by data of other authors in assessing the role

of Th(CD4) lymphocytes as the central pathogenesis link in HIV infection in children. They investigated the evidence in favor of such a version that the rapid development of deep immune suppression in children with HIV infection contributes to the transition of the disease to stage 4B. After 4–6 years from the onset of HIV infection, against the background of a significant decrease in Th(CD4) lymphocytes, attachment of various nosological forms of opportunistic infections and then its generalized forms was noted, which caused the formation of severe multiple organ failure and death [9].

In relation to Tk(CD16) in patients of both groups, their slight increase can be noted, which can be explained by the fact that this type of cell takes on a certain protective function due to the inadequate functioning of other types of cells.

It is also possible to isolate the disruption of the B (CD19) – cellular component of the immune system, but this was not statistically confirmed (Table 2).

Table 3. – Humoral parameters of the immune system in HIV-infected children with CT

<b>Indicator</b>	<b>Healthy (n = 19)</b>	<b>1<sup>st</sup> group (n = 21)</b>	<b>2<sup>nd</sup> group (n = 18)</b>
IgA, mg%	121.3 ± 11.7	89.4 ± 14.5*	79.7 ± 12.2**
IgM, mg%	90.1 ± 12.3	134.2 ± 20.7*	127.8 ± 23.3*
IgG, mg%	1093.2 ± 65.6	876.7 ± 44.52**	1084.3 ± 60.6

Note: in the numerator data before treatment, in the denominator – after treatment; \* –  $p < 0.05$ ; \*\* –  $p < 0.01$ ; \*\*\* –  $p < 0.001$  – compared with the control group.

It should be noted that the immune deficiency in the B-cell system of immunity was reflected in the spectrum of immunoglobulins. So, for example, in the 1st group, we revealed a tendency to a decrease in IgA and IgG with different levels of confidence ( $p < 0.05$  and  $p < 0.01$ , respectively) and an increase

in the level of IgM, then only a decrease was observed in the 2<sup>nd</sup> group Ig A.

A comparative analysis with the data of other researchers showed that in children suffering only chemotherapy (without mixed pathologies), the level of IgA was within normal limits, i.e. here, as it

were, “there was no second pathology in the form of AIDS,” which would affect the values of this IgA immunoglobulin and reduce it [3; 4].

On the contrary, the IgM level in patients of the 2<sup>nd</sup> group with VPI was higher compared with the control group, which was probably of a compensatory nature.

So, in sick children with mixed pathology of HIV and CT there are serious changes in their immune system, characterized by deep immune suppression and immune deficiency, with the development of a variety of clinical symptoms.

Thus, the presented results indicate the specific features of the clinical and immunological course of chemotherapy in HIV-infected children, depending on the route of infection. In patients of the 1st group with PPI, the characteristic symptoms of CT were frequent bacterial infections, generalized lymphadenopathies, viral infections and other symptoms against the background of deep prematurity. In patients of the 2<sup>nd</sup> group with VPI, chemotherapy was accompanied by more pronounced immune suppression and a relatively lower frequency of occurrence of clinical symptoms.

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*Tandilava Rene,  
MD., Ph D., Associate Professor,  
of the Batumi Shota Rustaveli State University,  
JSC "EVEX Hospitals" M. Iashvili Batumi Maternal  
and Child Central Hospital  
E-mail: dr.rene-geo@mail.ru.*

*Tandilava Zurab,  
student of The Faculty of Medicine, Friedrich–Alexander  
University Erlangen–Nürnberg, Germany*

## OUR METHOD OF SURGICAL TREATMENT FOR VARICOCELE IN CHILDREN

**Abstract.** The operation, named after Ivanissevich, performed in children for varicocele, under intraoperative phlebostesticulography, is highly effective. The venography method permits to prognosticate a postoperative period course, to prevent the disease recurrence occurrence. A surgical method, applied for varicocele correction has an advantages, because it includes the excision of the testis veins in a wide fashion together with anastomoses from the upper third of a lumbar portion to deep inguinal ring, to the testis vein formation region, permitting to omit a reason for the disease recurrence without application of roentgencontrast investigation. The method was used in 145 children for a left – sided varicocele stages II–III. Complications were not observed. In terms of follow – up before 2 years the recurrences were not observed.

**Keywords:** varicocele, phlebostesticulography, operation named after Ivanissevich, vein of testis.

### Introduction

Varicocele is a common disease that is found in 0.7–20% of older boys [5]. The interpretation of its origin remains controversial. The lateral varicocele appears to be an age-related puberty decompensation of a dysembryogenetic anomaly of the hemiazygos vein system. It is based on congenital mesenchymal dystrophy with subsequent development of local discomplexation of collagen in the vascular walls [3]. Coupled with circulatory disorders of the testicle, the disease leads to damage to the sperm epithelium and is one of the frequent causes of male infertility [9].

The process of organ parenchyma atrophy can be suspended surgically. Our observations and experience support the view that Ivanissevich technique is an optimal method of surgical operation. Palomo

technique aggravates the circulatory disorders in the testicle. Endovascular occlusion of the testicular vein and endoscopic interventions are expensive methods that have not solved the problem of varicocele treatment [6]. However, isolated interventions performed on the venous vessel, justified in terms of circulatory physiology, are not always effective. In the children and adolescents, unsatisfactory results reach 18–34% [7]. The same is proved by own experience of surgical treatment of 420 patients. The procedure was unsuccessful in 23% of patients [1; 2; 4].

Dissatisfaction with the results of treatment prompts the researchers to an in-depth study of the problem of varicocele, which in the circumstances of high morbidity and risk of irreversible changes in the genital glands becomes socially important.

There are reports in the literature about the existence of untapped possibilities of known methods of surgical correction of varicocele. There are evidence of the expediency of X-ray control over the course of surgical intervention [8; 10]. With use of phlebostesticulography performed at the afferent and efferent testicular vessels stages, the authors have achieved a significant reduction in the number of relapses to 3.6% [8]. This fact served as the basis for the application of our proposed modification of Ivanissevich technique.

### Materials and methods

We used the method of phlebostesticulography during surgery using Ivanissevich technique. During the surgery we find and ligate vena spermatica, cut and catheterize the distal end. Through the catheter syringe is injected 15–20 ml 60% solution of verografin within 10–15 seconds. An X-ray image is taken. Analyzing the resulting phlebogram, the condition of plexus pampiniformis is assessed, and the focus is fixed on the peculiarities of peripheral circulation, in cases of contrast of the proximal section of the testicular vein, the localization of collaterals responsible for it is performed. They are found, ligated and cut. The procedure is repeated until all the vessels bypassing the ligated section of the testicular vein are completely bound. When the operation is complete, the catheter is removed and the wound is sutured tightly. This technique is used in 45 children aged 12–15 years with left-sided varicocele 11 to 111 degrees, of which 13 had a relapse. In order to achieve a final result maximum number of phlebograms [3] was performed in 4 patients, in 25 patients 1 phlebogram was enough.

### Results and discussion

Long-term results of surgeries using Ivanissevich technique performed under the control of intraoperative phlebostesticulography were studied in 43 patients. Varicocele was eliminated in all children. No progression of trophic changes in testicles was registered by ultrasound results during 1.5–3 years of observation.

Phlebostesticulograms made it possible to study X-ray anatomy of testicular vein system, to determine the reasons for unsatisfactory results of Ivanissevich technique.

The analysis of intraoperative phlebostesticulograms confirms the opinion that the unsatisfactory results of Ivanissevich technique are connected with the renewal of blood circulation in the testicular vein basin by intra-system anastomoses represented by different caliber, sometimes thread-shaped, veins. They are located along the vascular bundle and may not be detected visually during the operation, but clearly contrast with intraoperative phlebostesticulography. This mechanism of disease recurrence has been confirmed in 13 patients who were previously operated on for left-side varicocele.

The testicular veins own anastomoses are most often located at the junction of the anterior and posterior parts of plexus pampiniformis at the deep groin ring (20). Collaterals were found in 6 patients in the middle third and 9 in the upper third. The satellite veins accompanied the main trunk in 5 patients. In 3 cases collaterals were not detected, the veins of the scatter type were anastomized between each other at different levels.

After cessation of reno-caval anastomosis, the blood flow from plexus pampiniformis is directed to iliac vessels along the direct path through the cremaster vein (42 patients). In this case, dilation of the enlarged veins in the scrotum occurred quickly, during the first hours or days after surgery.

These anatomical features of the testicular vein pool provided the basis for a more effective method of surgical correction of varicocele, which is aimed at preventing recurrence of the disease without the use of X-ray contrast examination. In order to achieve this goal, we skeletonize the vein in the terminal area at the level of the upper third of the lumbar spine by exposing the test vessels retroperitoneally and bandaging it. The ligated vessels are crossed 5 mm distally from the ligature. Similar actions are performed at the deep inguinal ring in

the area of the test vein formation. We tie all the vessels with collaterals detected by the ligatures underneath them and cross them 5 mm proximal to the ligature. The remaining section of the testicular vein crossed between two ligatures is separated from the peritoneum, gently released from the testicular artery and lymphatic collectors, and dissected over the length.

The method was applied in 145 children with left-handed varicocele of 11–111 degree. The surgeries were performed without complications. No relapses were found during 2 years of observation of the operated patients.

Examination of the testicular vein has an advantage in comparison with Ivanissevich technique as it provides for dissection of the main venous vessel in wide range together with visualized anastomoses, mechanical destruction during invisible “natural” collaterals, completely interrupting the blood flow in the pool of the testicular vein. Ivanissevich technique does not include excision, but a simple intersection of the venous vessel in its lower third does not prevent the recurrence of the disease.

Therefore, the efficiency of Ivanissevich technique is increased using intraoperative phlebosteculography at the stages of ligation of afferent and efferent testicular vessels. However, the applied method of surgical correction of varicocele has the advantage, as it involves the dissection of the testicular vein in a wide range together with anastomoses, which eliminates the cause of the disease recurrence without X-ray contrast examination.

Our observations clarify the pathogenesis of varicocele in terms of the pathophysiology of testicular circulation. In case of impaired venous outflow from the testicle, which caused the development of varicose veins of the spermatic cord, ligation of the main

venous vessel is a kind of provocative moment, an additional and deliberately created obstacle to the advancement of blood in the natural way. The calculation is carried out on the intensification of the blood circulation pathways bypassing the blocked zone by the prepared collaterals, first of all, by the creamy vein, capable of “unloading” the partially bulky plexus, recreating the acceptable conditions for hemocirculation, preservation of the hemotesticular barrier. In response to the ligation of the testicular vein, the peripheral resistance increases sharply, and more arterial blood enters the testicular vein as the peripheral resistance in the testicular vessels has become less than in the testicular vein after the ligation. As a result, the testicle receives full arterial nutrition. Varicosities of the spermatic cord become empty.

### Conclusion

When treating varicocele in children, Ivanissevich technique is justified from the point of view of circulatory physiology. Let us note the high efficiency of this technique, performed under the control of intraoperative phlebosteculography. The efficiency of the surgery is related to the unloading of the pool of the hemiazygos vein. The absolute condition is a thorough ligation and cutting of the main and smallest additional trunks of the testicular vein with obligatory preservation of the lymphatic collectors of the testicle and the seminal cord. Radiological control over the course of the operation allows predicting the course of the postoperative period and preventing the possibility of a relapse. However, the applied method of surgical correction of varicocele has an advantage, as it involves cutting of the testicular vein in a wide range together with anastomoses, which eliminates the cause of the disease recurrence without contrast X-ray monitoring.

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*Umarova Zamira Fakhrievna,  
Candidate of Medical Sciences, Associate Professor*

*Makhsুমakhon Khairullaevna Tashpulatova,  
Masters*

*Nakrzikulova Madina Shavkat Kizi,  
Masters*

*Tashkent Medical Academy*

*E-mail: ssht61@mail.ru; tashpulatovamaxsumaxon@gmail.com*

## DIAGNOSTIC QUESTIONS OF KIDNEY DISEASE IN ELDERLY PATIENTS WITH ARTERIAL HYPERTENSION

**Abstract.** the article describes the main problems in diagnosing kidney damage in patients aged 60 to 75 years and above. The goals and objectives of the study, materials and applied research methods are given. Based on the results obtained, recommendations for the treatment of patients in this category have been developed.

**Keywords:** chronic kidney disease, arterial hypertension, disease, activity, quality of life.

Of the total population of the republic, the proportion of people 60 years and older is 19.2%. In this regard, society is interested in continuing a full life, first of all, in lengthening the period of human activity in the elderly and senile. The quality of life of the elderly largely depends not only on the conditions and lifestyle, but also on the effective treatment of a number of diseases of the elderly and the early prevention of their complications.

Chronic kidney disease (CKD) is a significant factor that significantly increases the risk of adverse outcomes in elderly patients with diabetes mellitus, hypertension, heart disease and stroke, each of which, in turn, is the main cause of death and disability. Recent statistics indicate in most developed countries a steady trend towards a steady increase in the number of people with a persistent decline in kidney function. This is a general population problem, because terminal chronic renal failure requiring active treatment methods (programmed hemodialysis and / or kidney transplantation) are extremely expensive treatment methods, are not included in the compulsory medical

insurance program, and are paid by local authorities. Which, of course, places a heavy burden on the small budget of many regions [1–3].

Ischemic nephropathy is also a danger to elderly patients. This independent disease, unfortunately, often develops gradually, without visible clinical manifestations, against a background of decreased renal function. And only a timely blood or urine test can reveal anemia, an increase in nitrogenous toxins, albuminuria, which allows you to diagnose CPD [4; 5].

According to large population registers, the prevalence of chronic kidney disease (CKD) in certain categories of individuals (elderly, type 2 diabetes mellitus) reaches up to 20%. Arterial hypertension (AH) is one of the most common causes of impaired renal function. In patients with arterial hypertension, renal damage is up to 25%. In this regard, the search for markers of early kidney damage in hypertension is one of the urgent problems of modern nephrology and geriatrics.

The development of modern medical science and pharmacology has allowed the development of new affordable and highly effective methods of

prevention that can significantly slow down the progression of chronic renal diseases, reduce the risk of complications and the cost of treating patients with CKD. Interest in the preventive direction is also associated with the fact that impaired renal function and increased albuminuria are associated with the progression of cardiovascular diseases.

**Objective:** To study the incidence of CKD in patients with arterial hypertension in Tashkent. Assess the effectiveness of markers for the early diagnosis of CKD.

**Materials and research methods:** The study included patients 55–70 years old, who were treated in the nephrology department of the multidisciplinary clinic of the Tashkent Medical Academy. During the study, the analysis of medical documentation data and anamnesis was carried out, screening methods of instrumental and laboratory diagnostics were performed. The degree of renal impairment was determined using the Cockcroft-Gault and MDRD formulas developed by the Nephrological Associations and proposed in the EAG / EOC2007 Recommendations and National Kidney Foundation K / DOQI, 2002.

**Research results and discussion:** Studies have shown that over the indicated period 103 patients were treated in the nephrology department, of which 45% (57 people) were 55–70 years old. The average age of these patients was  $52.3 \pm 1.2$  years (from 55 to 70 years). Among diseases of the older age group in 56% of cases (56 people).

During the same period, at the reception of the multidisciplinary clinic of the Tashkent Medical Academy 157 patients were admitted to nephrology, among them 76 people at the initial appointment. The group of patients over 60 years old was 59 people: among the patients of the initial admission, there were 72 (60%) people. The average age of the patients was  $52.3 \pm 1.2$  years (40 to 70 years). The main diseases for which elderly and senile patients addressed in 83% were hypertension and various forms of coronary heart disease (42 people). Hy-

pertension, as the main disease in elderly patients of the study group, was 85 people or 61.1% of all cardiac patients.

All patients with cardiovascular disease underwent screening laboratory tests, including: a general urine test (with an emphasis on the presence of albuminuria), a general blood test, creatinine and blood urea, total blood protein, ECG, blood cholesterol. An ultrasound examination of the kidneys was performed for all patients with changes in the analysis of urine and / or GFR, with the detection of anemia.

The identification of constantly elevated blood pressure or episodes of its increase has led to a more in-depth examination. All patients with AH used a complex of modern instrumental methods of research: echocardiography, ultrasound duplex scanning, ultrasound dopplerography.

In order to exclude the secondary (renal) genesis of hypertension, an additional examination was performed: urine tests according to Nechiporenko, a sample according to Zimnyatsky, a biochemical blood test, ultrasound examination of the kidneys, dopplerography of the kidney vessels, and, if necessary, examination by narrow specialists – a neurologist, nephrologist, endocrinologist, and oculist.

Further, the study included patients with hypertension in whom, according to laboratory and instrumental methods of research, no primary organic diseases from the kidneys were detected. This group was 27 people.

Among the examined in this group, the average level of systolic pressure was  $159.21 \pm 6.68$  mm RT. Art., diastolic pressure  $90 \pm 6.13$  mm RT. Art.

An analysis of the data showed that of the total number of patients in the older age group with hypertension (67 patients), 21 patients (31.5%) had signs of chronic kidney disease.

At the same time, 65% (63 patients) of them had blood creatinine and blood urea indices within normal limits. In 9.5% (19 people), the level of creatinine was clinically significant and was in the range of 200–380  $\mu\text{mol} / \text{L}$ . In the remaining 12 patients, creatinine

level was slightly increased to 130  $\mu\text{mol} / \text{L}$ . Urinary excretion of albumin above 20 mg /L was detected in 36 people, which amounted to 47.9%. Moreover, microalbuminuria has been observed in these patients for a long time. However, the examination to determine its causes and preventive treatment has not been previously conducted.

In addition, in 12 patients with elevated creatinine levels, there was a varying degree of a decrease in red blood counts – hemoglobin and red blood cell counts.

Based on the data obtained, 21 patients with hypertension were diagnosed for the first time with chronic kidney disease, of which 11 patients with the development of chronic renal failure of varying severity.

#### **Conclusions:**

1. All patients with hypertension have a high risk of developing CKD. At least a third of patients with hypertension have chronic kidney disease. This circumstance should be taken into account when examining patients, for example, when performing coronary angiography.

2. It is necessary to screen patients with cardiac pathology, including hypertension, with the aim of early detection of CKD, timely initiation of nephroprotection, delaying the onset of chronic renal failure, and inhibiting the growth of patients requiring PST.

3. Blood creatinine level in patients with underlying extrarenal pathology is not always a reflection of the development of CKD.

4. When screening patients with cardiovascular disease, it is necessary to conduct a urine test for albuminuria and blood to detect anemia. The determination of MAU should be an obligatory part of the examination of patients with arterial hypertension with the aim of early detection of impaired renal function in hypertension and possible prevention of their progression.

5. When treating patients, it is necessary to focus not only on the recommendations of societies of nephrologists, but also cardiologists, in particular, this applies to the treatment of arterial hypertension and anemia, as well as other measures for nephro- and cardioprotection.

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## Section 4. Pedagogy

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*Berdieva Zulfia Muhiddinovna,  
Senior Lecturer, Bukhara Engineering  
and Technology Institute, Bukhara, Uzbekistan  
E-mail: b\_sspo\_devon@mail.ru*

### FUNCTIONS AND FORMS OF CHEMICAL EXPERIMENT

**Abstract.** The article discusses the organization and conduct of chemical experiments, the functions and forms of these experiments in higher, secondary specialized and general educational institutions.

**Keywords:** chemical experiment, educational experiment, demonstration experiment, cognitive function, educational function, developing function.

Teaching the basics of chemistry in higher educational institutions, secondary special and general educational institutions cannot be improved without the appropriate organization of a chemical experiment. A chemical experiment – a source of knowledge about a substance and a chemical reaction – is an important condition for activating the cognitive activity of students, fostering a steady interest in the subject, as well as ideas about the practical application of chemical knowledge [1; 2].

The implementation of the experimental part of the program requires a chemistry teacher to have high and comprehensive training, a deep understanding of the role of a chemical experiment in the educational process, and creative activity in the application of effective teaching methods [2; 4].

The experiment allows you to select and study the most significant aspects of an object or phenomenon with the help of various tools, instruments, technical means in the given conditions. The experiment can be repeated by the researcher if necessary. This largely determines the main function of a scientific experiment: obtaining reliable data about the surrounding reality. A training experiment differs from

a scientific one in that its results are known, the conditions for its implementation are selected so that in the process of conducting experiments or observing them, students should detect known signs of a reaction and arrive at the expected results.

In a chemistry course, an experiment is a peculiar object of study, a research method, a source and means of new knowledge. It is characterized by three main functions: cognitive – to learn the basics of chemistry, formulate and solve practical problems, identify the importance of chemistry in modern life; educating – for the formation of worldview, conviction, ideological need for work, orientation of students to working professions; developing – for the acquisition and improvement of general scientific and practical skills.

The experiment and related observations are necessary already in the formation of the initial chemical concepts. Their role grows in the study of theoretical problems of chemistry, in determining the properties of simple substances and compounds of the elements of the periodic system, the most important classes of organic substances, and also in identifying the genetic connection of the most important classes of inorganic and organic substances.



Acquaintance with a chemical experiment as a method of scientific research, mastering the skills of chemical experimentation to acquire new knowledge and apply it in practice play an important role in shaping the worldview of students, understanding the role of science and scientific facts in building a society.

A chemical experiment is also important for the polytechnic training of students: introducing them to the basics of chemical production, its features, and the conditions for chemical reactions.

On the basis of the perception of observed phenomena, students form ideas, and then concepts. Such an inductive way of cognition is peculiar to the initial stage of chemistry education. Gradually, this path of knowledge is supplemented by another – deductive. After the students armed themselves with theory, acquired practical skills, the experiment becomes not only a source of knowledge of new facts, but also a method of verifying judgments and finding the unknown [3].

The same experiment is used differently at different levels of student training. From this it follows that it is advisable to repeat chemical experiments, paying particular attention to those aspects that are the subject of study in this educational situation.

To understand the essence of the studied subject or phenomenon, a chemical experiment is often supplemented with other visual aids – tables, models, virtual manuals.

In the practice of teaching chemistry, it is traditionally accepted to divide a chemical experiment into a demonstration one, carried out by a teacher, and a student one, performed by students in the form of laboratory experiments, practical exercises, and solving experimental problems. This classification is based on the activities of teachers and students [1; 3].

Demonstrations are used primarily in cases where students have not previously met with the studied subjects and phenomena and are not prepared for observation. During the demonstration, es-

pecially the demonstration experiment, the teacher organizes the observation of students, shows the correct methods of handling laboratory equipment, fixes the students' attention on the appropriateness and principle of its operation, the conditions of the experiments, and safety measures.

The demonstration is a kind of visual instruction for which the teacher in the learning process has to spend a lot of time. Visual instruction based on imitation of a teacher, implemented with the help of various aids, including instruments, tables, diagrams, screen tools, reduces the time needed for the formation of skills of a chemical experiment and contributes to the correct implementation of the student experiment [2; 4].

A student experiment consists of laboratory experiments performed frontally or by a group in the process of studying, fixing and checking new material, as well as practical exercises, solving experimental problems according to options after studying individual topics of the program. A promising form is a workshop conducted in the form of separate generalizing works after completion of the entire course of chemistry.

The basic requirement for any chemical experience is the requirement that it be completely safe for students.

The teacher is responsible for the accident both morally and legally. Therefore, preliminary testing of experiments and compliance with all safety requirements are mandatory for all working in the chemical room. The main guarantee of the safety of demonstration experiments is the high technical literacy of the teacher, armed with the proper safety skills.

Thus, a chemical experiment permeates all topics of a chemistry course, contributing to the disclosure of its content and is a kind of teaching method. For the successful manifestation of the cognitive, educational and developing functions of a chemical experiment, its technical equipment, the rational organization of the experiments and their inclusion in the educational process play an important role.

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*Berdo Rimma,  
postgraduate student,  
the Department of Pedagogy and Educational Management  
Vunnychenko Volodymyr Central Ukrainian State  
Pedagogical University  
E-mail: rimma199320@gmail.com*

## **PECULIARITIES OF MOTIVATION-ORIENTATION COMPONENT OF PROFESSIONAL SELF-IDENTIFICATION OF A FUTURE PSYCHOLOGIST**

**Abstract.** Methods and results of research of the motivation-orientation component of the future psychologist are disclosed. The features of self-identification are covered, the types of motives in the choice of the future specialty are analyzed. According to the results of the research, gaps in the formation of professional self-identification in universities were identified.

**Keywords:** self-identification, professional self-identification, future psychologist, motivation-orientation component.

**Problem formulation in general and its connection with important scientific and practical tasks.** In the context of modern social changes becomes relevant to study the pedagogical mechanisms and conditions of self-identification of a specialist's personality as one of the main factors of personal and professional development.

Issue of self-identification is of interest to many researchers. At the theoretical and methodological level the problem of self-identification of personality is covered in national works (Afanasenko L. A., Bech I. D., Gerchanovskaya P. E., Grebenyuk M. A., Guba S., Zlivkov V. L., Kurguzov A. A., Melnik D. M., Semenova Yu. A., Stoyan O. O., Schneider L. B.) and foreign (R. Brubaker, E. Erickson, J. Marcia, J. Mead, F. Cooper, H. Tajfel) scientists. Their theoretical analysis [1] shows that through self-identification, the personality establishes the ideal of personal and social values, establishes the values of the socio-professional group, helps to form standards of spiritual and moral guidance, promotes active participation in the educational process. This, in turn, actualizes the problem of research on the professional self-

identification of future specialists in general and the motivational-orientation component in particular.

The motivational-orientation component of future psychologists contains such components as the attitude to the profession, interest in it, knowledge and understanding of the peculiarities and conditions of professional activity, its requirements for personality. The problem of preparing future psychologists has already been the subject of research (Borisyuk A. S., Renke S. O., Andriychuk I. P., Druzhinina I. A., Kobylnik L. M., Kucherenko E. V., Kulish V. I. etc). Thus, recently more attention is being paid to the formation of personal characteristics during the preparing of future psychologists – professional self-adjustment [2], professional self-improvement [6], professional self-development [3]. At the same time, pedagogical conditions for the formation of professional self-identification of future psychologists, despite all relevance, did not act as a subject of special research.

**The purpose of the article** – analysis of levels and factors of motivational orientation component of professional self-identification of future psychologist.

**Materials and methods.** The study involved 141 first- and fourth-year students of Dniprovskii University of the Humanities (DUH), Oles Honchar Dnipro National University (DNU), Alfred Nobel University, Volodymyr Vunnychenko Central Ukrainian State Pedagogical University (CUSPU), who study in the field of preparation 053 “Psychology”. The results of the study were processed using a table processor Microsoft Office Excel.

To evaluate the motivation-orientation component of professional self-identification of a future psychologist used the method “Motives for choosing a profession” (R. V. Ovcharova), the author’s modification of the method of studying the factors of attractiveness of the profession (author of the method Yadov V. A., modification I. Kuzmina, A. Rean) and author’s questionnaire “Professional self-identification of the future psychologist”.

**Results and discussion.** First, during an empirical study, the emotional component of the choice of future specialists was determined by the method of R. V. Ovcharova.

The processing of this methodology consists in the division of all statements into four groups of motives: internal individually significant motives, internal socially significant motives, external positive motives and external negative motives.

Internal motives for choosing a profession – its social and personal importance; the pleasure that the work gives due to its creative nature; the ability to communicate, lead other people, etc. Internal motivation arises from the needs of the individual, so on its basis, the person works with pleasure, without external pressure.

External motivation is income, striving for prestige, fear of condemnation, failure, etc. External motives can be divided into positive and negative. Positive motives include: material incentives, the possibility of promotion, the poisoning of the team, prestige, ie incentives for which a person deems necessary to make their efforts. Negative motives include influence on the individual through pressure,

punishment, criticism, condemnation and other sanctions of a negative nature.

The predominance of internal motives is most effective in terms of job satisfaction and productivity. The same goes for positive external motivation [5, p. 7–9].

It is established that for all the first courses of DUH, DNU and Alfred Nobel University the most important in choosing a profession were internal individually and socially significant motives. Moreover, the average values of these motives were almost the same (the difference of indicators in 0,02–0,33). However, more intrinsically individually relevant motives are more important to the students of the CUSPU (difference 0,49). It can be assumed that the difference in rates for students from different universities is due to their location – Dnipro City is a more promising career city, gives more opportunities to create their own social services through a larger population of the city, compared to Kropyvnytskyi City [4].

For the fourth-year students of all universities, the difference in the average individually and socially significant motives is almost insignificant (maximum – 0,2). Moreover, the values of almost all parameters are increased compared to the first year students, which indicates a more conscious attitude to the questions or answers.

As expected, the least significant are the negative external motives.

The next step in our research was to identify the most attractive factors of the future profession for the author’s modification of the method of Yadov V. A. The essence of the author’s modification was to change the instructions for closed questions. Students were offered the following: “Check the points (factors) that reflect your attitude towards your chosen profession. Only record what really matters to you. Optional in all rows is optional.” The methodology sets the levels of satisfaction with the profession, which are determined by the total number of answers: up to 3 answers – low level of satisfaction with the future profession, 4–7 – average level, more than 7 – high level.

The research did not identify future professionals with low satisfaction with their chosen profession; the average level was found in 27% of respondents, and the high level – 73%. In addition, the study found that for students of the first year of all universities there were statistically significant differences in the mean values for only three factors – satisfaction with wages, availability of conditions for self-improvement and the importance of the profession for society. For the fourth year, the average values of almost all parameters change, except for the value of satisfaction with pay, which, in our opinion, is related to the rethinking of the attitude to the profession during the years of study.

It is established that the most important factors for future first-year psychologists are the factors – the importance of the profession for society, creativity in the activity, the availability of conditions for self-improvement. The least significant factors are the satisfaction with the salary and the length of the working day.

At the same time, for the fourth year students, the most important factors are – the ability to work with people, creativity in the activity, possible fatigue, the availability of conditions for self-improvement and satisfaction with the length of the working day. The least important factor is wage satisfaction.

At the next stage of our research, using the author's questionnaire "Professional self-identification of the future psychologist", the features of the motivational-orientation component and students' understanding of the concepts of "self-identification", "professional self-identification" and the possibility of self-identification of the psychologist's personality by modern means of information technology were identified. Respondents were asked 8 questions for outlined questions. Below are these questions and survey results, with parenthetical percentages initially for first and fourth year students.

1. How do you understand the term "self-identification"?

Most of the students surveyed (61% of first year students and 49% of fourth year students) agree that

this is a process of defining oneself as an individual. Understanding the term as disclosing oneself in the context of a particular social group adheres to almost the same number as in the first year (28%) and in the fourth (25%). It was also proposed to define self-identification as the presence of certain intrinsic qualities, behavior, character traits. In the first year of study, only 10% are inclined to this definition, and by the end of the study the indicator increases to 21%.

Thus, most respondents correctly understand this definition, but due to the lack of attention given to the issue during the educational process, students have doubts about the meaning of the term.

2. How do you understand the term "professional self-identification"?

The answer to this question among students is also ambiguous. The greatest preference was given to the answers of "presenting yourself as a psychologist" – 49% of first year and 55% of fourth year courses and "desire to work in your chosen specialty" – 43% of first year and 35% of fourth year courses. A small number of first year students surveyed consider this presentation as a student (3%). While in the senior year this answer was not chosen at all. Also, freshmen understand professional self-identification as a complete definition in the profession, full disclosure of their professional skills, achievement of professional goals, process of becoming a professional in the chosen field.

3. How do you understand "readiness for professional self-identification"?

In this issue, the views of students of all courses agreed that it is the ability to acquire professional skills and qualities and understanding what difficulties will have to face in future professional activity. Some students (around 6%) consider this training as a practice. In addition, they offered their own answer options, such as the desire to develop in the field of psychology and to acquire professionalism, confidence in their professional abilities.

4. What prompted you (or could you induce) to professionally identify yourself as a psychologist?

This issue, like the previous one, also did not cause differences in different courses. The majority of respondents to professional self-identification are interested in their chosen future profession (46% and 41%), slightly less – life experience (32% and 34%), interesting literature (14% and 20%) and very few – Internet materials (8% and 5%). Respondents were also offered their options of motivation – the desire to know themselves and others better, the desire to improve themselves, the presence of life difficulties, the solution of which requires the help of a psychologist.

5. What hinders (or might interfere with) your professional self-identification as a psychologist?

As it turned out, the biggest obstacles to professional self-identification were self-doubt (32% at all courses) and sloth (35% and 28%). Significantly smaller are the obstacles in life (14% and 23%). Minimal influence on the professional self-identification of the future specialist financial position (9% and 14%). In addition, respondents noted as a hindrance to the professional self-identification of society's attitude towards psychologists.

So, we see that as students age, there are some life-changing obstacles that may lead to financial difficulties. However, the statistics concerning self-doubt are quite impressive. Thus, in the educational process it is necessary to introduce measures that will develop future specialists self-confidence.

6. What methods of professional self-identification do you know?

All the proposed options were selected by the respondents as effective for the formation of professional self-identification. The difference in rates only affected the rating of the answers provided. Yes, in the first year the rating was lined up as follows:

- 1) tests, surveys – 32%;
- 2) trainings and seminars – 31%;
- 3) communication with experienced psychologists – 25%;
- 4) Internet materials, literature – 11%.

The fourth year rating is as follows:

- 1) trainings, seminars – 33%;

- 2) communication with experienced psychologists – 33%;

- 3) tests, surveys – 21%;

- 4) Internet materials, literature – 13%.

We see that future professionals have the least confidence in the Internet materials, but try to improve themselves more through the experience of already formed specialists.

7. Do you use information technologies for professional self-identification?

The answers to this question also change with the student's course of study. In the first years, respondents consider webinars, Youtube (44%) and thematic sites (37%) important for professional self-identification, slightly less – blogs, e-books, Wikipedia (15%). However, in the fourth year, webinars, Youtube and blogs, e-books, Wikipedia (30% each) are equally important in the opinion of respondents, and content sites (23%) are inferior. 16% do not consider it necessary to use information technology for professional self-identification.

Therefore, it is necessary to introduce more information technology tools into the educational process as an element of professional self-identification.

