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# AGRICULTURAL SCIENCES

## OPTIMIZATION OF TECHNOLOGIES OF GRAIN CROPS IN THE STEPPE OF UKRAINE IN THE CONDITIONS OF CLIMATE CHANGE

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### Abstract

It is determined that the efficiency of realization of high natural-climatic potential of the Steppe zone of Ukraine is limited by the increase of climate aridity. Therefore, the strategic objectives of the agricultural sector of the economy should be aimed at increasing crop productivity, saving energy resources, improving soil fertility, reducing anthropogenic pressure on the environment in order to ensure sustainable use of nature. According to the results of generalization of long-term data it is inserted that the maximum grain yield of maize hybrids of different maturity groups is formed in wet years, and the lowest - in dry, and plants best use the heat potential of southern Ukraine in wet and medium wet years, due to the highest intensity of production processes. Using the obtained regression equations, it is possible to select the most optimal hybrid composition for regional and local agroclimatic conditions of the Southern Steppe of Ukraine. According to the results of research, different degrees of variability of meteorological and agronomic indicators have been established. The use of statistical methods allowed to estimate the years of research on the index of favourable agrometeorological conditions and to establish regression equations of plant productivity.

**Keywords:** irrigation, grain crops, agro-measures, agrometeorological conditions assessment index.

Obtaining high and sustainable yields of crops is based on the highly efficient use of soil and climatic resources. In agricultural production, in contrast to other sectors of the economy, these conditions are the most important components, without which the process of obtaining crop products is impossible [1]. However, natural resources differ from conventional means of production in that they are able to naturally restore their properties, lost completely or partially in the process of use [2]. The degree of recovery of the properties of some types of resources (solar radiation, heat, etc.) depends little on the nature of production, and the degree of recovery of others (agrophysical structure of soil, nutrient reserves and productive moisture in the soil) is determined by the intensity of their use the process of growing crops [3].

Many years of experimental experiments of the Institute of Irrigated Agriculture of NAAS were used in the research [4]. To establish indicators of agroecological potential, methodological approaches were used with its division into subsystems - climatic potential,

soil potential, agrohydropotential, etc. [5]. At the same time, a number of yield indicators (according to long-term data of the Institute of Irrigated Agriculture of NAAS) are interpolated to the level of technology of a given year.

The general assessment of the agroecological potential of the Steppe of Ukraine can be expressed in the potential gross grain harvest of all arable lands of the region or as a weighted average of the statistical maximum yield. It is necessary to keep in mind the inequality of products of different crops grown in the region. This approach allows to obtain a more generalized estimate of the AEP than the grain yield, but does not cover a complete set of crops. Therefore, the general assessment of the AEP of the region can be determined by the yield of energy accumulated in the organs (in GJ/ha) due to the value of the dry mass yield and so on. The agroecological potential of the steppe zone of Ukraine is directly related to climate change, especially natural hydrothermal conditions in some local areas, which can differ significantly over the years (Table 1).

Table 1

**Annual sum of active and effective temperatures for 2010-2019  
(according to the Kherson agrometeorological station)**

Years	Annual amount active temperatures				Annual amount effective temperatures		
	over 0°C	over +5°C	over +10°C	over +15°C	over +5°C	over +10°C	over +15°C
2010	<u>4443*</u> +13% **	<u>4338</u> +17%	<u>4066</u> +21%	<u>3330</u> +26%	<u>3142</u> +21%	<u>1892</u> +22%	<u>1042</u> +40%
2011	<u>4060</u> +3%	<u>3795</u> +2%	<u>3534</u> +5%	<u>3169</u> +18%	<u>2720</u> +4%	<u>1748</u> +13%	<u>934</u> +25%
2012	<u>4688</u> +19%	<u>4654</u> +26%	<u>4293</u> +27%	<u>3780</u> +42%	<u>3388</u> +30%	<u>2219</u> +42%	<u>1246</u> +67%
2013	<u>4385</u> +12%	<u>4120</u> +11%	<u>3466</u> +3%	<u>3211</u> +21%	<u>2932</u> +16%	<u>1788</u> +15%	<u>1009</u> +35%
2014	<u>4386</u> +11%	<u>4228</u> +14%	<u>3792</u> +13%	<u>3050</u> +15%	<u>2970</u> +14%	<u>1860</u> +20%	<u>1005</u> +35%
2015	<u>4408</u> +12%	<u>4176</u> +13%	<u>3458</u> +3%	<u>3228</u> +22%	<u>2872</u> +10%	<u>1788</u> +15%	<u>979</u> +31%
2016	<u>4345</u> +10%	<u>4178</u> +13%	<u>3710</u> +11%	<u>2924</u> +10%	<u>2910</u> +11%	<u>1822</u> +17%	<u>966</u> +29%
2017	<u>4507</u> +15%	<u>4275</u> +15%	<u>3625</u> +8%	<u>3262</u> +23%	<u>2956</u> +13%	<u>1826</u> +18%	<u>1016</u> +36%
2018	<u>4419</u> +12%	<u>4326</u> +17%	<u>4194</u> +25%	<u>3420</u> +29%	<u>3191</u> +23%	<u>2102</u> +35%	<u>1127</u> +51%
2019	<u>4549</u> +16%	<u>4299</u> +19%	<u>3856</u> +15%	<u>2924</u> +10%	<u>3017</u> +16%	<u>1868</u> +20%	<u>1031</u> +38%
Average	4419	4239	3799	3231	3010	1891	1035
Average long-term norm	3926	3705	3357	2648	2604	1553	746
Deviation, °C	+493	+534	+442	+583	+406	+338	+285
Deviation, %	+13	+14	+13	+12	+16	+22	+38

**Note:** \* - indicator; \*\* - percentage of deviation from the average long-term indicators

According to the analysis of meteorological observations, changes in the climatic parameters of the Kherson region have been shown to have a close negative relationship between fluctuations in average annual air temperatures and the amount of precipitation. It is determined that over the last 30 years the average annual air temperature has a steady tendency to increase, and in 2019 reached a maximum of 12.9°C.

Precipitation tends to fluctuate significantly, with a minimum in recent years of 310 mm (2017). It should also be borne in mind that the increase in atmospheric air temperature in different temperature ranges is not uniform. Thus, in 2012, the total increase in the sum of active temperatures was 19%, and the increase in the sum of effective temperatures above 15°C was 63%.

It is determined that the efficiency of realization of high natural-climatic potential of the Steppe zone of Ukraine is limited by the increase of climate aridity. Therefore, the strategic objectives of the agricultural sector of the economy should be aimed at increasing crop productivity, saving energy resources, improving soil fertility, reducing anthropogenic pressure on the environment in order to ensure sustainable use of nature.

Our calculations show that under the optimal irrigation regime, the level of favorable agrometeorological conditions for the growth and development of corn for grain varies for the period 1970-2018 from 0.42 to 1.49, with a long-term average value of 1.0.

Significant fluctuations in the index of assessment of agrometeorological conditions are caused by annual fluctuations of individual meteorological indicators. Statistical modeling shows that the most favorable weather conditions were in the periods 1980-1983, 1991-1993, 1997, 2004, and 2018. In these years, there was an increase in precipitation and moderate heat. On the contrary, in 1994-1996, 1998-1999 and 2006-2007 there was a sharp decline in corn productivity due to extremely high air temperatures, a sharp shortage of natural moisture, dry winds and more. In recent years (2014-2018), due to favorable weather conditions - the productivity of corn - is increasing.

Thus, according to the results of generalization of long-term data it is inserted that the maximum grain yield of maize hybrids of different maturity groups is formed in wet years, and the lowest - in dry, and plants best use the heat potential of southern Ukraine in wet and medium wet years, due to the highest intensity of production processes. Using the obtained regression equations, it is possible to select the most optimal hybrid composition for regional and local agroclimatic conditions of the Southern Steppe of Ukraine. According to the results of research, different degrees of variability of meteorological and agronomic indicators have been established. The use of statistical methods allowed to estimate the years of research on the index of favourable agrometeorological conditions and to establish regression equations of plant productivity.

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## BIOCHEMICAL REACTIONS AND YIELD STRUCTURE OF CHICKPEAS IN SELECTION FOR RESISTANCE TO LOW POSITIVE TEMPERATURES.