8. What forms of professional self-identification do you use when studying at your University?

Group training (14% and 21%, respectively) was considered to be the least effective for developing professional self-identification. Seminars (39% and 22%) and practical assignments (28% and 27%) are influential forms. They also demand the transfer of experience from experienced psychologists (18% and 27%).

So, with age, future professionals are finding new and more effective ways to professionally identify themselves.

**Conclusions and prospects for further research.** High motivational component, but insufficient level of orientation component of motivational and orientation component of professional self-identification of future psychologist are defined. The study found that for most future psychologists,

the chosen specialty is interesting and they want to develop it as professionals, but because of socio-economic conditions, psychological obstacles may arise when receiving higher education. Although, even with these factors, future professionals are beginning to neglect. There is also a lack of awareness of the concepts of “self-identification”, “professional self-identification”, “readiness for professional self-identification”, distrust of information technology as a powerful tool for professional self-identification, psychological problems (self-doubt, laziness) and lack of self-identity in higher education institutions.

Therefore, the next stage of our work is to develop a program for the development of a motivational-orientation component as an important factor in the professional self-identification of a future psychologist.

**Abbreviations:**

Dniprovskii University of the Humanities – DUH;

Oles Honchar Dnipro National University – DNU;

Volodymyr Vunnychenko Central Ukrainian State Pedagogical University – CUSPU

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## Section 5. Political science

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*Kuppayeva Botagoz,  
Associate professor, Candidate of Political Science,  
Kazakh National Agrarian University  
Almaty, Kazakhstan  
E-mail: Bota160@mail.ru*

### REFLECTIONS ABOUT THE NATURE OF AUTHORITARISM AS A POLITICAL PHENOMENON

**Abstract.** The article aim is to understand the nature of authoritarian leadership. The nature of authoritarianism as a political phenomenon is quite complex and cannot be unequivocally interpreted. Research into authoritarian leadership helps clarify its subjective mechanisms. Notable contributions to the development of authoritarian leadership were made by Wilhelm Reich, Alfred Maslow, scholars from the Frankfurt School Erich Fromm, Theodor Adorno, Herbert Marcuse. They have identified a type of personality that predisposes to authoritarianism and seeks power. Such a personality is formed in an unhealthy social environment that generates mass frustrations, neuroses and the desire of man to flee from all this into the sphere of domination and submission.

**Keywords:** Frankfurt School of Leadership, authoritarianism, fascism, “Escape from Freedom” authoritarian character, authoritarian personality, “one-dimensional” society, “one-dimensional” man, “one-dimensional” consciousness.

#### **Western scientific tradition. Frankfurt School of Leadership**

The nature of authoritarianism as a political phenomenon is quite complex and cannot be unequivocally interpreted. Research into authoritarian leadership helps clarify its subjective mechanisms. Notable contributions to the research of authoritarian leadership were made by Wilhelm Reich, Alfred Maslow, scholars from the Frankfurt School Erich Fromm, Theodor Adorno and Herbert Marcuse. They have identified a type of personality that predisposes to authoritarianism and seeks power. Such a person is formed in an unhealthy social environment that generates mass frustrations, neuroses and the desire of

man to flee from all this into the sphere of domination and submission. For an authoritarian personality, power is a psychological need to get rid of his own complexes by imposing their will on other people.

One of the first researchers of authoritarianism was Austrian scientist Wilhelm Reich, who in the early 1930s undertook a special study of authoritarianism in his connection with fascism. In “The Mass Psychology of Fascism”, Reich expressed the hypothesis that fascist ideology is subject to individuals with a certain psychological structure, which he called “mechanistic-mystical character”.

Fascism, as something irrational and unconscious, is, in the opinion of Reich, the attitude of the



“little man” towards authoritarian society and power, when the individual simultaneously gravitates towards the establishment of dictatorship and spontaneously revolts against it [1, 170]. Reich’s analysis of the origins of fascism does not so much correlate with the socio-economic structure of the Weimar Republic as with the disclosure of the specifics of the authoritarian family and intra-family relations. Reich believes that in the policy that led to the dictatorship of fascism in Germany, the decisive factor was the ideology rooted in the character structure of the average person. Since a person’s character is shaped in childhood, in the circle of the family with its traditions, moral principles and norms of behavior, Reich needs to understand the specifics of family relations, the type of family that contributes to the formation of a certain structure of character. Reich considers the authoritarian ideology of this type of family, the aggressive impulses of the average person, and the role of sexuality in the formation of the fascist dictatorship, stressing that “sexual and economic sociology deals with the structure of man” and that it cannot be anything but a study of the subjective factor of history – “the structure of the character of people of a given epoch” [1, 171].

Reich sees the origins of fascism in the patriarchal family, where the basis for the manifestation of authoritarianism, perverted sexuality, for the formation of such a structure of human character, where the secondary layer, “secondary impulses” that formed the basis of fascism, began to play a dominant role. Since this type of family and the personality structure based on it are particularly typical, it is, according to Reich, the potential base of fascism. Reich deduces the psychological foundations of fascism through the prism of suppressing the sexuality of children, through the dual attitude of the “little man” towards authoritarian power. Reich believes that the psychological consequences of suppressing natural sexuality have an impact on the formation of the pathological character of the personality. Fascism, according to Reich, is a pathology that corrodes the internal psy-

chological structure of a person. Reich also seeks to reveal the role of sexuality in the formation of the fascist dictatorship. It tries to explain the symbolism of the fascist swastika and its impact on the unconscious attractions of man. Reich examines the history of the swastika from East Indian beliefs to Western European versions and concludes that the swastika was originally a sexual symbol. It is in this capacity that the swastika, as a symbolic sign of sexuality, is understood by Reich to have an effect on man.

Reich believes that the basis of fascist mentality is sexual suppression in the family, so its disestablishment is associated with the elimination of sexual suppression and the emancipation of natural sexuality, with the destruction of the gap between sexual morality and a truly human manifestation of love. The destruction of repressive morality should undermine the foundations of the patriarchal family and, at the same time, the sources of development of human pathological character. In the opinion of Reich, a sexual revolution is necessary, which will lead to a true liberation of people from political oppression. Reich believes that the need for such a revolution is essential, not only because authoritarian society and its patriarchal family, suppresses the natural expression of sexuality in people, giving rise to various forms of perverted understanding of love [1, 73]. But because this is the basis for the emergence of antisocial, aggressive types of human behavior, the pathological structure of the individual, and alienated relationships that are the basis for the emergence of authoritarian consciousness. For Reich, “sexual revolution” is not simply an “addition” to political revolution, but a necessary element of radical transformation, a fundamental moment of liberation of the individual from moral, social and economic ways, a starting point for any transformation in society [1].

Reich believes that the reactionary way of thinking, combined with revolutionary excitement, generates fascist feelings, while sadistic brutality, combined with mysticism, generates fascist ways of thinking. According to Reich, Hitler was an expression of the

tragic contradiction inherent in the masses – the contradiction between the desire for freedom and the fear of it. The masses of Germans wanted freedom, Hitler promised an authoritarian, absolutely dictatorial leadership, and the masses accepted it. The masses felt helpless, unable to solve social problems within the old political framework of thought and the old political system. The Fuhrer had to solve this problem for them. Hitler promised to abolish the democratic struggle. The masses were tired of this struggle, which passed by their personal daily needs. Hitler promised the abolition of individual freedom and the establishment of a national one. This illusory freedom relieved them of all individual responsibility. They wanted the “freedom” that the Fuhrer had to win and provide. Hitler promised to make women subordinate to a man, to abolish their maternal autonomy. Hitler promised the destruction of socialist and bourgeois-democratic organizations. Disappointment of the masses in institutions guided by the ideals of freedom, combined with the economic crisis and the will to freedom, generates a fascist way of thinking. Hitler introduced a strong, though irrational emotion into old ideas.

“Mother Germany” and “God Father Hitler” became symbols. Identifying themselves with the “strong and unique German nation”, any citizen who feels his inferiority and really unhappy, could mean something, even if it is illusory. Reich concludes that the characteristic structure of the average person coincided with that of their leader, so phenomena such as Nazism in Germany and totalitarianism in the Soviet Union became a reality.

Following Reich, Fromm addresses the authoritarian problem. In his work “Escape from Freedom”, published in 1941, Fromm makes a radical discovery. He describes a specific cultural and anthropological phenomenon – “escape from freedom”. He analyzes such a mechanism of escape from freedom, which consists in a tendency to renounce the independence of one’s personality, to merge one’s “ego” with someone or something external, so as to find the power missing from the individual himself [2, 56].

The people of mass do not long for freedom. Psychologically, they are much more comfortable when their lives, their will and minds are controlled by a totalitarian leader. People need leaders who make decisions for them. Fromm says that in the XIX century the problem was that “God died”, and in the XX century it was that “man died”. The individual became more lonely. Previously, their “Ego” could rely on property, prestige, power and family. Loneliness, fear, loss remain, but people, according to Fromm, can’t tolerate them forever. A person is unable to move from negative to positive freedom, trying to get rid of freedom in general. The main way to escape from freedom is to obey a leader in totalitarian countries, i.e. to become a faceless and obedient mass. “The history of mankind is full of periods when the crowds rushed from freedom to tyranny, because such slavery seemed to be a deliverance from freedom, from oneself, from duty” [3]. According to Fromm, both masochistic and sadistic aspirations help an individual get rid of the unbearable feeling of loneliness and powerlessness. Since the term “sadistic-masochistic” is associated with perversions and neuroses, Fromm prefers to talk not about sadistic-masochistic, but about “authoritarian” character. A common trait, according to Fromm, of authoritarian thinking is the belief that life is determined by forces outside of the individual, outside his or her interests and desires. The only possible happiness is to submit to these forces. In an authoritarian mind, activity is based on a deep sense of powerlessness that one tries to overcome. In the opinion of Fromm, an authoritarian person gains power to act only by relying on a higher power. It must be indestructible and immutable. Lack of power is a sign of guilt and inferiority for such a person. If power shows a sign of weakness, his/her love and respect turns into contempt and hatred. According to Fromm, the courage of an authoritarian person is to endure everything that fate has sent her/him, or its live representative leader. To suffer painlessly, not to change their fate, but to obey it – is the virtue of an authoritarian character. The world for a person with an authoritarian character consists of people

who have or do not have power and authority, that is, the highest and the lowest. They are only capable of domination or obedience. Any difference – gender or race – for a person is a sign of superiority or inferiority.

Fromm shows that authoritarian character has masochistic and sadistic tendencies. Forms of manifestation of masochistic tendencies are feelings of own inferiority. They are perceived as pathological and meaningless. In addition to masochistic tendencies, the same type of tendencies are sadistic. The scientist identifies three types of sadistic tendencies. This is the desire to put other people in dependence on themselves and gain unlimited power over them. This desire is not only to have absolute power over others, but also to exploit them. It is an aspiration to make others suffer or to see them suffer [2, 281].

According to Fromm, the destruction of one's own self and the attempt to overcome the unbearable feeling of powerlessness at the expense of this is one of the sides of masochistic tendencies. The other is an attempt to dissolve into an external force. This force can be an institution, a nation. Becoming a part of the force, a person becomes, according to Fromm, involved in its power and glory. The individual renounces themselves, their "ego", their own freedom, they get rid of decision-making, of responsibility for their destiny.

The basic aspiration of sadistic impulses is to become the absolute master of another person, to do with them anything the master wants. But the most radical way to manifest the power, as Fromm writes, is the ability to cause suffering, pain to those who are unable to defend themselves. Such a mentality, as the scientist believes, defines the "human base" of fascism. This concept of Fromm denotes a special social type with a characteristic structure that allows its owners to successfully adapt to the requirements of totalitarian, fascist political regimes. Summarizing the above, we can identify the main features of an authoritarian character:

- the need for authority, which can be both personal (political leader) and super personal (corporation, party, nation, state);

- lack of need for freedom, constant readiness to 'escape from freedom', inability to control oneself in conditions of freedom, perception of it as a burden;

- the conviction that human life is at the mercy of super personal forces, the willingness to obey external dictatorship, to see it as something that resembles a will of fate or fate;

- an aversion to the idea of social equality; a belief in a hierarchical vision of a world in which the principles of domination and subjugation reign, where the presence of a ruling power and a kneeling weakness are indispensable;

- a willingness to accept all the trials from the authorities, to bear all the burdens and to see valour in that completeness;

- the perception of any force as an asset and any manifestation of weakness as an object worthy of contempt; Sadomasochistic combination of the willingness to repent before force with the willingness to despise and trample on the personality – synonymous with inferiority;

- conformism, readiness to follow the group in everything, to reproduce in their worldview and social behavior the accepted worldview and activity stereotypes;

- traditionalism of thinking, disregard for spiritual, intellectual innovations;

- xenophobia expressed in acute dislike and hatred towards all those who differ in their racial, national-ethnic and other characteristics from herself and her social environment, whose intellectual level is superior to her own; hence, a sharp denial of the authoritarian personality to the intelligentsia;

- the readiness to submit to the government and power is combined with the expressed need to rule over all those whose worldview and behavior do not meet her ideas of what is right and looks in her eyes as the lowest form of life position [4].

Fromm writes that first of all, the "leaders" enjoy the power, but the masses are also feeling sadistic satisfaction. Racial and political minorities in Germany, and then other peoples, are the objects of sadism,

which “feed” the masses. Hitler and his bureaucracy revel in power over the German people, and at the same time they teach them to enjoy power over other nations and seek world domination. As a result of thousands of years of perversion in education and social life, the masses have acquired biological cruelty and have lost their ability to freedom.

In the works of E. Fromm it is impossible to find a detailed consideration of the problem of leadership, but at the same time he says that in order to understand the specifics of the totalitarian regimes, it is necessary to look at the leaders of these regimes, who embodied whole nations. Fromm describes Hitler in his famous work “Adolf Hitler, A Clinical Case of Necrophilia”. The scientist concludes that Hitler is a narcissist, which cares only about himself. His main ambition was the desire for power and conquest of the world. The three most characteristic features of character of Hitler, according to Fromm are narcissism, withdrawal from reality and an absolute lack of ability to love, give warmth and empathy. The love of the strong and the hatred of the weak, so typical of a sadistic-masochistic personality, explain, according to Fromm, the many political acts of Hitler, who hated the Weimar Republic because it is weak. He admired the industrial and military leaders because they had power and strength. Undoubtedly, Hitler had certain abilities, which helped him to climb the Olympus of political power. It was certain magnetism, an ability of suggestion. He also had a simple and straightforward phrasing and a good memory.

Fromm also analyzed another dictator of the twentieth century – Stalin. One of the traits that he points out in Stalin, is the desire to display his limitless power over people. He, just like the God, had power over life and death, could destroy, cause pain or heal [3]. Fromm does not hide his personal sympathy for Stalin, defining him as the undisputed leader. Fromm insists that if the people did not want these dictators to come to power, they would not have claimed their place in history.

Fromm and Reich have tried to go beyond the one-dimensional psychoanalytics and to present specific leaders as holders of a social character that coincided with the social character of the masses at the time.

In 1943, A. Maslow’s work “The Authoritarian Character Structure” was published, which showed that not only internal psychological factors play a role in the formation of the authoritarian structures of the individual, but also the situation, or “field” in which the formation of the individual takes place. Maslow distinguished typical features of an authoritarian character, such as:

- hierarchy of consciousness – to consider all other people as competitors who are either superior or have a lower position in comparison with the most authoritative person;
- a tendency to generalise characteristics of superiority or inferiority;
- a tendency to generalize the characteristics of superiority or inferiority; a desire for external attributes of prestige – power, money, status;
- the presence of hostility, hatred, prejudice in character;
- coupling of kindness with weakness;
- sadomasochistic tendencies;
- constant dissatisfaction;
- intrapsychic conflict;
- a sense of guilt that generates a sense of hostility.

The authoritarian character is also manifested in such situations as:

- infringement of the personality of women;
- the development of homosexuality;
- the desire for a militarized, super-organized ideal, the desire to humiliate others;
- an aversion to education;
- avoiding responsibility for personal destiny.

In 1950, in New York the famous book of T. Adorno, E. Frenkel-Brunswik, D. Levinson, N. Sanford “The Authoritarian Personality” was published [5, 13]. The authors of this work pursued pragmatic goals – to develop psychological weapon against potential threat of fascist thinking. This project was

conceived as a search for personality characteristics explaining the reasons for accepting fascism. None of Adorno's respondents belonged to a fascist organization. They were white, "middle" class, Christian, San Francisco suburb residents. The result of the study was unexpected. It turned out that among these middle-class Americans, an authoritarian type is also common. And their researchers found the same basic psychological features that were typical of the Germans who welcomed Hitler to power. The authoritarian personality, according to researchers, is a special set of psychological characteristics, among which they identified the desire to suppress others, intolerance, ethnocentrism and a number of others. In doing so, the person repressing the weak is afraid of those who are stronger than him.

Researchers of authoritarianism saw their task not only to describe this type of personality, but also to discover the origins of authoritarianism, which they find mainly in the family, in relationships with parents. In their opinion, strict discipline, submission to the head of the family gives rise to an inferiority complex in children. Education, on the other hand, reduces the emergence of prejudice. In "The Authoritarian Personality", ideas about the deep, unconscious determinism of the political appearance of fascism were expressed in the form of empirical indicators and measured on a special scale F. Also noteworthy is the theoretical study of the concept of "authoritarian syndrome", which provides a tool for identifying and microanalyzing macro-political objects. Empirical studies conducted by Adorno and other scientists have confirmed the real existence of the authoritarian type of personality and revealed some new features. As a whole, this project has greatly expanded the understanding of the nature and inner motivations of striving for authoritarian leadership.

Scientists' conclusions about the danger of authoritarianism were also confirmed in the post-war period. Outwardly, authoritarianism has changed. Impersonal authoritarianism, embodied in anonymous bureaucratic structures of state institutions,

replaced the Fuhrer's personalized power. This authoritarianism gave birth to a new type of personality, called the "one-dimensional man". The study of such a person was undertaken by Herbert Marcuse.

In 1964, the work of Marcuse "One-Dimensional Man: Studies in the Ideology of Advanced Industrial Society" was published. The ideas shown in "One-Dimensional Man" quickly turned Marcuse into a popular ideologist of the "new leftists", an idol of the opposition student movements of the 60s and one of the most influential Western philosophers. The central idea in Marcuse's book is the idea of "one-dimensional". His interest in the "one-dimensional" man was dictated by the desire to break through the alienation that arose between man and Western society.

Marcuse's starting point is antiauthoritarianism. His arguments in criticizing Western society and alienation are quite radical. Marcuse vividly illustrates the domination of impersonal forces over the individual, which leads to the impoverishment of the individual, to the appearance of a "one-dimensional" man.

In the sphere of production, Marcuse sees the basis for "one-dimensional" in the unification of separate production units and links into a single organism, all organs of which are strictly subordinate. As a result, according to Marcuse, the movement to "totalization", i.e. to creation of comprehensive, integral rational-regulated system of production, management, educational institutions influencing each other, system of universal functional interaction of all elements of social life is decisive for the whole social climate. Technological, economic, managerial "totality" and "one-dimensional", according to Marcuse, finds its continuation in the "one-dimensional" political and social reality; in politics, the external differences of the main parties hide the internal unity; the opposition turns into a force that contributes to the preservation of balance and self-reproduction of the existing system. The role of the working class is reduced to the function of a "pressure group" [6, 83].

Marcuse considers the main feature of the "one-dimensional society" to be the ability to resist de-

structive social forces and changes and to preserve continuity and stability. As Marcuse writes, this society and its state achieve “unity of opposites”. Marcuse is aware of the dangerous, destructive consequences for society and man, which are caused by “one-dimensional”. One of the main dangers for humanity, according to Marcuse, is that the “one-dimensional” consciousness in the USA and in the countries of Western Europe often perceives this state as having advantages over the historically preceding social states, and sometimes even sees it as an embodiment of ideals. Explaining this fact, Marcuse describes the advantages of the society criticized by him – it is an increase in material welfare, the level of consumption of quite large numbers of people. All this contributes to the formation of a person with a kind of “happy” consumer consciousness, with social conformism. In Marcuse’s opinion, this is the rational and material basis for “unification of opposites”, for “one-dimensional political behavior”.

According to Marcuse, the category of “one-dimensional” lets clearly and concisely capture the nature of this society. “One-dimensionality” is homogeneity, absence of a clearly expressed and effective alternative (social, political, ideological). It means that this is also homogeneity, unidirectionality. “One-dimensionality” means the absence of any confrontation, any criticism, any going beyond the existing system of relations, institutions, evaluations, and reconciliation with the existing system. From the social and political point of view, “one-dimensionality” means the absence of social forces within society that oppose the existing social relations and seek to overthrow them [7, 56].

According to Marcuse, there are no antagonistic forces within the system, since both the proletariat and the bourgeoisie pursue common goals and share common political ideals. The style of life in the developed industrial society is homogeneous. A worker and an entrepreneur watch the same TV programs, films, read the same press, use the same advertised toothpaste, drive around in their own cars. And most

importantly, both are generally satisfied with these benefits and have no desire to destroy the existing structure of needs, to go beyond it. The “one-dimensional” art, the “one-dimensional” language, as well as radio, cinema, television, advertising, allow to influence the consciousness of the proletariat, so that it begins to think in a direction favorable to manipulators. His proletarian consciousness dulls, the working class ceases to be a “class for itself,” that is, a revolutionary class [8].

Formation of “one-dimensional” society, “one-dimensional” person with his “one-dimensional” consciousness Marcuse connects with new forms of control over people, based on modern science and technology, on “technical rationality”. Marcuse distinguishes three elements in them: a) system of creation and satisfaction of enslaving needs; b) all-pervasive mass communication means – television, radio, press, “when the worker and the master enjoy the same television program and visit the same place of rest”; c) new forms of social control. According to Marcuse, the theory of human relations in an enterprise, the science used to influence the human psyche, also prevents the possibility of forming opposition sentiments.

Marcuse considers “rational one-dimensionality” to be a negative characteristic of his modern society. This society is irrational, continues Marcuse. What Marcuse says is that direct, open and forced control gives way to administrative, ideological and psychological control, that the nature of labor changes and there is a certain increase in living standards. That the majority of people in the “one-dimensional” society do not realize their dependence “Slaves in the developed industrial civilization are slaves with sublimated feelings, but they are slaves...” [8, 140]. Marcuse in his concept gives a negative assessment – mainly from the fact that the development of this society deforms the will and abilities of the individual and condemns him to undoubted, though disguised slavery. Marcuse concludes that such a society must be destroyed in a revolutionary way and replaced by

a society of a fundamentally new type. He dreams of a social revolution.

In “The End of Utopia” (1967), “An Essay on Liberation” (1969), Marcuse forms a new concept of revolution: the concept of world revolution, where he raises the question of the processes taking place in the “third world” and their relationship to the dynamics of social change in “developed industrialized countries”, and the concept of revolution as applied to the developed countries themselves. According to Marcuse, radical students and intellectuals are the “detonator”,

the “catalyst” of the revolution in the developed industrial society and its driving forces. In his opinion, they can start an anti-capitalist revolution [9, 133].

Marcuse was looking for an alternative to Western society on the way to rejecting rational political behavior, developing new forms of sensuality, and emancipation of the individual. These anti-Western forms challenge the “one-dimensional” society and are political protest against impersonal authoritarianism embodied in anonymous bureaucratic structures of state institutions.

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*Sultanova Nigar Tahir Qizi,  
Phd candidate at the Academy of Public Administration  
under the President of the Republic of Azerbaijan  
E-mail: Nigart.sultanova@gmail.com*

## **EU ON GLOBAL ARENA: NEED FOR REBOOT OF A FOREIGN POLICY**

**Abstract.** This article explores EU's ability in establishing its strong position in world politics. Essential to this analysis is the assumption that the EU will remain closely entangled with its immediate neighbors and this will shape the evolution of its external action. Key aim of this article is to analyze main ways for EU to enhance its involvement in global issues. The article begins by exploring the history of formation of EU foreign policy and current level of its involvement in different regions. It also analyzes the reasons EU is being criticized today for its passive international participation. Then article suggests main responses EU might take with response to challenges it faces today. The conclusion sums up the state of the of EU external action and concludes EU needs to take serious actions in order to face the impact of the challenges in the global arena.

**Keywords:** European Union, foreign policy, global politics.

### **Introduction**

The world today is dominated by the rivalries of global powers. The criteria for being considered the center of power as well as the list of states that can be attributed to these centers are also debatable. Often along with such countries as USA and China, European Union also finds itself in that list. Let us see to what extent this approach is justified.

There are different views related to EU's position in world affairs. Over the last years EU is putting a lot of efforts in order to consolidate its foreign policy. In defense issues there has been made some progress, notably Permanent Structured Cooperation (PESCO) and the European Defense Fund (EDF) were established [10, P. 7]. However, EU foreign policy overall still fails to find quick common response to modern international challenges. Although the Lisbon Treaty has created quite an extensive institutionalized machinery of EU and also strengthened its foreign policy apparatus, today there are fears over a decrease in Europe's general influence over the global politics. With respect to the evolution of the CFSP the Lisbon Treaty has boosted the range

of instruments available for EU action in this field. But despite this, in many areas, EU foreign policy still falls short. Pertinent research questions would be why does the EU have great or weak power in global affairs?

### **The formation of EU foreign policy**

EU member States realized that a common foreign policy was inevitable and the idea itself started to form in 70s (European political cooperation and Common Foreign and Security Policy). It was then reaffirmed in Maastricht and Amsterdam Treaties and in a more elaborated way in the Lisbon Treaty of 2009 [5; 8; 9]. Despite of abovementioned institutional reforms until Lisbon foreign policy remained profoundly intergovernmental. Lisbon Treaty granted EU's foreign policy an institutional and legal basis. The post of the High Representative of the European Union for foreign affairs (at the same time Vice President of the European Commission) was set up in order to encourage the coordination of Member States.

EU enlargements made the decision-making process more complicated. Member States seek to show that their national interests are in some cases more



important than the common EU policy. Therefore, despite the creation of a single institutional structure, the EU still has limited opportunities to act with one voice in the international arena. Quite often we see states like Russia, China or USA seek to develop bilateral and multilateral formats for interaction with European states rather than tedious and futile negotiations on certain aspects with Brussels. Today in the context of Brexit, as well as discrepancies with the United States, experts suggest EU needs to enhance its independence in the field of foreign policy.

### **EU as global actor**

The EU traditionally relies in its foreign policy on political and economic instruments such as European Neighborhood Policy, attention to standards of democracy and human rights, humanitarian assistance in the event of disasters, cooperation with the UN and other multilateral institutions. The EU played an important role in developing dialogue between Serbia and Kosovo in 2013, in concluding a “nuclear deal” with Iran in 2015, in reaching the world’s first universal, legally binding peace agreement, adopted at the Paris Climate Conference.

Indeed, the EU has strong arguments in favor of its claim to be a global player. First of all, it is the economic potential and a high standard of living. The EU ranks third in the world in terms of population (after China and India). With its high GDP indicators, it ranks largest economy in the world and largest trading block [1].

Secondly, we need to underline its “soft power”. Despite a number of crises being experienced by Europe, the democratic and integration EU remains attractive, both for European countries and for more distant countries.

Third argument would be the “hard power” of the EU: 22 out of 28 EU member states are members of the North Atlantic Alliance. EU military leaders are Britain, France and Germany, with the first two possessing nuclear weapons.

Today more than ever, EU member states are striving to find ways to focus on the European com-

mon interest. “Promoting European interests and values on the global stage” is among the main priorities of the European Council’s new strategic agenda for 2019–2024 [4]. In it, covering issues like migration policy, fight against crime, resilience against disasters, strengthening single market, social and environmental issues, the European Council commits to make CFSP and CSDP “more responsive and active and be better linked to the other strands of external relations”. Relations with strategic partners are to be guaranteed by “more synergies between the EU and the bilateral levels” and in an “integrated manner” and “in a joint endeavor”.

Looking back on a bit more than ten years since the Lisbon Treaty was signed illustrates how difficult it remains to find the necessary consensus and support for joint foreign policy action within the CFSP framework. The EU often had no adequate answers to foreign policy crises, and its influence on the international system as a whole has declined.

Along with outlined priorities of the mentioned agenda, EU also outlined as a priority the six Balkan states (Serbia, Kosovo, Montenegro, Albania, Bosnia and North Macedonia) aspiring to join the Union, stronger EU arms export control, a policy to stabilize Libya and maintaining EU sanctions on Russia [7].

With its immediate neighbors the EU has strong links via Eastern Partnership. We witness today EU’s unity in its support of Ukraine’s territorial integrity and sovereignty as well as in restrictive measures towards Russia over Ukraine crisis. European diplomatic response comprises dialogue with Russia and at the same time commitment to support such principles as principle of democracy and territorial integrity.

One of the main challenges the EU faces is the migration crisis. Along with its humanitarian aid today EU seeks to back UN activities to advance good local governance and a political transition in Middle East (Syria, Yemen) which is key to the return of refugees. The same approach is also valid with respect to Israeli-Palestinian conflict where EU strives

to play crucial role of facilitator in communication between all parties.

### **EU foreign policy: lack of ability to act**

Today EU foreign policy is being criticized for its irrelevance which is due to the structural inconsistency between supranational and intergovernmental elements of EU CFSP. This inconsistency refers to the lack of unity and flexibility both between the member states themselves and also between EU institutions and member states. The decision of UK to leave the EU, US withdrawal from the Iran nuclear accord [6] and EU's inability to contribute to stabilize neighbor countries starting from the Caucasus region to Africa have further undermined the EU's global weight. Critics claim that foreign policy still remains in a national domain of EU member states [3]. This and also voting rules of the Council of Ministers hold back frequently collective action at union level.

EU is also being criticized for having neither means nor the political will to play a decisive role in world politics issues ranging from transatlantic partnership to EU enlargement. It has been largely absent in the Middle East, including the crisis in Syria and Libya. EU's failure to act as an effective player on a global politics is quite often depends on its relative lack of military might. But it is obvious that not only lack of military resources makes the EU weak.

With respect to the EU's shrinking role in world politics, EU High Representative for Foreign Affairs and Security Policy and Vice-President of the European Commission Josep Borrell, who assumed his post in December 2019, underlined the need for EU to become a real geopolitical player:

*"... we see the rebirth of geostrategic competition," notably between China, Russia and the United States, the EU "has the option of becoming a player, a true geostrategic actor, or being mostly the playground" [2].*

To be able to become a true global player Borrell as well as other leadership team in Brussels, namely recently nominated President of European Commission Ursula von der Leyen and European Council President Charles Michel need to have a mandate from the

member states to lead some priority foreign policy portfolios and member states go along with them.

One of the main reasons critics argument the inefficient EU foreign policy is the fact that foreign policy related decisions are taken unanimously with a possibility of veto by any member state. In 2019, for instance, veto was applied by Italy during a resolution on Venezuela and by Poland and Hungary on migration accord between the EU and the Arab League. Another example would be China-friendly EU member states driven by their needs blocking EU initiatives aimed against China.

Another reason for criticism would be different perception of certain problems and country-specific attitude of particular EU members. For instance, Germany's support to the gas pipeline project (to be built between Russia and Germany through Baltic Sea) rises concerns of EU members over increase of energy dependence from Russia.

In the area of security and defense the need for further reform derives from the fact that, the PESCO does not guarantee the participation of all EU Member States.

### **Suggestions**

Common proposal suggested to fix at least partly the problem of lack of unity is to abolish unanimity voting on certain issues and introduce qualified majority voting (when 55% of member states representing at least 65% of the EU's population are in favor) for foreign policy. This would have enabled EU to certain actions (impose sanctions, authorize civilian missions etc.) which it is unable to implement today unless unanimous decision is made. However, if adopted, it will not be a whole solution because, as per Treaty of European Union, there will still be issues for member states to decide unanimously.

Another option to overcome the deadlock in a decision-making process would be to implement constructive abstention in order to avoid the situation when a decision is blocked by a member state(s). Experts also suggest ideas such as to have a single seat at United Nations Security Council, form "ad

hoc coalitions” of like-minded member states that would act together but don’t undermine the cohesion of the EU and to grant EU exclusive competence in the field of foreign policy. The latter seems for now unrealistic but it would have enabled EU with true united stance in world politics.

With respect to transatlantic relations EU can still use existing legal frameworks to face new challenges with greater unity. Solution here would be promoting structured dialogue with different U.S. stakeholders based on common values.

Enlargement of EU will still be based on the support of democratic development, pluralism, etc. But, more transparent, open and constructive approach is to be demonstrated in the accession process itself. For instance, Turkey, a candidate for accession since 1999, has strained relations with EU despite

of strong economic and social relations. It is obvious that enhanced dialogue between the two parties would be beneficial both for Turkey and the EU.

### Conclusion

Overall analysis of global politics shows that the EU cannot stay aside from world affairs and on the contrary needs to figure out common response to the modern challenges. By using its wide diplomatic experience, the EU needs to position itself in a more united way in today’s world order. can face the growing number of challenges is by uniting and acting even stronger together. Despite of national politicians are in favor of prioritizing their national interests over the EU interests, it is clear that weakened EU means weakened nation states. In a globalized world effort will be not be spared to create an effective and united common European foreign policy!

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## Section 6. Agricultural sciences

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*Davidovsky Anatoly Grigorievich,  
Associate Professor, the Faculty of Computer Engineering  
Belarussian State University of Informatics and Radioelectronic  
E-mail: agd2011@list.ru*

### THE METHODOLOGICAL BASICS OF INFORMATION SYSTEMS FOR FORECASTING OF THE AGROPHYTOCENOSIS PRODUCTIVITY IN THE FORTH INDUSTRIAL REVOLUTION

**Abstract.** Has been viewed biophysical models and functional components of the Information System for Forecasting of the agrophytocenosis productivity (ISFAP) based on biophysical modelling of the “climate-soil-microbiome-plant” systems.

**Keywords:** agrophytocenosis productivity, biophysical modelling, information systems, forecasting, Forth Industrial Revolution.

#### Introduction

One of the main directions of the Forth Industrial Revolution is the design of digital bioagrotechnologies for solving problems of precision farming and preventive management of productivity of agrophytocenoses. In this regard, an important direction in the development of digital bioagrotechnologies is the development of information systems for predicting the productivity of agrophytocenoses based on cognitive and fuzzy models and algorithms. The production of agrophytocenosis is dependent by soil and climate conditions, including season changes in temperature, humidity, and air mass movements. These weather and climate conditions may to influence on plant species-specific rhizosphere community, which included many microbial, fungi and viruses components. The rhizosphere microbiome may be the mediator between plant and environmental climate conditions [1]. The structure of microbiome communities largely

determined by the composition of plant exudates, performing as a substrate. Its dependence on external factors such as the type of soil, microbial species and climate factors is convincingly shown [2]. Plants have universal systems of interaction with microorganisms, but they can be mutualistic or antagonistic, depending on the type of micro-symbiont, environmental conditions, the genotype of specific individuals [3]. The forecasting of the agrophytocenosis production may be realised on biophysical modelling of the “climate-soil-microbiome-plant” systems, including climate fluctuations. Besides, productivity agrophytocenosis largely depends on both microbiome community and metabolic networks in agroecological system “climate-soil-microbiome-plant”. Factors of heliophysical and geophysical activity play an important role in this system [4].

The aim of this article is the grounding of methodological aspects of the Information systems for

forecasting of the agrophytocenosis productivity (ISFAPs) based on biophysical modelling of the “climate-soil-microbiome-plant” systems.

### The biophysical simulation of the agrophytocenosis productivity

The formal and biophysical models of ISFAPs are based on the cognitive algorithms, which are an implementation of the evolutionary operators, which recursively calculates the vectors of values of all characteristics of the simulated. Even relatively simple models of the dimension of the  $\mathbf{x}$  vector can be counted in tens. Each implemented algorithm for modeling the dynamics of agrophytoecosystems may be formally written using the  $\mathbf{x}(\mathbf{k})$  – vector of the system state variables at the  $\mathbf{k}$ -th step, then creating the model (1) is equivalent to defining the evolutionary  $\mathbf{f}$  operator:

$$\begin{aligned} x(k+1) &= f(x(k), a, w(k), u(k), \\ x(0) &= x_0, k = 0, 1, \dots, T. \end{aligned} \quad (1)$$

where  $\mathbf{k}$  is the account step number;

$\mathbf{x}(\mathbf{k}), \mathbf{x}(\mathbf{k}+1)$  are the vectors of the model state on two adjacent steps;

$\mathbf{a}$  – is the vector of static parameters of the model;

$\mathbf{w}(\mathbf{k})$  – is the vector of uncontrollable external influences (weather);

$\mathbf{u}(\mathbf{k})$  – is the vector of control actions of agro-technics;

$\mathbf{x}_0$  – is initial conditions;

$T$  this is the end time of the simulation process, usually coinciding with the date of the beginning of the harvest [5].

The biophysical models for ISFAPs are calculated by repeatedly applying the operator  $\mathbf{f}$  to the initial state vector and observing the evolution of the agrophytocenosis under study over time. For the model account, set the values of the parameter vector, external influences (or their parameters), and the initial state of the agrophytocenosis. At the same time, the main problem of modeling and forecasting the yield of agrophytocenosis based on the distri-

bution of received assimilates between all the plant organs included in the consideration – vegetative and non-vegetative. The total possible increment of its biomass as the total input item of the plant growth balance can be described in mathematical terms. It is the mathematical formalization of this problem that is the essence of building a model of organogenesis of cultivated plants based on the model of distribution of primary assimilates [5; 6]. In this case, the mathematical simulation of the problem in terms of the dynamical system theory may be to write by differential equations (2):

$$\left\{ \begin{aligned} \frac{dx}{dt} &= UZ, \\ \frac{dZ}{dt} &= F_Z, \\ \frac{dY}{dt} &= F_Y(X, Y, V, t), \\ \sum_{i=1}^n U_i &\geq 1. \end{aligned} \right. \quad (2)$$

where  $\mathbf{X}$  is the vector of all dynamic variables that describe the current state of plant organ compartments,

$\mathbf{Z}$  – determines the total number of available primary assimilates (growth resource),

$\mathbf{Y}$  – is vector of current values of concentrations, or absolute contents of nutrient or structure-forming elements,

$\mathbf{V}$  – is vector of random uncontrolled external influences (weather).

The vector of agrophytocenosis yield management  $\mathbf{U} = \mathbf{U}(\mathbf{X}, \mathbf{Y}, \mathbf{V}, \mathbf{Z}, t)$  characterizes the relative proportion of primary assimilates arriving and available growth resource, where  $\mathbf{X}$  is the vector of all dynamic variables that describe the current state of a particular organ of the plant organism compartments at time  $t$ .

It is necessary to take into account that by definition  $\mathbf{L}$  represents the maximum value of the functional forecast of crop yield of agrophytocenosis under a given influence of climatic factors. This allows you to write the basic equation of dynamic programming of the yield of  $i$ -th agrophytocenosis (3):

$$U_i = \begin{cases} 0, & \frac{dL}{dX_j} = \min_j \left( \frac{dL}{dX_j} \right) \\ 1, & \frac{dL}{dX_j} = \max_j \left( \frac{dL}{dX_j} \right). \end{cases} \quad (3)$$

If  $L(\mathbf{X}, \mathbf{Y}, \mathbf{Z}, t)$  is the maximum value of the goal functional that can be reached, that  $\mathbf{X}$ ,  $\mathbf{Y}$ , and  $\mathbf{Z}$  are values of the model's dynamic variables in time  $t$ . The function  $L$  for the utility index may be expressed as the record (4):

$$L(X, Y, Z, t) = \max \left( L \left( \begin{matrix} X + \Delta X(U, \Delta t); \\ Y + \Delta Y(U, \Delta t); \\ Z + \Delta Z(U, \Delta t)t + \Delta t \end{matrix} \right) \right). \quad (4)$$

The logical interpretation of the resulting solution is trivial. At any given time, all available assimilates are directed to the single organ whose growth is most important in achieving the ultimate goal [6].

The environment in interaction with agrophytocenosis is a reservoir of a nutrient substrate or a growth resource that depends on integral indicators of meteorological characteristics, including changes in temperature, humidity, and air mass movements. This resource autonomously may fluctuate over time. The rate of resource consumption is determined by the capacity of the vegetative organs. The share of resources directed by the plant at any given time to the growth of vegetative and generative organs is management. The standard Bellman dynamic programming procedure can be used to search for management of agrophytocenosis productivity at the climatic condition fluctuations.

**The conclusion**

The ISFAP will be developed methodological foundations of geoclimatic agrophysical bioinformatics, applicable for modeling and forecasting yield reductions of crop species. The ISFAP include the inpatient database (SDS – Sationary Data Set), the online database (ODS–Operational Data Set), the User interface DUIs (Data Set user interfaces) and models of microbial-plant interactions.

The inpatient database (SDS – Sationary Data Set) – the repository of agro-physical, agrotechnology, bioecological, geoclimatic and heliophysical data and the results of metagenomic analysis of agrophytocenosises. It is constantly updated with the onset of new seasons of vegetation. However, even for the first run of the model “on account” it must contain information for the period including the last 50 years of vegetation. The database is a hierarchically organized relational structure with cross-references. SDS consists of 60 tables and about 500 storage fields, where heterogeneous data relating to the period of time over the past 50 years is stored.

The online database (ODS–Operational Data Set) contains data for the executable file of the model, and its structure is a file that contains a standard set of named ranges. ODS includes topics such as: Place (terrain data), Weather and Climate (dynamics of weather and climate data), Agroculture (data on agriculture), Soil data (physico-chemical data of soils), Agrotechnology (data on used agricultural technologies), Initials fate of Agrophytocenosises (initial conditions the functioning of agrophytocenosises), Common Date of Agrophytocenosises (dataset description about agrophytocenosises).

The user interface DUIs (Data Set user interfaces) – is a separate program for interaction with the user in the formation of an operational database from a stationary database based on SQL-query.

Associated web resources (LWR–linked web resources) include specialized web-platforms for biophysical analysis of agrophytocenosis development.

Beside of, the special information support for ISFAPs may to include the integrated environments of planning and carrying out multifactor computer experiments containing the relational databases of field observations and parameters of biophysical models and the approaches of system analyses of the agrophytocenosises and its productivity. The biophysical models of the “climate-soil-microbiome-plant” systems are able to have powerful simulation effects for formal and biophysical modelling

and forecasting of the agrophytocenosis production at different conditions of climate fluctuations, including season changes of temperature, humidity, and air mass movements. The ISFAPs may be integrated with the systems of monitoring for weather, climate, and soil factors, unmanned agrotechnical

systems, and autonomous intelligent agricultural robots. The development of the methodological basis for creating ISFAPs based on biophysical modeling will allow us to move to digital agricultural technologies that meet the realities of the Forth Industrial Revolution.

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*Megrelidze Tamaz,  
Department of Food Industry, Georgian Technical University,  
Tbilisi, Georgia*

*Isakadze Tamaz,  
Department of Food Industry, Georgian Technical University,  
Tbilisi, Georgia*

*Tabatadze Lali,  
Department of Chemistry, Faculty of Natural Science,  
Mathematics, Technology and Pharmacy,  
Sokhumi State University, Tbilisi, Georgia*

*Gugulashvili Givi,  
Department of Food Industry, Georgian Technical University,  
Tbilisi, Georgia*

*Kintsurashvili Ketevan,  
Department of Food Industry, Georgian Technical University,  
Tbilisi, Georgia*

*Kopaliani Tamar,  
Department of Food Industry, Akaki Tsereteli state University,  
Tbilisi, Georgia*

*E-mail: tamazmegrelidze@gmail.com*

## **THE POSSIBILITY OF OBTAINING TEA SUCH AS PARAGUAYAN MATE FROM THE CAUCASIAN RHODODENDRON**

**Abstract.** The question is raised of identifying and producing products with nutritional, preventive and therapeutic properties that are important for human life and health. Unique tonic and other useful indicators of a drink (tea) made from Paraguayan mate and Caucasian Rhododendron, critical for human health, are examined and the similarity of indicators of both drinks is shown. It has been proved that Paraguayan mate can be replaced by Caucasian Rhododendron, which will provide the possibility of producing mate type tea in Georgia. This will expand the raw material base for the production of this expensive product and will make it possible for Georgia to become a producer of the product required worldwide. It is shown that for a complete replacement it is necessary to ensure the maximum approximation of the taste indices of both products, which requires the implementation of appropriate research and experimental work.

**Keywords:** Mate tea; rhododendron tea; useful properties; raw material base; taste indicators.

In today's world, it is very important for us, as well as all over the world, to identify, create and produce highly effective products that will have both nutritional, preventive and curative proper-

ties. Particular importance is given to products capable of timely and fully releasing oxidants and other harmful substances accumulated in the human body (such products are also called functional products).

The impact on human health of food products depends on both the chemical composition of the raw material and its processing technology and the use of optimal technological equipment. Therefore discovering and researching new resources for food production and their effective use is a very important and topical issue. Due to the importance of the issue, intensive scientific and research work is underway both with us and abroad. The main purpose of these studies is to obtain and produce non-toxic food-preventive products with ecologically pure, pleasant organoleptic and biological properties, using raw materials innature.

In this regard, the Georgian vegetable world is distinguished by its great diversity and richness of nutritional and therapeutic properties. Plants rich in a wide variety of biologically active substances are abundant here with a wide variety of nutritional and medicinal properties. Among such plants, the Caucasian Rhododendron (*Rhododendron caucasicum* Fahl), or the Caucasian Deca, is notable.

### Material and Methods

One of the most important products for human health is Paraguayan tea, or "mate tea", made from the leaves and young shoots of the tropical plant *Ilex Paraguerinsis* St.Hil.

Mate tea became a true gastronomic hit in Europe just 10–15 years ago, but it was not the beginning of the popularity of this unique drink. Its tonic and other beneficial properties were known centuries ago, but these properties were only available in the 20<sup>th</sup> century after scientific research.

Mate has a truly unique chemical composition, which is why it is often referred to as a "store of useful properties". It contains a very large number of vitamins and microelements, and at the expense of it has remarkably potent healing properties.



Figure 1. Mate tea utensils calabash; bombilla

According to the Pasteur Institute in Paris and the Paris Scientific Society, mate contains vitamins A, C, E, P, all B vitamins, magnesium, calcium, iron, copper, sulfur, nicotine and pantothenic acids and many more.

Mate contains mateine, which acts similar to the positive effects of caffeine on humans,

but differs from it in the absence of adverse effects. In particular, it does not cause an increase in heart rate, nerve palsy. Matein is a stimulant for both physical and mental activities of humans, but with milder effects than caffeine. If caffeine acts on humans for 3–3.5 hours, exposure to methane lasts for 9–10 hours, but it does not cause accustomment. Mate reduces depression, neurosis, and regulates the sleep cycle.

Scientists point to the immune-stimulating effect of drinking. They also suggest that mate is often used by residents of large cities, as it contains oxygen and chlorophyll to purify the blood. In addition, mate tea enhances appetite, stimulates heart rate, expands capillaries, lowers blood pressure and more. It is noteworthy that a comparison with green tea found in the *Journal of Alternative Medicine* that mate tea is very rich in polyphenols and its antioxidant properties exceed the antioxidant properties of green tea. Traditionally, mate is found to be much more effective in producing polyphenols than green tea and red wine and in increasing their blood concentration.

Due to the many unique properties mentioned above, mate tea is in high demand not only in Europe and South America but worldwide. But as we mentioned, the raw materials needed to produce the mate are tropical. The native of this endemic plant are the countries of South America: Paraguay, Argentina, Chile and Brazil. Because of this, the raw material resources needed for production are extremely limited, leading to unmet market demand and cost.

Existing problems have put on the agenda the discovery of alternative raw materials for the production of mate tea-like beverages and the development of technology for the production of the corresponding products from these raw materials.

In Georgia, based on the search for alternative raw materials, the plant – *Rhododendron caucasicum* Pall, or Caucasian Decca, which is very close to the mate tea raw material, is selected based on its structural-mechanical characteristics and chemical-biological properties. *Rhododendron* is also an endemic plant, but unlike mate it is common in the Caucasus. In Georgia it is mainly found in the mountains of Svaneti, Tusheti and Bakhmaro.



Figure 2. Caucasian Decca

With its chemical composition, *rhododendron* is almost unlike mate. It contains a large number of essential elements for human health and life, such as flavonoids, tannins, arbutins,

essential oils, sugars, Vitamin C, nicotine and pantothenic acids, etc. Its composition includes all the metals needed for humans: magnesium, calci-

um, potassium, iron, copper, sulfur, etc. However, virtually every element in the composition of the Caucasian *Rhododendron* is characterized by drug properties.

It is these properties that make the Caucasian *Rhododendron* extremely useful for humans. It enhances the release of sweat and thus releases toxins and other harmful substances from the body, regulates body temperature and reduces heat when cooled, removes cholesterol from the blood, soothes the nervous system, burns fats and helps to lose weight, helping to reduce diarrhea. Ave. draws, strengthens the heart muscle contractions and blood flow in the body, reduces venous pressure, the benefits of rheumatism, epilepsy and kolitebisa case.

These healing properties of *rhododendron* have been known since ancient times and have been widely used (and are still used) in public health areas. Scientific research has made it possible to make many medicines from *rhododendron* that are used against various diseases. They are currently used to treat the following diseases: cardiovascular problems, rheumatism, dental problems, insomnia, joint diseases, upper respiratory diseases, overweight, stomach problems, nervous disorders, osteochondrosis, etc. *Rhododendron* crude leaves can be used to treat dangerous metal poisoning such as mercury. It should be noted that *rhododendron* does not contain strong alkaloids (caffeine, theobromine, and theophylline), which gives it an advantage over mate.

### Results and Discussion

As we can see, the Paraguayan Mate and the Caucasian *Rhododendron* are similar not only in chemical composition but also in human health benefits.

These two products are similar in their negative effects on the human body. Both Paraguayan mate and Caucasian *Rhododendron* tea are undesirable for pregnant and lactating women, for people with allergic reactions and kidney disease and for children aged 10–12 years. It should be noted that the basic technological processes for making Caucasian

Rhododendron and Paraguay mate tea are similar. To obtain the Paraguay mate, the leaves and small stem (less than 4 mm in diameter) are coated, fixed on open fire, dried at 80°C to final moisture content of 5–7%, crushed to 4–6 mm in size and stored in a dark dry place. Caucasian rhododendron is also harvested from leaves, small stem (less than 4 mm in diameter) and flowers, dried in shade under natural conditions or artificially at 50–60 to final moisture content of 5–7%, crushed to 4–6 mm in size and stored in the dark. In a dry place.

Accordingly, in terms of processing technology, the difference mainly lies in the process of raw material fixing using open fire. This difference plays a very important role in shaping the taste and aroma of these two targeted products. In view of the foregoing, it can be safely assumed that the Paraguayan mate can be replaced by the Caucasian Rhododendron. This will create an opportunity for the production of mate tea in Georgia, which will increase the raw material base for the production of a very useful product for human health and contribute to the improvement of socio-economic issues.

In order to achieve the best results, it is necessary to conduct scientific studies to maximize the flavor and aroma of these two products.

### Conclusion

It can be said that besides the Caucasian Rhododendron there is no other plant that, like the Paraguayan mate, has such a wide range of positive effects on human health. The Caucasian Rhododendrons can be freely replaced by the Paraguayan mate as they resemble each other in chemical composition, with a positive impact on human life and health, and with recycling technology.

Such a replacement would be beneficial to consumers of these products, as the expansion of the raw material base would increase the number of products produced. And Georgia could become the world's most demanding product producer, which will have a positive impact on its economy. It is also worth noting, however, that the complete replacement of the Paraguayan mate would require a maximum convergence of their taste properties, which would require some scientific and experimental research.

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## Section 7. Technical sciences

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*Sidikov Isamidin Hakimovich,  
Atajonov Muhiddin Odiljonovich,  
Sayora Yunusova Toshkenboyevna,  
Nashvandova Gulruxsor Murod Qizi,  
Tashkent State Technical University,  
Department of Information Processing  
and Control Systems Tashkent, Uzbekistan  
E-mail: cool.atajonov@mail.ru; atajonovmuhiddin80@gmail.com*

### **ADAPTIVE ANALYTICAL CONTROL OF TECHNOLOGICAL PARAMETERS BASED ON THE PROBABILITY METHOD OF OIL REFINING INSTALLATIONS**

**Abstract.** A systematic analysis of the existing system of analytical control of the technological parameters of the equipment of oil refineries was carried out. It has been studied as an adaptive control object, which quickly changes its parameters, depending on the real state of the controlled technological process. A technique is proposed for determining the frequency of removal of technological parameters, based on the methods of mathematical statistics and based on the analysis of experimental data of a particular process. One of the ways to increase production efficiency is to obtain reliable, accurate, and timely data for management purposes. In this regard, an important role is played by the analytical control of technological processes in production, covering its entire life cycle, in the production station, i.e. from raw materials to final products.

The character of the functioning of this system in many respects depends on the completeness of reflection of the state of the technological process and the effectiveness of decisions made by the managing staff. In this regard, the use of the considered adaptive control algorithm of the analytical control system is essential for improving the production economy and increasing the level of technological discipline.

**Keywords:** Adaptive control, artificial intelligence, analytical control, optimization of the technological process, safety, self-adjusting regulator, stochastic control, probability.

#### **1. Introduction**

In modern conditions, the effectiveness of production management is largely determined by the methods and technical means of monitoring and

product quality control at all stages of technological processes [1]. The tasks of monitoring and controlling the quality of industrial products, optimization of technological processes are solved on the basis of

integrated production automation, widespread implementation of automation systems and tools [2]. One of the main conditions for successfully solving the problem of automation of production is the provision of automatic control systems by means of operational automatic control of parameters – characteristics of technological processes: physical, chemical and other quantities, information about which is necessary to ensure optimal control [3].

The stochastic nature of the course of most real technological processes during the processing of petroleum products creates the prerequisites for deviations from the planned quality indicators of materials, substances and industrial products [4]. In this regard, attempts are currently being made to improve the quality of theoretical models used in the management of technological processes in industrial production. The creation of such models will allow the transition to adaptive control problem solving methods based on the theory of stochastic control, vector optimization methods, and artificial intelligence theory [5].

## 2. Methodology

Deviations of technological parameters from regulated set norms, due to various destabilizing factors of real production, require adjustment of the composition of the feedstock, intermediate reagents. In practice, such an adjustment occurs with a certain delay, when compared with the moment the managerial decision is made about its necessity [6].

It should also be taken into account that the technological processes occurring at various stages of production are of both fleeting and slow-flowing nature, which essentially fulfills the control process [7].

In addition, information on technological parameters can be either redundant or insufficient, and these factors affect the quality of the management process, and this ultimately affects the quality of products and economic indicators of production [8].

These and other factors determine the creation of an effective control system that takes into account the features of the current state of the pro-

cess. In this regard, there is a need to search for solutions that allows to reduce the cost of analytical control of the process parameters while maintaining the necessary reliability, reliability and accuracy of the information received [9]. To this end, it is proposed to determine the frequency of data collection on the state of the technological process based on the most effective experimental studies of the variability of a real technological process as a result of which an adaptive control algorithm for this system can be developed [10].

It is known that changes in the composition parameters and the properties of technological flows that need to be controlled in the real case are probabilistic in nature. Existing methods for reflecting the characteristics of objects under the influence of interference require not only information about their static and dynamic properties, but also full information about their static characteristics. Therefore, in our case, it is necessary to create a control system that provides high quality control processes for the control of the technological process under conditions of incomplete information on the static characteristics of signals and interference.

The technological parameters for solving this problem will be investigated by the system of analytical control of oil refining production as a control object. It should be taken into account that the quality of control of material flows of a technological process depends on the operating modes of technological equipment. Moreover, for all monitored parameters, the following states are characteristic: normal and emergency state. The emergency state has two varieties:

- “leaving” from a normal state;
- “return” from emergency to the zone of normal condition.

## 3. Experimental part

The nature of the changes in the controlled parameter of the technological parameter is presented in (Figure 1).

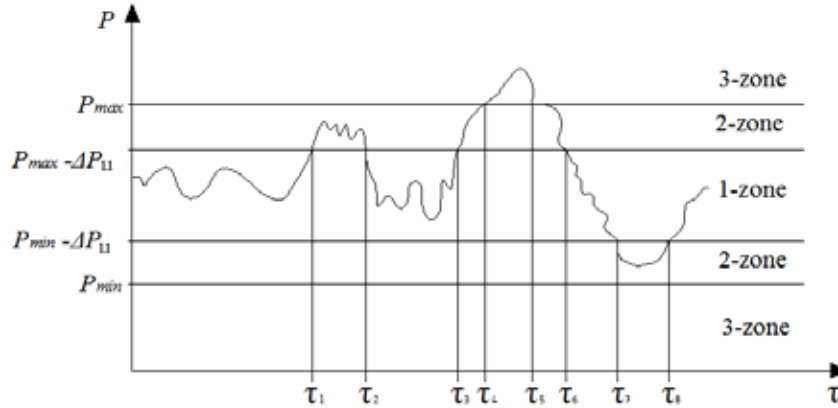


Figure 1. The nature of the changes in the controlled process parameter

Marked states of controlled parameters are characterized by the following features (see Figure 1) normal state (observed in time intervals  $(\tau < \tau_1, \tau_2 < \tau < \tau_3, \tau_6 < \tau < \tau_5, \tau > \tau_8)$  the parameter values are located in the central part of the zone of its regulated (permissible) changes (1<sup>st</sup> zone):

$$P_{\min} + \Delta P_{l.l.} \leq P_{\max} - \Delta P_{l.l.} \quad (1)$$

where is  $P$  – the current value of the controlled parameter;

$P_{\max} - \Delta P_{l.l.} = P_{u.l.l.}$  and  $P_{\min} + \Delta P_{l.l.} = P_{u.l.l.}$  – the values of the upper and lower warning limits of regulation (representing a reduced and accepted value  $\Delta P_{l.l.}$  margin of regulation upper and lower limits allowed values of the parameter).

The emergency state of “departure” of the parameter values (observed in time intervals  $\tau_1 < \tau < \tau_2, \tau_3 < \tau < \tau_4$  and  $\tau_5 < \tau < \tau_6, \tau_7 < \tau < \tau_8$  the parameter values are inside the zone of regulated limits of its permissible changes, but near one of its borders (2<sup>nd</sup> zone)):

$$P_{\min} < P < P_{\min} + \Delta P_{l.l.} \text{ or } P_{\max} - \Delta P_{l.l.} < P < P_{\max} \quad (2)$$

emergency state of “return” of indicator values (in the figure is observed in the time interval  $\tau_4 < \tau < \tau_5$ ) – the parameter values are outside the zone of regulated limits of its permissible changes (3<sup>rd</sup> zone):

$$P > P_{\max} \text{ or } P < P_{\min} \quad (3)$$

The determination of the optimal control frequency for each of the conditions considered above is possible on the basis of the information obtained

on the characteristics of the variability of the controlled parameters of the technological process in a form that allows developing a reasoned approach to determining the reasonable time for their subsequent control. To obtain such information, it is necessary to conduct several series of focused experimental studies of the characteristics of the real variability of the technological process and its parameters.

Determination of the required control frequency (control interval) of the process parameters consists of the following steps:

1. Conduct several series (experiments) of the survey of the current production at the above-mentioned characteristic modes of its operation, during which it is necessary to determine the value of the parameter for each parameter at regular intervals  $X$ .

$$X_{iz}^T = X_{iz} \quad (4)$$

where  $i$  – point number in this experiment ( $i = 1, 2, \dots, k$ );  $z$  – experiment number ( $z = 1, 2, \dots, m$ );

$X_{iz}^T$  – current parameter value in  $i$ - the point  $z$ -is experiment.

According to the results of each of the  $z$ -th experiments, it is necessary to determine the estimate of the mathematical expectation at the  $z$ -th implementation of the random process

$$M(X_z) = \frac{\sum_{i=1}^k X_{iz}}{K} \quad (5)$$

where  $K$  – total number of points obtained in this experiment.



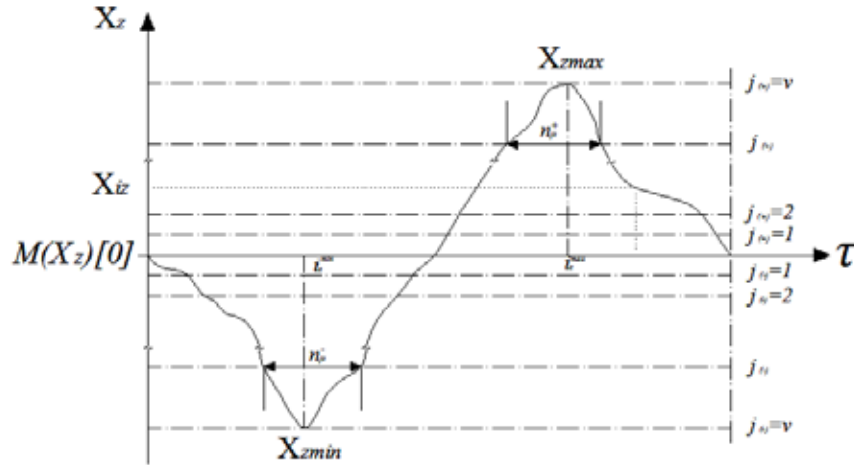


Figure 2. An example of an experimental study of the variability characteristics of a controlled process parameter

2. For each of the experiments, it is necessary to construct the corresponding graphs of the parameter changes (see the example in Fig. 2), plotting on them also the lines corresponding to:

- assessment of mathematical expectation  $M(X_z)$ ;
- the boundaries of the zone of regulated parameter values  $X_{z,max}^{reg}$  and  $X_{z,min}^{reg}$  (they correspond to any of  $j_{(+)}$  and  $j_{(-)}$  levels respectively);
- actual boundaries of the zones of increased risk of parameter control in this experiment  $X_{z,max}$  and  $X_{z,min}$ .

In each of the experiments, it is necessary to determine the magnitude of the levels of variation in the intensity of control of the parameter:

$$\Delta X_z^{var+} = \frac{\Delta X_{z,max}}{\nu} \text{ at the } \Delta X_{z,max} = X_{z,max} - M(X_z) > 0 \quad (6)$$

$$\Delta X_z^{var-} = \frac{\Delta X_{z,min}}{\nu} \text{ at the } \Delta X_{z,min} = X_{z,min} - M(X_z) < 0 \quad (7)$$

where is  $\Delta X_z^{var+}$ ,  $\Delta X_z^{var-}$  – steps to vary the levels of control intensity, respectively, for cases when the current value of the parameter is greater or less  $M(X_z)$  the mathematical expectation of a variable in this experiment;

$\nu$  – the number of selected levels of variation of the parameter control intensity (selected depending on the requirements for the accuracy of the experimental data processing).

3. Next, calculate the magnitude of the levels of intensity control parameter is calculated by the equations:

$$X_{jz}^+ = \Delta X_z^{var+} \cdot j_{(+)} \quad (8)$$

$$X_{jz}^- = \Delta X_z^{var-} \cdot j_{(-)} \quad (9)$$

where  $j$  – parameter control intensity level number ( $j = 0, 1, 2, \dots, \nu$ ).

For each of the levels of control parameter intensity, relative coefficients of control intensity are determined. For this, the current values  $X_{iz}^T$  (see Fig. 2) in each experiment are compared with the corresponding values  $X_{jz}^+$  и  $X_{jz}^-$  and the number of points in the experiment is calculated  $n_{jz}^+$  and  $n_{jz}^-$  by inequalities

$$n_{jz}^+ \text{ at the } X_{iz}^T \geq X_{jz}^+ \quad (10)$$

$$n_{jz}^- \text{ at the } X_{iz}^T \leq X_{jz}^- \quad (11)$$

The relative coefficients of the intensity control parameter determine the equations:

$$A_{jz}^+ = \frac{n_{jz}^+}{K} \quad (12)$$

$$A_{jz}^- = \frac{n_{jz}^-}{K} \quad (10)$$

where  $A_{jz}^+$  – relative coefficient of intensity of parameter control at  $\Delta X_{iz}^T \geq \hat{M}(X_z)$ ;  $A_{jz}^-$  – relative coefficient of intensity of parameter control at  $\Delta X_{iz}^T \leq \hat{M}(X_z)$ .

For each of  $z$  experiments, data obtained in the form  $A_{jz}^+ = \phi'(X_{jz}^+)$ ;  $A_{jz}^- = F'(X_{jz}^-)$

represent two generalized variational series of the form

$$A^+ = \phi(X_{jz}^+), \quad (13)$$

$$A^- = F(X_{jz}^-), \quad (14)$$

The values of the arguments of the variation series (13) and (14) are divided into equal intervals, the values of which are taken equal to the maximum values of the steps of variation of the relative coefficients of the intensity of control and. To determine the value of the functions  $A^+$  and  $A^-$  at each interval, one should be guided by the recommendations of the “theory of pessimism”. According to this theory, when assessing the case of stochastic uncertainty of conditions when the probability distribution for the parameters either does not exist or cannot be obtained, it is always necessary to focus on the worst conditions. Therefore, from several values of the functions that appear inside the interval, the value corresponding to the smallest relative coefficient of control intensity is selected and is taken as the value of the function in this interval. After performing these calculations in all intervals, two curves are constructed that characterize the value of the relative coefficient of control intensity depending on the deviation of the parameter from its mathematical expectation of the form,

$$A_{\min}^+ = \alpha(X^+), \quad (15)$$

$$A_{\min}^- = \alpha(X^-), \quad (16)$$

4. We accept, based on practical experience, the time interval between measurements:

– with parameter values located in the area of its mathematical expectation (1<sup>st</sup> zone in Fig. 1),  $\Delta\tau = \Delta\tau_{M(X)}$ ;

– at parameter values close to the boundary values of the regulated zone (2<sup>nd</sup> zone in Fig.1)  $\Delta\tau = \Delta\tau_{\min}^{\text{reg}}$  и  $\Delta\tau = \Delta\tau_{\max}^{\text{reg}}$ ;

– for parameter values equal to the boundary in high-risk areas (2<sup>nd</sup> zone of Fig. 1), the time interval between measurements can be determined, for example, on the basis of Kotelnikov’s theorem according to which:

$$\Delta\tau \leq \frac{\pi}{\omega_c}, \quad (17)$$

where is  $\Delta\tau$  – time between measurements;

$\omega_c$  – maximum frequency of the spectrum of the studied variable.

Therefore, in our case  $\Delta\tau_{\max} = \Delta\tau = \frac{\pi}{\omega_c}$

5. Based on the dependences obtained above, we can construct the desired resulting dependences of the time intervals between measurements on the deviation of the measured parameter from its mathematical expectation in the form at the  $X^+$

$$\Delta\tau^+ = \Delta\tau_{\max}^{M[X]^+} - A_{\min}^+ B^+ \{X^+ - M[X]\}, \quad (18)$$

at the  $X^-$

$$\Delta\tau^- = \Delta\tau_{\max}^{M[X]^-} - A_{\min}^- B^- \{X^- - M[X]\}. \quad (19)$$

The use of the considered adaptive control algorithm of the analytical control system (which allows you to quickly determine the occurrence of violations and quantify changes in the parameters of the process) is essential for improving the production economy and increasing the level of technological discipline.

## 5. Conclusion

Thus, we performed an analysis of the analytical control system of oil refinery equipment as a control object, determining the requirement for experimental studies of the variability of the parameters of analytical control in the development of an adaptive control algorithm for an analytical control system, an image of the prerequisite for creating an adaptive analytical control system for the process of production of oil refineries. The character of the functioning of this system in many respects depends on the completeness of reflection of the state of the technological process and the effectiveness of decisions made by the managing staff. In this regard, the use of the considered adaptive control algorithm of the analytical control system (which allows you to quickly determine the occurrence of violations and quantify changes in the process parameters) is essential for improving the production economy and increasing the level of technological discipline.