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### Abstract

This scientific work shows the results of research to assess the yield structure of promising source material for the selection of high-yielding varieties of chickpeas, determining the biochemical characteristics of the vegetative mass and roots, which indicate increased cold resistance. Determining the difference between biochemical parameters of chickpea plants at different growing technology. The results of these studies are covered in this article.

**Keywords:** chickpeas, breeding, influence of low positive temperatures, cold resistance, sugar level.

### Introduction

The problem of moisture supply more and more often arises when growing crops. The impact of global climate change is inevitable and permanent. In Ukraine, droughts often occur in the steppe zone during the growing season and this process is intensifying and spreading territorially [1]. Chickpeas in drought resistance is one of the first places among legumes, but to obtain seedlings need 130-140% moisture by weight of seeds [2]. Therefore, in conditions of frequent soil and air droughts, early crops have their advantages for obtaining quality seedlings. After all, although it is a drought-resistant crop, the impact of prolonged droughts has a negative impact on the formation of a good and quality crop [3,4,5]. Therefore, our scientists continue to work on creating a highly productive source material of common chickpeas, resistant to low positive temperatures and capable of winter cultivation technology.

### Methodology.

The fields of the Plant Breeding and Genetic Institute - NCSC are located in the central part of Odessa

region. The soil cover of the experimental fields is homogeneous and is represented by the southern medium-humus heavy loamy chernozems with a humus content in the arable layer of 3.5-4.1%. The reaction of the soil solution is neutral (pH = 6.1) hydrolytic acidity - 3.29 mg / eq. per 100 g of soil, the amount of absorbed bases - 37.8 mg / eq. per 100 g of soil.

The climate is moderately warm, formed mainly under the influence of Atlantic and Mediterranean air masses. The average annual air temperature is + 9.6°C, the sum of effective temperatures is 3300°C, the average long-term precipitation is 430 mm. Winter is mild and short. The coldest month is January, with an average long-term air temperature of -2°C. Early spring, the transition of temperature through + 5°C occurs in the second or third decade of March. Summers are hot and long, dry winds are often observed. Due to high temperatures and low relative humidity, the soil loses a lot of moisture in the summer. We studied 10 lines obtained as a result of targeted hybridization for resistance to low positive temperatures, namely: 5030, 5033, 5150, 5360, 5362, 5381, 5382, 5383, 5384, 5387 and parental forms from the collection of chickpeas, namely



Col.20 and Col. 229. Research methods include field, analytical and statistical analysis (according to Dospekhov), biochemical analysis.

#### Main part.

In 2021, F5 lines were sown, which were obtained by selection for resistance to low positive temperatures. After harvesting, a structural analysis of these lines and

parental forms involved in the selection process was performed. The results of this experiment are presented in table №1.

As we can see from the results of this experiment, there is a very high difference in the characteristics of the vegetative mass of plants. All lines quite convincingly outweigh the parental forms in plant height.

Table №1

#### Structural analysis of F5, chickpea lines obtained as a result of selection for cold resistance

№ geno- type	Plant height, cm	Height of the bot- tom beans, cm.	Number of beans, pcs.	The number of seeds in the plant, pcs.	The mass of seeds in the plant, g.
Col.20	46,33±1,08	22,66±1,78	10,33±3,19	6,66±2,16	2,00±0,35
Col. 229	43,28±1,23	23,71±1,69	12,14±1,44	7,00±0,93	2,01±0,26
5030	74,30±2,84	43,81±1,35	10,20±1,63	5,20±0,91	2,20±0,22
5033	69,06±1,33	43,81±1,85	14,18±1,63	8,62±1,44	2,16±0,28
5150	68,65±2,47	46,05±1,59	15,95±3,34	8,50±2,75	3,19±0,82
5360	71,91±3,26	41,58±2,67	15,66±1,85	4,41±0,58	1,57±0,13
5362	63,77±3,68	34,00±2,40	14,77±1,53	6,77±0,55	2,78±0,27
5381	72,95±1,71	46,15±1,34	18,65±2,31	14,45±2,02	4,35±0,52
5382	72,87±3,20	37,12±2,01	25,50±4,05	12,00±3,45	4,55±1,16
5383	69,60±0,89	46,50±1,19	14,30±1,60	10,15±1,42	3,42±0,41
5384	70,00±1,87	43,85±2,18	21,42±2,36	10,42±2,24	3,36±0,56
5387	67,80±2,62	42,20±1,37	10,20±1,08	6,45±1,08	1,64±0,34

After analyzing the data from the structural analysis of F5 lines, we can note the increased productivity of almost all lines, except 5360 and 5387, which proved to be below the level of parental forms. Numbers 5150, 5381, 5382, 5383 and 5384 have a very convincing advantage in terms of yield over other lines and parent form, namely in seed weight (5150 -  $3,195 \pm 0,82$  g per plant, 5381 -  $4,35 \pm 0,52$  g, 5382 -  $4,55 \pm 1,16$  g, 5383 -  $3,42 \pm 0,41$  g, 5384 -  $3,36 \pm 0,56$ ).

In October 2020, the lines obtained because of selection for resistance to low positive temperatures dur-

ing germination were sown to test this material for winter cultivation technology. In February 2021, samples of vegetative mass of chickpea were taken for biochemical analysis to detect biochemical markers of resistance to low temperatures in winter, the samples were taken in the phase of 3-4 true leaves. According to the literature, this phase is critical for plants [6], which is due to reduced resistance of plants to low temperatures. Indicators that were taken for testing are sugar levels, chlorophyll, carotenoids, flavonoids, proteases, protease inhibitors. The results of this analysis are presented in table №2.

Table № 2

#### Biochemical parameters of chickpea plants for winter sowing 2020-2021

Plot num- ber	Variety name	Sugar level %	Chlorophyll, mg%		Carotenoids mg%	Flavonoids g / 100g	Proteases H cat / kg	Protease in- hibitors	
			a	b				g/kg	Pete. Act.
2	5033 (vegeta. mass)	15,05	167,16	58,94	70,26	0,204	1,868	0,124	1,82
2	5033 (root. mass)	5,61	—	—	—	0,056	1,514	0,036	1,56
3	5150 (vegeta. mass)	13,36	149,53	50,51	61,82	0,182	1,734	0,075	1,27
3	5150 (root. mass)	8,04	—	—	—	0,054	1,474	0	-
5	5362 (vegeta. mass)	11,75	162,61	52,16	69,58	0,211	1,674	0,152	2,45
5	5362 (root. mass)	7,63	—	—	—	0,054	1,160	0	—
6	5381 (vegeta. mass)	16,24	158,09	52,53	71,16	0,185	0,811	0,249	3,72
6	5381 (root. mass)	6,13	—	—	—	0,052	1,602	0	—
7	5382 (vegeta. mass)	13,06	178,43	56,7	76,91	0,245	1,120	0,177	2,77
7	5382 (root. mass)	7,11	—	—	—	0,057	1,516	0	—

Based on the results of biochemical analysis, we can conclude that the stability of chickpeas is due to such indirect indicators of stability as sugar levels and protease inhibitors. In contrast to the results of biochemical analysis in 2019-2020 when the winter was warm and snowless, and the level of sugars was higher in the root mass, in 2020-2021, this figure was higher in the vegetative mass, because the winter of 2020-2021 was quite cold and had a snow cover. This suggests that chickpea plants thus protect themselves from

damage by low temperatures. In addition, in contrast to the data presented in the table [7], we have a much larger amount of sugars, in the vegetative mass; this figure was not less than 10%. In the spring of 2021, we also selected samples of spring crops of the same genotypes that were taken from winter crops for biochemical analysis on the same indicators. The data are presented in table № 3.