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*Doborjginidze Giorgi,  
PhD in Engineering sciences, Georgian Technical University,  
PhD in Engineering sciences, the Faculty of Business Engineering  
E-mail: G. Doborjginidze@gtu.ge*

*Petriashvili Lily,  
PhD in Engineering sciences,  
PhD in Engineering sciences, the Faculty of Informatik  
Georgian Technical University  
E-mail: L. Petriashvili@gtu.ge*

## IMPROVING EFFICIENCY OF INVENTORY IDENTIFICATION SYSTEM

**Abstract.** Increasing globalization process requires permanent transformation in the supply chain management to meet present-day challenges and improve competitiveness of the local economy. Following from the above- stated, the complexity supply chain increases. Thus, intelligent automation of the supply chain processes using modern information technologies becomes necessary. Supply chain management industry progressively develops throughout the world and implementation of its efficiency depends on growth of economic potential of a country [5].

Movement of material flows in supply chain is impossible without concentration of the inventory reserves in certain locations. Management of inventory flows becomes a key issue for the competitiveness of supply chains. The process of efficient management of the above- mentioned material flow is complex, as it is related with compliance with quantitative and stock management requirements, stock keeping accuracy, formalization of necessary documents, loading and unloading processes, transportation, etc.

**Keywords:** RFID, SCM, Material flows, Identification, Modulation-demodulation, Non-contact data, Inventory, Warehouse, Algorithm, ABC classification.

**Definition.** Movement of material resources through warehouse is related to significant labor inputs, which increases the cost of goods sold. The problems, related to warehouse operation have impact on rationalization of movement of material resources in supply chain as well as to transportation and logistics costs.

Non-contact data exchange RFID (Radio Frequency Identification) technology, which allows consumers to receive, remotely, the existing identification information about any object and the report about this object using radio frequency waves, may be considered as one of the innovative

achievements of the recent years [1]. Introduction and implementation of the above-mentioned technology provides new opportunity of efficient management of the whole supply chain as well as one of its important components – warehouse. In warehouse logistics, the potential of use of RFID innovative technology is quite high, on the basis of which strategic results of high standard can be received. In the case of use RFID technology, identification of any goods is possible without the physical touch, i.e. visible contact. Use of RFID technology in warehouse logistics saves time and reduces the costs of operation.

RFID technology, as a system, consists of several components: the first one is RFID-transponder (i.e. RFID-labelled RFID-tag), where ID code of the object and various important information about the object is stored. The second one is a RFID-reader, which allows remote (max. 20 m), contactless reading of information from the transponder, attached

to the object and its transfer to the software, where processing/ analyzing of this information is possible. In its turn, RFID transponder represents the unity of a memory chip, radio frequency modulation- demodulation block and antenna. Fig. 1 [4] schematically presents the principle of operation of RFID technology:

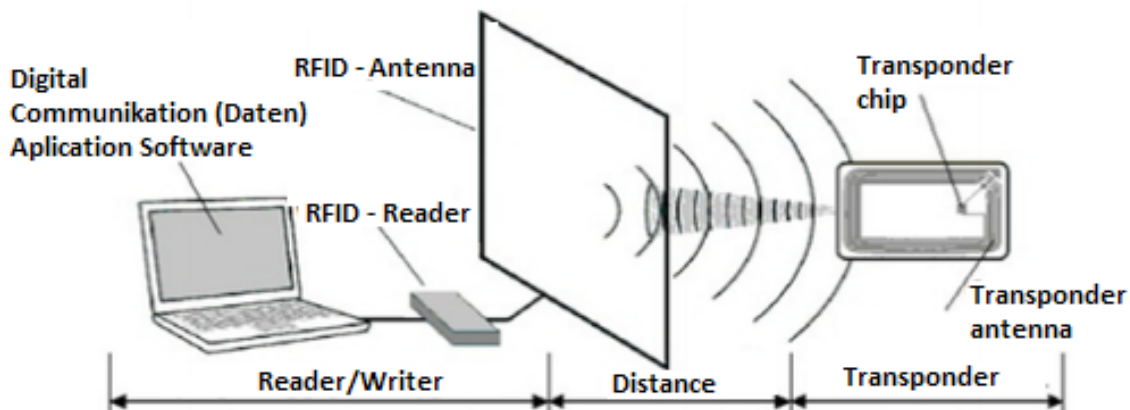


Figure 1.

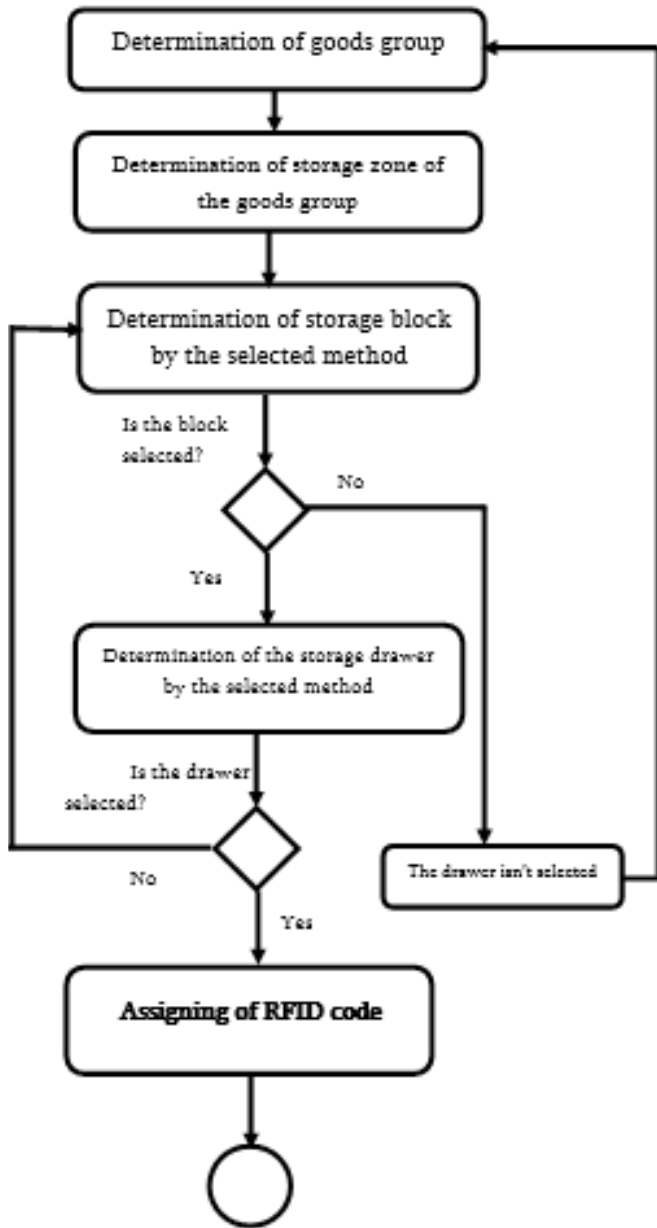
**Automation of warehousing processes.** As it was already mentioned, RFID technology plays important role in efficient management of economic processes, occurring in supply chain, and is particularly favorable in warehousing processes.

Activities, occurring in warehouse may be divided into three conditional processes:

- Receipt of goods in warehouse;
- Identification and storage of goods;
- Issue of goods.

When attaching RFID code, one of the most important processes is assigning of code to the goods and placing of goods on the relevant shelves in the warehouse. The subject of our research is a sectional warehouse of relatively complex structure, where goods are stored thematically. This, warehouse is divided into sections correspondingly. Certain SKUs (Stock Keeping Unit) is stored in specially allocated sections or racks. The goods, received in the warehouse, shall be attached an address, i.e. the place of its storage (number of rack, number of shelf, line, section on the shelf) and shall be recorded into transponder.

It is possible to divide the whole storage space into several functional areas, e.g. according to the SKUs and inventory velocity. According to this principle, the warehouse area is divided into storage blocks, having similar parameters (proximity to the goods loading/ discharge zone, similar temperature regime, similar humidity regime, etc.). In their turn, storage blocks are unified into zones. Specific block cannot belong to several zones. For creation of storage blocks, these blocks shall have certain attributes. Certain storage zone corresponds to each group of goods nomenclature. Such approach allows creating flexible mechanism of placement of the newly received goods in rack drawers. If the storage zone of the warehouse consists of several blocks and the system tries to place the newly received goods in the first block but finds out that the number of places is not sufficient, it will look for places in the next block of the zone, etc. Looking for the free places in the blocks is carried out according to the priority of the block in the zone.



In this paper the algorithm is discussed, which has been developed for the assigning of RFID code to the goods and arranging them on appropriate racks. This method will contribute to fast identification of the goods and their placement on the shelf as well as fast issue/receipt process of inventory (Fig. 2). When arriving to the warehouse, the nomenclature group of goods will be identified. Storage zone will be determined according to the assigned goods nomenclature code. Determination and control of norms of the status of inventory will be carried out through division of goods (inventory) of all no-

menclatures, material resources and other valuables into three unequal sets – A, B and C, which are equivalent to some algorithm. In our case, total quantity of orders, received during certain period, shall be counted and divided by total number of SKU; thus, mean value of orders P per SKU of N nomenclature will be received.. In their turn, A, B and C sets may be considered as the unity of

$$A = (a_1, a_2, a_3, \dots a_k),$$

$$B = (b_1, b_2, b_3, \dots b_n),$$

$$C = (c_1, c_2, c_3, \dots c_m),$$

elements. The elements of these sets may be specific type of material resources as well as certain group.

All elements (material resource, goods), for which the number of orders exceeds average value of the number of orders P 10 times or more, will be unified in subset A. The sub-set C unifies the elements, for this the number of orders is twice less as P, and subset B unifies the rest. The probability of demand for specific material resources for sets A, B, C is based on different laws of distribution (2). It is assumed, that for example in retail and distribution 75% of the inventory cost is made up ca. 10% of total SKUs (subset A). 20% of the inventory cost is made up of only 25% of SKUs (subset B). Consequently, 5% of the remainder cost includes 65% of goods (subset C). Taking into consideration the above-mentioned method, the priorities of ABC sets in zones shall be necessarily indicated. As a rule, the most easily accessible inventory are allocated for block A (as a rule, the shelves of the lowest line of the racks in the closest proximity to the loading/discharge area), as the goods of this category have the highest inventory velocity and the number of their issue and receipt is quite high. Less accessible inventories are allocated for the goods of group B (second tier of racks, relatively remote from loading/ discharge area, etc.). Consequently, inventory with lower velocity (shelves, located at higher level) are allocated for the goods of group C. Certainly, such method can be developed in any way; We assigned ABC classes according to the inventory velocity and, consequently, goods will

be placed in storage according to the number of their issue/receipt. We may divide into ABC groups not according to the inventory velocity, but according to perishability of goods, storage temperature regime, humidity level, etc [6]. Correspondingly, ABC blocks will be allocated not according to the principle of easy accessibility/ difficult accessibility, but according to temperature zones, humidity zones, etc.

Table 1.

Nomenclature class	Sequence of searching		
	I	II	III
A	A	B	C
B	B	C	A
C	C	B	A

In the blocks of goods storage zones of the warehouse, goods are placed in the first free shelf which is available. It means that up to the level of zone blocks, the warehouse is organized according to sectional (static) model, and inside the blocks – according to usual (dynamic) model. To ensure higher mobility of arrangement of the goods in the warehouse and compliance with every-day demands, periodically (once a week, once a month) the variance of demand for goods shall be determined, i.e. mean value  $P$  of the number of orders shall be calculated, i.e. new ABC classification shall be determined and, correspondingly, arrangement of the goods on shelves shall be changed.

After the shelf for storage is determined for the goods using one of the methods, the goods will be assigned a code (address), which is recorded in transponder and the warehouse staff will be able to place the goods in the appropriate shelf. Another important process is development of algorithm for control of movement of goods and empty shelves on the basis of data of RFID reader. Automated identification of products using RFID technology allows control of movement of various goods in different time periods (manufacturing, storage, transportation, etc.). Similar control is possible through introduction of the systems of automated identification and reading of transponder, which significantly determines the efficiency of an enterprise [7; 8].

The developed algorithm is based on statistical analysis radio frequency reader (RFID) data and their processing for the purpose of identification of products. For identification of goods and storage racks/shelves, active transponders are used, which allow reading of data in relatively large radius (up to 20 meters) and 100% result can be achieved in the case of simultaneous reading as a result of analysis of identification frequency in reading zone.

Special feature of the below given algorithm is in its uninterrupted operation, turning on/off which does not require human involvement. Operation of the algorithm may be divided into two logical parts: accumulation of data in time unit ( $n$ ) about frequency on reading

$$\zeta[\tau, a] = \sum n$$

Where  $\zeta$  is frequency, time interval,  $a$  – identification number of the rack, read from the transponder,  $n$  – the number of ID codes read in time ( $\tau$ ) unit. This part of the algorithm works permanently and consists of two parts of memory, where the information, read from the transponders is stored in one, and the data, read from the rack transponders – in the other. The data are stored as the key (data) set, where time interval is the central data, on which the frequency of reading the keys depend.

After each elapsed  $\tau$  period the code of rack is checked. In specific time period, transfer from the rack, marked with transponder 1 to the rack, marked with transponder 2, occurs. Consequently, the algorithm of detection of transfer from one rack to the other will be as follows: if the current position (rack number) does not exist, maximum frequency indicator in  $n$  seconds will be set.

$$\gamma_{\max} = a[n_{\max}]$$

Where  $\gamma_{\max}$  is the position of maximum demonstration of frequency.

As soon as the frequency indicator of appearance of transponder exceeds the current one, timer will start; interval indicator is selected experimentally and represents a constant value

$$\tau_{time} = \frac{\tau_{overall}}{2}$$

Where  $\tau_{time}$  is the time of timer starting,  $\tau_{overall}$  – total time of current movement. If transponder changes and timer did not manage to start, timer value will be zeroed and restarted, and in the case of starting – the value of movement in the form of initial and final rack values will be transferred.

The given algorithm and RFID technology allow 24-hour tracking and recording of products, presented on the shelves.

### Conclusion

Use of modern RFID technology in the process of optimal management of material resources in supply chain and their identification ensures not only achievement of high economic efficiency, which is reflected in the process of supply/ demand

of products, but also reduces the time, costs and risks, related to inventory management.

The algorithms discussed in this paper, are based on statistical analysis of radio frequency reader (RFID) data and their processing for the purpose of recognition of product. For identification of goods and storage racks active transponders are used, from which data are read and frequency parameters are analyzed. With minimum time and costs, compliance of product with quantitative and nomenclature demands is determined, type and quality is accurately identified, necessary documents are drawn up, loading on/ discharge from transport vehicle is carried out, etc., which, finally ensures efficient management of processes, occurring in improvement of supply chain efficiency.

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## Section 8. Physics

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*Rasulov Voxob Rustamovich,  
docent of Fergana State University.*

*Rasulov Rustam Yavkachovich,  
professor of Fergana State University  
E-mail: r\_rasulov51@mail.ru.*

*Akhmedov Bahodir Bahromovich,  
researcher of Fergana State University*

*Rayimjonova Umidakhon Gayratjon qizi,  
bachelor of Fergana State University*

*Abduxolikov Akmaljon,  
master of Fergana State University*

### NONDIAGONAL MATRIX ELEMENTS OF THE EFFECTIVE HAMILTONIAN IN A SEMICONDUCTOR (TAKING INTO ACCOUNT SPIN-ORBIT INTERACTION)

**Abstract.** The matrix elements of the effective carrier Hamiltonian are calculated as in the Kane approximation, where the conduction band, the valence band consisting of light and heavy hole subbands, and the spin-split band, as well as in the Luttinger-Kohn model, are considered.

**Keywords:** matrix element, effective Hamiltonian, current carriers, wave function.

As indicated in the first part of this article [1], many physical parameters of the crystalline potential depend on the band structure of the semiconductor [2–10]. Moreover, usually in band theory it is assumed that the crystalline periodic potential is always an even function of coordinates. However, in some cases, for example, in a semiconductor, where there is a heterojunction, the periodic potential of the crystal, along with the symmetric part, can have an asymmetric part. This case requires a separate analysis of the matrix elements of the effective Hamiltonian of current carriers in the approximation where the conduction band, the

valence band consisting of light and heavy hole subbands, and the spin-split band are considered [7; 8].

Following [1] we have the following Schrödinger equation

$$\left\{ H_0 + \frac{\hbar}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma} \right\} \psi_{n\vec{k}}(\vec{r}) = E_n(\vec{k}) \psi_{n\vec{k}}(\vec{r}). \quad (1)$$

Here and below, the notation corresponds to the notation of [1].

If the solution (1) is searched in the form of the Bloch function  $\psi_{n\vec{k}}(\vec{r}) = e^{i\vec{k}\vec{r}} u_{n\vec{k}}(\vec{r})$ , then we obtain the equation for the Bloch amplitude  $u_{n\vec{k}}(r)$  as

$$\left\{ H_0 + \frac{\hbar}{m_0} \vec{k} \vec{p} + \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \times \vec{\sigma} + \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \times \vec{\sigma} \right\} u_{n\vec{k}}(\vec{r}) = E' u_{n\vec{k}}(\vec{r}). \quad (2)$$

where  $E' = E_n(\vec{k}) - \frac{\hbar^2 k^2}{2m_0}$ . The last term in (2) describes the spin-orbit interaction, which depends on the wave vector of current carriers. Thus, the effective Hamiltonian acting on the periodic function  $u_{n\vec{k}}(\vec{r})$  is expressed as:

$$H = H_0 + \frac{\hbar}{m_0} \vec{k} \vec{p} + \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \times \vec{\sigma} + \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma} \quad (3)$$

Here  $H_1 = \frac{\hbar}{m_0} \vec{k} \vec{p}$  and  $H_2 = \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \cdot \vec{\sigma}$  appear due to the transition from the Bloch function to the function  $u_{n\vec{k}}(\vec{r})$ , the term  $H_3 = \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma}$  describes  $\vec{p}$  dependent in-orbit interaction. The Bloch amplitude  $u_{n\vec{k}}(\vec{r})$  for electrons in the conduction band can be represented as:  $|iS \uparrow\rangle$ ,  $|iS \downarrow\rangle$ , and for holes in the valence band  $-|X \uparrow\rangle$ ,  $|X \downarrow\rangle$ ,  $|Y \uparrow\rangle$ ,  $|Y \downarrow\rangle$ ,  $|Z \uparrow\rangle$ ,  $|Z \downarrow\rangle$  with the corresponding intrinsic energies  $E_s$  and  $E_p$ , which are defined as  $H_0|S\rangle = E_c|S\rangle$ ,  $H_0|X\rangle = E_p|X\rangle$ ,  $H_0|Y\rangle = E_p|Y\rangle$ ,  $H_0|Z\rangle = E_p|Z\rangle$ , where (see, for example, [1, 11])

$$|S\rangle = \frac{1}{\sqrt{4\pi}}, |Z\rangle = \sqrt{\frac{3}{4\pi}} \frac{z}{r}, |X \pm iY\rangle = \sqrt{\frac{3}{4\pi}} \frac{x \pm iy}{r}, \quad (4)$$

Below, the basic functions of current carriers both in the conduction band and in the valence band are presented as in [1] (see formulas (8, 9)). Based on these functions, we define the nondiagonal matrix elements of the Hamiltonian (3). This requires calculating the matrix elements of each term (3) separately, where in further calculations we take into account that  $\iiint_{-\infty}^{\infty} \frac{x^{2m+1} \times y^l \times z^\mu}{r^n} d\vec{r} =$

$$= \iiint_{-\infty}^{\infty} \frac{x^m \times y^{2l+1} \times z^\mu}{r^n} d\vec{r} = \iiint_{-\infty}^{\infty} \frac{x^m \times y^l \times z^{2\mu+1}}{r^n} d\vec{r} = 0,$$

where  $d\vec{r} = dx dy dz$ ,  $m, l, \mu$  are integers. Then the matrix elements of the operators

$$H_1 = \frac{\hbar}{m_0} \vec{k} \vec{p}, H_2 = \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \cdot \vec{\sigma}, \quad (5)$$

$$H_3 = \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma}$$

are defined with the following relations: due to the orthogonality of the spinors, the nondiagonal matrix elements  $\langle 1|H_0|2\rangle$ ,  $\langle 1|H_1|2\rangle$  is equal to zero, and the expression for the nondiagonal matrix elements  $\langle 1|H_2|2\rangle$  and  $\langle 1|H_3|2\rangle$  are given below

$$1|H_2|2 = \langle 1|H_2|2\rangle = \langle -iS \downarrow | H_2 | \frac{X - iY}{\sqrt{2}} \uparrow \rangle =$$

$$= \frac{\hbar^2}{4m_0^2 c^2} \{ \mathcal{J}_{21} - i\mathcal{J}_{22} \},$$

$$1|H_3|2 = \langle 1|H_3|2\rangle = \langle -iS \downarrow | H_3 | \frac{X - iY}{\sqrt{2}} \uparrow \rangle =$$

$$= \frac{\hbar^2}{4m_0^2 c^2} (\mathcal{J}_{31} - i\mathcal{J}_{32}),$$

where

$$\mathcal{J}_{21} = \mathcal{J}_{21}^{(1)} - i\mathcal{J}_{21}^{(2)}$$

$$\mathcal{J}_{21}^{(1)} = k_z \sqrt{\frac{1}{4\pi}} \sqrt{\frac{3}{4\pi}} \iiint_{-\infty}^{\infty} \frac{\partial V(\vec{r})}{\partial y} \frac{x - iy}{r} dx dy dz,$$

$$\mathcal{J}_{21}^{(2)} = k_y \sqrt{\frac{3}{4\pi}} \sqrt{\frac{1}{4\pi}} \iiint_{-\infty}^{\infty} \frac{\partial V(\vec{r})}{\partial z} \frac{x - iy}{r} dx dy dz;$$

$$\mathcal{J}_{22} = \mathcal{J}_{22}^{(1)} - i\mathcal{J}_{22}^{(2)}$$

$$\mathcal{J}_{22}^{(1)} = k_x \sqrt{\frac{1}{4\pi}} \sqrt{\frac{3}{4\pi}} \iiint_{-\infty}^{\infty} \frac{\partial V(\vec{r})}{\partial z} \frac{x - iy}{r} dx dy dz,$$

$$\mathcal{J}_{22}^{(2)} = k_z \sqrt{\frac{3}{4\pi}} \sqrt{\frac{1}{4\pi}} \iiint_{-\infty}^{\infty} \frac{\partial V(\vec{r})}{\partial x} \frac{x - iy}{r} \frac{x - iy}{r} dx dy dz;$$

$$\mathcal{J}_{31} = S \left[ [\vec{\nabla} V \times \vec{p}]_x \right] \frac{X - iY}{\sqrt{2}} = \mathcal{J}_{31}^{(1)} - \mathcal{J}_{31}^{(2)},$$

$$\mathcal{J}_{31}^{(1)} = \frac{\hbar}{i} \sqrt{\frac{1}{4\pi}} \sqrt{\frac{3}{4\pi}} \times$$

$$\times \iiint_{-\infty}^{\infty} \left\{ \frac{\partial V(\vec{r})}{\partial y} \right\} (-1) \frac{z}{r} \frac{x - iy}{r^2} dx dy dz,$$

$$\mathcal{J}_{31}^{(2)} = \frac{\hbar}{i} \sqrt{\frac{1}{4\pi}} \sqrt{\frac{3}{4\pi}} \iiint_{-\infty}^{\infty} \left\{ \frac{\partial V(\vec{r})}{\partial z} \right\} \frac{1}{r^3} \{-i(x^2 + z^2) - yx\} dx dy dz;$$

$$\mathcal{J}_{32} = S \left[ \left[ \vec{\nabla} V \times \vec{p} \right]_y \right] \frac{X - iY}{\sqrt{2}} = \mathcal{J}_{32}^{(1)} - \mathcal{J}_{32}^{(2)},$$

$$\mathcal{J}_{32}^{(1)} = \frac{\hbar}{i} \sqrt{\frac{1}{4\pi}} \sqrt{\frac{3}{2\pi}} \iiint_{-\infty}^{\infty} \left\{ \frac{\partial V(\vec{r})}{\partial z} \right\} \frac{1}{r^3} \{y^2 + z^2 - iyx\} dx dy dz,$$

$$\mathcal{J}_{32}^{(2)} = \frac{\hbar}{i} \sqrt{\frac{1}{4\pi}} \sqrt{\frac{3}{4\pi}} \iiint_{-\infty}^{\infty} \left\{ \frac{\partial V(\vec{r})}{\partial x} \right\} (-1) \frac{z}{r} \frac{x - iy}{r^2} dx dy dz,$$

whence it is clear that the nonzero values of these matrix elements are determined by the physical nature, i.e. depending on the coordinate of the crystalline potential:  $V(\vec{r}) = V_{ass}(\vec{r}) + V_{sim}(\vec{r})$ .

Now we analyze the functions of  $\mathcal{J}_{lm}$ : a)  $\mathcal{J}_{21}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{asim}(y) + V_{asim}(z)$ ; b)  $\mathcal{J}_{22}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{asim}(y) + V_{asim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ ; c)  $\mathcal{J}_{21}^{(1)}$  differs from zero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ ; d)  $\mathcal{J}_{21}^{(2)}$  and  $\mathcal{J}_{22}^{(1)}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{asim}(z)$ , and the second is not equal to zero when  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{asim}(z)$ ; e)  $\mathcal{J}_{22}^{(2)}$  consists of two terms, the first of which is not equal to zero when  $V(\vec{r}) = V_{asim}(x) + V_{asim}(y) + V_{sim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ ; f)  $\mathcal{J}_{31}^{(1)}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{asim}(z)$ , and the second differs from zero at  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{asim}(z)$ ; g)  $\mathcal{J}_{31}^{(2)}$  consists of two terms, the first of which is nonzero at  $V(\vec{r}) = V_{sim}(x) + V_{sim}(y) + V_{asim}(z)$ , and the second is differs from zero at  $V(\vec{r}) = V_{asim}(x) + V_{asim}(y) + V_{asim}(z)$ ; i)  $\mathcal{J}_{32}^{(1)}$  consists of two terms, the first of which is not equal to zero when  $V(\vec{r}) = V_{sim}(x) + V_{sim}(y) + V_{asim}(z)$ , and the second is nonzero at  $V(\vec{r}) = V_{asim}(x) + V_{asim}(y) + V_{asim}(z)$ ; k)  $\mathcal{J}_{32}^{(2)}$  consists of two terms, the first of which is differs from zero at  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{asim}(z)$ , and

the second is not equal to zero when  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{asim}(z)$ .

Similarly, we obtain the expressions for the following matrix elements:  $(H_0)_{13} = |H|3 = -iS \downarrow |H|Z \downarrow = 0$ ,  $(H_1)_{13} = -iS \downarrow |H_1|Z \downarrow = -i \langle S \left| \frac{\hbar}{m_0} \vec{k} \vec{p} \right| Z \rangle = k_z \wp_z$ , where  $\wp_z = -\frac{\hbar^2 \sqrt{3}}{m_0 4\pi} \times \iiint_{-\infty}^{\infty} \frac{x^2 + y^2}{r^3} dx dy dz$ .

А также and

$$(H_2)_{13} = \langle -iS \downarrow |H_2|Z \downarrow \rangle = \langle -iS \downarrow \left| \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \cdot \vec{\sigma} \right| Z \downarrow \rangle = i \frac{\hbar^2}{4m_0^2 c^2} \frac{1}{\sqrt{4\pi}} \sqrt{\frac{3}{4\pi}} \iiint_{-\infty}^{\infty} \left( \frac{\partial V}{\partial x} k_y - \frac{\partial V}{\partial y} k_x \right) \frac{z}{r} dx dy dz,$$

It can be seen from the latter that the first term is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{asim}(z)$ , and the second term is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{asim}(z)$ . Also

$$(H_3)_{13} = \langle -iS \downarrow |H_3|Z \downarrow \rangle = -(-i) \frac{\hbar}{4m_0^2 c^2} S \left[ \left[ \vec{\nabla} V \times \vec{p} \right]_z \right] Z = -\frac{\hbar^2 \sqrt{3}}{4m_0^2 c^2} \frac{1}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^3} \left\{ yz \frac{\partial V}{\partial x} - xz \frac{\partial V}{\partial y} \right\} dx dy dz$$

whence it is clear that this matrix element is nonzero at  $V(\vec{r}) = V_{asim}(x) + V_{asim}(y) + V_{asim}(z)$ .

Thus, it was shown that, taking into account the asymmetric part of the crystalline potential in semiconductors, additional terms are obtained in the nondiagonal matrix elements of the effective Hamiltonian.

If we assume that the crystalline potential does not have an asymmetric part, then all the expressions obtained above and related to  $V_{asim}(x, y, z)$  turn to zero automatically.

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*Rasulov Voxob Rustamovich,  
PhD, assistant professor*

*Rasulov Rustam Yavkachovich,  
DSc, Professor of Fergana State University  
E-mail: r\_rasulov51@mail.ru.*

*Sultonov Ravshan Rustamovich,  
Researcher of Fergana State University*

*Eshboltaev Ikbol Mamirjonovich,  
PhD, lecturer at the Kokand Pedagogical Institute*

*Muminov Islombek Arabboyevich,  
Researcher of Fergana State University*

## MATRIX ELEMENTS OF TWO AND THREE-PHOTON ABSORPTION OF POLARIZED RADIATION IN A CUBIC SYMMETRY SEMICONDUCTOR

**Abstract.** A quantum-mechanical calculation of the matrix elements of two and three photon absorption of polarized radiation due to optical transitions between the subbands of the valence band of a semiconductor of cubic symmetry is carried out. In this case, both the absorption of single photons and the simultaneous absorption of two photons are taken into account.

The mechanism of two, three, and four photon linear circular dichroism of light absorption in a p-GaAs semiconductor is revealed.

**Keywords:** quantum-mechanical analysis, matrix elements, two and three photonic optical transitions, light absorption, semiconductor.

The advent of lasers and masers made it possible to research nonlinear optical phenomena and the multiphoton linear circular dichroism of light absorption in a semiconductor [1–2].

At present, multiphoton linear-circular and circular-circular dichroism has been researched in semiconductors by absorbing light of different frequencies and polarizations [3–6], which is caused between optical band transitions, i.e. two and three photon absorption of unpolarized light, due to optical transitions between the valence band and the conduction band of the semiconductor, are researched.

In the above researches, the processes of light absorption due to multiphoton optical transitions between the subbands of one, for example, the va-

lence or conduction bands of a semiconductor have remained open, and the simultaneous absorption of two photons has not been taken into account [4–6]. To fill this research gap, we first discuss the phenomenology of two and three photon linear circular dichroism in cubic symmetry semiconductors.

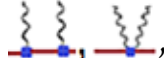
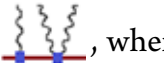

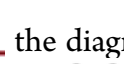
In further quantum-mechanical calculations of the coefficient of two and three photon absorption of light (linearly circular dichroism), we follow [4–6].

Note that the research of some optical parameters of a semiconductor, for example, when calculating a single and multiphoton absorption coefficient of polarized radiation or a polarization-dependent photocurrent, it is necessary to calculate the matrix elements of the optical transitions under consider-


ation. Therefore, we will further analyze the matrix elements of optical transitions for specific cases.

$$\left| M_{\pm 3/2, \pm 1/2}^{(N=3)}(\vec{k}) \right|^2 + \left| M_{\pm 3/2, \mp 1/2}^{(N=3)}(\vec{k}) \right|^2 = \frac{9}{8} \left( \frac{eA_0}{c\hbar} \right)^6 \frac{B^3}{(\hbar\omega)} |e'_z|^2 \left\{ -40e'_z{}^2 + 84e'_z{}^4 - 6e'_z{}^2 e'_\perp{}^2 + \frac{5}{2} e'_\perp{}^4 \right\}. \quad (1)$$

where  $H_{\Gamma_6}^{(2)}(\vec{e}') = H_{\Gamma_6}^{(2)}(\vec{k} \rightarrow \vec{e}')$ ,  $H_{\Gamma_6}^{(2)}(\vec{k})$  is the effective Hamiltonian of holes in the Luttinger-Kohn representation [7; 8],  $e_{x'}, e_{y'}, e_{z'}$  are the components of the vector  $\vec{e}'$ , where  $e_{x'}, e_{y'}$  are the projections of the light polarization vector  $\vec{e}$  on the axis  $x', y'$  perpendicular to the wave vector of holes ( $\vec{k}$ ). Note that the first term (1) describes a two quantum interband subband optical transition occurring by the absorption of two single photons, and the second term (1) characterizes the contribution of two photonic optical transitions flowing through virtual states located far from the valence band to the composite matrix element.  $M_{m\vec{k}, m'\vec{k}}^{(2)}$  therefore, the second term (1) describes the simultaneous absorption of two photons.

Since we are interested in optical transitions of the type  $|\pm 3/2\rangle \mapsto |\pm 1/2\rangle$ , we therefore present the expressions for the matrix elements of photonic optical transitions ( $\|M_{m, m'}^{(N)}\|$ ) occurring between the subbands of the semiconductor valence band. In the calculations of  $\|M_{m, m'}^{(N)}\|$ , we pay attention to the multiphoton optical transitions depicted by the following  $N=2$  , for  $N=3$  , where  the diagram describes a single-photon, and the diagram  describes the simultaneous absorption of two photons.

Next, we calculate the matrix elements for various types of two photonic optical transitions, depending on the degree of polarization of light.