Table № 3

**Biochemical parameters of spring chickpea plants 2020-2021**

Plot number	Variety name	Sugar level %	Chlorophyll, mg%		Carotenoids mg%	Flavonoids g / 100g	Proteases H cat / kg	Protease inhibitors	
			a	b				g / kg	Pete. Act.
2	5033 (vegeta. mass)	6,42	312,46	106,19	94,83	0,295	1,602	0	—
2	5033 (root. mass)	9,29	—	—	—	0,055	1,408	0	—
3	5150 (vegeta. mass)	6,17	309,33	106,63	87,79	0,318	1,922	0	—
3	5150 (root. mass)	5,13	—	—	—	0,040	1,465	0,017	0,44
5	5362 (vegeta. mass)	6,82	296,31	103,91	78,88	0,273	1,091	0	—
5	5362 (root. mass)	5,15	—	—	—	0,043	1,448	0	—
6	5381 (vegeta. mass)	6,49	301,59	103,5	83,67	0,300	1,871	0	—
6	5381 (root. mass)	5,89	—	—	—	0,043	1,422	0	—
7	5382 (vegeta. mass)	6,33	293,4	104,77	77,90	0,315	1,514	0	—
7	5382 (root. mass)	7,08	—	—	—	0,045	1,297	0,068	1,74

Comparing the results of biochemical analyzes we can conclude that: 1. the level of sugars is radically different in the technology of cultivation. In winter sowing this indicator is increased and more than 10%, in spring sowing this indicator is less than 10%, which means that the sugar level is an indirect indicator of resistance to low temperatures. 2. The level of chlorophyll is also quite radically different; in spring sowing this figure is 2 times higher than in winter sowing. 3. The main difference is the presence of protease inhibitors. As we can say, spring sowing does not have these substances in contrast to winter sowing. This suggests that these substances suspend the plant's metabolism by putting it in a state of stasis to survive under the negative factor.

#### Findings.

Numbers 5150, 5381, 5382, 5383 and 5384 have a very convincing advantage in productivity over other lines and parent forms, namely in seed weight (5150 -  $3,195 \pm 0,82$  g per plant, 5381 -  $4,35 \pm 0,52$  g, 5382 -  $4,55 \pm 1,16$  g, 5383 -  $3,42 \pm 0,41$  g, 5384 -  $3,36 \pm 0,56$  g). Chickpea plants have mechanisms to slow down the metabolism to reduce the risk of stress damage as evidenced by increased levels of sugars and protease inhibitors.

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# ECONOMIC SCIENCES

## IMPROVEMENT OF STATE CONTROL AS A BASIS FOR THE EFFECTIVE USE OF BUDGETARY FUNDS

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### Abstract

The state financial control is aimed at establishing proper order in the sphere of budgetary and financial relations. This goal can be achieved only if financial control is clearly organized and stable. The purpose of this article is to analyze the development of state financial control in the Russian Federation, as well as to develop measures to improve it on the example of the activities of the Accounting Chamber of the Russian Federation.

**Keywords:** state control, state budget, budgetary and financial relations, targeted use of budget funds, effective use of budget funds, Accounting Chamber.

State financial control in the Russian Federation is a form of state regulation of financial and industrial relations of all economic entities, contributing to the implementation of a unified financial, credit and monetary policy in the country, protection of the financial interests of the Russian Federation. Being a mandatory element of public property management, "state financial control is carried out in order to ensure the implementation of a unified financial, budgetary, monetary, tax, currency and investment policy in the Russian Federation, ensuring economic security and protecting the financial interests of the state, as well as its citizens and business entities." [1].

At the moment, the state financial control plays a key role in the system of efficient use of budget funds. The federal budget has been a vulnerable sector for many years. This is primarily due to the misuse of budgetary funds. Currently, a large number of state bodies and services have been created and are functioning in the Russian Federation, which are entrusted with the functions of state financial control and audit. Their functions, powers, status and areas of control activities are determined on the basis of decrees of the President of the Russian Federation, the Decree of the Government of the Russian Federation, relevant regulatory legal acts and relevant regulations.

Due to the lack of transparency, there is no trust in decision makers. Any amount of expenditure, in particular with the use of budgetary funds, leads to suspicion of inefficiency in the distribution of financial resources [2].

The mechanisms should be aimed at ensuring transparency in the expenditure of funds from the budget. At the same time, transparency is very important not only for the actions of the recipient of funds, but also for the entire chain of execution, whether it is government contracts or recipients of subsidies who continue to use the funds for their intended purpose. A huge reserve of work is associated with the so-called continuity of activity or continuity of control. The volume is so large that it is not possible to work out all the information. To solve this problem, it is necessary to pay attention to the budget monitoring system. The development of a budget monitoring system as a tool for managing the state budget is one of the priorities for improving control over the execution of financial resources. Also, the problem of state audit is the lack of professional personnel in this area. For the development of state audit in Russia, young highly qualified professionals are needed. A professional state auditor should have basic knowledge of economics, law, and a foreign language. He especially highlights the difficul-

ties of the language barrier of specialists. Thus, a significant role in the implementation of financial control belongs to the state (municipal) control bodies.

In particular, we can detect the intersection of the competencies of the Government and the Central Bank of the Russian Federation in the field of guarantees and the implementation of a unified financial, credit and monetary policy. Also, the similarity of the powers of the Federal Treasury and the Central Bank of the Russian Federation in terms of currency regulation.

The bodies of the State Fiscal Committee, including the Accounts Chamber of the Russian Federation, do not have independent levers of power, therefore their strength and influence lie in the quality of the work carried out. In order to consolidate its influence, the GFC must be constantly improved, which should result in an increase in the efficiency of the GFC and the quality of the state audit, which makes it possible to assess not only the legality of spending budget funds, but also the effectiveness of using state resources to achieve socio-economic goals [3].

Such events are predetermined by the vagueness of the wording, which entails a misinterpretation of legal norms, the absence of acts, the adoption of which is conditioned by practice.

Taking into account all the above, in order to improve state financial control, it is necessary to:

- improve the control of public expenditures, and assess their effectiveness;
- strengthening the transparency of the activities of organizations using taxpayer funds;
- introduction of new technologies for conducting control checks on the use of budget funds;
- development of a single methodological basis for performance audit for the control and accounting bodies of financial control;
- ensuring compliance with financial discipline and minimizing financial irregularities and corruption;
- combining the efforts of regulatory bodies of legislative and executive authorities to create a system for auditing the effectiveness of the use of budgetary funds;
- determining the direction of capital movement, limiting the export of capital abroad;
- creation of personnel training centers for advanced training and professionalism of specialists engaged in control and economic work [4].

The organization and functioning of an effective financial control system is a mandatory and indispensable element of the state financial policy. State financial control, playing an essential role in ensuring the functioning of the state, can simultaneously be qualified as a function of social management and legal regulation.

One of the ways to improve the financial system in the regions is to conduct an annual analysis of the financial activity of the entity. Analysis as one of the methods of financial control is understood as a detailed study of the annual financial and accounting statements for the purpose of a general assessment of the results of financial activities. This control method is characterized by a systematic approach and includes various economic and mathematical techniques.

The organization and functioning of an effective financial control system is a mandatory and indispensable element of the state financial policy. State financial control, playing an essential role in ensuring the functioning of the state, can simultaneously be qualified as a function of social management and legal regulation [5].

The development of a budget monitoring system as a tool for managing the state budget is one of the priorities for improving control over the execution of financial resources. Also, the problem of state audit is the lack of professional personnel in this area. For the development of state audit in Russia, young highly qualified professionals are needed. A professional state auditor should have basic knowledge of economics, law, and a foreign language. He especially highlights the difficulties of the language barrier of specialists. Thus, a significant role in the implementation of financial control belongs to the state (municipal) control bodies.

In order to improve the system of financial control, it is necessary:

- to establish an equal position for all subjects of financial control;
- to tighten measures for the suppression of offenses identified during the financial control;
- to endow the Accounts Chamber of the Russian Federation with additional powers to conduct financial control throughout the territory of the Russian Federation;
- systematize the activities of the control and accounting bodies of the subjects of the Russian Federation, as well as municipalities;
- to fix the methods of financial control in regulatory acts [6].

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## PROTECTIONISM AND IMPORT SUBSTITUTION AS PART OF THE NATIONAL SOCIO-ECONOMIC AND SCIENTIFIC-TECHNOLOGICAL DEVELOPMENT POLICY

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### Abstract

This article describes protectionism policy and import substitution mechanisms for national economic development, support for the development of "emerging" and priority economic sectors, the relationship between protectionism and openness policies, analyzing the state policy of import substitution and the emerging risks associated with its implementation.