First, we group the optical transitions by their physical nature, i.e. let us consider both the sequential absorption of two or three photons, and the simultaneous absorption of two photons. Calculations show that the matrix element of two photon optical transitions of the type  $|\pm 3/2\rangle \longrightarrow |m\rangle \longrightarrow |\pm 1/2\rangle$  described by the diagrams  is equal to  $-\left(\frac{eA_0}{c\hbar}\right)^2 B \frac{\sqrt{3}}{2} e'_\mp{}^2$ , and for

Following [4–6], the matrix element of two photon optical transitions can be represented as

$$\text{the matrix element of two photon optical transitions of the type } |\pm 3/2\rangle \Rightarrow |\pm 1/2\rangle \text{ described by the diagram } \text{---} \text{ is equal to } -\left(\frac{eA_0}{c\hbar}\right)^2 B \sqrt{3} e'_z e'_\mp \text{ and for } |\mp 3/2\rangle \Rightarrow \Rightarrow |\pm 1/2\rangle \text{ is } -\left(\frac{eA_0}{c\hbar}\right)^2 B \frac{\sqrt{3}}{2} e'_\mp{}^2. \text{ As a result, the square of the modulus of the matrix element of two photon optical transition described by the sum of the diagrams } \text{---} + \text{---} \text{ is described by the expression}$$

$$\left| M_{\pm 3/2, \pm 1/2}^{(N=2)}(\vec{k}) \right|^2 = 75 \left( \frac{eA_0}{c\hbar} \right)^4 B^2 |e'_z e'_\mp|^2, \quad (2)$$

and the square of the modulus of the matrix element of two photon optical transition type  $|\pm 3/2\rangle \longrightarrow |m\rangle \longrightarrow |\mp 1/2\rangle$ ,  $|\mp 3/2\rangle \Rightarrow |\pm 1/2\rangle$  is defined as

$$\left| M_{\pm 3/2, \mp 1/2}^{(N=2)}(\vec{k}) \right|^2 = \frac{3}{4} \left( \frac{eA_0}{c\hbar} \right)^4 B^2 |e'_\mp{}^2|^2, \quad (3)$$

and after angular averaging we have

$$\begin{aligned} & \left\langle \left| M_{\pm 3/2, \mp 1/2}^{(N=2)}(\vec{k}) \right|^2 \right\rangle = \\ & = \frac{1}{20} \left( \frac{eA_0}{c\hbar} \right)^4 B^2 \begin{cases} 8 \text{ for linear polarization,} \\ 7 \text{ for circular polarization,} \end{cases} \end{aligned} \quad (4)$$

Then the coefficient of linear circular dichroism calculated for the above optical transitions is 8/7.

If we take into account the coherent saturation effect [7–9], then the contribution of this effect to the matrix element of the above optical transitions is defined as

$$\begin{aligned} & \sum_{m'=\pm 1/2, m=\pm 3/2} \delta \left| M_{m'm}^{(N)}(\vec{k}) \right|^2 = \\ & = \sum_{m'=\pm 1/2, m=\pm 3/2} \frac{\left| M_{m'm}^{(N)}(\vec{k}) \right|^2}{\sqrt{1 + 4 \frac{\alpha_\omega}{\hbar^2 \omega^2} \left| M_{m'm}^{(N)}(\vec{k}) \right|^2}} - \left| M_{m'm}^{(N)}(\vec{k}) \right|^2 \end{aligned} \quad (5)$$

We note here that in order to determine the probabilities of optical transitions or the light absorption coefficient, angular averaging of expressions (2, 4, 5) over the solid angles of the hole wave vector is required.

These angular averages for  $N = 2, 3, \dots$  taking into account the effect of coherent saturation (taking into account (3a)) cannot be analytically solved. Considering that the condition is satisfied for the experimentally interesting region of light intensity

$$\sum_{m'=\pm 1/2, m=\pm 3/2} \delta |M_{m'm}^{(N=1)}(\vec{k})|^2 = -\frac{9}{4} \frac{\alpha_\omega}{\hbar^2 \omega^2} \left( \frac{eA_0}{c\hbar} \right)^8 B^4 \left[ 1296 |e'_\pm e_z|^4 + \left( 36 e_z'^2 |e'_\pm|^2 + |e_\pm'^2|^2 \right)^2 \right] \quad (6)$$

and after angular integration we obtain the following relations

$$\left\langle \sum_{m'=\pm 1/2, m=\pm 3/2} \delta |M_{m'm}^{(N=1)}(\vec{k})|^2 \right\rangle = -\frac{9}{4} \frac{\alpha_\omega}{\hbar^2 \omega^2} \left( \frac{eA_0}{c\hbar} \right)^8 B^4 \frac{1}{315} \begin{cases} 29792 & \text{for linear polarization,} \\ 30395 & \text{for circular polarization.} \end{cases} \quad (7)$$

It can be seen from the last expression that the contribution of the coherent saturation effect to the coefficient of two photonic linear circular dichroism in p-GaAs is 0.98.

Next, we will calculate the matrix elements of the three photon optical transition described by a diagram



which can be represented as  $|\pm 3/2\rangle \rightarrow |m\rangle \rightarrow |m'\rangle \rightarrow |\pm 1/2\rangle$ . This matrix element

$$\text{is equal to } 2\sqrt{3} \left( \frac{eA_0}{c\hbar} \right)^3 \frac{(Bk)^3}{(\hbar\omega)^2} e'_+ \left( 4|e_z|^2 - \frac{3}{8}|e'_\pm|^2 \right),$$

where  $|m\rangle, |m'\rangle$  are the numbers of intermediate states located in the subbands of the valence band of the semiconductor.  $|m\rangle \rightarrow |m'\rangle$  describes a single photon optical transition between  $|m\rangle$  and  $|m'\rangle$  states. In the calculations, a summation will be made according to the numbers of these states. If we denote the optical transition occurring during the simultaneous absorption of two photons as  $|n\rangle \Rightarrow |m\rangle$ , then the matrix element of the three photon optical

$$\sum_{m'=\pm 1/2, m=\pm 3/2} |M_{m'm}^{(N=3)}(\vec{k})|^2 = \left( \frac{eA_0}{c\hbar} Bk \right)^3 \frac{24}{(\hbar\omega)^4} \left\{ \left| e'_+ \left( 4|e_z|^2 - \frac{3}{8}|e'_\pm|^2 \right) \right|^2 + \left| e'_- \left( 4|e_z|^2 - \frac{3}{8}|e'_\pm|^2 \right) \right|^2 \right\}.$$

After angular averaging over the solid angles of the wave vector of holes in the last expression, we have:


for linearly polarized light

$$\left\langle \left\{ \left| M_{+1/2;+3/2}^{(1-1-1)} \right|^2 + \left| M_{-1/2;-3/2}^{(1-1-1)} \right|^2 \right\} \right\rangle_{\text{linear pol}} = \frac{297}{4} \left( \frac{eA_0}{c\hbar} \right)^6 B^3 \frac{1}{\hbar\omega},$$

and for circularly polarized light

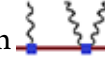
$1 \gg 4 \frac{\alpha_\omega}{\hbar^2 \omega^2} |M_{m'm}^{(N)}(\vec{k})|^2$ , it is therefore convenient to

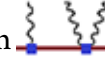
integrate the hole vectors over the solid angles of the wave by expanding the radical (5) in a series. In particular, for one photon optical transitions, we have

transition described by the diagram , which can be represented as  $|\pm 3/2\rangle \rightarrow |m\rangle \Rightarrow |\pm 1/2\rangle$ , is determined by the expression

$$-\frac{\sqrt{3}}{2} \left( \frac{eA_0}{c\hbar} \right)^3 \frac{B^2 k}{\hbar\omega} e'_+ \left\{ \left[ 2 \left( \frac{A}{B} - 1 \right) + 2e_z'^2 + \frac{1}{2}e_\pm'^2 \right] - 4 \left( \frac{A}{B} - 1 \right) e_z'^2 \right\}.$$

Similarly, the expression for the matrix element of



the diagram  is defined. Then the resulting matrix element of the optical transitions described by the diagrams

$|\pm 3/2\rangle \rightarrow |m\rangle \rightarrow |m'\rangle \rightarrow |\pm 1/2\rangle$ ,  $|\pm 3/2\rangle \rightarrow |m\rangle \Rightarrow |\pm 1/2\rangle$ ,  $|\pm 3/2\rangle \Rightarrow |m\rangle \rightarrow |\pm 1/2\rangle$  is

$$\text{expressed as } -\frac{\sqrt{3}}{8} \left( \frac{eA_0}{c\hbar} \right)^3 \frac{B^2 k}{\hbar\omega} e'_+ (136e_z'^2 - 13e_\pm'^2).$$

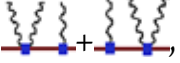
Matrix elements for optical transitions of a type  $|\pm 3/2\rangle \Rightarrow |m\rangle \rightarrow |\mp 1/2\rangle$ ,  $|\pm 3/2\rangle \rightarrow |m\rangle \rightarrow |m'\rangle \rightarrow |\mp 1/2\rangle$ ,  $|\pm 3/2\rangle \rightarrow |m\rangle \Rightarrow |\mp 1/2\rangle$  are defined in a similar way.

Thus, for the square of the modulus of the matrix element of optical transitions of the type  $|\pm 3/2\rangle \rightarrow |m\rangle \rightarrow |m'\rangle \rightarrow |\pm 1/2\rangle$ , we have the following expression

$$\left\langle \left\{ \left| M_{+1/2;+3/2}^{(1-1-1)} \right|^2 + \left| M_{-1/2;-3/2}^{(1-1-1)} \right|^2 \right\} \right\rangle_{\text{circ. pol.}} = \frac{405}{16} \left( \frac{eA_0}{c\hbar} \right)^6 \frac{B^3}{\hbar\omega}.$$

whence we obtain that the coefficient of linear circular dichroism of three-photon light absorption in p-GaAs semiconductors is greater than one, i.e.

$$\eta_{\pm 1/2; \pm 3/2}^{(1-1-1)} = 44/15.$$

For optical transitions of type , we have the following relations

$$\left| M_{\pm 3/2, \pm 1/2}^{(N=3)}(\vec{k}) \right|^2 + \left| M_{\pm 3/2, \mp 1/2}^{(N=3)}(\vec{k}) \right|^2 = \frac{9}{8} \left( \frac{eA_0}{c\hbar} \right)^6 \frac{B^3}{(\hbar\omega)} |e'_{\pm}|^2 \left\{ -40e'_z{}^2 + 84e'_z{}^4 - 6e'_z{}^2 e'_{\pm}{}^2 + \frac{5}{2} e'_{\pm}{}^4 \right\}.$$

where from

$$\left| M_{\pm 3/2, \pm 1/2}^{(N=3)}(\vec{k}) \right|^2 + \left| M_{\pm 3/2, \mp 1/2}^{(N=3)}(\vec{k}) \right|^2 = \frac{9}{8} \left( \frac{eA_0}{c\hbar} \right)^6 \frac{B^3}{(\hbar\omega)} |e'_{\pm}|^2 \left\{ -40e'_z{}^2 + 84e'_z{}^4 - 6e'_z{}^2 e'_{\pm}{}^2 + \frac{5}{2} e'_{\pm}{}^4 \right\}.$$

Thus, we obtained an expression for the matrix elements for two and three photonic optical transitions, where the simultaneous absorption of two photons was taken into account. It is shown that tak-

ing the last optical transitions into account gives a nonzero contribution to two and three-photon linear circular dichroism in semiconductors with a complex valence band.

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*Rasulov Voxob Rustamovich,  
PhD, assistant professor*

*Rasulov Rustam Yavkachovich,  
DSc, Professor of Fergana State University  
E-mail: r\_rasulov51@mail.ru.*

*Sultonov Ravshan Rustamovich,  
Researcher of Fergana State University*

*Eshboltaev Ikbol Mamirjonovich,  
PhD, lecturer at the Kokand Pedagogical Institute*

*Akhmedov Bahodir Bahromovich,  
Researcher of Fergana State University*

## PHENOMENOLOGY OF TWO AND THREE PHOTON LINEAR-CIRCULAR DICHROISM OF LIGHT ABSORPTION IN p-GaAs

**Abstract.** a phenomenological analysis of the matrix elements of two and three photon absorption of polarized radiation due to optical transitions between the subbands of the valence band of a semiconductor of cubic symmetry was carried out.

The mechanism of two, three, and four-photon linear circular dichroism of light absorption in a p-GaAs semiconductor is revealed.

**Keywords:** phenomenological analysis, matrix elements, two and three photon absorption of light, optical transitions, semiconductor.

The advent of lasers and masers made it possible to research nonlinear optical phenomena and the multiphoton linear circular dichroism of light absorption in a semiconductor [1–2].

At present, multiphoton linear-circular and circular-circular dichroism has been researched in semiconductors by absorbing light of different frequencies and polarization [3–6], due to interband optical transitions, i.e. Two and three photon absorption of polarized light, due to optical transitions between the valence band and the conduction band of the semiconductor, are researched.

In the above researches, the processes of light absorption due to multiphoton optical transitions between subbands of one, for example, valence or conduction band of a semiconductor, remained open, and the simultaneous absorption of two

photons was not taken into account [7–11]. In particular, the theory of linear circular dichroism of multiphoton light absorption in semiconductors with a complex band structure in the developed nonlinearity region was constructed in [9], i.e. in the field of intensity, when the condition is not satisfied  $\frac{2\pi e^2 I |\vec{e} \vec{p}_{cv}|^2}{cn_\omega \omega^2 m_0^2 (\hbar\omega)^2} \ll 1$ , where  $\vec{e}$  and  $I$  are the polarization vector and light intensity,  $p_{cv} = p_{\vec{c}\vec{k}, \vec{v}\vec{k}} = \vec{e} \vec{p}_{\vec{c}\vec{k}, \vec{v}\vec{k}}$  is the interband matrix element of the operator momentum,  $n_\omega$  is the refractive index of medium light at a frequency  $\omega$ , and  $m_0$  is the mass of a free electron. To fill this research gap, we first discuss the phenomenology of two and three-photon linearly circular dichroism in cubic symmetry semiconductors.

When linearly and circularly polarized light is absorbed, multi-quantum optical transitions through virtual electronic states are allowed, which are found both in the valence and conduction bands and in the zones located far from them. According to the law of conservation of the angular momentum of current carriers, the physical nature of optical transitions depends on the degree of polarization of light. In particular, with photon absorption of circularly polarized light, photoexcited carriers will have non-zero angular momentum. So that the following photons will interact with optically oriented current carriers. According to the rule of choosing the optical transition under consideration for the projection of the moments of current carriers relative to the wave vector of the photon, the probability of two and three-photon optical transitions will depend on both the frequency and the degree of polarization of light. The latter leads to the identification of linearly circular dichroism of light absorption. This is true when the dependence of the absorption of polarized radiation

$$W_{cv}^{(N)}(\vec{k}, \omega, \vec{e}) = \frac{2\pi}{\hbar} \left( \frac{2\pi e^2 I}{cn_\omega \omega^2 m_0^2} \right)^2 \sum_{c,v;\vec{k}} |M_{cv}^{(N)}(\vec{k})|^2 \left\{ f_c(\vec{k}) [1 - f_v(\vec{k})] - f_v(\vec{k}) [1 - f_c(\vec{k})] \right\} \times \delta [E_c(\vec{k}) - E_v(\vec{k}) - N\hbar\omega],$$

with the help of which the spectral and temperature dependences are determined  $K_{cv}^{(N)}(\omega, \vec{e})$ , where  $f_c(\vec{k})$ ,  $f_v(\vec{k})$  are the electron distribution function in the conduction band (valence band,  $M_{cv}^{(N)}(\vec{k})$  is the composite matrix element of the transition),  $\delta [E_c(\vec{k}) - E_v(\vec{k}) - N\hbar\omega]$  describes the energy conservation law of the optical transition under consideration.

Note that the polarization dependence of the probability of two (three and four) photon interband optical transitions is determined by the tensor of the fourth (sixth and eighth) rank, i.e.  $W_{cv}^{(N=2)}(\vec{e}) = \Xi_{\alpha\beta\gamma\eta}^{(N=2)} e_\alpha e_\beta e_\gamma^* e_\eta^*$  ( $W_{cv}^{(N=3)}(\vec{e}) = \Xi_{\alpha\beta\gamma\eta\mu\lambda}^{(N=3)} e_\alpha e_\beta e_\gamma^* e_\eta^* e_\mu e_\lambda^*$  and  $W_{cv}^{(N=4)}(\vec{e}) = \Xi_{\alpha\beta\gamma\eta\xi\zeta\chi}^{(N=4)} e_\alpha e_\beta e_\gamma^* e_\eta^* e_\mu e_\xi^* e_\zeta^* e_\chi^*$ ), where summation over repeated indices is implied;  $\alpha, \beta, \gamma, \eta, \mu, \xi, \zeta, \chi = x, y, z$ . For example, for tetrahedral symmetric semiconductors, the tensor has three linearly independent components. Therefore

on the anisotropy of the semiconductor crystal is not taken into account.

As a result, we find that in crystals of cubic symmetry, when the absorbed light propagates along the principal axis of symmetry, a linearly circular dichroism of two- and three-photon absorption of light should be observed. We note here that in the spherical approximation in the energy spectrum of current carriers, the linearly circular dichroism of single-photon absorption of light can be observed when taking into account coherent saturation of the final state of photoexcited current carriers.

In the future, we will calculate then  $N$  photon absorption coefficient of polarized radiation  $K_{cv}^{(N)}(\omega, \vec{e})$  using the golden rule of quantum mechanics [12] under the condition  $\frac{2\pi e^2 I |\vec{e}\vec{p}_{cv}|^2}{cn_\omega \omega^2 m_0^2 (\hbar\omega)^2} \ll 1$ . Then the probability of  $N$  photonic interband optical transitions in a semiconductor is determined by the expression

$$W_{cv}^{(N=2)}(\vec{e}) = \Xi_1^{(N=2)} |\vec{e}\vec{e}|^2 + \Xi_2^{(N=2)} |\vec{e}\vec{e}^*|^2 + \Xi_3^{(N=2)} (|e_x|^4 + |e_y|^4 + |e_z|^4)$$

where parameter  $\Xi_n^{(N=2)}$  ( $\Xi_{\alpha\beta\gamma\eta\mu\lambda}^{(N=3)}$  and  $\Xi_{\alpha\beta\gamma\eta\xi\zeta\chi}^{(N=4)}$ ) is proportional to the square (cubic and fourth degree) of the light intensity and it was believed that the axes  $Ox, Oy, Oz$  are directed along the principal axes of symmetry of the semiconductor. If light propagates along the axis  $[111]$ , then for semiconductors of tetrahedral and cubic symmetry we have

$$W_{cv}^{(N=2)}(\vec{e}, \vec{q} \uparrow \uparrow [111]) = (\Xi_1^{(N=2)} + \frac{1}{2} \Xi_3^{(N=2)}) |\vec{e}\vec{e}|^2 + (\Xi_2^{(N=2)} + \frac{1}{3} \Xi_3^{(N=2)}) |\vec{e}\vec{e}^*|^2.$$

Here  $\vec{q}$  is the wave vector of the photon, whence for linear polarization the quantity  $W_{cv}^{(N=2)}(\vec{e}, \vec{q} \uparrow \uparrow [111])$  does not depend on the light polarization vector. Then the coefficient of two photon linear-circular dichroism  $\alpha_{cv}^{(N=2)} =$

$= W_{cV}^{(N=2,lin)} / W_{cV}^{(N=2,circ)}$  is determined by the relation  $(2\Xi_2^{(N=2,lin)} + \Xi_3^{(N=2,lin)}) / (3\Xi_2^{(N=2,circ)} + \Xi_3^{(N=2,circ)})$ , where it is taken into account that for linear polarization  $|\vec{e} \cdot \vec{e}| = 1$ ,  $\vec{e} \times \vec{e}^* = 0$  (for circular polarization, conversely) and for an arbitrary complex vector  $\vec{a}$ , the relation holds  $|\vec{a} \cdot \vec{a}^*|^2 + |\vec{a} \times \vec{a}^*|^2 = (\vec{a} \times \vec{a}^*)^2$ .

Thus, a similar argument can be made for the quantities  $\alpha_{cV}^{(N=3)} = W_{cV}^{(N=3,lin)} / W_{cV}^{(N=3,circ)}$ ,  $\alpha_{cV}^{(N=4)} = W_{cV}^{(N=4,lin)} / W_{cV}^{(N=4,circ)}$ .

We also note the probability of the interband optical transition occurring by the absorption of two photons with different frequencies  $(\omega_1, \omega_2)$  and polarization  $(\vec{e}_1, \vec{e}_2)$ , then the spectral and polarization dependence of the probability of two photonic optical transitions is determined by the relation

$(\omega_1^{-2} + \omega_2^{-2} + \omega_1^{-1}\omega_2^{-1}|\vec{e}_1 \cdot \vec{e}_2^*|^2)$ . Then, having performed angular averaging over the solid angles of the wave vector of electrons  $\langle W_{cV}^{(N=2)}(\vec{e}_1, \vec{e}_2; \omega_1, \omega_2) \rangle$ , it is easy to verify that for semiconductors in a simple zone (when the energy spectrum of electrons is spherical), the value  $\langle |\vec{e}_1 \cdot \vec{e}_2^*|^2 \rangle$  of two photon linear circular dichroism is unity, since the value is the same as for linear, i.e. in this case, two photonic linear circular dichroism does not occur. Note that it arises when the contribution of the resonance saturation effect to the absorption coefficient of polarized radiation is taken into account (see, for example, [6–11]).

Similarly, one can make for reasoning for multiphoton optical transitions, taking into account the symmetry of the crystal.

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*Rasulov Rustam Yavkachovich,  
Professor of Fergana State University*

*E-mail: r\_rasulov51@mail.ru.*

*Akhmedov Bahodir Bahromovich,  
Researcher of Fergana State University*

*Ruzaliev Muydin Baxtiyor ogli,  
Master of Fergana State University*

*Abduxolikov Akmaljon,  
Master of Fergana State University*

*Rayimjonova Umidaxon,  
Bachelor of Fergana State University*

## DIAGONAL MATRIX ELEMENTS OF THE EFFECTIVE HAMILTONIAN IN A SEMICONDUCTOR (TAKING INTO ACCOUNT SPIN-ORBIT INTERACTION)

**Abstract.** The matrix elements of the effective Hamiltonian of current carriers are calculated as in the Kane approximation, where the conduction band, the valence band consisting of light and heavy hole subbands, and the spin-split band, as well as in the Luttinger-Kohn model, are considered.

**Keywords:** matrix element, effective Hamiltonian, current carriers, wave function.

It is known that many physical parameters of the crystalline potential depend on the band structure of the semiconductor [1–5]. Moreover, usually in band theory it is believed that the crystalline periodic potential is always an even function of coordinates. However, in some cases, for example, in a semiconductor, where there is a heterojunction, the periodic potential of the crystal, along with the symmetric part, can have an asymmetric part.

This case requires a separate analysis of the matrix elements of the effective Hamiltonian of current carriers as in the Kane approximation, where the conduction band, the valence band consisting of light and heavy hole subbands, and the spin-split band, as well as in the Luttinger-Kohn model [6; 7]. Next, we consider the case when the extreme points of the zones are in the center of the Brillouin zone, i.e. at the point  $\vec{k} = 0$ , where  $\vec{k}$  is the wave vector of

current carriers. In this case, the effective Hamiltonian can be represented as

$$H = H_0 + \frac{\hbar}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma} \quad (1)$$

and the corresponding (1) Schrödinger equation has the form

$$\left\{ H_0 + \frac{\hbar}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma} \right\} \psi_{n\vec{k}}(\vec{r}) = E_n(\vec{k}) \psi_{n\vec{k}}(\vec{r}), \quad (2)$$

where  $H_0 = \frac{p^2}{2m_0} + V(r)$  consists of kinetic and potential energy operators, the second term in (1) is the spin-orbit interaction operator,  $\vec{\sigma}$  is the vector of Pauli spin matrices with components:

$$\sigma_x = \begin{Bmatrix} 0 & 1 \\ 1 & 0 \end{Bmatrix} \sigma_y = \begin{Bmatrix} 0 & -i \\ i & 0 \end{Bmatrix} \sigma_z = \begin{Bmatrix} 1 & 0 \\ 0 & -1 \end{Bmatrix} \quad (3)$$

whence for the spinors  $\uparrow \equiv \begin{Bmatrix} 1 \\ 0 \end{Bmatrix}$   $\downarrow \equiv \begin{Bmatrix} 0 \\ 1 \end{Bmatrix}$  we have the following relations

$$\sigma_x \uparrow = \downarrow, \sigma_y \uparrow = i \downarrow, \sigma_z \uparrow = \uparrow, \sigma_x \downarrow = \uparrow, \sigma_y \downarrow = -i \uparrow, \sigma_z \downarrow = -\downarrow \quad (4)$$

$$\left\{ H_0 + \frac{\hbar}{m_0} \vec{k} \vec{p} + \frac{\hbar}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma} + \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \cdot \vec{\sigma} \right\} u_{n\vec{k}}(\vec{r}) = E' u_{n\vec{k}}(\vec{r}) \quad (5)$$

where  $E' = E_n(\vec{k}) - \frac{\hbar^2 k^2}{2m_0}$ . The last term in (5) describes the spin-orbit interaction, which depends on

$$H = H_0 + \frac{\hbar}{m_0} \vec{k} \vec{p} + \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \cdot \vec{\sigma} + \frac{\hbar}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma} \quad (6)$$

Here  $H_1 = \frac{\hbar}{m_0} \vec{k} \vec{p}$  and  $H_2 = \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \cdot \vec{\sigma}$  appear due to the transition from the Bloch function to the function  $u_{n\vec{k}}(\vec{r})$ , the term  $H_3 = \frac{\hbar}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma}$  describes  $\vec{p}$  dependent in-orbit interaction. The Bloch amplitude  $u_{n\vec{k}}(\vec{r})$  for electrons in the conduction band can be represented as:  $|iS \uparrow\rangle, |iS \downarrow\rangle$ , and for holes in the valence band  $-|X \uparrow\rangle, |X \downarrow\rangle, |Y \uparrow\rangle, |Y \downarrow\rangle, |Z \uparrow\rangle, |Z \downarrow\rangle$  with the corresponding intrinsic energies  $E_s$  and  $E_p$ , which are defined as  $H_0 |S\rangle = E_c |S\rangle, H_0 |X\rangle = E_p |X\rangle, H_0 |Y\rangle = E_p |Y\rangle, H_0 |Z\rangle = E_p |Z\rangle$ , where [8]

$$|S\rangle = \frac{1}{\sqrt{4\pi}}, |Z\rangle = \sqrt{\frac{3}{4\pi}} \frac{z}{r}, |X \pm iY\rangle = \sqrt{\frac{3}{4\pi}} \frac{x \pm iy}{r}, \quad (7)$$

where it was considered that the wave function of the electrons in the conduction band is the wave function of the s-state, and for the valence band, the p-state of the hydrogen atom. Since the states in the conduction band are twofold degenerate along the spin, and in the valence band fourfold degenerate, therefore, the basic functions can be represented as:

$$|1\rangle = |iS \downarrow\rangle, |2\rangle = \frac{X - iY}{\sqrt{2}} \uparrow, |3\rangle = |Z \downarrow\rangle, |4\rangle = -\frac{X + iY}{\sqrt{2}} \uparrow, \quad (8)$$

$$|\bar{1}\rangle = |iS \uparrow\rangle, |\bar{2}\rangle = -\frac{X + iY}{\sqrt{2}} \downarrow, |\bar{3}\rangle = |Z \uparrow\rangle, |\bar{4}\rangle = \frac{X - iY}{\sqrt{2}} \downarrow, \quad (9)$$

First, we determine the diagonal matrix elements of the Hamiltonian (6) from the basis functions (8) and (9). This requires calculating the matrix elements of each term (6) separately, where in further calculations we take into account that

If the solution (3) is sought in the form of the Bloch function  $\psi_{n\vec{k}}(\vec{r}) = e^{i\vec{k}\vec{r}} u_{n\vec{k}}(\vec{r})$ , then we obtain the equation for the Bloch amplitude  $u_{n\vec{k}}(\vec{r})$  as

the wave vector of current carriers. Thus, the effective Hamiltonian acting on the periodic function  $u_{n\vec{k}}(\vec{r})$  is expressed as:

$$\begin{aligned} \iiint_{-\infty}^{\infty} \frac{x^{2m+1} \times y^l \times z^\mu}{r^n} d\vec{r} &= \iiint_{-\infty}^{\infty} \frac{x^m \times y^{2l+1} \times z^\mu}{r^n} d\vec{r} = \\ &= \iiint_{-\infty}^{\infty} \frac{x^m \times y^l \times z^{2\mu+1}}{r^n} d\vec{r} = 0, \text{ where } d\vec{r} = dx dy dz, m, \\ &l, \mu \text{ are integers. Then the matrix elements of the operators} \end{aligned}$$

$$\begin{aligned} H_1 &= \frac{\hbar}{m_0} \vec{k} \vec{p}, H_2 = \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \cdot \vec{\sigma}, \\ H_3 &= \frac{\hbar}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma} \end{aligned} \quad (10)$$

are defined with the following relations

$$(H_0)_{11} = \langle 1 | H_0 | 1 \rangle = \langle -iS \downarrow | H_0 | iS \downarrow \rangle = \langle S | E_s | S \rangle = E_s, \quad (11)$$

$$(H_1)_{11} = \langle 1 | H_1 | 1 \rangle = \langle -iS \downarrow | H_1 | iS \downarrow \rangle = \langle S | \frac{\hbar}{m_0} \vec{k} \vec{p} | S \rangle = 0, \quad (12)$$

$$\begin{aligned} (H_2)_{11} &= \langle 1 | H_2 | 1 \rangle = \langle -iS \downarrow | H_2 | iS \downarrow \rangle = \\ &= \langle -iS \downarrow | \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{k}] \cdot \vec{\sigma} | iS \downarrow \rangle = -\frac{\hbar^2}{16\pi m_0^2 c^2} \mathcal{J}_1, \end{aligned} \quad (13)$$

where

$$\mathcal{J}_1 = \iiint_{-\infty}^{\infty} \left\{ \frac{\partial V}{\partial x} k_y - \frac{\partial V}{\partial y} k_x \right\} dx dy dz. \quad (14)$$

and take into account that  $\vec{p} |S\rangle = 0$  (since the function S is a constant value), as well as the conditions of orthonormal spinors

$$\begin{aligned} \sigma_x \uparrow = \downarrow, \sigma_y \uparrow = i \downarrow, \sigma_z \uparrow = \uparrow, \\ \sigma_x \downarrow = \uparrow, \sigma_y \downarrow = -i \uparrow, \sigma_z \downarrow = -\downarrow. \end{aligned} \quad (15)$$

If we consider that the crystalline periodic potential consists of two: even and odd terms with respect to the coordinate inversion:  $V(\vec{r}) = V_{ass}(\vec{r}) + V_{sim}(\vec{r})$ , where  $V_{sim}(\vec{r})V(\vec{r}) = (-\vec{r})$ ,  $V_{ass}(\vec{r}) = -V_{ass}(-\vec{r})$ ,

$V_{ass}(\vec{r})$ , then it is easy to verify that the integral  $\mathcal{J}_1$  has nonzero terms. Therefore, we analyze the following cases.