**Keywords:** long-term economic development, world economy, scientific and technological progress, state policy, globalization, protectionism, import substitution, support for the development of "emerging" and priority economic sectors, international competition

### Introduction

Economists have been arguing for many decades in the academic community about which economic models allow a country to develop sustainably in the long term, increase a country's wealth and its citizens' prosperity, and which are detrimental to the national economy. Scientific battles about the state's role in national development, national governments' development mechanisms and state regulation efficiency under global economic development, the markets' openness and the cross-border flow of capital, workforce, knowledge and technologies also continue unabated.

Some economists argue, based on empirical research, that development is only possible through international trade, the maximum openness of markets and competition's unlimited power. Others say, also confirming their arguments with research results, that the basis for development is a protectionist policy, an active role in the economic development and national market management. At the same time, international economic history has taught the world some important lessons.

In the first place, completely open or closed economies have failed. But countries that combined models that provided protection for national companies while managing national economic openness have succeeded.

Second, for some countries, globalization and openness have been a source for development and increased state, economic agents and citizens' well-being, but for others they have been the cause of poverty, economic or technological dependence on the former. A country benefits from globalization only by having strong national production.

Third, absolute openness of the domestic market sooner or later leads to technological and product dependence of the country. Countries possessing a technology benefit meaningfully from openness at the other countries' expense, and then, when it is profitable, use their monopolistic rights to these technologies to put economic and political pressure on other countries that have become their "technological colonies".

Fourth, for each country that chooses to take advantages of globalization and openness, or the benefits provided by protectionism and import substitution tools, there is a price, which depends on many internal and external factors and conditions.

Fifth, it is possible to distinguish five basic socio-economic development strategies based on scientific and technological progress. Countries combine different strategies based on their development stage and "windows of opportunity", with protectionism, openness and export support policies being an integral part [7].

### Scientific basis of protectionism and import substitution

Theoretical and practical aspects of the protectionism policy and the application of import substitution mechanisms for national development purposes have received significant attention from many scientists and researchers, including P. Samuelson, F. List, S. Neumann, A.R. Adwale, S. Mukherjee, A. Jaleel, W. Baer, Ko Min Lin, A.H. Amsden, A.R. Adewale, S. Cooke, P. Watson and others.

For example, P. Samuelson pointed out that, on the one hand, protectionism prevents comparative advantage forces from acting as efficiently as possible, and on the other hand, protectionism in one country

prevents comparative advantage forces from acting as efficiently as possible to obtain benefits from another country. At the same time, F. List says that eliminating barriers that helped create and develop national production should only be done when these barriers begin to hinder development, or if an industry has achieved a comparative advantage in contrast to other countries. In his works, List also pointed out the most important sequence of development: national technological and human capital development - national industrialization and formation of a diversified economy based on own and attracted technological capital simultaneously with strong protectionist measures - developing aggregate comparative competitive advantages based on national technological capital, human capital and strong production capabilities - integration into the global economy. Those countries that act in a different sequence, usually subsequently face significant difficulties and barriers to development, and efficiency of government support is greatly reduced.

Development models based on protectionism and import substitution, on the one hand, contradict globalization and growth models based on the international division of labor, and on the other hand, are an integral part of the economic development policy of most developed states and developing countries, which were able to ensure sustainable growth and create new economic growth points in a relatively short time. Researchers note that in globalization and huge international trade volumes, creating one's own large-scale and technologically developed industrial production is possible only through import displacement in the national economy with the latter forcing out technology groups, products and services in the international market [2].

Primarily at the "birth" stages of new industries or developing existing industries, an adaptation phase of their production systems resulting from new technologies, knowledge, production factor combinations, changes in technological and consumer standards, national producers face limited capital and investment opportunities, human resources with appropriate skills and competences, limited demand, technological capital and a high competition level from transnational corporations.

National economic agents (companies, households, the state) credit the other world through product, equipment and service imports, national capital outflows from the country, foreign currency, foreign government securities and foreign company security purchases. In this regard, an import substitution policy becomes a mechanism for forming additional resources and sources for national companies by reducing lending to foreign producers through displacing imported products and services in the national market, as well as by reducing national consumers' propensity to import. At the same time, in the author's opinion, regulatory mechanisms that lead to a decrease in the propensity to import and the opening of demand in the domestic market for national producers are a higher priority than a direct and complete ban on imports, unless such a ban is a necessary measure caused by economic and political factors related to national security.

R. Barre expresses an important idea that exports, like investments, lead to the growth of profits, while imports do not create new income in the importing country, and consuming a certain imported product can be carried out at a certain income and consumption level only by reducing national consumption [9]. Neo-classical economic model followers express several arguments against an import substitution model's application. On the one hand, these arguments are important for assessing the risks associated with import substitution, and on the other hand, they are important aspects for applying a mixed policy, which provides for the use of protectionist tools at the initial stages and free trade and globalization mechanisms at later stages.

For example, S. Haggard says that openness does not prevent countries from industrialization, but allows them to develop through technological adaptation and obtaining new knowledge. Neoclassics note that in the transition to a development model based on import substitution produced equipment and consumer products often do not meet international quality standards and are inferior to used technologies in terms of efficiency. This position is certainly not unreasonable. However, lower product quality and their lower technological efficiency in comparison with imported products almost always occurs at the early development stages. However, at subsequent stages, due to the use of more modern national and foreign technologies, establishing interaction with consumers, improving production processes, developing the R&D system, product quality and their compliance level with buyers' needs increases over time, and labor productivity in the respective industries recovers and grows.

It is possible to state that a development model based on protectionism and import substitution and the export-oriented development models complement each other. The relationship between import substitution policy and exports can be explained through intersectional demand theory, developed in 1961 by the Swedish economist S. Linder, according to which the necessary condition for exporting products and services is a high domestic demand for these products and services. In turn, A. Jaleel in his study expressed the position that a country cannot export what it does not produce, export capacity growth is greater if domestic production capacity and penetration of national products in the domestic market are greater, indicating that there is a positive relationship between manufacturing production per capita and their export share in total manufacturing production [2].

Thus, in fact, import substitution policy in essence acts as the accelerator for exports' further development. The policy of protectionism and import substitution is not an alternative for export-oriented strategy. At the first stage it is necessary to ensure goods' production and consumption in the domestic market in order to develop them to a competitive level corresponding to the level of applied technologies and global quality standards, and then actively begin to promote them in foreign markets. Both policies involve the implementation of existing opportunities for the regional economy through the domestic market (import-substitution policy) and foreign markets (export-oriented policy).

An important aspect for the domestic market is whether the regional economy in a certain time period, considering the rate of S&T progress and diffusion dynamics of technologies and produced on their basis sets of products and services, can produce products or create intangible assets and provide the same or higher quality services at the same or lower price, or offer principally new products based on more advanced technologies to consumers than foreign companies do [11].

An import substitution policy is also aimed at reducing the risks for a country associated with national economy technological dependence on foreign knowledge and technology, reducing possible political influence from the countries that are technological leaders in the national economic system and national development institutions.

So, it is possible to give an import substitution policy the following definition. Import substitution policy is a policy and mechanism set implemented simultaneously and on a par with other development models, scientific-technological and innovative development mechanisms, which is aimed at: (1) national economic development and ensuring economic, commodity and technological state security, providing for a gradual transition from simple products to science-intensive and high-tech products in order to further export them to global markets; (2) economic diversification through national production capacity development in "emerging" and priority industries with scientific, technological, human and (or) production potential; (3) support for developing "emerging" and priority industries with significant potential in the domestic and foreign markets and creating new economic growth points on their basis.

An import substitution policy provides opportunities for development in case of its successful implementation, effective coordination and interrelation with other economic development mechanisms and state support. The import substitution strategy can give impetus for rapid "emerging" and priority industry development, accelerate productivity growth in these and related sectors, and launch economic development mechanism based on market and technological specialization, while ensuring the country a leading position in the global market.

At the same time, given the limited resources, the import substitution policy should not and cannot be implemented in all sectors simultaneously, which is fraught with resource dispersion and the inability to accumulate sufficient investment capital in different sectors for development and technological modernization, problems in the process administration, too much pressure on the state budget (direct costs to support industries and related industries, expenditure on research and development, shortfall in income associated with tax incentives).