It follows from (14) that: a) if  $V(\vec{r})$  has an odd term with respect to  $z$ , then  $\mathcal{J}_1 = 0$ ; b) if  $V(\vec{r})$  has

$$(H_3)_{11} = \langle -iS \downarrow | H_3 | iS \downarrow \rangle = \langle -iS \downarrow | \frac{\hbar}{4m_0^2c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma} | iS \downarrow \rangle = -\frac{\hbar}{4m_0^2c^2} S \left[ [\vec{\nabla} V \times \vec{p}]_z \right] S = 0. \quad (16)$$

The diagonal matrix elements of the effective Hamiltonian are defined by the following expressions:

$$(H_0)_{22} = \left\{ \frac{X+iY}{\sqrt{2}} | H_0 | \frac{X-iY}{\sqrt{2}} \right\} = E_p, \quad (17)$$

$$(H_1)_{22} = \frac{X+iY}{\sqrt{2}} \uparrow | H_1 | \frac{X-iY}{\sqrt{2}} \uparrow = \mathcal{J}_{22}^{(1)} + \mathcal{J}_{22}^{(2)} + \mathcal{J}_{22}^{(3)} + \mathcal{J}_{22}^{(4)},$$

where

$$\begin{aligned} \mathcal{J}_{22}^{(1)} &= -\frac{\hbar^2}{4m_0^2c^2} \frac{1}{i} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^4} \left\{ x^2 y k_y + (xy^2 + xz^2) k_x \right\} dx dy dz, \\ \mathcal{J}_{22}^{(2)} &= +\frac{\hbar^2}{4m_0^2c^2} \frac{1}{i} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^4} \left\{ (yx^2 + yz^2) k_y + xy^2 k_x \right\} dx dy dz, \\ \mathcal{J}_{22}^{(3)} &= -\frac{\hbar^2}{4m_0^2c^2} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^4} \left\{ (x^3 + xz^2) k_y + x^2 y k_x \right\} dx dy dz, \\ \mathcal{J}_{22}^{(4)} &= -\frac{\hbar^2}{4m_0^2c^2} \frac{1}{i} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^4} \left\{ xy^2 k_y + (y^3 + yz^2) k_x \right\} dx dy dz, \end{aligned}$$

whence it is clear that: a)  $\mathcal{J}_{22}^{(1)}$  consists of three terms, the first of which is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ , and the second is different from zero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ ; b)  $\mathcal{J}_{22}^{(2)}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ ; c)  $\mathcal{J}_{22}^{(3)}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{sim}(y) + V_{asim}(z)$ ; d)  $\mathcal{J}_{22}^{(4)}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ .

$$\begin{aligned} (H_2)_{22} &= \frac{X+iY}{\sqrt{2}} \uparrow | H_2 | \frac{X-iY}{\sqrt{2}} \uparrow = \\ &= \mathcal{R}_{22}^{(1)} + \mathcal{R}_{22}^{(2)} + \mathcal{R}_{22}^{(3)} + \mathcal{R}_{22}^{(4)}, \end{aligned} \quad (18)$$

where

$$\mathcal{R}_{22}^{(1)} = \frac{\hbar^2}{4m_0^2c^2} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^2} \left\{ x^2 \frac{\partial V}{\partial x} k_y - x^2 \frac{\partial V}{\partial y} k_x \right\} dx dy dz,$$

an odd term with respect to  $x$ , then  $\mathcal{J}_{11} \uparrow 0$ ; c) if  $V(\vec{r})$  has an odd term with respect to  $y$ , then  $\mathcal{J}_{12} \uparrow 0$ ; e) if  $V(\vec{r})$  has an odd term with respect to  $x$  and  $y$ , then  $\mathcal{J}_1 \uparrow 0$ .

$$\begin{aligned} \mathcal{R}_{22}^{(2)} &= \frac{(-i)\hbar^2}{4m_0^2c^2} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^2} \left\{ xy \frac{\partial V}{\partial x} k_y - xy \frac{\partial V}{\partial y} k_x \right\} dx dy dz, \\ \mathcal{R}_{22}^{(3)} &= \frac{i\hbar^2}{4m_0^2c^2} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^2} \left\{ xy \frac{\partial V}{\partial x} k_y - xy \frac{\partial V}{\partial y} k_x \right\} dx dy dz, \\ \mathcal{R}_{22}^{(4)} &= \frac{\hbar^2}{4m_0^2c^2} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^2} \left\{ y^2 \frac{\partial V}{\partial x} k_y - y^2 \frac{\partial V}{\partial y} k_x \right\} dx dy dz. \end{aligned}$$

The last relations show that: a)  $\mathcal{R}_{22}^{(1)}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{sim}(y) + V_{asim}(z)$ , and the third for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ ; b)  $\mathcal{R}_{22}^{(2)}$  consists of three terms, the first of which is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{sim}(y) + V_{asim}(z)$  and the third with  $V(\vec{r}) = V_{asim}(x) + V_{asim}(y) + V_{sim}(z)$ ; c)  $\mathcal{R}_{22}^{(3)}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ , and the second and third terms are nonzero when  $V(\vec{r}) = V_{asim}(x) + V_{asim}(y) + V_{sim}(z)$ ; d)  $\mathcal{R}_{22}^{(4)}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ .

$$(H_3)_{22} = \frac{\hbar}{4m_0^2c^2} \left\{ \mathcal{J}_{33}^{(1)} + \mathcal{J}_{33}^{(2)} + \mathcal{J}_{33}^{(3)} + \mathcal{J}_{33}^{(4)} \right\}$$

$$\mathcal{J}_{33}^{(1)} = i \frac{3\hbar}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^4} \left\{ \frac{\partial V(\vec{r})}{\partial y} z x^2 - \frac{\partial V(\vec{r})}{\partial z} x^2 y \right\} dx dy dz,$$

$$\mathcal{J}_{33}^{(2)} = i \frac{3\hbar}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^4} \left\{ \frac{\partial V(\vec{r})}{\partial y} y^2 z + (yx^2 + yz^2) \frac{\partial V(\vec{r})}{\partial z} \right\} dx dy dz,$$

$$\mathcal{J}_{33}^{(3)} = + \frac{3\hbar}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^4} \left\{ xyz \frac{\partial V(\vec{r})}{\partial y} + (x^3 + xz^2) \frac{\partial V(\vec{r})}{\partial z} \right\} dx dy dz,$$

$$\mathcal{J}_{33}^{(4)} = - \frac{3\hbar}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^4} \left\{ xyz \frac{\partial V(\vec{r})}{\partial y} - xy^2 \frac{\partial V(\vec{r})}{\partial z} \right\} dx dy dz,$$

Analyzing the last relations, we have that: a)  $\mathcal{J}_{33}^{(1)}$  is nonzero at  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{asim}(z)$ ; b)  $\mathcal{J}_{33}^{(2)}$  consists of three terms, the first of which is nonzero at  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{asim}(z)$ , and the second is nonzero at  $V(\vec{r}) = V_{sim}(x) + V_{sim}(y) + V_{asim}(z)$ , and the third with  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ ; c)  $\mathcal{J}_{33}^{(3)}$  consists of three terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{asim}(z)$ , and the second and third terms are nonzero when  $V(\vec{r}) = V_{sim}(x) +$

$+ V_{sim}(y) + V_{asim}(z)$ ; d)  $\mathcal{J}_{33}^{(4)}$  consists of two terms, the first of which is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{asim}(z)$ , and the second is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ .

Below are expressions for the matrix element of each member of the Hamiltonian. In particular,  $(H_0)_{33} = \langle Z \downarrow | H_0 | Z \downarrow \rangle = \langle Z | E_p | Z \rangle = E_p$  and does not depend on the parity of the crystal potential relative to the coordinates;

$$(H_1)_{33} = Z \downarrow | H_1 | Z \downarrow = Z \downarrow \left| \frac{\hbar}{m_0} \vec{k} \vec{p} \right| Z \downarrow = \langle \downarrow \downarrow \rangle Z \left| \frac{\hbar}{m_0} \vec{k} \vec{p} \right| Z =$$

$$= i \frac{\hbar^2}{4m_0^2 c^2} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^2} \left\{ k_x (-xz^2) + k_y (-yz^2) + k_z z \frac{y^2 + x^2}{r^3} \right\} dx dy dz,$$

whence we have that the first term of the last integral is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ ,

and the second for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ , the third is when  $V(\vec{r}) = V_{sim}(x) + V_{sim}(y) + V_{asim}(z)$ .

$$(H_2)_{33} = Z \downarrow | H_1 | Z \downarrow = Z \downarrow \left| \frac{\hbar}{m_0} \vec{k} \vec{p} \right| Z \downarrow = \langle \downarrow \downarrow \rangle Z \left| \frac{\hbar}{m_0} \vec{k} \vec{p} \right| Z =$$

$$= i \frac{\hbar^2}{4m_0^2 c^2} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^2} \left\{ k_x (-xz^2) + k_y (-yz^2) + k_z z \frac{y^2 + x^2}{r^3} \right\} dx dy dz.$$

It can be seen from the last relations that the first term of the matrix element  $(H_2)_{33}$  is nonzero for  $V(\vec{r}) = V_{asim}(x) + V_{sim}(y) + V_{sim}(z)$ , and the second

for  $V(\vec{r}) = V_{sim}(x) + V_{asim}(y) + V_{sim}(z)$ , the third is when  $V(\vec{r}) = V_{sim}(x) + V_{sim}(y) + V_{asim}(z)$ .

$$(H_3)_{33} = \langle Z \downarrow | H_3 | Z \downarrow \rangle = \langle Z \downarrow | \frac{\hbar^2}{4m_0^2 c^2} [\vec{\nabla} V \times \vec{p}] \cdot \vec{\sigma} | Z \downarrow \rangle =$$

$$= - \frac{i \hbar^2}{4m_0^2 c^2} \frac{3}{4\pi} \iiint_{-\infty}^{\infty} \frac{1}{r^4} \left\{ z^2 \frac{\partial V(\vec{r})}{\partial x} y - xz^2 \frac{\partial V(\vec{r})}{\partial y} \right\} dx dy dz$$

and this matrix element is nonzero at  $V(\vec{r}) = V_{asim}(x) + V_{asim}(y) + V_{sim}(z)$ .

If we assume that the crystalline potential does not have an asymmetric part, then all the expressions obtained above and related to  $V_{asim}(x, y, z)$  turn to zero automatically.

Thus, it was shown that, when the asymmetric part of the crystalline potential in semiconductors is taken into account, additional terms are obtained in the matrix elements of the effective Hamiltonian.

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## Section 9. Philology and linguistics

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*Karimova Madina Saydulla kizi,  
2<sup>nd</sup> year PhD doctorate at  
Andizhan State University,  
Republic of Uzbekistan  
E-mail: oybek.komilov@bk.ru*

### MATERIALS FOR THE STUDY OF MODERN PHRASEOLOGICAL UNITS

**Abstract.** This article provides information on the problems of translating phrases, terms and phrases that are part of paremiology into other languages. All terms are easily translated into another language, and they have a general and clear meaning. The idiom on the contrary is individual, and often in direct translation is unintelligible and meaningless and needs special interpretations. Numerous examples have been proved by their use of text and their semantic analysis. It is also illustrated by the fact that different sets of phrases in different languages are not homogeneous, some of them are in sentences and their translation of syntax complicates the process.

**Keywords:** Phraseology, Phraseologisms, terms, idioms, understanding, development, language, translation.

#### Introduction

Phraseology is “a section of linguistics that studies stable figurative combinations of words with a generalized-integral meaning in their current state and historical development. The subject of study of phraseology is phraseological turnovers, also called phraseological units”.

Phraseologisms are called stable language units consisting of two or more components, the sum of the values of which is not equal to the whole. So, the phraseology “through the sleeves” does not mean deflated sleeves in the literal sense, but conveys the idea of “poor quality work.” In English, the phraseological unit will be, for example, the expression “to look forward” in the meaning of “expect”.

According to B.A. Larina, “only phrases are included in the circle of observations and become the

subject of research of phraseology. However, not all, not all phrases... As the simplest form of expression of synthesizing thought, phrases are dissected unity of speech related to syntax. But those phrases in which the internal commeasure of component words is determined by semantic unity, semantic integrity cannot be the object of syntactic study – they are so close to vocabulary as compound tokens that they must be considered either completely independently – in phraseology or in terms of lexicology, lexicography, as was done until recently. The phrase, as a special and peculiar kind of speech unity, has been relatively recently noticed and highlighted by linguists. Further, it became apparent that the richest collection of phrases of any language is heterogeneous, that one part of it gravitates to a sentence and relates to syntax, the other approaches

the word – these are “indecomposable combinations” (A. A. Shakhmatov), “stable combinations” (S. I. Abakumov), i.e. close unity of several words expressing a holistic view. They are decomposable only etymologically, i.e., outside the system of the modern language, in historical terms. This part of phrases should be distinguished from the syntax, but cannot be transferred to the jurisdiction of lexicology – it is precisely this that constitutes the subject of phraseology” [1].

### Methods

There are several options for classifying phraseological units. A. A. Reformatski shared all the words into terms and idioms. The term is easily translatable into other languages, it is general and unambiguous. The idiom, on the contrary, is individual, often incomprehensible in translation, needs special comments. As an example of an idiom Reformatski cites the word “hare” in the meaning “passenger without a ticket” [2, P. 95].

### Results and discussions

In his opinion, idioms are identical to phraseological units which allows us to speak of an extremely broad understanding of phraseological units: in this case, almost all words used in a figurative meaning fall under this concept.

By V. V. Vinogradov phraseological units in the languages of the world can be divided into three types:

1) Phraseological accretions – “maximally frozen lexical combinations, where the understanding of the whole does not depend on incomprehensible words (“get rid of it”; “near the devil on the sand pipes, “sharpen the baldness”), from incomprehensible grammatical forms (“add nothing”, “can hardly”; Parable”; and the whole short term”) or where the words and forms are understandable, but the meaning of individual words does not clarify the whole (to starve a worm, sit on beans, how to drink to give), finally, in cases where this the phrase requires a special intonation that conveys a special expression (here’s to you al! God forbid! That’s how cranberries! Vanish into thin air!)” [3, P. 119].

In English, phraseological units of this type include expression using the zoononym it’s raining cats and dogs, as well as expressive exclamations of the type by Jove!

2) Phraseological unity, where “there are weak signs of the semantic independence of individual words and the presence of dependence on understanding the whole on understanding the components (what the hell is not joking; and cheap and cheerful; not a bottom or a tire; an elephant grains; pour from empty to empty; make from an elephant’s flies; to keep a stone in his bosom; to take litter out of the hut)” [4, P. 66]. In English, combinations of this type are expressions in a nutshell – in a nutshell, a rolling stone gathers no moss – a rolling stone of moss cannot collect, every cloud has its silver lining – each cloud has a silver side (there is no silver lining), etc.

3) Phraseological combinations are the most “free” of non-free combinations, where “understanding the meaning of individual words is necessary for understanding the whole and, as a rule, substitutions are possible, but within certain lexical limits, and the meaning of the whole may change: look down (look, eyes, head), thought found (doubt, inspiration), horror takes (fear, longing, chagrin, envy)” [5]. In English, such phraseological units are the expressions (as) blind as a bat (brickbat or mole) – blind as a bat (mole, bat), (as) dead as a door-nail – dead as a door nail, (as) dry as a bone – dry as a bone, (as) sober as a judge – drunk as a judge, (as) soft as butter – soft as butter, (as) weak as a cat (or as water) – weak as cat (like water).

N. M. Shansky later added to this classification the type of “phraseological expressions”, to which he attributed expressions consisting of freely used words, but reproduced in speech – that is, case statements.

Precedent statements form part of precedent phenomena. Precedent phenomena can be divided into precedent texts – a reference to some well-known text, precedent situations – a reference to a certain proposition, plot, and precedent statements – a reference to a proverb, proverb and famous quote.

A case statement is “a reproduced product of speech and thought activity; a complete and self-sufficient unit, which may or may not be predicative; a complex sign, the sum of the values of which is not equal to its meaning; the latter is always “wider” than a simple sum of values; the precedent statement itself is included in the cognitive base” [6, P. 47]. In Russian and English practice, this can be a proverb, a proverb, a hidden or explicit quote from a classic work – To be or not to be – To be or not to be, May there always be a sun!

B. A. Larin considers phraseological units from the point of view of their history: for each phraseological unit, as he points out, there is a certain precedent situation (which brings phraseological units closer to case phenomena), and its essence allows us to divide phraseological units into idiomatic and metaphorical ones. “The first category is the variable phrases that prevail in every language at any stage of its development. According to the steps of ascending to indecompos-

able combinations (idioms), the closest category in the available classifications should be transition from free to stable, stereotypical phrases. ... The second category of collocations is clearly distinguished by the presence of stereotype, traditionality and metaphorical rethinking, a departure from the original meaning, allegorical application. We will call this group metaphorical phrases – according to the main attribute that defines them. ... The third and final category are idioms ... Idioms differ from metaphorical phrases in a more deformed, abbreviated, distant from the original composition (lexical and grammatical) and a noticeable weakening of the semantic articulation, which determines metaphoricality, i.e., semantic duplicity. Idioms, as was said, are formed as a result of the long-term development of both the form and meaning of phrases; this is the last stage, since in the future they can only fall out of the phraseological reserve, either turning into service elements of speech, or completely disappearing from everyday life” [7].

Table 1. – Classification of phraseological units by V. V. Vinogradov and B. A. Larin [8]:

		<b>V.V.Vinogradov</b>		<b>B.A. Larin</b>		
<b>Phraseology</b>		<b>Free</b>	=	<b>Free</b>		
		Phraseological combinations	=	Free Metaphorical collocations		
		Idioms	Phraseological Unities	=	Metaphorical word combinations	
				Phraseological adhesions		Phraseology
						Idioms

A. I. Smirnitsky, considering phraseological units on the example of the English language, identifies two main types of phraseological units – single-peak and two-peak. “In modern English, it is possible to distinguish two structural-semantic types of phraseological units. Some of them, similar to derivative words, have one semantically full-valued element and can be conditionally called single-peak. Others, like complex words, have at least two such meaningful elements, but may have more (cf. every other day – every other day) – the same as the number of

components of complex words (cf. one-hundred-horse-power- engine – a car with a capacity of one hundred horsepower). It seems possible to call this phraseological units conditionally two-peer and multi-peaks” [9, P. 212].

An example of a single-peak phraseological unit in the Russian language can be an expression from a plow characterizing a person with a peasant past, and a two-peak expression, reluctantly, washing hands, etc.

N. N. Amosova, classifying English phraseological units, identifies the so-called idioms and

phrases. If phraseologism is easily divided and its general meaning is deduced from the meaning of its parts, then such combinations are called phrases: “We agree to name the meaning of a semantically realized word, depending on a constant, that is, the only possible index minimum, a phraseologically related meaning. The unit of a constant context in which the meaning of a semantically realized word is phraseologically connected, we agree to call a phrase” [10, P. 59]. Phrases differ from idioms

whose components are less independent in meaning: “Therefore, we have a special type of constant context in which there is no distribution of contextual functions characteristic of the phrase between the components of the phrase: there is no semantically realizable and keyword, and none of the components has a phraseologically related meaning, depending on the relationship with other components. There is a certain general, indivisible meaning of the whole phrase as a whole ...

Table 2. – The classification of English phraseological units by Smirnitsky can be combined in the following summary table:  
Single-vertex and two-vertex phraseological units

	<b>Phraseologisms</b>	<b>Idioms</b>
Single vertex	Yes	No
More than one vertex	No	Yes
Stylistically Neutral	Yes	No
Stylistically labeled	No	Yes

Units of a constant context in which the index and semantically realizable element normally make up the identity and both are represented by the general lexical composition of the word combination and which are characterized by a holistic meaning, we agree to call idioms” [11, P. 72].

Close to this is the understanding of the idioms of A. V. Kunin: “Holistic meaning is a type of structural meaning of phraseological units with constant completely rethought components. As a result of this rethinking, both the literal meanings of the components and the syntactic relations are weakened. ... An idiom is a nominative, interjective, or communicative phraseological unit with a holistic meaning, characterized by a monolithic structure, i.e. being a closed turnover. From this definition it follows that open phraseological units, even with completely rethought constant components, do not belong to idioms” [12, P. 316].

To phraseologisms according to Amosova’s classification, one should include such expressions as smoking bamboo (phrasem), to take off – take off

(phrasem), beat baclos (idiom), an Easter egg – Easter egg (idiom).

A very detailed classification of English phraseological units belongs to A. V. Kunin. In his work, “English phraseology” provides a summary table of types of phraseological units. (Look to the Table 3).

In the work of A. V. Kunin distinguished nominative phraseological units, interjection units and communicative phraseological units:

“By nomination, we mean the designation of a non-linguistic entity (object, phenomenon, process, etc.) by means of a word, phrase or nominative-predicative phrase, i.e. turnover with the structure (of an object, phenomenon, process, etc.) by means of a word, phrase or nominative-predicative turnover, i.e. turnover with the structure of the proposal with nominative value”.

These include, for example, phraseological units be on top of the world – to be on top of the world, a bitter pill to swallow – to swallow a bitter pill, a bull in a china shop – an elephant in a china shop, a cog in a machine – a tooth of a machine, a Daniel come to judgment – Daniel came to court, Hamlet without

the Prince of Denmark – Hamlet without the Prince of Denmark, have bats in the belfry – have bats in

the tower, new wine in old bottles – new wine in old bottles and others.

Table 3. – Types of phraseological units by A. V. Kunin

Nominal phraseological units	Nominative-communicative phraseological units	Phraseological units that cannot be considered either nominative or communicative	Communicative phraseological units
collocations with coordination link collocations with control link predicative combinations	verbal units that can be transformed into a passive voice of the verb	Interjection	other types of phraseological logisms
as the crow flies – how a raven flies	the ice is broken – the ice is broken	By Jove! – By God!	

In Russian, phraseological units of this type include not all of his expressions at home, Permian – salty ears, quieter driving – you will continue on, etc. “Interjectional phraseological units are phraseological units that serve to express feelings and volitional impulses. They have neither nominative nor communicative functions. Their syntactic nature remains unclear to this day” [12, P. 315]. These phraseologisms include: by George! – I swear by St. George! by Jove! – by golly, hear, hear! – listen, listen!, sakes alive! – for the sake of the living! Jesus christ! – Jesus Christ! Father’s lights! Christmas trees, sticks, etc.

Under communicative A. V. Kunin understands phraseological units, which are whole sentences. “Communication in accordance with the traditional linguistic understanding is a message about reality expressed by a sentence. The message can be both narrative, and interrogative and incentive. Hence the division of sentences into narrative, interrogative and incentive”.

For example, these expressions are the coast is clear – the shore is clean, the fat’s in the fire – add oil to the fire, the shoe is on the other foot – the shoe is on the wrong foot, that’s a horse of another color – this horse is a different color, that’s another pair of shoes is another pair of shoes, it’s as broad as it’s long = it’s as long as it’s broad – as long as wide (what to put, what to put).

In the Russian language to communicative phraseological units by A. V. Kunin should include all sorts of proverbs and sayings. “Among communicative phraseological units, one should distinguish sayings, that is, communicative phraseological units of a non-logical character, and proverbs, i.e. communicative units, which are short sayings of a generalizing and edifying nature. At first glance, the difference between proverbs and proverbs is purely semantic. However, it is not. In general, proverbs have a more closed structure than sayings. This is proved by the absence of proverbs with constant-variable and constant-variable-variable dependencies of the components. Proverbs are characterized not only by a completely rethought meaning, but also partially rethought, rarely found in proverbs, and the English proverb may contain one word with a metaphorical meaning, two words with a metaphorical meaning or a phrase with a metaphorical meaning” [13, P. 313].

The phraseology of any nation is inextricably linked with the history, culture, traditions and literature of a nation that speaks that language, and accordingly is often used by authors of literary works. Phraseologisms in Russian and English differ in their characteristics, since Russian phraseological units are more often single-peak phraseological unions in which obsolete or uncommon words are

preserved: beat bacilli, sharpen laces, etc. English-language phraseological units are for the most part more flexible, more transparent in meaning, and therefore, you can often see a component replacement or addition in them: for example, the name of the Die Hard franchise in the fifth series is expanded to Good Day to Die Hard.

Further, Russian phraseological units often go back to some precedent situations: for example, porridge from an ax is part of a fairy tale about a soldier who cooked porridge from an ax a lime foot is also part of a fairy tale about a bear that broke his leg. In English-language practice, many phraseological units have not retained ties with certain precedent texts.

If we take the situation with the use of phraseological units in speech, then the use of phraseological units in everyday speech, in anecdotes, in stories of life stories, etc. is common in the Russian language *uzus*. At the same time, phraseological units are more often used in English-language practice as part of a journalistic and even scientific style. In Russian practice, there is a “gap” between everyday colloquial style and book styles: official business, scientific, etc. In English practice, this “gap” does not exist: a person can use phraseology in an official speech, and this will not seem inappropriate to any of the listeners or offensive.

Thus, phraseological unit (phraseological unit) is a stable expression consisting of two or more words, the meaning of which does not equal the sum of the values of the whole, but acquires a special idiomatic character. Several approaches to the classification of

phraseological units are proposed. V. V. Vinogradov identifies phraseological units, phraseological unity and phraseological combinations based on the tightness of the cohesion of the elements of phraseological units. N. M. Shansky adds to this a fourth type with even less close connections between the components, phraseological expressions. B. A. Larin examines the types of phraseological units by their origin, highlighting the metaphorical and idiomatic phraseological units.

### Conclusion

In order to study modern phraseological units, it is advisable to evaluate them according to the following criteria:

- The presence of one or more peaks of phraseologism – the number of phraseological units, which are semantic centers;
- The attribution of this phraseology to one of the types according to the classification of V. V. Vinogradova – phraseological units (indivisible units in which one of the components or both practically does not have independent use), phraseological units (independent units that combine into phraseological units, the meaning of the whole is not equal to the sum of the values of the components) and phraseological combinations (independent components in stable phrases);
- The type of phraseologism stability – sustainable use, lexical stability (a typical combination with a stable meaning), syntactic stability (a typical often reproduced phrase structure);
- The connotation attached to the precedent statement within the framework of phraseology.

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*Sokolova Galina Pavlovna,  
senior lecturer, Department (Faculty) of Ukrainian  
and Russian languages as foreign (UkrRKI),  
Beketov's Kharkov National University of Municipal Economy  
(KNUME named Beketov), Kharkov city, Ukraine  
E-mail: galasokolovadudova@gmail.com*

## SYMBOLS-IMAGES AND SPATIAL DOMINANTS IN THE GEOMETRICAL POETIC UNIVERSE OF ANDREI BELY: A HORIZONTAL VECTOR

*"I'm happy only when I travel ..." / Andrei Bely*

**Abstract.** The article is devoted to the organization of the space of the poetic model of the world by Andrei Bely, as well as to the studying of a number of spatial images (and not spatial – floristic and faunistic, which perform the function of organizing space) and geometric symbols in the context of “travel literature”; the ways of comprehending and overcoming the space of Bely are analyzing through the prism of the author’s “life text”, spiritual searches, the idea of the synthesis of “East-West”.

**Keywords:** spatial images, symbols, geometry of “meaning”, path, travel, “East-West” synthesis.

In modern literary criticism, a lot of attention is paid to comprehending and studying the life and work of Andrei Bely, the brightest representative of the Silver Age literature: his individual works, the author’s idiosyncrasy and motives (the idea of synthesizing East and West, “spiritual pilgrimage”, about the connection of the Russian idea with the West, and also consider philosophical and aesthetic issues of culture and literature in the “transitional” periods, the stages of “cultural breakdown” (as, for example, in the “travel literature”): [2, 7, 28, 18, 16, 20, 24, 11, 12, 14, 13, 22, 19, 30, 15, 17]. However, in the region studies of the spatial model of Bely’s poetic world, the relationship of these two complex and contradictory phenomena, mysterious and inexplicable – Space (“Topos / Aristotle seems to be something great and elusive) and Andrei Bely (“There is neither Time nor Space”; “And there will be new times and new spaces” / Andrei Bely) – there are practically no full-fledged scientific works and monographs. Turning to one of the constants of the “Bely poetic Universum – the” horizontal “vector – we set as our

goal to determine the main spatial parameters and images-symbols that allow us to perform tasks: using the “travel literature” as an example, we reveal the urgent orientation in the work of the leading representative of Russian symbolism (the symbolic component of the “vertical” sphere of space and the futuristic code of “mixed” space were considered by us in other articles) [24, 25, 26]. The material of the study is individual works of Andrei Bely prose related to the literature of travelogues (African Diary, Orfeira, Traveling Notes ...). As basic methods are used: structural-semantic and interpretive.

The literary text can be considered as “a device to the input of which texts circulating in the culture, which, having crossed its internal borders, are transformed into new messages, are sent” [18, 105]. So, any works, “turning out to be the object of research attention, can be better and more correctly understood if their understanding begins with the work of textual” [1, 4]. The most interesting material of literature is “travels” (“travel literature”, from the French. Voyage – travel) or “travelogue” (from the English travelogue –

description of the trip), being a literary text and space of culture, at the same time carries information about countries, cultures, events and people, and also represents a dialogue of cultures (“a dispute between the possibilities of culture”, “logic of the dialogue of logics”), expressed in the text [9, 131]). It is known that “a traveler seeks to expand his personality, to something that he hopes to achieve through increasing and diverse sensations from external reality” (according to Schönle) [Cit. By: 22, p. 44–45]. We see that external movement is impossible without correlation with the internal movement, and any external landscape immediately turns into a “landscape of the soul”, composed of impressions, experiences, memories, appeals to previous cultural impressions.

In studies on semiotics (Y. M. Lotman), travel is perceived as a situation of “cultural breakdown”, a clash of cultures; and in this regard, literary travels represent the basic material for applied linguistic and cultural studies, which was originally based on a comparative (contrastive-comparative) basis).

On the one hand, almost all of Bely’s works in the context of “travelogues” represent a single metatext in which the motive of pilgrimage and spiritual quest (including the synthesis of East and West) is dominant. On the other hand, the text model of “literary travels” – both fictional and real – is often constructed by Bely by analogy with the author’s life context model; and then it becomes difficult to separate a life biography from any fiction and fantasy, “Having denied the name of “autofiction” (S. Dubrovsky, M. Darr’ssek ta in.) [8, 8]. Many literary figures whose creative production was not limited to writing poetry or prose (just refer to the works of V. Rozanov, A. Remizov, M. Tsvetaeva, V. Kamensky and others) involved life forms in their sphere (cf. Rozanova: “Every person in his lifetime must write at least one book – the book of his life”).

The desire for spiritual knowledge of the East, which swept Russia in the late XIX – early XX centuries, when it was time for new discoveries, reassessment of values and changes in the country’s life and

public consciousness, manifested itself in a special way in Russian literature. And, of course, one of the main intellectuals of the Silver Age, Andrei Bely, a vivid representative of the “conquerors” of space and lovers of wanderings and travels, “strange wanderers” (A. M. Remizov), could not leave his mark in the literature of the “travelogue”, associated with travels in the East. Andrei Bely is not attracted to the journey as such, but to spiritual pilgrimage as a religious and philosophical idea.

The ideas and images of the East were for the poet and philosopher Andrei Bely a way of “world-experience.” The peculiarity of Russian literature, which is based on the principle of the struggle of two principles – “homesickness” and “homesickness” (in Kant’s terms) was manifested in the fact that at the turn of the century a large number of works with “foreign” oriental themes appeared in Russian literature. “Travel Literature” is an attempt to find “homesickness” in a “welcome foreign land”, the desire for the synthesis of “one’s own” and “another’s”, eastern and western in a “single country of his personality” [2, 31].

The journey of Andrei Bely (whose relationship with space was based on the formula “I love you, but with a strange love”) through the countries of the Mediterranean and North Africa becomes a key moment in his life and creative pursuits. In 1910 he and his wife Asya Turgeneva went to Italy, and from there – to Tunisia; Having left cozy Rades, they head to Egypt (with a stop in Malta), then to Palestine and return to Odessa. Bely prepared his travel notes back in 1912, however, for the first time they were published only in 1922 under the title “Ofeira” (later a second, enlarged edition entitled “Travel Notes” and “African Diary” was also published). In one of the Glossolalia essays, the author talks about the heavenly Aeria (Ofeira or Zephyra), emphasizing that there is no “on earth” this desired ancestral home of mankind, and does not clarify where the “golden earth”, formed from a substance “invisible to ordinary eye (“oko”).

An important role in organizing the artistic space in Notes and the African Diary, Andrei Bely,

endowed with the special gift of “keenly seeing the world in lines and colors” [5], assigns light and color (as the foundations that form spatiality) that are involved in creating storylines and motives.” “Tunis la blanche!” – that inscription was thrown clearly from all the windows of Tunisia; and white spots are thrown again when I recall Tunisia; he is the snowiest, he eats unbearably eyes with the spots of houses, ... I only know that these are white days, and that white Tunisia; yes, it is internally white; and at the same time it is white for the outside eye. So he first appeared; and so he stands before me. “This color” – a symbol of the embodied fullness of being” [6] – and this image of the “white city” receive a special cultural and semantic content in the work of Bely. Thus, the Tunisian “snowballing” takes on its bright (sometimes excessively geometrized) shape: bizarrely built squares of houses, “pot-bellied” domes and minarets, turrets and “white burnus” (national men’s clothing). Light and color, the brightness of colors are refracted in the “Notes ...” in the decorative elements of architecture, in national clothes, the tunic of Tunisia: “I open a window on the Arab street; colorful spots – where is white Tunisia? He – parted on a rainbow of colors, he published white; near – glossy, earthenware, rainbow < ... > So is the Arab: how to throw a burnus – a ghost, whitish fog; it will open – it is orange, blue, bluish and pink; and Tunisian street: from a distance – white; if it comes closer, it’s a motley evidence” [3, 178]. A diverse atmosphere of the work is created by the diverse characters found in Bely’s book – representatives of almost all ranks and professions, with different religious backgrounds – bei, qadi (judge), dervish, lawyer, sheikh, merchants and merchants, “silver-wandering” old man, Monsieur Epinat, Mahmoud, Ali Jalluli and others. The national color is reproduced by the writer through the names of national clothes, local names of certain things, etc. (Burnus, Chechi, Litam, grandmothers, there and there), and the national diversity and multicolor of Tunisia (which goes back centuries), hiding behind the external “snowy” whiteness, the large and

diverse population of the country (Berbers, Moors, Arabs, Sudanese, Tuaregs, French, Italians, Sicilians, Jews), is transmitted in “Ophira ...” sound recording of speech of different peoples. So Bely, (fully mastering the art of musical instrumentation of the text) through the means of visualization of sound recreates the feeling of what is depicted: “... the Arabic language sprinkles around a wooden-laryngeal fraction, from which an Italian-French solo emerges, like a violin amid a swarm of deaf drums: – “Dha – dharbabab! ”... then the Arabs drum with their larynxes. “Zen-zen-zen,” the thin-legged Frenchman hummed with a mosquito. – “Jare-jare-majare” – then two Italians met [3, 178].

On the pages of the *Traveling Notes* and the *African Diary*, Bely represents several spaces that are comparable to each other, endowed with completely opposite characteristics, with different color schemes. One of the spatial oppositions is the eastern and European quarters in Tunisia: The contrast between the two cities (the eastern whiteness of the Arab quarters and the yellow, dirty color of the European quarter) smoothly switches to a comparison of two nations: on the one hand, the Frenchman has neurotic gestures, a funny figure, he is “Mouse stallion”, not strong in body, not proud, but on the other hand, the Arab has beautiful lazy leisurely movements, “delicate gestures”, he is proud and noble, old people are “white worthy”; (Compare: “the pale moor in a luxurious turban”, “the white marbles of the moor ... emitting smoke rings”) [4, 353].

Another comparable pair of spatial images can be considered the images of two countries – Tunisia (through eastern exoticism) and Egypt (through the prism of the West): “Tunisia has sprouted for centuries; he built the body from ancient times: the Arabs of Tunisia made up of Carthaginian, strong stone: the whiteness of its walls is gray, it is whitened with lime: old age ...” [3, 233]. Passing through the “boring” streets of Port Said (“a town sticking sadly above the sea among the sands < ... > and overflowing with the hubbub of all the dialects where Europe, Asia,

Africa sends its crooks”) Andrei Bely disappointedly remarks: “a strange country; there is one remarkable phenomenon: a pile of ash; a pile of ashes – old Egypt”, while noting the beauty and originality of Egyptian landscapes [23, 172].

These models of spaces, the difference in images, and the incompatibility in the guise of two peoples (and cultures) are a kind of opposition between two cultures, a confrontation between Europe and Africa, West and East. On the one hand, condemning the “cultural” colonization of Africa, the writer is outraged: “Tunisia – where is Tunisia? Not Tunisia, but Paris; <...> why did they pollute Tunisia here, off the coast?” [3, 175], believing that Europeans are appropriate in Europe, and the Moors and Berbers are harmonious in Africa. On the other hand, as if anticipating today’s realities, Andrei Bely wrote: “Bely compares Africa and France, believing that Africa is the “twenty-two” of France, which over time can conquer France itself: “France is gaining weight quickly, she is a black woman; not a Galician cock her symbol; and – not the square dance of her dance, rather her symbol is a giraffe, her dance is a cancan; and one does not have to be a subtle seer in order to clearly understand: even in the 20<sup>th</sup> century, the muffled, wailing sound of a drum, tam-tama, will enter into the subtle sounds of the “piano culture” of Europe; “La-la” will turn into a sound: “boom”. And the sound of the booming boom space of Europe. Oh, poor France” [4, 330]. Bely sought the true path of development of his country not in the East and not in the West, but in their synthesis, striving, as usual, to “unite the unconnected”.

In addition, another opposition of two spaces appears on the pages of the African topos of the writer, reinforced by numerical, color and sound symbols and geometric lines and figures. This is an urban space with a positive connotation – filled with “things”, a cozy and cramped space of minarets and turrets, colored streets with cafes and bazaars (sukk): “The whole of Cairo is on the edge of the pyramid”; “Here is the mosque of the Three Gates, this one is a white turret, bearing

walls high above ... , the window eyes are square”; “Eight-gang Susa – the arsenal of the whole of Tunisia”; “Like fleur, black and white spots of people along with arcs, cells ... ; white checkers on a powerful arc of the turned gate.” At the same time, there is another space, natural – empty, spacious, yellow space of sand, evil and uncomfortable: “And there is nothing but the chaos of yellow screaming ... sand from the window”; “Look through the window: how evil, how yellow!”; “From the sands – it is planned: the deadly yellow sand of Kairouan ... <...> exactly the Kremlin <...> is strengthened by the yellowing walls of the battlements” [4, 340]. On the pages of the “trips”, visual images of the perceptual, perceived space appear: old and gray-haired, shabby and rebellious, ancient and burnt Kairouan – with a clear geometry of the picture, with a dominant black and white architectural filling, repeating in the color of clothes (Compare: “turn black silk”, Sudanese in a “white burnus”) and young, beautiful, arrogant and proud filled with vital energy, reminiscent of a “pale Moor”, at the same time white and motley Tunisia – with floral ornaments (“arabesques”), and bright colors (Cf.: Yellow Tunisia’s blue ornament”, tunisia “wrapped in a glaze of silk”).

In Bely’s letters, a comparison of Cairo with Tunisia arises: “Tunisia is charming, cheerful, graceful; Cairo is more significant, more impressive, more amazing; Tunisia is cozy, Cairo is threatening, something is overwhelming in Cairo: the millennia of the past unwittingly stand up. <...> here everything looks predatory at a foreigner “[23],” Tunisia is assembled, Cairo is scattered; Tunisia is snow-white, Cairo is black-gray “...”; Tunisian mosques are gracefully small; Cairo – “magnificent”; “Tunisia refers to Cairo (in the sense of the Arabs) as pre-Raphaelitism refers to Rococo; ... Tunisia is nice, comfortable, cheap; Egypt is majestic, terrible, monstrously dear; but, in spite of everything, this is the most beautiful country in terms of landscape ...” [23, 165].

In the exotic of the new space and new culture, the writer finds some similarities with his native expanses, and the outlines of the Kairouan plain

remind him of the Russian plain of the middle zone: "... through the wind the same sands creep from the East in the spaces of the dashing Orenburg, Samara steppes" [4]. We have already noted Bely's special "spatial" dictionary, worked out and very rich, in a number of our other articles [25]. The number of uses of the elements of this dictionary in a number of fragments of the text is very large, which even gives the impression of some spatial "logomania" (according to V. N. Toporov):

One of the leading spatial images can be considered the "distance" locus, and this is understandable, since the road and the path are connected with the horizon line: "Next – they gave the desert; <... > further – the world of expansion of swam". But besides this, "distant distances" and the worlds of outer space contribute to the comprehension of the inner ("near" world) space of the soul, the world of the "wanderer". Images of empty spaces of the steppe and desert are often associated with thanatological motifs: "The remote steppe, not the desert ..."; "We reached the stone cubes of a dead planet, which fell sideways to the ground: and now – my head fell over on my shoulders" [4, 426]; "From the sands is outlined: the dead yellow sand of Kairouan"; "And there is nothing but the chaos of yellow, screaming, flying sands outside the window" [4, 454].

However, in Bely's "Notes ..." even the Chaos of deserts and cities, which in many medieval topographies was called the "great void", is perceived more as "the beginning of Order" (and not "mess"), carries the potential of "new places". The horizontal image of the steppe and desert is emphasized by the vertical of the spiritual world of the East: "And the whole distance came out with minarets ... ps" [4, 422].

In general, Bely's African topos is built on the contrast, the contrast of two main defined space models that change their appearance during the trip: two different images of culture in the same space of the country and the continent (the cities of Tunis and Kairouan, the countries of Tunis and Egypt), the images of two continents Europe and Africa),

as two incompatible cultures. Tunisia has become a turning point in the biography of a symbolist writer, a "moment" that gave rise to an "adventurer, entrepreneur": "... I felt Tunisia as a base from where I could dive into the vast Africa, like a diver attached by a rope to a ship." [4, 348] Bely notes this revolution in his journey, which turned out to be not only a journey somewhere, an escape from myself ("... I came to Tunisia to relax, wait out the cold"), but also became a journey inside myself, a kind of revelation: "... They were waiting for us: Messina, Catania, Pompeii, Naples, Rome, galleries, museums; and we looked somewhere in the opposite direction; called south and east; and the voice of the Sahara was heard" [ibid]: "... staying in a quiet Arab village in Rades was a tremendous revelation to me, expanding the horizons; from here I traveled mentally into the bowels of Africa, into the depths of the centuries that made up her modern life; we already feel this life, thousands of threads connect us with Africa," writes Bely in the preface to the "Diary ..." [4, 330]. That is, in this case, we can talk about the journey not only of the body, but also of the soul, moreover, "the journey "outside the body" is rather the plot motivation for the "journey of the soul" [13, 174]. In "Notes ..." and "Diary ..." there is no sense of hopelessness in the perception of space; the "living soul" does not suffocate. Foreign spaces turned out to be closer and dearer to his soul. Africa for the writer was associated with the idea of a genuine "earthly paradise" (as for many Cueists), presented in the form of the primary, blessed world, the world of the natural order of things. There Bely found refuge with his rushing soul – the soul of "self-aware", his "captive spirit" [29]. It is no coincidence that in one of the letters that the writer wrote to A. M. Kozhebatkin, Bely called himself and Asya (wife) "the perfect patriots of Africa" [23].

Thus, **in conclusion**, the expressive landscape lyrics and urban topos, the sophistication and brightness of associative images and motives (landscape and architectural), their complex interweaving, in

which part of the images flow into each other or merge, are contaminated, creates the impression of multi-layer, a kind of “palimpsest” of the Bely’ African topos. An incredible sense of space and a thirst for knowledge of the new world allowed Bely to build his geometrical spatial model of the Universe, which we examined on the example of the “African topos”. The Bely’s inherent love for exotic countries, for energetic overcoming and knowledge of space brings him closer to representatives of the acmeistic trend (Comp.: African diary” by N. Gumilyov). Andrei Bely, like many acmeists, overcomes emptiness, non-existence by creating “filled places”, bizarre lines, ornaments and patterns, geometric shapes.

One of the main spatial parameters of Bely’s poetic world – “fret” can be considered the “Farness”-locus (overcoming the external, real, perceptual – visible and felt – “space-I”) and the spatial locus “Depth” (comprehension of “I-space”, “The inner space of the soul; compare the expression of N. Berdyaev:” The depth of a person pulls him in height”). The image of travel and the image of the traveler, the image of a new real space (geographical and cultural) and the image of the soul, whose life, according to Bely, “is determined by internal impulse, movement to distant horizons, desire to distant” [19]. The holistic image of Africa is represented by the vast and not fully developed space, clothed in sands and steppes. And at the same time, “alien open spaces” turned out to be much more understandable, closer and dearer to his soul for his soul. In Belyi’s “travel literature” (the “horizontal vector” of his model of the Universe), the acmeistic attitude of being is traced. Hence not only the material detail, visibility and tangibility of

space (its essence), dynamism and movement, but also the deduction of the category of space from the number of abstract ones and endowing it with real ontological features. Such an attitude led to anthropomorphism of a number of spatial categories, as well as to the substantialization of space, endowed with a visible, perceived materiality. In some spatial images, “faunistic” and “floristic” motifs are traced. In descriptions of the urban landscape, steppes and deserts of Africa (comp.: image-metaphor – symbol of the Sahara – gate of Africa) Bely actively uses the “organic” metaphor. A number of non-spatial images-symbols (snake, fez, burnus, etc.) perform the function of organizing the artistic space of Bely.

Spatial symbols and semantic images are extremely saturated with geometric terminology. The combination of geometric symbols of a circle (in the concept of Bely – East, nature, semicircular lines, arcs, etc.) and a square (West, city, cubes, straight lines) leads to another recognizable image – the image of a “mandala” (figures where the circle inscribed in a square, and the square is in a circle), a symbol of stability, harmony and order. One of the philosophical thoughts of Andrei Bely reflects the writer’s desire to synthesize the cultural concepts of the “East” and “West”, to search for “his own way” in world culture and literature:

“Spiritual science and Christianity are synonyms for me now; and the children’s song of the soul, turned into an orchestrated Symphony, is our way; song of the soul – East; orchestration and counterpoint – the West: and the human desire (not the man himself), leading him from the song to the Symphony, is east in the west or west in the east” (Andrei Bely).

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*Kholisova Gavharoy Mannobjon kizi,  
2<sup>nd</sup> year doctorate at Andizhan State University,  
Republic of Uzbekistan  
E-mail: oybek.komilov@bk.ru*

## SOME THOUGHTS ON COMMERCIAL DISCOURSE

**Abstract.** This article illuminates important tasks of linguistic stylistics at the present stage of its development is the study of functional styles. Besides, in the recent time increasing transparency between cultural models, strengthening intercultural social and business relationships is being transformed, traditional communication styles and, above all, commercial discourse are being updated.

**Keywords:** linguistics, modern stage, development, physical, communicative, presentation.

### Introduction

One of the most important tasks of linguistic stylistics at the present stage of its development is the study of functional styles. Today, increasing transparency between cultural models, strengthening intercultural social and business relationships is being transformed, traditional communication styles and, above all, commercial discourse are being updated.

It should be noted that the concept of commercial discourse combines the totality of interactions in the economic, political, technical, social, scientific and cultural spheres of human activity. Modern business communication is faced with the need to adapt to modern communicative requirements, new conditions and means of communication, as a result of which commercial discourse over the past decades has acquired new features that have become “canonical”, determining its textual and linguistic-stylistic identity. At the same time, despite the widespread recognition that commercial communication, like communication in any other field, is undergoing profound transformations and changes today, to this day new signs that have emerged in recent decades, the essential characteristics of commercial discourse remain poorly understood, little studied in modern scientific literature. Meanwhile, business communication is an integral part of the life of each individual, society, nation-state and state alliances.

Without business communication today, it seems impossible to reach an agreement in any sphere of life: from the military to the cultural, to the sphere of art, therefore, understanding the features and specifics of the modern business discourse is an urgent, significant problem.

### Methods

First of all, it is necessary to dwell on the study of the essence of commercial communication. E. G. Azimov, A. N. Shchukin is understood by commercial communication as “a type of communication whose purpose is to exchange information in the professional, commercial and non-commercial fields of activity” [1, P. 448], emphasizing that the main difference between business communication is the sphere functioning. According to scientists, in the course of business communication, each of the participants seeks to solve, first of all, the tasks relevant to their own profession, which allows us to conclude that business communication is always focused.

### Results and discussions

Business communication takes place in the professional sphere, reflects the focus of communicants on achieving certain professionally significant goals, covers the whole variety of interactions in the profession, which lead to the formation of various forms of business communication. A. M. Sosnovskaya dis-

tinguishes the following forms of commercial communication [2, P. 92, 117]:

1. A business conversation is “the desire of one person or group of people through words to arouse the desire of another person or group of people to take action that will change the situation or establish new relations between the participants in the conversation” [2, P. 92]. In the most general form, a business conversation is understood as oral contact between partners, interlocutors.

2. Negotiations are “interdependent processes of the development, exchange and fulfillment of certain sets of promises (contracts, agreements, treaties, conventions, etc.) that satisfy the basic interests of the contracting parties” [2, P. 96];

3. Press release – “press release; an informational message containing news about the organization (possibly a private individual) that issued the press release, an exposition of its position on any issue and transmitted for publication in the media” [2, P. 105]. There are several types of press releases:

a) Press release announcement – an informational message about an upcoming event;

b) Press release-news – an informational message about an event that has already occurred;

c) Informational press release – an informational message about the current, unfinished event;

d) Background grader – “informational PR material for the media, representing information about the organization, its profile, products and services, history of creation, development, etc.” [2, p.106];

e) Fact sheet – information material for the press containing reference information about the organization, its products and services. Unlike the background grader, it may contain information about the organization’s management, statistics, lines of business, etc. A fact list is usually created for publications that work directly in the area in which the organization issues goods or services.

4. Briefing – a brief informational message that is usually voiced by an official: a representative of the government, commercial structures, international

organizations, etc. with media representatives in order to inform about important events, the progress of negotiations, conferences, results achieved, etc.

5. Business meeting – “a discussion of the organization of production, company management, marketing activities, conducted by the first person or his replacement specialist”;

6. Presentation – “the presentation of one’s abilities, one’s product or one’s company to partners, customers, investors or consumers in order to obtain the necessary solution (action) from them” [2, P. 111].

Of course, commercial communication is not limited to these forms. In a separate type of communication can distinguish commercial, business letters, documents, etc., which can accompany a business conversation, negotiations, etc.

As you can see, business communication can take a variety of forms of its implementation, covers a totality of the most diverse situations, one way or another related to the achievement of professionally significant values, is characterized by high variability, can occur verbally and in writing, be aimed at the implementation of certain functions, which significantly complicates the processes of researching business discourse.

The form of business communication and communicative intentions determine the characteristics of the formation of commercial discourse. Moreover, other communicative factors also influence the formation of commercial discourse. V. A. Zhelamskaya names the following factors as such [3, p. 116–117]:

1) the nature of the addressee (s), first of all, the criteria of certainty / uncertainty of the addressee; number of recipients.

2) the nature of the addressee (s);

3) positional (role) relationships: whether the addressee occupies a higher or lower social position or are the communicants equal

4) socio-psychological distance: for example, close distance, which may be in commercial communication between colleagues, or far, which may be in interactions between individual commercial organizations.

These factors are external to the commercial discourse, form its communicative context, their significance, influence significantly differ depending on the form of commercial communication, as well as communicative intentions.

At the same time, despite the high variability and variety of manifestations of business communication, it seems possible to identify a number of unifying signs that allow us to identify the interaction as commercial. First of all, such characteristics should include the sphere of communication – professional, which determines the characteristics of the course of interaction, the formation of significant features, characteristics of communication.

The objectives of commercial interaction are directly related to the profession, the functioning of commercial organizations or institutions. V. Zhelem-skaya names the following as the goals of commercial discourse [3, p. 97–101]:

1) Information, information function, which dominates in the field of commercial communication. One way or another, all forms of business communication, all commercial discourses serve the purpose of informing;

2) A description of the fact, event: as a rule, the initiation of commercial communication in this case is due to a certain fact, an event that necessitated the implementation of communication. Achieving this goal, as a rule, is carried out on the basis of a representation of facts, a chronological sequence of events;

3) Fixation of a specific fact or event – communication devoted to the preparation of estimates, catalogs, registers, etc. It is important to add that not only real, but also alleged events can be recorded;

4) Confirmation / denial of a certain fact;

5) The establishment / consolidation of a certain order: this communicative intention is associated with the need to regulate the economic, production activities of the organization, institution. Decisions, documents resulting from this form of communication are binding, as they constitute the legal basis for the activities of the organization, institution;

6) the prescription of action – one of the most important functions of commercial communication, which determines the order of actions, the circle of persons, actors involved in commercial, industrial or other activities. In other words, as noted by G. I. Bubnova and N. K. Garbovsky, the implementation of the indicated intention “consists in prescribing to the addressee a specific character of action, for which it is necessary to name the addressee, indicate the action that he needs to perform, and indicate the conditions, in which this action can or should take place” [4, P. 20];

7) Request for action – a form of communication initiated by the author so that certain actions are taken to correct the negative, according to the initiator, situation. As a rule, this form of interaction consists of two parts: the first sets out the features of the current situation, the factors that led to its occurrence; the second contains information that clarifies the actions and their sequence, which will make it possible to change the situation for the better;

8) the establishment of legal relations between the parties – forms of commercial communication involve interactions with various individuals and legal entities, moreover, these interactions are most often accompanied by the presence of certain obligations to each other, therefore, there is a need for the establishment, coordination and legal consolidation of these obligations;

9) expression of an authoritative opinion – a form of communication, which, as a rule, consists in the fact that an authoritative specialist offers his opinion, vision regarding a particular situation, actions that should be taken to increase the efficiency, productivity, effectiveness of commercial interactions.

Researcher A. M. Sosnovskaya names the following functions, intentions of business communication [2, P. 92]:

1) The beginning of promising events, processes;

2) Control function – control and coordination of already begun activities and processes, regulation, coordination of joint actions of partners;

3) Supporting function – support for business contacts;

4) The search, promotion and development of work ideas;

5) A communicative function – establishing new connections and relationships, getting to know potential partners, exchanging ideas, points of view;

6) The distracting function is to gain time [2, P. 98].

In other words, commercial communication is always focused, focused on achieving professionally significant goals, regulating interactions between authors, working out agreements, agreements, and the legal basis for interactions.

Based on the analysis of theoretical sources, the relationship of various forms of commercial communication, communicative intentions and communicative factors can be presented in the form of (Table 1):

Table 1. – The relationship of forms of commercial communication, communicative intentions and communicative factors

<b>Form of commercial communication</b>	<b>Communicative intentions</b>	<b>Communicative factors</b>
<b>1</b>	<b>2</b>	<b>3</b>
Business conversation	Informational; description of fact, event; fixing fact, events; confirmation / denial of a certain fact; establishing / securing a certain	specific addressee and addressee; role relationships and socio-psychological distance can be any
Business meeting	order; prescription of action; request for action; establishment of legal relations between the parties; expression of authoritative opinion; the beginning of promising events, processes; control function; supporting function; search, promotion and development of work ideas	specific addressee and addressee; as a rule, the addressee is in a higher position than the addressee socio-psychological distance may be close or far
Conversation	informational; description of fact, event; fixing fact, events; confirmation / denial of a certain fact; establishment / consolidation of a certain order; prescription of action; request for action; establishment of legal relations between the parties; communicative function; control function; distracting function	specific addressee and addressee; as a rule, the addressee and the addressee occupy equal social positions; socio-psychological distance tends to close

<b>1</b>	<b>2</b>	<b>3</b>
Press conference	informational; description of fact, event; fixing fact, events; confirmation / denial of a certain fact; request for action; expression of authoritative opinion; communicative function; control function; distracting function	The addressee can be either specific (target audience) or uncertain. The message is always directed not to an individual person, but at least to a group of people, most often, to a mass audience.
Press release Briefing	informational; description of fact, event; fixing fact, events; confirmation / denial of a certain fact; request for action; communicative function; control function; distracting function	Destination always defined Role relationships can be different Socio-psychological distance is far, even if the producer of the statement seeks to express closeness to the audience
Presentation	informational; description of fact, event; fixing fact, events; confirmation / denial of a certain fact; establishment / consolidation of a certain order; prescription of action; expression of authoritative opinion; the beginning of promising events, processes; control function; supporting function; search, promotion and development of work ideas; communicative function; control function; distracting function	The addressee can be either specific (target audience) or uncertain. Destination always defined Role relationships and socio-psychological distances can be different

As the data in (Table 1), forms of commercial communication differ both in their basic functions and in their communicative factors. If business conversations and negotiations, as a rule, are designed to optimize the activities of an individual institution, are multifunctional, then press releases, briefings are intended primarily for “external” to the actor’s institution, their functional potential is somewhat different.

Goals, functions of commercial communication determine the style characteristics, features of commercial communication.

At its core, communicative interaction in the business sphere refers to the business functional style, which, according to O. A. Krylova, is a system of linguistic means of all levels, which was developed and formed in the process of functioning of the language in the field of official business com-

munication [5, P. 214]. In other words, the sphere of business communication operates with special language units, the choice of which is determined by the requirements of the communicative situation, as well as the communicative attitudes of the participants in the interaction.

In the most general form, all the principles of business communication in French linguistic culture are presented as follows: the desire for clarity, accuracy, the need to adapt to the requirements of the audience, emphasized courtesy and the desire to avoid any demonstration of excellence [6].

As noted by E. A. Konyaeva, the influence of business speech etiquette finds its representation in the choice of language tools that are understandable only to specialists in this field, a certain grammatical, syntactic and stylistic specificity [7, P. 28]. Features of business communication are formed under the influence of the desire to save language resources, due to the desire for compression.

Achieving officiality, accuracy, standardization, conciseness of commercial communication is achieved through the selection of appropriate lexical, syntactic tools. According to V. A. Zhelamskaya, the lexical system of commercial communication is organized by three stylistic meanings [3, P. 137]:

1. “Norma” – “a literary processed language standard that is regarded as the best example of a national language and is introduced by society through the educational system and through the mass media” [8, P. 74]; “The rules of pronunciation, grammatical and other linguistic means, the rules of word use adopted in the social and speech practice of educated people” [9, P. 163]; “The conditioned socio-historical result of speech activity, fixing traditional system implementations or creating new linguistic facts in the context of their connection both with the potentialities of the language system, on the one hand, and with realized patterns, on the other” [10, P. 9]; “The choice of one of the functional variants of the language sign historically accepted in this language collective” [11, P. 22].

2. Functionally marked vocabulary – clericalism [12, P. 36],

3. “Norm plus terminology” [13, P. 34].

### **Conclusion**

Taking into account the nature, diversity, variability of commercial communication, we can conclude that the vast majority of commercial texts will refer to multi component, complex texts, including several equal components. Moreover, each of the components can have its own structure, its own design features, language tools and designs.

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*Egamnazarova Durдона Shuhratillaevna,  
Scientific researcher, Andijan State University  
Faculty of Foreign Languages  
E-mail: durdona-e@mail.ru*

## WORD ORDER AND THE COMMUNICATIVE STRUCTURE OF THE SENTENCE IN UZBEK

**Abstract.** The present paper is concerned with the the communicative structure of the sentence in Uzbek and the importance of word order in it. A certain sentence can be used with different informative shades and carry out different communicative functions, depending on the purpose of the speaker/author, and in Uzbek, it is mainly carried out through word order. As word order is relatively free in Uzbek, it is considered to be a dominant factor in the information structure of the sentence. The main characteristics of word order variations are highlighted through examples from literature.

**Keywords:** the communicative structure, the actual division of the sentence, word order, topic, focus, theme, rheme, communicative centre, inversion.

The order of words in a sentence refers to the arrangement of the syntactic units in the sentence [1, 5–6]. Therefore, words in any language are arranged a particular syntactic sequence in the sentence. The order of words is reflected simultaneously on two levels of sentence structure – syntactic structure and the communicative structure. However, the role of the word order in these two levels is not the same – the syntactic function depends on the communicative function [3, 12].

In modern linguistics, there is a significant deviation from the tendency of syntactic study of this phenomenon – the approach is not only syntactic, but also communicative-semantic and stylistic.

M. Tukhsanov approaches to the issue on the basis of the theory put forward by K. G. Krushelnitskaya, arguing that the structural-syntactic and communicative-syntactic division of the sentence is a factor that determines their interconnectedness, the form and meaning of the thought expressed [8, 76].

Hence, the syntactic structure of the sentence stems from the communicative purpose of the speaker. Therefore, it is not accidental that the word order, especially in the Turkic languages, is considered to

be the dominant factor in the actual division of the sentence.

Word order may have different functions. According to O. B. Sirotonina there are three different functions of the word order: [5, 16].

1. Grammatical function, which serves to express certain syntactic relationships, that is, the relation of the subject with the predicate and the other parts;

2. Stylistic function. The use of word order here aims at giving a certain stylistic and expressive shade to a sentence;

3. Communicative function is often understood as the role of word order in the actual division of the sentence P. Adamets highlights the functions of the word order in the following framework [1, 5]:

1. In the syntactic structure;
2. In the actual division of the sentence;
3. In emotional and expressive shade of the sentence;
4. Within the stylistic framework.

Many linguists have similar views mentioned above on the function of the word order [6], however, due to the specific language structure and features, these functions may be involved in different



plans, that is, the word order can simultaneously perform several of the above functions, but one of these functions certainly plays a dominant role. From the foregoing, one can conclude that as the word order is free in the Uzbek language, its communicative function is predominant in almost all contexts, that is, it identifies the communicative centre in the content of the message, but also performs a stylistic task, such as expressive shade.

As the Uzbek language belongs to the group of agglutinative languages, the peculiarity of the word order in the sentence is that the predicate, the logical and grammatical centre of the message, comes at the end of the sentence. All the other parts fill in the “blank spaces” of the predicate and come in a specific cases related to it. [9,9] In particular, in the right order, the subject is at the beginning of the sentence, the parts subordinating the predicate – object and adverbial modifier are unstable in a sentence, they substitute their position in different variants during the communicative-syntactic division [8, 76].

It is worth noting that even though the word order in the grammatical level is free, it cannot be said in terms of the communicative level – the communicative center of any sentence is preceded by the predicate and becomes relevant with intonation. Let's see how the word order defines the communicative centre of the sentence in Uzbek by the following examples: *Anvar buvisini ko`rgani kasalxonaga bordi* (It was to the hospital that Anvar went to see his grandmother) – communicative centre here is the adverbial modifier of place

*Anvar kasalxonaga buvisini ko`rgani bordi* (It was to see his grandmother that Anvar went to the hospital) – communicative centre here is the adverbial modifier of purpose

*Buvisini ko`rgani kasalxonaga Anvar bordi* (It was Anvar who went to the hospital to see the grandmother) – communicative centre here is the grammatical subject of the sentence

As can be seen, free word order in Uzbek, unlike in English, enables the sentence to be used for

different communicative purposes without marked grammatical changes. Hence, the syntactic structure of the sentence in most cases obeys the requirements of communicative structure, that is, the main factor that changes the word order is the communicative purpose of the speaker. Therefore, the study of the actual division of the sentence in Uzbek serves as a solid basis for a communicative approach to the issues of word order in the language [4, 106].

The logically correct structure of a literary language that is stylistically neutral in Uzbek requires the point of the sentence (topic) known to the listener or reader to be at the beginning of a sentence. The rheme (focus) that gives the information new to the listener / reader comes at the end of the sentence, after the theme/topic. The violation of this rule results in the change in the logical consistency, or the formation of a sentence with expressive- emotional colour [4, 106].

Hence, in the communicative-syntactic level in the Uzbek language, word order units are denoted by the parts of the sentence. In neutral sentences in the Uzbek language, there are various structural and communicative forms of the word order, depending on which part of the sentence is actual (according to the position of the predicate):

In simple unextended sentences, the syntactic form combines with the communicative structure, that is, the subject coincides with the theme, the predicate – with the rheme, but in such sentences the function of the word order decreases and the communicative center is defined according to the intonation:

*Abdulla kuldi* (Abdulla laughed)

*You mother has come* (Onang keldi)

In simple extended sentences, the communicative-stylistic function of the word order becomes dominant, and the actual part is often placed before the predicate, and so is the subject: *To`yga nuqul soldatlar, ofitserlar kelganmish* (Only soldiers and officers came to the wedding) [11, 94]

*Endi bitmagan yana bitta ishimiz qoldi* (We have one more thing to do) [12, 42]

*Sirdaryoning beldan yo`g`on laqqa balig`i cho`zilib yotibdi.* (There is a very thick catfish of Syrdarya lying) [10, 274]

It is worth noting that the presence of certain adverbs of degree, quantity and manner in the sentence restricts the possibility of actualizing the subject through the word order, that is, it is impossible to “push” the subject to the position before the predicate, otherwise the syntactic-semantic relationship of the sentence may be violated, thus, the meaning may change or become illogical. For example:

*Chempion tez yugurdi* (Champion ran fast)t – *Tez champion yugurdi* (Fast champion ran);

The actualization of the object also occurs in the position before the predicate:

*Men nima deb maslahat berishni bilmas edim, shuning uchun yelkamni qisib qo`ya qoldim* (I didn't know what to advise, so I shrugged my shoulders) [12, 73].

Moreover, the object in the active voice can be the communicative centre as the subject in the passive voice. In this case, the object becomes more important from communicative point of view than the performer of the action; although the subject is actualized, the speaker / author's purpose is to draw the listener / reader's attention to the object of the sentence:

*U kitob o`qidi* (He read a book) – *Kitob o`qildi* (A book was read) Among the parts of the sentence, the adverbial modifier is distinguished by its fixed or free order. The adverbial modifiers of fixed order get into a close semantic-grammatical relationship with the predicate and do not change their position. The adverbial modifier of free order may come in various positions in a sentence [4, 74].

*Abstutay o`choq boshiga pildirab ketdi* (Abstutay briskly walked to the hearth – adverbial modifier of free order) [13, 278].

*Men gap nimadalgini bilganidan ataylab indamadim* (I specially didn't say anything as I knew what had happened – adverbial modifier of fixed order) [12, 229].

It is important to note that as the intonation is the main means of the actual division of the sentence,

depending on what part the logical or emphatic stress falls on, it causes the adverbial modifier before the predicate to leave the rheme group. In this case, the speaker tries to convey the communication center only through prosodic means, without changing the order of words: *Farzandining muomalasidan xafa bo`ldi* (He was offended by how his child treated him (the focus here – the predicate, i.e. the fact that he was offended is emphasized); *Farzandining muomalasidan xafa bo`ldi* (What offended him was how his child treated him (how his child treated him is the focus, but not anything else).

In reverse order of the words, the rheme usually moves to the position before the theme. In this type of discourse, extra emotional and expressive shade is added to the message, which is typical for poetry and verbal communication. In this case, the syntactic structure of the sentence changes depending on the speaker's emotional state and communicative purpose:

*Qulog`ini kesib olaman uning!* (I'll teach him a lesson! – fronting of the object) [12, 90]. As the above examples show, inversion is an effective means of achieving the speaker's communicative purpose.

When the speaker wants to emphasize a certain part of the sentence in the course of the speech, to draw the listener's attention to it, to remind them of the importance of the action performed by the subject, the subject and predicate inversion is used. In this case, the subject of the sentence moves to the position after the predicate. This can also change the grammatical nature of the sentence: a declarative sentence may become an exclamatory one, albeit both declarative and exclamatory shades are retained.

The inversion of the secondary parts also has the above-mentioned characteristics. The subject and predicative inversion occurs more frequently in interrogative, imperative and exclamatory sentences, while the inversion of the secondary parts does not change the grammatical nature of the sentence. In this case, the highlighted part will only be moved to the position next to the predicate.

The inversion is a very active and effective tool, especially in imperative sentences. The predicate, which is the central part of the imperative sentences, moves to the beginning of the sentence: *Olib ket meniyam. Va`da beraman! Boshqa qilmayman! Odam bo`laman!* (Take me with you too! I promise! I won't do it anymore. I'll be a good person!) [11, 65] / *Ur, nomard qo`shmachini!* (Hit the mean souteneur!) [10, 258].

Also, the omission of the predicate (ellipsis) is a characteristic feature of imperative sentences. Ellipsis is a common tool in Uzbek not only for language economy but also for actualizing a particular part, and the effective use of ellipsis in the imperative mood is particularly sensitive to the emotional and expressive form of spoken language.

In this situation, imperative sentences imply the meaning of invitation, involvement, compelling and the communicative center of the sentence often corresponds to the adverbial modifier of manner or place: *Qisqaroq!* (Shorter! (which means "make it shorter")) [11, 56]; *Vatan uchun jangga!* (To the battlefield for the Motherland!, which means "Let`s go to the battlefield and fight for the Motherland") [12, 80].

Thus, inversion is a pure speech phenomenon, and its use in written discourse is the result of attempt to express the opinion in the most appropriate way [2, 100].

In interrogative sentences, the communicative center is defined according to their form and content structure. In particular, in special questions, the communicative structure is remapped as the focus precedes the topic:

*Nega kech qolding?* (Why are you late?); / *Kim keldi?* (Who has come?);

In neutral interrogative sentences which are free from expressiveness the actual division is in the topic-focus (or theme-rheme) sequence as in declarative sentences, and the part where the particle is usually the communicative center:

*O`zimizning sigir-chi?* (What about our own cow?; Here, the particle is the suffix *-chi*, which changes a declarative sentence into a question).

In Uzbek, as in many languages too, a declarative sentence may gain an interrogative meaning through the intonation of interrogation. This phenomenon is mainly characteristic of oral discourse, and here the theme precedes the rheme: *Tanimayman, degin?* (So you don`t know him?/) [10, 241]; *Taroziga qo`y, bolam,-dedi chol ruschani chaynab gapirib.* – *Kilosi yetmish tiyin;* – **Yetmish tiyin?** – *Lyova ajablandi* (Put it onto the scale, son,-said the old man murmuring in Russian. – Seventy tiyinsa a kilo; – **Seventy tiyins?** – Lyova was surprised) [11, 40].

The communicative centre of such sentences is the part where the emphatic or logical stress falls on.

According to the abovesaid, it can be stated that inversion is an effective means of enhancing the content of the message and moving it from neutral to expressive emotional position.

In sum, the communicative aspect of any sentence, that is the actual division, is a method chosen by the speaker to convey a message that is relevant, and it is characterized by the actualization of certain parts of the sentence. Word order variations in Uzbek, are used to convey the communicative purpose in discourse, which is associated with specific pragmatic functions [7, 150]. In non-emphatic declarative sentences the initial position tends to be the topic, pre-verbal position is the communicative centre, that is the focus, whereas interrogative sentences and orders have the focus in the front position. As can be seen, the communicative structure of the sentence is quite different from the syntactic composition, as the former is related to the communicative content of the text, and the latter is of grammatical importance. Both of them, however, play an important role in the semantics of the sentence and are inextricably linked to each other.