The most important condition is to formulate the import substitution policy while considering risks and technological threats to the country, assess the technological and resource capabilities of the government and private business, analyzing all the comparative competitive advantages, the existing development level of pro-

duction infrastructure, evaluating domestic and potential foreign markets, identifying key barriers and mechanisms to overcome them, etc.

In general, an import substitution policy can be aimed at developing industries that have technological potential, significant domestic market and export potential, whose goods are already produced by national manufacturers. An import substitution policy may be aimed at a product group that is not produced by national manufacturers, but there is technological capital (or it can be formed in the short term), with a large enough domestic market and dynamically developing foreign markets.

### **Protectionism and import substitution for national development**

Protectionism and import substitution mechanisms have been applied by a significant number of countries, including economically and technologically developed countries, for example, Brazil, Argentina, Mexico, South Korea, China, Malaysia, Germany, the Netherlands, France, Switzerland and even the USA.

Import substitution policy is inextricably linked to protectionist measures for national companies in the domestic market, but it must be recognized that export capacity development and export support are also inextricably linked to national companies' protectionism, but in foreign markets. Using protectionism and import substitution mechanisms, developed countries adapted the models and economic development tools used, and through the national market they ensured the development of their own technological advantages, competencies in national companies, forming a powerful industrial base, cultivating large national companies, and then through free trade and an openness policy, "generous financial assistance" to other countries they created their national transnational corporations.

Developed countries, which are fierce supporters of the free trade and globalization model, see protectionism and import substitution as an important element of their economic development and an advantage. J. Ahmad notes that import substitution is used by countries with a high level of industrial development as an additional tool to support economic growth [1]. In turn, H-J Chang points out that almost all rich countries today used tariff protectionist tools and subsidies for national industries at their initial development stages. It is especially interesting that such countries as the US and the UK, which have proposed and advocated for open markets and free trade models, most actively use various mechanisms to protect their national producers [4].

Moreover, these countries, using their technological and economic superiority, through establishing international development institutions and international legislation on trade, initially laid the mechanisms and conditions for limiting protectionist instruments and import substitution models for individual national economies.

For example, the US Office of Technological Development report dedicated to the US Congress' 100th meeting [6] noted that the US government through large-scale international negotiations should form a new organizational and legal system of international relations, providing trade barrier removal, obstacles for

foreign direct investment and for cross-border technological exchange. These conditions were formulated as mechanisms to circumvent trade and investment barriers set up by foreign countries to protect domestic markets, to gain future economic benefits for the U.S. or to influence other countries through limiting access to more advanced technologies or limiting uses of already transferred technologies, as well as to distort the then existing financial and trade flows.

The author considers it important to cite several statements belonging to the U.S. leadership that, in their essence, reflect the true economic policy objectives pursued at the international and national levels. A. Lincoln has been attributed with the following words: "I do not know much about tariffs. All I know is that when I buy a coat from England, I get a coat and England gets money. When I buy an American coat, I get a coat, and America gets money" [8]. One report to the U.S. President pointed out that "protectionism in international trade ... even if it is costly to the American economy in the short term, can nevertheless be justified if its strategic goal is to raise protectionist policy costs for foreign countries. Thus, a potential role should be played by carefully considered measures ... aimed at

persuading other governments to limit their activities aimed at disrupting trade relations" [8]. P. Bairoch in his article "Economics and world History: Myths and Paradoxes" pointed out that the U.S. government has always engaged in protectionism as the most important element of its economic development strategy. As early in the 19th century Ulysses Grant said that "Within 200 years, when America has gotten out of protection all that it can offer, it too will adopt free-trade principles". [3]

Using the approaches outlined by P. Samuelson, who considers openness as a ratio of international trade to GDP [8], it is possible to observe multidirectional dynamics regarding both the openness level of the world economy and individual economies in the period from 1980 to 2018. In general, data analysis shows that for all countries that are part of an existing "System-World" core, economic openness is slightly higher than the global average, and significantly lower than developing or small countries. This actually means that the countries that speak loudest about globalization and openness are actively engaged in protectionism and the protection of their national companies. At the same time, it is the U.S. that is one of the most closed economies among countries with a high income per capita.

Table 1.

**International trade-to-GDP ratios for the world and individual countries between 1980 and 2018.**

Country name	1980	1990	2000	2010	2015	2018
USA	0,20	0,20	0,25	0,28	0,28	0,27
China	0,23	0,35	0,45	0,55	0,42	0,40
Japan	0,29	0,21	0,21	0,31	0,37	0,38
Germany	0,48	0,51	0,65	0,83	0,88	0,89
India	0,16	0,16	0,28	0,48	0,45	0,45
Republic of Korea	0,74	0,55	0,71	0,98	0,85	0,84
Russian Federation	0,34	0,45	0,68	0,51	0,59	0,51
Singapore	4,29	3,73	3,45	3,58	3,14	3,17
Netherlands	0,96	0,99	1,34	1,55	1,95	2,02
The world	0,44	0,38	0,48	0,58	0,57	0,59

Source: compiled by the author based on World Bank and WTO data

The effectiveness of an import substitution policy for different countries was not the same. For some countries, such as Argentina, import substitution mechanisms may be recognized as not entirely successful, which was largely due to the one-sided economic growth tools and state support mechanisms used, which actually led to a high closure of certain economic sectors and a decrease in economic competitiveness as a whole. Using a rather traditional mechanism to support national companies (state subsidies, restrictions on imports of foreign products), Argentina at the same time restricted foreign capital flow. With a small domestic market for import substitution consumption, this led to an inability to reproduce sufficient resources to develop its own technological and human capital, investment in R&D and investment in fixed capital, while limiting foreign technology transfer into the country's economy. In addition, the revenues from exports were directed

mainly to state reserves and were not invested in scientific and technological development and high-tech industry building. However, Latin American countries were able to get a positive effect from the import substitution policy, but in the short term.

At the same time, Asian countries' experience is much more successful due to the initial application not only of protectionism mechanisms and restrictions related to foreign product and service imports, but also mechanisms aimed at accelerating scientific and technological progress, developing human capital, supporting national companies in priority economic sectors and stimulating national exports of goods and services (an "export-oriented import-substitution" strategy). For example, the Indian experiment from 1950 to 1965 showed that import substitution under the first Indian industrial development plan ensured 33% industrial production growth (for manufacturing equipment and



components), under the second plan - 13% (for such industries as paper production, printing, petroleum products and electrical equipment production) and under the third plan - 25% (for manufacturing equipment) [5].

In general, according to the UN [12], increasing national production share in total product output and satisfying consumer demand in the domestic market through import substitution explains 50% of national economic industrialization growth.

### State policy of protectionism and import substitution

According to the author, there is an important difference between the state protectionist policy to support national companies and import substitution policy. Under increasing competition between countries in the context of S&T progress and globalization, transnational corporate activities, resource constraints for the national economic agents' development, the policy aimed at protecting and supporting national companies in domestic and foreign markets, primarily in the "emerging" and priority industries, should be implemented on an ongoing basis. Otherwise, national companies' competitive opportunities will decrease, which will result not only in reducing national income, but possibly in technological and commodity dependence of the country.

As protectionism policies and support for national companies in "emerging" and priority industries, government actions encompass in their totality various objectives, including: (1) S&T development and technological capital accumulation, forming favorable conditions for S&T activities; (2) human capital development, human capacity development; (3) support for national production capacity development; (4) stimulating consumption and developing aggregate demand for products and services produced (provided) by

national economic agents; (5) supporting commercialization processes for new technologies and innovation; (6) developing international trade, supporting national exports, and increasing national companies' competitiveness in global markets.

In some cases, mechanisms aimed at national companies' protectionism and their state support are applied whether or not import substitution policy is implemented, while in other cases, mechanisms of protection and supporting national companies and import substitution tools are applied at the same time. Moreover, their simultaneous application is a prerequisite for import substitution policy efficiency. At the same time, import substitution mechanisms are reasonable to apply in a limited time period when certain conditions or the need to solve specific problems arise.