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## Section 10. Philosophy

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*Norboev Tura,  
Candidate of philosophical sciences, docent  
Department of social science, Tashkent Institute of Finance  
E-mail: lider8304@list.ru*

### THE FIGHT AGAINST CORRUPTION AS A PRIORITE CONDITION FOR THE DEVELOPMENT OF CIVIL SOCIETY

**Abstract.** The article analyzes the problem of corruption and its manifestation as a global problem. And the article shows the ways of protecting society from corruption.

**Keywords:** Society, democracy, civil society, globalization, corruption, anti-corruption actions, rule of law state, problem.

As a social phenomenon, corruption has existed since ancient times and, like a virus, has spread to all of humanity, poisoning the consciousness of people.

And of course, corruption is becoming a national problem. Even Abraham Lincoln said: “The first of civil rights is freedom from fear.” Do not be afraid of corruption, it must be defeated. In addition, Karl Marx’s statement can describe the essence of corruption: “There must be something rotten in the very core of a social system in which crime grows even faster than the population.” Corruption is not just ordinary theft, cheating and fraud, it is a crime that leads the country into complete decline. With certain differences in views on the very concept of corruption expressed by a number of researchers, most authors correlate with corruption abuse of state power, use of official position in selfish, other personal or group purposes [2].

The problem of the difficulty in eradicating is described by the great utterances of Leo Tolstoy, who accurately noted: “One of the usual temptations leading to the greatest misfortunes is the temptation

of the words “everyone does it”. The manifestation of corruption can be seen already from an early age, starting from kindergartens and clearly manifesting itself in the system of higher educational institutions.

Corruption is a long-standing disease, therefore it constantly changes its images and manifestations and, together with social, social, economic relations, also evolves, mimics. In this regard, to combat it, it requires not only anti-corruption legislation, but also a study of the causes and conditions that give rise to it, the formation of a social environment for the rejection of corruption in all its manifestations [3].

According to statistics, 70% of the country’s population are afraid of those who should protect them – law enforcement officials. It is not necessary to show weak character in the fight against corruption. We need tough, punitive measures, repressive measures against those who abuse their official position, use the benefits illegally. After all, we want to live in a country free from lawlessness, the arbitrariness of officials, and the criminal irresponsibility of the authorities.

Uzbekistan is constantly taking measures to limit corruption, organizing special events and introducing laws and regulations to combat corruption. A vivid example of the manifestation of a serious attitude in the fight against corruption in the country is the adopted reforms. One of these was the reform that was implemented in the framework of the event, organized with the cooperation of the General Prosecutor's Office of the Republic of Uzbekistan, the Republican Interdepartmental Commission for Combating Corruption, the OSCE Office in Uzbekistan and other partner organizations, an international conference on the topic "Anti-corruption reforms of the Republic of Uzbekistan: achievements and priority tasks." At the opening of the conference, the Deputy Prosecutor General of the Republic of Uzbekistan E. Yuldashev emphasized that the fight against corruption in our country has been raised to the level of state policy. Anti-corruption in the field of public service is one of the most important areas in politics, and also acts as the basis for an anti-corruption mechanism that implements the principles of openness and publicity in the functioning of state bodies. Practice shows that public servants are most corrupt. Due to the violation of the law by officials, the quality of state administration of the country decreases, the process of progress of the anti-corruption policy is hindered and the entire state apparatus is compromised. As noted in the report of the President of the Republic of Uzbekistan Shavkat Mirziyoyev at the solemn meeting dedicated to the 25<sup>th</sup> anniversary of the adoption of the Constitution of the Republic of Uzbekistan, we are mobilizing all the forces and opportunities for the widespread introduction in society of the principle "Our priority is law and justice, punishment for crime is inevitable". Along with significant work in this direction, the creation of an integrated anti-corruption system should be noted.

Indeed, in our society, strict measures are envisaged to stop corruption, the commission of various crimes and other cases of offenses, their prevention,

ensuring in practice the requirements of the law that punishment for a crime is inevitable. The Law of the Republic of Uzbekistan "On Combating Corruption", which entered into force on January 4, 2017, served as an important legal basis in this direction.

The Republic of Uzbekistan in 2008 ratified the United Nations Convention against Corruption. In 2010, the Organization for Economic Cooperation and Development joined the Istanbul Anti-Corruption Action Plan:

- "No state in the world can consider itself immune from corruption. Therefore, the fight against this phenomenon should be ongoing," says Ashita Mittal, the regional representative of the UN Office on Drugs and Crime;

- The UN Convention against Corruption is important in this area. It is noteworthy that by joining this convention, Uzbekistan is increasing attention to ensuring the priority of the law, strengthening the judiciary and the rule of law, and most importantly, the prevention of offenses and crimes.

In his report to the 72<sup>nd</sup> session of the UN General Assembly, the President of Uzbekistan Shavkat Mirziyoyev acquainted the whole world with the ongoing reforms. It is noteworthy that the report emphasizes that it is not the people that serve the government, but the government that should serve the people. Considerable work is being done to put this principle into practice.

On February 2, 2017, a resolution of the President of our country "On measures to implement the provisions of the Law of the Republic of Uzbekistan "On Combating Corruption" was adopted, in accordance with which the State Program on Combating Corruption for 2017–2018 was approved. Under the leadership of the Prosecutor General, the Republican Interdepartmental Commission on Combating Corruption was formed, its position was approved.

The General Prosecutor General's Office has been identified as the working body of the Republican Interdepartmental Commission for Combating Corruption. The commission included senior officials

of ministries and departments, non-governmental non-profit organizations, scientific institutions – a total of 43 people.

“Over the past period, the interdepartmental commission carried out systematic legal work and practical measures to combat corruption,” said Bahrom Kobilov, deputy head of the Office for Combating Organized Crime and Corruption of the General Prosecutor’s Office of the Republic of Uzbekistan.

Draft laws have been developed that include anti-corruption provisions. A number of departmental legal documents have been adopted. The expected results are achieved by the establishment of cooperation between state bodies, non-governmental non-profit organizations and civil society institutions in the fight against corruption, ensuring the implementation of legislative documents related to the field.

Another example, which confirms that the fight against corruption is conducted at the state level, is the speech of President Shavkat Mirziyoyev at the solemn meeting dedicated to the 26<sup>th</sup> anniversary of the adoption of the Constitution of Uzbekistan. In his speech, the Head of state proposed to form anti-corruption committees in the chambers of the Oliy Majlis. As representative authorities, they should contribute to strengthening the fight against corruption in public institutions at all levels.

In the parliaments of many countries, including the United States, Russia, Great Britain, Bulgaria, Greece, Latvia, Estonia, there are commissions and committees to combat corruption. Now a similar structure is formed in the Legislative chamber of the Oliy Majlis. The Committee on combating corruption and judicial and legal Affairs will exercise parliamentary control over the implementation of internal anti-corruption programs in state bodies, analyze the current legislation to identify the norms that create conditions for corruption, prepare proposals for its improvement.

In our country, especially important are the laws adopted by the Oliy Majlis, which should not contribute to the emergence of corruption. Among the

main tasks, as the Chairman of the Committee on combating corruption and judicial and legal Affairs of the legislative chamber of the Oliy Majlis Tulkun Abdusattarov says, are monitoring the implementation of legislative acts in the spheres of state and public construction, combating corruption and judicial and legal issues. In the fight against corruption, a special role belongs to civil society institutions in the systematic study of the identification and disclosure of corrupt authorities, therefore, on the initiative of President Shavkat Mirziyoyev, the organization of parliamentary hearings on the activities of state officials is envisaged. Appeals of individuals and legal entities with the availability of materials on corruption will also be considered. It is believed that in order to combat corruption, it is necessary to develop comprehensive measures with the participation of civil society institutions, especially non-governmental non-profit organizations at the level of districts, regions and republics.

A weak civil society cannot keep the state apparatus under its control, which ultimately leads to the separation of managers from it and their “privatization” of their posts, due to the lack of staff rotation in the state apparatus. Because of this, the real threat of corruption of democratic institutions is real, which is a political consequence of corruption. As a rule, this entails the expansion of the shadow economy sector. Consequently, the competitive mechanism of the market is violated, since it is not the one who is competitive who wins, but the one who can get advantages for bribes. As a result, the effectiveness of market relations decreases, which discredits the idea of market competition. In addition, corruption in government and officials acts as an obstacle to the development of public administration [5].

At the event, it was stressed that corruption is a great threat to the socio-economic development of the country and destroys the spiritual and moral foundations of society, the idea of reform, negatively affects the participation of citizens in the management of state and society. The purpose of the organi-

zation and holding of this event was not propaganda of the party or another entertaining meeting, but the intention to explain to society, especially to young people, that corruption not only causes damage to daily public relations, but also leads to the internal destruction of entire States. The fight against it will be effective if the majority begins to understand that corruption is a Vice that destroys the constitutional foundations of the state and the spiritual and moral foundations of society.

The analytical material of sociological studies on the problem of corruption shows that the widespread abuse of officials dissuaded people from the possibility of bringing high-ranking criminals to justice. According to the data received, only 10.3% of respondents complained about officials infringing on their legal rights. To the question “Why did not complain?” answered that consider the complaint against the official hopeless. They are convinced that abuse of officials has become the rule, and that higher agencies have no interest in a fair trial. Of all the officials

who complained of abuse, only 2.3% remained fully satisfied with the proceedings, partially-3.3%. Thus, the conceptual idea of the fight against corruption is that it should be fought primarily by the forces of civil society, using such mechanisms as the creation of independent non-governmental public associations, independent media, strengthening the independence of the judiciary, the wide dissemination of local self-government. It is important to emphasize that success in the fight against corruption depends primarily on the active participation of the population in this process. To change the situation, people must realize their legitimate right to control officials, demand from them a report on the expenditure of public funds, check their professionalism and moral qualities, get rid of negligent and dishonest bureaucrats.

Thus, it is necessary to remember that at the present stage of the fight against corruption and the construction of civil society, one of the main conditions is the revival and restoration of justice in the state, as well as the protection of human rights and freedoms.

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*Hidirov Mustafo Toyirkulovich,  
researcher, The faculty of social sciences  
National University of Uzbekistan  
E-mail: lider8304@list.ru*

## EVOLUTION OF PHILOSOPHICAL THOUGHTS RELATED TO THE ESOTERIC VIEW OF THE WORLD

**Abstract.** The article analyzes the evolution of philosophical teachings on the esoteric view of the world and their key development factors. Esoteric knowledge also emphasizes the role and place of time and space in the esoteric view of the world.

**Keywords:** philosophy, hermeticism, esoteric knowledge, myth, spiritual existence, society, theory and practice.

In recent years, there has been a growing interest in the study and interest of view in the field of philosophy. In the context of rationalism and irrationalism, esoteric views of the world and plots, symbols and ideas associated with various aspects of the scientific view of the world play an important role among different sectors of society. Esoteric essence is directly embedded in the scientific, philosophical, religious and mythological paradigms. In particular, from the 60s of the XX century, departments and research societies were created to study esotericism in the United States and in some European countries (France, Germany, Great Britain, and the Netherlands). Since the 1990s, this problem has been the focus of attention of Russian scientists. As a result, several funds served to study the esoteric landscape of the world.

Firstly, a deep philosophical study of the essence of esoteric teachings; Secondly, to identify the negative and positive features of esoteric teachings that manifest themselves in social processes;

Thirdly, to determine the relevance of these ideas to scientific realities by determining the status of such doctrines on the world stage;

Fourthly, on this basis, the need will be studied for the development of textbooks of a theoretical and methodological nature and recommendations in the work of spiritual and ideological education. This, in

turn, expresses the importance of the natural study of esoteric culture, the study of esotericism, as well as the role and role of the human factor in the esoteric space. At the same time, the importance, role and role of esoteric doctrines in the consciousness and experience of social life in modern society.

The study of the esoteric nature of the world is a product of a great period, from antiquity to the present day. In particular, it can be argued that the foundations of Indian philosophy used early esoteric knowledge in India. Because in Hinduism and Jainism there are rituals associated with esotericism [1, 131–137]. But Indian mythology, on the one hand, connects the concept of supernatural manufacture, and on the other, an extraordinary event, which is a figurative lesson. That is why Indian esoteric teachings have a special place.

Mystics also have different ways and means to understand the hidden nature of the world. In particular, Muhammad Ghazali is an exercise and effort to achieve his final inner ideology, and it refers to moral purification and human perfection [2, 144].

To date, a number of approaches to the esoteric phenomenon of the world have been developed, of which the most popular are A. Faivre, Hanegraaf, Stukrad, V.M. Rosen and S.V. These are the approaches developed by Pakhomov: to interpret

the esoteric landscape of the world as an integrated system, you must first understand its essence. The esoteric picture of the world and its evolution is connected with modern postclassical science. In particular, the fact that during the sociocultural crisis the structure of values in a number of areas underwent natural changes, the sociocultural character of the cultural system is manifested in esoteric views. The principle of maintaining my esoteric view of the world and hidden knowledge about a person from people who do not know about him, but share them with educated students.

Esoteric researchers note that in critical times in society, escalation of esoteric, mystical, eschatological moods occurred in dramatic times [3; 6].

Therefore, it is based on the principle of unity and progress as a system of knowledge representing the world through the esoteric view of the world. The principle of uniqueness is, first of all, the theoretical level of awareness of the integrity of the esoteric landscape of the world and nature in which it combines. Secondly, it is the experience of human theoretical knowledge of the integrity of the esoteric view of the world and the objective unity of the universe. The whole model of man's creation of an objective universe is reflected in the nature of his mental activity and his psychology.

Esotericism of Faivre is a "form of thinking", which differs from other forms of thinking by the following criteria: 1) reasoning in harmony, proportion; 2) the idea of living nature; 3) imagination and mediation; 4) transmutation skills; 5) the fundamental coincidence of several or all spiritual traditions; 6) The idea of a mysterious passage of spiritual knowledge, that is, a radiant esoteric, selective mentor [5; 12]. For reflections of the universe, we can see the specific stages of the living image of the world, an analysis of the esoteric view of the world.

"We note that the problem of determining the parameters and grounds for highlighting the esoteric discourse as a separate, independent type of discourse is currently debatable. The definitions of

this discourse that appear in studies can be called "experimental"- claims Pokrovskaya O. S. [6, 77–84].

In esotericism, the concepts of space are associated with a sacred concept, the study of which is R. Genon. Later this question was addressed to M. Eliade A. G. Dunes were taken into account. According to the followers of esoteric teachings, space is not only physical, but also physical. It includes all esoteric teachings on the existence of a plan of existence that can be captured in one or another of these sacred places. Sacred spaces are vibrant, moving, vibrating and evolving in accordance with their own laws. It is filled with all kinds of mental influences and is open in all directions – deep, wide, up and down. Each element in the sacred environment is reborn.

All points and objects in the sacred environment are connected by a complex chain of relationships. Each of these points indicates that the adherent is moving to another similar point and the reality behind this point. Thus, the entire space is absorbed by images. These images may appear in a special place or where they have never been. The esoteric landscape of the world served as the basis for the emergence of various esoteric views as a spiritual part of human existence and a distinctive part of culture. The time category requires a direct definition of time. A similar picture of time is found in esotericism. For esoteric time, time has a cyclic structure. But in many esoteric doctrines, with the exception of archaic and primitive societies, there is no idea that participation in the rituals associated with the cycle actually provides space for renewal and its existence. In esotericism, the emphasis shifts from objective history to subjective history. During Great Practice, an adherent separates his personal history of eternity from his archetypal history.

Schekhlova L. V. and Borisova Yu.V say: "Esoterics and science operate in modern culture with the same, mostly natural, scientific concepts ("substance", "energy", "information", "quantum reality")" [7, 22–27].

From the earliest times, esotericism was seen as a mysterious, special form of knowledge that combines

with types of scientific, everyday, and religious knowledge. The division of esotericism into a specific field of knowledge allows us to study it from the point of view of the phenomenological features of philosophy, which is an important component of phenomenological science. This is because knowledge is the main object of philosophy, in particular epistemology, and knowledge arises in society. The main attention is paid to the function and distribution of knowledge, the social definitions of knowledge, their transfer and preservation, as well as the social status of various types of thinking at different times. However, the study of esoterics as a sociocultural phenomenon is an important factor in choosing this methodology. We also see an interdisciplinary integration of approaches to the esoteric view

of the world. At the same time, esoteric studies were carried out without any doubt, both in the natural direction and through emerging psychology.

Summing up all of the above, we can conclude that the esoteric view of the world retains a special kind of knowledge that has an irrational source. The basis of this knowledge lies in the construction of a figurative world that allows the formation of mystical or occult skills. This is the theoretical foundation upon which both mystical and occult practices are built. Modern science, in turn, combines the esoteric landscape of the world and the similarities of ancient hermetic knowledge, as well as the most important hypotheses about the enrichment of science at the end of the second millennium.

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## Section 11. Chemistry

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*Sidikova Xulkar Gulomovna,  
applicant of the Jizzakh State  
pedagogical Institute of Jizzakh city, Uzbekistan*

*Eshkobilova Mavjuda Ergashboyevna,  
Doctor of Philosophy Chemistry (PhD),  
teacher of Samarkand Construction  
Institute of Samarkand city, Uzbekistan*

*Abdurakhmanov Ergashboy,  
Doctor of Chemical Sciences,  
Professor, Head of the Department of  
Analytical Chemistry Samarkand State  
University of Samarkand city, Uzbekistan  
E-mail: ergash50@yandex.ru*

### RANGE OF MEASURING OF BASE ERROR OF SELECTIVE THERMOCATALYTICAL SENSOR ON METHANE

**Abstract.** In wide interval influence of voltage on the analytical signal of thermocatalytic sensor on methane has been investigated. Additional error of thermocatalytic sensor in the process of determination of methane caused by changing temperature in interval from  $-10$  to  $+40^{\circ}\text{C}$ , pressure in intervals from 600 to 800 mm Hr. and humidity of the gas mixture up 95% has been determined.

**Keywords:** Sensor, methane, thermocatalytic method, catalyst, measurement range, determination error.

**Introduction.** The most widely used in the elaboration of analyzator of  $\text{CH}_4$  is the thermocatalytic method. The principle of operation of this control method is consisted in flameless burning of  $\text{CH}_4$  on the surface of catalyst and measuring the amount of released heat [1]. Thermocatalytic methane sensor consists of two sensible elements, which, depending on the purpose are divided at measuring (or working) and compensating (or comparative). Both sensible elements are in the reaction chamber. Comparative ( $R_1$ ) and measuring ( $R_2$ ) elements are

included, as a rule, in one of the arms of the bridge measuring scheme [2, 3]. Auxiliary resistors ( $R_3$  and  $R_4$ ) are included in the other arm of the bridge. At heat extraction changing of the resistance ( $R$ ) of the spiral on the value  $\Delta R$  was carried out which was determined by the formula:

$$\Delta R = R_0(1 + \alpha \Delta T) \quad (1)$$

where:  $R_0$  is the resistance of the spiral at  $T = 25^{\circ}\text{C}$ ;  $\alpha$  is the temperature coefficient of resistance of the platinum wire,  $\Delta T$  is the change of temperature of the spiral. The reaction rate of methane oxidation in

the kinetic region is usually represented as a function of volume-molar concentrations of methane and oxygen:

$$W = kF_e f(C_{CH_4} C_{O_2}) \quad (2).$$

where:  $W$  is the reaction rate, mol / s;  $k$  is the reaction rate constant, s<sup>-1</sup>;  $F_e$  – active surface of the catalyst, m<sup>2</sup>. The value  $k$  does not depend on the concentration of methane in the air and has increased with increasing of temperature.

The low concentration limit of explosive methane (LEL) is usually 5%, and the upper explosive limit (ERW) is 16% [4]. An explosion of maximum strength corresponds to stoichiometric methane concentration 9.5%. Therefore, the main range of application of this method is monitoring before explosive concentrations of methane as a rule in the range of 0–5% vol. All this has provided the actuality of investigation aimed on improving of control of fire and explosion hazard of gas mixtures by elaboration of selective sensors of combustible components of a gas mixtures.

**The experimental procedure and the obtained results.** For analytical devices, as a rule, the interval

characteristic of error has been standardized as limit of the main absolute ( $\Delta_i$ ), relative ( $\delta_i$ ) or reduced ( $\gamma_i$ ) errors.

Control of the measurement range and the main error was carried out by supplying on input of GS sensor of gas mixtures (GM) in the following sequence No. 1-3-5-5-1-5, where number of GM corresponds to content of measured component (%): No. 1 = 10 ± 5; No. 2 = 50 ± 5; No. 3 = 95 ± 5. All calculations were carried out in accordance with GOST 13320-81. The main absolute ( $\Delta_i$ ) and reduced ( $\gamma_i$ ) errors of sensor were determined by formulas (3) and (4):

$$\Delta_i = C_n - C_m \quad (3)$$

$$\gamma_i = (C_n - C_m) / (C_k - C_p) \quad (4),$$

where:  $C_n$  – is the readings of the device, %;  $S$  is the volume fraction of methane in the standard mixture, %,  $C_k - C_p$  are the initial and final limits of measuring of concentrations of the determined component of the gaseous mixtures, %. The results of checking the measurement range and the basic error of the gas-analyzator with measurement limits of 0–5.0% vol. are presented in table.

Table 1. – The results of error determination of the thermocatalytic sensor on methane

Contents methane in a mixture, % vol.	TKC-CH <sub>4</sub> 0–5.0 % o6.		
	Found CH <sub>4</sub> % vol	Basic Abs. error.(D)	Basic. pref. error.(g)
0.51	0.52	0.01	0.2
2.55	2.51	0.04	0.8
4.74	4.81	0.07	1.4

As followed from the presented data in the investigation interval the main reduced error of the sensor with range of 0–5.0% vol. was equaled 0.2–1.4%. Control of the additional error of TKS-CH<sub>4</sub> caused by changing of temperature of environment was carried out in the temperature range –10 ± 50 °C. The influence of the parameters of the gaseous mixture on the additional error of the sensor (%) for each point was determined by the formula:

$$g_{\text{don}} = g_t + g_{\text{nop}}, \quad (5)$$

where:  $g_t$  – is the error obtained at  $i$ - value of temperature;  $g_{\text{nop}}$  is the error of the gas-analyzator at usual temperature (20 ± 2 °C). The results of

determination of the additional error of the gas-analyzator due by changing of temperature of environment (0 – 50 °C) are presented in table 2, from which it followed that it doesn't exceed 3% in range –10 ± 50 °C and less than the main error of the device by GOST 13320-81.

As follows from the presented data, the output signal of sensor has remained stable and has allowed continuously control of the methane content even in the region of low temperatures.

In the results of experiments was found that in the range of pressure from 600 to 800 mm rt. the sensor signal has maintained stable.

Table 2. – The results of determination of additional error of sensor in the temperature range – 10 to + 40 °C (n = 5, P = 0.95)

The temperature of the gas mixture, °C	Finding value of additional error			Additional error by GOST
	C <sub>CH<sub>4</sub></sub> =0.5%	C <sub>CH<sub>4</sub></sub> =2.5%	C <sub>CH<sub>4</sub></sub> =5.0%	
-10	0.4	3.0	2.0	5.0
0	0.2	2.0	2.0	5.0
+10	0.7	1.0	0.7	5.0
+20	0.6	0.3	2.0	5.0
+30	0.5	0.3	0.4	5.0
+40	0.2	0.3	0.7	5.0

The analyzer error due by change of moisture content in the analyzed gas mixture was determined as difference between signals of the humidified and didn't-moistened mixtures of the analyzed gas at usual conditions. Some of the obtained results are presented in (table 3), from which it can be seen that the average value of the changing of output signal doesn't exceed 2.3 mV. Control of sensor stability to

concentration overloads was carried out at the methane content in the mixture 7.50% vol. As a control mixture a gas mixture was used where the methane content was equal to 4.85% vol. At this concentration the output signals of TCS-CH<sub>4</sub> before and after exposure to an concentrations overload were compared. The time of influence of the transshipment mixture was 20 min.

Table 3. – The results of determination of the dependence on TCS-CH<sub>4</sub> signal on the changing of moisture content in the gas mixture (CH<sub>4</sub> content in the mixture 2.0%; n = 5, P = 0.95)

Sensor signal ( $x \pm \Delta x$ ), mV		Changing of output signal ( $\Delta$ )
Dry gas mixture	Humidified gas mixture	
126.4	123.8	2.6
127.7	124.8	3.1
126.3	124.9	1.4
Средн. 126.8	Средн. 124.5	Средн. 2.3

The recovery time of the usual work of the sensor was determined by its output signal in zone of the main error. The experiments have shown that

elaborated sensor by CH<sub>4</sub> in the investigated range of concentrations was stable to concentration overloads (table 4).

Table 4. – The results of checking the signal resistance to concentration verloads (measurement range of CH<sub>4</sub> 0-5.0%; vol. CH<sub>4</sub> = 4.85% vol., N = 5, P = 0.95)

TCS signal, mV		The main absolute error ( $\Delta$ ), mB	The main given error ( $\gamma$ ), %
Before exposure to overload	After exposure to overload		
312	305	7	2.24
310	307	3	0.97
311	308	3	0.96
312	306	6	1.92
314	308	6	1.91

The value of the main reduced error of TKS-CH<sub>4</sub> at influence of overload concentration didn't exceed 2.24%. The total additional error characterizing the set of error values from the influence of various factors was determined by the formula:

$$\gamma_s = \sqrt{(\gamma_1^2 + \gamma_2^2 + \gamma_3^2 + \gamma_4^2 + \gamma_5^2 + \gamma_6^2 + \dots)}, \quad (6)$$

where:  $\gamma_s$  and ... are the values of the additional errors obtained at changing the influencing factors. According to GOST 13320-81, the maximum permissible value of the total additional error should not exceed of the twice value of the limit of the permissible main error.

The total additional error of the thermocatalytic sensor TCS-CH<sub>4</sub> was  $\pm 2.1\%$ . Carrying out investiga-

tions have shown that the thermocatalytic methane sensor TKS - CH<sub>4</sub> has corresponded to metrological and some other characteristics and fully requirements of GOST for this class of devices.

**Conclusion.** Using of the elaborated catalysts selective thermocatalytic sensor on natural gas was manufactured. The values of the main absolute, relative and reduced errors of selective sensor TKS-CH<sub>4</sub> have been determined. Additional error of the thermocatalytic sensor was established in the process of methane determining caused by temperature changing in the  $-10 +40$  °C, pressure in the range 600 – 800 mm Hg and humidity of gas mixture up to 95%. The signal stability to concentration overloads was determined.

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## Section 12. Science of law

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*Zulfuqorov Abduvahob Abdumalik son,  
The teacher of the department is the captain,  
Academy of the Ministry of Internal Affairs  
Forensic examination  
E-mail: lider8304@list.ru*

### **EXPLANATION AND CLASSIFICATION OF TRACES IN THE THEORY OF TRASOLOGICAL EXPERT**

**Abstract.** The article analyzes the the concept of traceological traces which allows the classification of traces. Criminological literature has not developed a broader definition of traces or materialistic traces in the criminal sense. This is because the concept and types of tracheological traces are also regarded as criminalistic traces.

**Keywords:** traceologica traces, sunken traces, static traces, globalization, dynamic traces, local traces, rule of law state, problem.

Defining the concept of traceological traces allows the classification of traces. In the forensic literature there is a great deal of commentary on the classification of traces. For example, scientists such as LK Litvinenko, LG Granowski, VYKoldin, MM Grrodzinsky, GM Minkovsky and AA Eysman have created a classification system in which the traces of mechanical effects are It is.

Any subject or any of its fields is its subject. It is important for the science of trasology to define a research framework that focuses on its tasks and methodology. Therefore, the definition of traceological traces is a prerequisite for studying trasology as an important area of forensic science. Criminological literature has not developed a broader definition of traces or materialistic traces in the criminal sense. This is because the concept and types of tracheological traces are also regarded as criminalistic traces.

For example, LK Litvinenko describes the concept of traces as follows: “traces are defined in a trasological way, that is, they reflect the appearance of one object in another, and as a result it is possible to identify the trace object.” It is the same author who has included traces of rupture and breakage in trasology. However, since these traces have not had any effect on their formation, it would be a mistake to include them in the trasology. Therefore, as the author knew of his mistake, he also explained the concept of traces produced by exposure. As a result of an object, one object interacts with another, and the effects of that object are reflected in the structure of one object. This notion of traces more fully explains the nature of trasological traces.

Another forensic scientist GL Granowski described the traces differently. In his view, it is the result of actions and actions related to the crime, as well as the material reflection of features and external



features of various objects. The other properties of the objects are not fully described in this description because they are the subject of research in trasology and are the external structure of traces reflected on the trace surfaces of objects.

Such descriptions have been described by many forensic scientists, but one of the last authors, BI Shehevchenko, has given a clear and complete description of the tracological traces. This definition can be regarded as a definitive definition of tracheological traces.

Trasological traces are defined as changes in the environment that result in the exterior of one object being reflected in another. Such traces are known as reflections of external structures.

Two important considerations should be made in the definition of tracheological traces.

The first side is that the traceological traces are the result of changes in the material environment and, therefore, have a common trait.

Second, and most importantly, these traces are traces in which the outer structures of an object only reflect their expression in the second.

From this definition it is possible to identify traces belonging to the trasology itself, that is, to remove traces that do not reflect on the trace sites and have no external structure. Such traces can be counted as whole or fragments, small objects (hair, matches of grains, etc.), biological and fluid (blood, saliva, etc.), unless their identification is done by trasological methods.

Thus, the traces are widely understood in terms of the various shapes and signs left behind. Any object leaves its reflection in the second.

The narrow trace marks are the traces left from objects, objects and objects directly related to the crime.

As mentioned earlier, the concept of footprints has not been developed for a long time. Some criminals interpreted the traces in the narrow sense, that is, only tracheological traces, while some authors interpreted the traces only in the broadest sense, ie in the meaning of forensic traces.

Science is a network of forensic science that develops the mechanism for the formation of traces, group and individual affiliation of trace objects, the methods and techniques used to detect, record and verify traces.

Each subject, thing or object has its own individual or distinctive features and symbols. There are no two objects, objects or objects that are similar in all their signs and features. Identities are identified based on these individual or individual characters and symptoms.

The mechanism for the formation of traces is unique, that is, unique. The characteristic of the traces is that they are identified only on the basis of their individuality or individuality, as well as their individual characteristics and characteristics. These particular signs and symptoms leave one object in the process of interacting with another object, resulting in traces.

Based on the definitions of the aforementioned tracheological traces, the following classification of the traces is

1. By origin: – sunken traces; – superficial or superficial traces.
2. The mechanism of formation: – static traces – dynamic traces.
3. By traces of traces from a third object:
  - local traces – Peripheral traces.

It should be noted that at least two objects must be involved in the formation of both tracological traces and broader, ie criminalistic traces. One of these two objects is called a trace object and the other is called a receiving object.

The concept of traces, from a trasological point of view, is based on independent material. The image of such an object on the surface of another similar object is considered to be a trace. Due to the fact that different trace data can be obtained from different trace parameters, there is still an unsolved question in the literature and practice that questions on non-identification tasks should be raised by forensic authorities. These are very different questions, such as the timing of the other traits, correlation data, and so on.

Definition of footprint. In criminalistics, the concept of traces has two main dimensions.

The first direction is to carry out scientific research and scientifically justify the concept of trace in its broadest sense.

The second direction is the scientific research to determine the nature and nature of tracological traces.

These two directions are interconnected, since the tracological traces form part of the forensic trace and should therefore not be separated. Perhaps their cohesive study provides the basis for the development of forensic doctrine.

While some forensic scientists do not deny that there is a difference between the basic and the structural concepts of traces, the main problem has been to create a trasological understanding of the traces. For example, Danisyavichus said of the notion of large-scale traces: "This kind of trace is very broad and does not determine the direction of criminal forensic research, nor does it partly reveal the importance of traces in other evidence-based systems."

In our view, such conclusions are not scientifically grounded. The problem of defining the general concept of footprints is the problem of forensic science. This problem has arisen at the time of criminalistics and still exists. As for the notion of traceological traces, this question arises from the emergence of trasology and is developing within this network of criminalistics. Then this question poses little problem, and P. It is reflected in the works of such scientists as Danisyavichus.

Indeed, A. Kanger (1934), E. Anushat (1954), K. Tbiden (1957), E. Knobloch (1959) and many other forensic scientists rate the concept of traceability in criminalistics. Attempted to give. Thanks to the efforts of several foreign and domestic scientists, we have a common understanding of the trail. Consider the Polish scientist Yan Sehnang's tariff: "Forensic traces are the changes in objective reality that are the basis for re-establishing and determining the course of a process or event as an occurrence of an event, process or activity".

Although such rates do not cover all the components of the tracks and therefore do not fully cover the nature of the tracks, this tariff covers the grounds previously unknown to us. This tariff emphasizes the criminalistic importance of traces.

All of the above traces lead us to believe that the following key elements must be included in the concepts of the traces:

The trace is, first and foremost, the material reflection of the crime scene. The crime, which is proved by the advances in modern science, that the material world is capable of reflecting events and processes in its environment, is subject to this general law, and vice versa.

Trace is a reflection of material reality in various dimensions. All other previous track rates are reflected in the change elements. The changes play a key role in the crime mechanism. However, it is not enough to justify the concept of footprints with this single concept. Changes are expressed in various forms and levels as a form of action, which cannot be altered in any crime or crime scene. Therefore, as a sole basis for the tracks, the whole of the tariff itself adds uncertainty to the notion of footprints. For changes that are represented as traces, other forms of reflection are also needed, within which the traces should be reflected.

Traces are carriers of information about changes in objective reality as a result of crimes or criminal acts. The nature of the information or information that the trailers bear is not limited to identifiable data or information, such as tracological traces.

As a result of the advanced advances in science and technology, micro-organisms, which are still unknown, are indicative of the greatness of human thinking. The discovery of microRNAs also indicates that human thinking is unstoppable in the future.

It is necessary to fully analyze the presented classification system and to mention some conditions for its further improvement. Separate tracks in this system include the characteristics of other traces. Other

traces, such as trasological traces, are insufficiently studied. There is very little information about the third. All this is indicative of the need for a deeper study of the traces, their essence and foundations.

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