Import substitution policy should consider the economic cycle phases, trajectory stages of innovation and industrial development in the relevant economic sectors, consider the level of technological penetration in the world, as well as emerging opportunities for development on an imitation basis of technology and innovation.

International experience shows that import substitution policy can be implemented in stages, but at each stage no more than 5-10 economic sectors can be prioritized. In general, for import substitution policy the planning period should be from 15 to 25 years. This planning period is chosen based on the need to cover the time period for the technological trajectory and for the part of the product development trajectory, the impossibility of the rapid concentration and forming the necessary resources, the long-term transition of national development institutions, human capital development and production organization and, as a consequence, the impossibility of achieving fast and significant results in the short term.

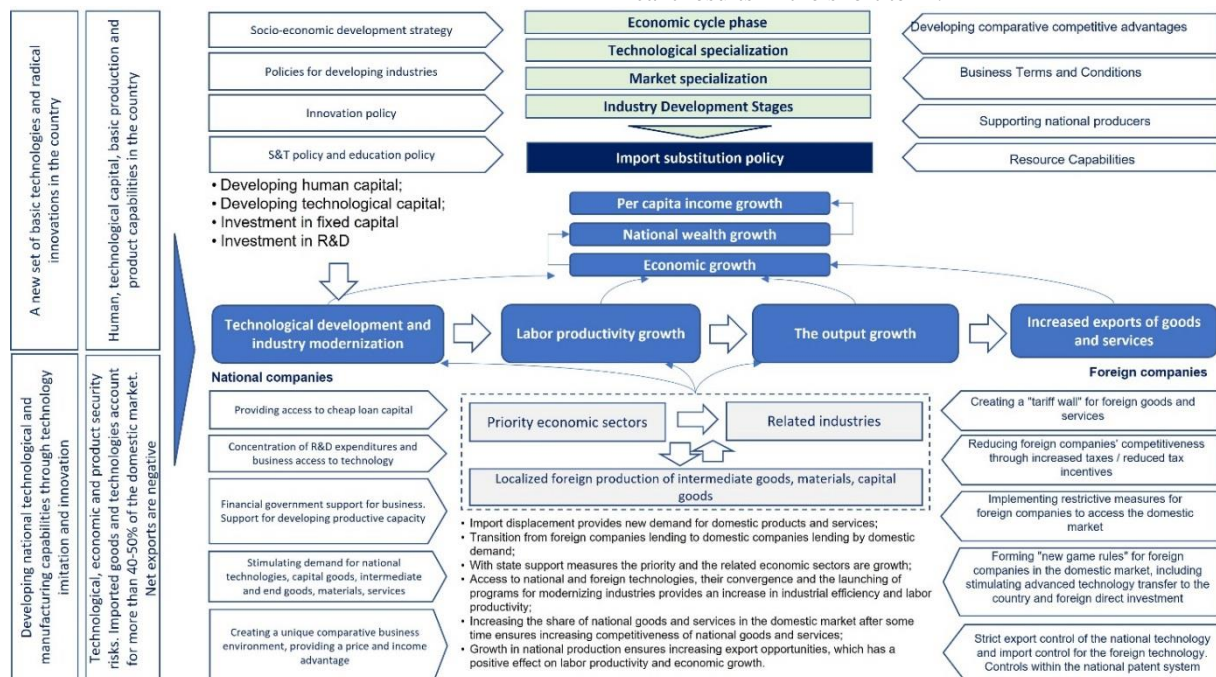


Figure 1. Development model based on import substitution policy application

Source: Developed by the author

Import substitution policy can also be aimed at those products, whose production is not efficient in economic terms in a certain time period, but imports and high foreign technology penetration pose a strategic threat to the economic and technological national security. According to the author, import substitution mechanism application is reasonable in conditions, if import share of any product group or import share in strategically important economic sectors in domestic consumption exceeds 40-50%, depending on the economic sector. During import substitution policy implementation there can be a sectoral approach (vertical import substitution for certain economic sectors), a technological approach (import substitution policy is built through identifying a set of critical and promising basic and sub-technologies for priority and related industries), as well as a mixed approach.

#### **Specific features of the state import substitution policy**

Implementing an import substitution policy and, even more so, obtaining a positive effect is a complex process and requires from national governments significant efforts in governance, regulatory influence on markets, transforming state development institutions and their highest coordination in a dialogue with the private economic sector. The "rationality" principle must be applied. On the one hand, there should certainly be a "strong hand" of the state, which is able to launch the "import substitution locomotive", technological modernization processes and rapid developing national production capabilities for priority industries, and on the other hand, it is important to ensure a balance between the closed and openness level of these industries.

When implementing import substitution policy, it is important "to separate the benefits of the isolated development path and the costs associated with protectionism" [10]. That is, on the one hand, it is necessary to clearly understand what benefits will be derived in the long term, and what costs will have to be incurred for this purpose. At the same time, the assessment should be carried out for priority industries, for which import substitution tools will be introduced, for related economic sectors and the economy as a whole. That is, it is advisable to use assessment methods of broad impact and comparing the total benefits and total costs. However, it is important to understand that it is often impossible to identify all the benefits and estimate all the potential costs.

In simple words, the national government, when deciding to implement import substitution policy, should not fall into the "import substitution trap," having the desire to build its own fully independent industrial industries. The wrong and hasty choosing of industry and technology priorities can divert significant resources, leading to an even greater technological lag in other industries in the absence of a substitutive positive effect.

The policy implemented by the state must ensure a balance between the application, including non-competitive mechanisms, of financial and non-financial government support tools that ensure national company development and their product and service penetration

into the domestic market, and the conditions for foreign companies to do business in the national market. Achieving this balance is important based on the need to stimulate foreign direct investment in the country and to assess the opportunities that foreign companies can provide for national economic development (investment, new highly productive and highly profitable jobs, technology transfer, re-export of goods, increased national companies' participation in global value chains).

Government policy in the import substitution sphere with simultaneous implementation of development support mechanisms should, on the one hand, provide a price advantage in the domestic market for national goods and services in relation to imported goods and services, and, on the other hand, ensure that national producers in "emerging" and priority industries have high profitability.

As national goods and services penetrate the domestic market, obtain scale effects and develop national technological capital, the state should gradually reduce government support and restrictive barriers for foreign companies in order to support national companies' development through competitive mechanisms while ensuring appropriate control over the propensity to import goods and services and control exports and imports of intellectual property.

In addition, when a certain penetration level of products produced by national companies in the domestic market is reached, the state should gradually move to an export-oriented policy, support in developing scientific and technological potential through converging national and foreign technologies and knowledge, and human capital development. At the same time, it remains important to ensure high profitability in the relevant national industries, which will ensure an investment inflow in the next round.

When implementing import substitution policy, the state should pay attention to the forming following conditions:

1. The aggregate level of restrictions related to imports should ensure a significant price advantage for national goods and services in the domestic market, taking into account the national companies' aggregate costs, given that there is no scale effect and application of less efficient technologies at the first stage, and also considering foreign producers' opportunities under restrictions imposed by the state to maintain their return rate on the national market, equal to or above the average global values for the same product categories and services and opportunities for foreign parent companies to subsidize potential losses in order to maintain their positions in important regional markets;

2. Restrictions should not lead to the cessation of similar foreign good or service imports, but should reduce the propensity to import;

3. Potentially high prices for nationally produced goods and services should be compensated for by government support mechanisms for national manufacturers to ensure, on the one hand, a lower price level compared to foreign analogues under restrictions, and on the other hand, a high profit margin for national manu-

facturers sufficient for investment in accelerated development to bring national and imported goods closer in technology, quality, cost and price levels, etc;

4. The introduced restrictions should be applied simultaneously while creating such conditions for business activity under which it will be profitable for foreign companies to transfer technologies, intellectual property to the country which implements the import substitution policy, to create on its territory in partnership with national companies their production, R&D centers and to place headquarters of the companies;

5. Implemented measures should be focused primarily on restrictions on finished products with a high value added. Since software accounts for up to 80% of the high-tech products value today and is a key factor in ensuring technological independence, the state should form a legislative framework based on the need to use national IT solutions in industry;

6. Import substitution policy in some industries should be accompanied by the technological modernization of processes in other industries, which are key consumers of import-substituting technologies, capital goods, intermediate and end products. That is, the chain "development of import-substituted production - consumption of import-substituting goods" should be built while ensuring significant growth in domestic demand;

7. National development institutions should be fully restructured to support import substitution processes in priority industries and support national companies in these industries, and the national innovation system and scientific and educational environment should provide technologies, knowledge and human capital in accordance with the needs and "just-in-time".

At the same time, the state should apply development mechanisms and restrictive mechanisms for foreign and national companies, which should be interconnected with each other, with clear goals and time limits.

Table 2.

**Mechanisms for development and restrictive mechanisms in the state policy of import substitution**

	<b>Foreign companies</b>	<b>National companies</b>
<b>Restrictive mechanisms</b>	<ul style="list-style-type: none"> <li>• Policies involving a "tariff wall" and a reduction in the pricing power of competition;</li> <li>• Anti-monopoly policy - removing barriers that prevent national products and services from accessing the domestic market, destroying oligopolies;</li> <li>• Fiscal policy (various tax benefits for national and foreign companies);</li> <li>• Patent policy and technology import control system;</li> <li>• Restrictions through changes in technological and consumer standards, and in system of mandatory licensing and certification.</li> </ul>	<ul style="list-style-type: none"> <li>• Restrictions on certain technology sales to foreign companies;</li> <li>• Restrictions on selling companies (controlling interest) - for companies receiving state support;</li> <li>• Requirements on reinvested earnings in capital and R&amp;D within a certain timeframe, if the companies receive government support, including through public procurement;</li> <li>• Additional government requirements for development or customization solutions for other market segments (depending on the industries), considering technological development priorities;</li> <li>• Introduction of control over technology, high-tech capital goods, software imports by national companies ("ban/restrictions policy", if there are national equivalents);</li> <li>• Requirements for intellectual property;</li> <li>• Restrictions through changes in technological and consumer standards and in system of mandatory licensing and certification.</li> </ul>
<b>Mechanisms for development</b>	<ul style="list-style-type: none"> <li>• Creating a special favourable environment for doing business for foreign companies, considering the requirement to protect national manufacturers in certain segments of the domestic market, aimed at:               <ul style="list-style-type: none"> <li>○ Encouraging direct and venture foreign investment;</li> <li>○ Stimulating technology transfer with their possible processing and convergence with the national technologies;</li> <li>○ Stimulating the creation in the country the modern high-tech equipment production and technology-intensive end goods with a high-level of national materials, technologies, intermediate goods, software for the further re-export of manufactured products and equipment.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Various tax benefits (fixed assets, R&amp;D, payments to the State budget and social funds, etc.);</li> <li>• Activity subsidies, grants (R&amp;D, developing new goods, equipment, materials, software etc.);</li> <li>• Target grants and subsidies for technologies and R&amp;D development (refinement);</li> <li>• Providing national companies with access to foreign technologies and national technological capital;</li> <li>• Stimulating technological innovation in industry;</li> <li>• Direct state investments;</li> <li>• Access to loan capital (special regime, soft loans for a long term);</li> <li>• Stimulating demand, including through state regulation tools, public procurement, changes in depreciation policy, development of new consumption and quality standards.</li> </ul>

Source: compiled by the author

### **Risks and errors in the implementation of the state import substitution policy**

State policy orientation exclusively on replacing foreign technologies and products in the domestic market, as well as orientation only on own technologies, lack of interrelation between import substitution mechanisms and other economic and scientific-technological development tools carries significant risks for a developing country's national economy, including:

- Potential "technological degradation" of economic sectors;
- Retaliatory measures by other states to restrict access of goods, services and technologies, which are already competitive in the world market, to their domestic markets, which will lead to a reduction in exports and a decline in production;
- Uncontrolled growth of commodity prices, caused, on the one hand, by lower competition and, on the other hand, by high production costs at the initial development stage (total costs are always higher than the foreign competitors with modern technologies and an efficient production base, in their absence of economies of scale and due to the insufficient innovation level in the technologies used);
- Lower good quality, which will not provide value added for the consumer and, as a consequence, will lead to a further refusal to purchase domestic goods after restrictive measures have been lifted;
- Foreign investment outflow, which will not only affect the overall investment climate in the country, but also lead to restrictions on national producer access to modern advanced technologies. In turn, limited access to foreign technology will lead to a reduction in the possibility of using imitation foreign technology and innovation mechanisms, which will adversely affect state technological development and economic growth rates in the future. However, this risk is significant on condition of significant accumulated foreign investments in the economy, foreign companies' investments in the national industry in the relevant economic sectors;
- Diversion of significant state resources. If the economy is stagnating or shrinking, if revenues for the country's budget are falling, due to a drop in export, there are risks that other areas of state support for development will be underfunded. In this case, it is possible to talk about an ill-considered choice of priorities when deciding on the implementation of import substitution policy.

Based on international and Russian experience it seems possible to identify a number of problems and errors that are confronted by national governments when implementing import substitution policy:

- Inconsistency between the desired goals and the state's vision and the resources and opportunities available in the national economy. The limited capital and investment resources, the state system's inability to ensure resource concentration from all sources for priority sector development, technological and human capital development;
- The lack of measurable indicators for import substitution goals, interrelated and decomposed in the system of socio-economic, scientific and technological

development, innovation and sectoral development indicators;

- Too short a planning period for the import substitution processes. The lack of stability in the declared public policy;
- A one-sided state policy, providing for the national industry development only on an import substitution model, "without the aim" of further exports at subsequent stages;
- Lack of technological and market specialization in implementing import substitution policy - import substitution policy is implemented for all economic sectors simultaneously, which leads to falling into the "import substitution trap", there is no balance between the opportunities offered by globalization, and the desire to have a fully independent regional value-added chain;
- Limited human capital and the lack of interconnection of the import substitution policy with human capital development mechanisms for priority sectors;
- A weak domestic market, which does not allow national companies to obtain economies of scale and experience, and consequently significant revenues, which will not allow national companies to develop quickly and will significantly increase state expenditures;
- Orientation only on own technologies without transfer of foreign technologies and knowledge with the purpose of their further convergence with the national technological capital;
- The state simultaneously while implementing tools to support national producers does not pursue an aggressive policy to stimulate demand and ensure increased national expenditure for national goods and services in the domestic market, including through market price management for foreign and national goods and services, state regulation of industries that are consumers of import-substituted technologies and products, through changes in national standards;
- Orientation only on national product quality standards and technological standards. Lack of orientation to international quality standards and technological production and consumption standards will lead to the quality and the manufacturability of the products always being lower than their foreign counterparts, which, in turn, can later become a serious barrier to exports;
- The government uses a limited combination of restriction mechanisms and development mechanisms, the system does not provide for changes in the applied combinations in case of their insufficient efficiency (the effect of "lagging regulatory impacts"). The lack of interaction between import substitution mechanisms and other tools and mechanisms of economic and S&T development. The government does not assess the aggregate benefits and aggregate costs when choosing limiting tools and mechanisms of state regulation;
- The government does not ensure high profitability for national and foreign companies (for foreign companies that make decisions about real investments in the country, technology transfer "in exchange for

high profitability" and joint ventures with national companies);

- The public policy leads to the exiting of foreign companies from the market, which entails a decrease of the national product quality in the absence of competition and market aspiration at the import substitution stage to form monopolies or oligopolies, reducing foreign technology inflow into the national economy, technological stagnation or even the degradation of national production and technological system and increasing technological gap in comparison with foreign producers;

- The state does not seek to create transnational high-tech and innovative corporations and increase the number of small and medium innovative and high-tech companies;

- Elements of the national innovation system and scientific-educational system do not support the chosen technological and market specialization within the import substitution processes, do not ensure continuous production of new technologies and knowledge, their transfer to the business sector for commercialization. The educational system is still aimed at training and forming skills in the use of foreign products and solutions. That is, the import substitution effect and government support for the development of certain sectors will not be supported by the "demand of the future";

- Lack of inter-industry integration, support for the developing related industries.

### Conclusion

The study has shown that, on the one hand, import substitution policy entails many risks and problems, but on the other hand - with a pragmatic approach, its combination with support mechanisms for national producers, tools and other socio-economic and S&T national development models, import substitution policy can provide the country with more significant aggregate benefits than total costs.

The study showed that development models with import substitution and protectionism are integral elements of all basic strategies for long-term socio-economic development. Recent years, in which the U.S. launched a technology war against China and Russia, have shown how important and relevant the implementation of mechanisms related to protectionism and import substitution is. Such tools from the U.S. are not yet used against other Asian and European countries. However, it is worth thinking about what may happen when the economic policies and political interests of these countries in the context of the transition to a new systemic capital accumulation cycle will be contrary to the US interests?

In the near future the author plans to consider Russia's experience in the information and communication technology import substitution in the in the context of globalization and the fifth technological wave.

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# JURISPRUDENCE

## THE IMPACT OF THE COVID-19 PANDEMIC ON HUMAN TRAFFICKING SITUATION IN UKRAINE: NGOs' PERSPECTIVE

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### Abstract

In the light of COVID-19 pandemic international community raises concerns about its impact on the human trafficking situation worldwide. This paper seeks to address human trafficking situation in Ukraine during COVID-19 pandemic and examine the role, effectiveness and impact of NGOs that work in the field of human trafficking prevention and combating. We undertook this study as a part of our PhD research and aiming to evaluate current trends and approaches in combating of human trafficking via NGO's perspective. The aim of our research is to highlight NGOs' experience of working with human trafficking victims and provide recommendations for further preventative measures.

**Keywords:** human trafficking, NGO, crime prevention, COVID-19 impact, international organized crime, labour migration, cyber crime, civil society.

Human trafficking is considered to be one of the most shameful phenomenon of the XXI century. Modern society with its new technologies, new order of maintaining peace and prosperity is still unable to leave derogatory activity such as slavery and human abuse behind. Thousands of legislative acts, governmental and non-governmental institutions were created to face this problem but unfortunately it is still not enough. Every single country in the world is affected by this crime more or less. Ukraine is not an exception.

COVID-19 pandemic has changed our ways of life irrevocably. On one hand a great number of people got an opportunity to work from home, hence the risk of getting in trouble reduced, the value of the Internet and technology rose up giving more opportunities to people to make a living without leaving their safe homes and supportive family environment. On the other hand, abilities of governmental institutions and police forces became limited due to constant on and off lockdowns, number of non governmental organizations ceased to exist without proper financing and inability to communicate with human trafficking victims, however international organized crime adapted fast to the new circumstances and transferred its operations to the Internet significantly.

A lot of national and international researchers addressed COVID-19 related issues of human trafficking, mostly focusing on the consequences of the pandemic, inefficiency of police and governmental structures, lack of resources and diversion of the states' attention to the medical issues, but very few have researched how COVID-19 effected NGOs' that work in the field of human trafficking combating, prevention and rehabilitation of victims. Today we'd like to provide you with an insight into the real situation with human trafficking in Ukraine during COVID-19 pandemic via the prism of NGO's activities and share their experience and further recommendations to combat human trafficking in the COVID-19 and the post-COVID-19 environment.

Current research is based on the continuous and longstanding cooperation of the author with the WICC

(Women's Information Consultative Center) NGO dedicated to the prevention of human trafficking and rehabilitation of its victims and the Ukrainian Coalition of Non-Governmental Organizations for Combating Trafficking in Human Beings (hereinafter the Coalition). Presented material was collected during regular meetings with NGOs' specialists, victims, regulatory authorities and analysis of internal NGO's reports. International paradigm of the key international actors' activity in the field of combating of human trafficking was examined and compared with researcher's own findings.

Based on the researched data, the COVID-19 pandemic did not create fundamentally new ways and problems for the spread of human trafficking, but exacerbated existing and complicated the work of countering institutions, so the hidden shortcomings of the system became more apparent. Analysis of the activities of NGOs to combat human trafficking during the pandemic allows us to identify key trends, challenges and propose new adaptation mechanisms to combat the problem.

The loss of employment and economic insecurity as a result of COVID-19 will increase the number of vulnerable people desperately searching for work and economic opportunities in the foreseeable future. It is estimated that global hours worked could drop by 10.5 per cent in the second quarter of 2020, equivalent to 305 million full-time workers. Estimates suggest that COVID-19 will push 49 million people into extreme poverty in 2020 [7, p.7]. The same trend remains in 2021.

The global economic downturn and the sharp increase in unemployment in many parts of the world will likely increase cross-border trafficking in persons from countries experiencing the fastest and longest-lasting drops in employment [8, p.]. Inevitably increased labour migration will put additional pressure on the migration regulatory authorities and law enforcement institutions worldwide. This situation will create a demand for cheap workforce, hence the spike in human trafficking should be expected. As long as the Internet

is currently the most common way to search for employment additional measures need to be implemented to reduce cyber crimes and raise awareness about potentially suspicious job offers and risks associated with them.

Ukrainian NGOs drew our attention to a spike in 2020 in the number of complaints of victims of human trafficking. This is due to the rapid increase in the incidence of COVID-19 and the need to impose strict quarantine restrictions worldwide. In this regard, there was a mass return of workers and citizens of Ukraine from abroad, especially in January-March 2020. The figure increased by 39% compared to 2019 [2], and from May 2020 to January 2021 began to decline gradually. This is due to the closure of borders, restrictions on the mobility of citizens and the general shock of sudden changes in the world.

According to the Ukrainian Coalition of Public Organizations for Combating Trafficking in Human Beings almost 150 criminal cases in human trafficking were detected in Ukraine, more than 50 traffickers were identified, and more than 100 criminal proceedings were filed. Ukraine's positive results in the fight against human trafficking are reflected in the annual report of the US State Department, where Ukraine for the third year in a row is classified in the 2nd category (ie removed from the checklist of countries where human trafficking thrives)[1]. However, the current human trafficking situation might significantly influence previous achievements.

As a result of COVID-19, many services, helplines, clinics and shelters have already closed or become restricted. The United Nations Entity for Gender Equality and the Empowerment of Women (UN-Women) and the Office for Democratic Institutions and Human Rights conducted a specific survey to capture the experiences of survivors and trafficking services during COVID-19. In the survey of 397 organizations working on anti-trafficking initiatives across 102 countries, only 14 percent of respondents reported that national referral mechanisms for trafficking victims were fully operational. Trafficking survivors face significant negative impacts with regard to access to services, health and well-being, with approximately 70 per cent reporting negative impacts on psychological and financial well-being. 43 Survivors reported that the pandemic had created new difficulties in accessing services. Of 94 survivors who responded to the survey, over two thirds reported difficulties in accessing medical services, 60 per cent reported challenges in accessing employment services, 55 per cent reported challenges in accessing psychological health services and 53 per cent reported challenges in accessing legal support. COVID-19 has also had a negative impact on the capacity of survivors to meet basic needs, such as safe and comfortable accommodation, food and water [7, p.9-10].

Another significant factor is the release of victims of trafficking by exploiters due to the introduction of quarantine restrictions, increased risk of contracting the virus and the potential increase in the cost of personal care and medical care for the exploited. However, it was not the anxiety of the exploited people that worried the traffickers, but their own safety and the potential threat of contracting the virus. Although we are familiar with a number of "happy ending" cases, in general the pandemic has worsened the situation of the victims, leaving them even more isolated, at risk of infection,

reduced number of sources of assistance and reduced chances of being detected and released by law enforcement agencies.

The NGO Coalition identified 8 main factors of the COVID-19 impact on the human trafficking situation in Ukraine:

- closing of borders and introduction of quarantine restrictions in the countries of destination of Ukrainian labor migrants;
- deepening economic crisis and declining demand in the internal labor market;
- psychological pressure caused by prolonged isolation and fear of contracting the virus, combined with a general feeling of anxiety and uncertainty;
- introduction of strict quarantine restrictions in Ukraine;
- cancellation of mass events;
- closing or restricting access to public institutions;
- mandatory use of personal protective equipment;
- termination of transport links [2, p.3].

Our experience of working with human trafficking victims as a legal counsel for WICC let us summarise that the main reason of ending up in human trafficking situation is economical unstability. 98% of victims suffered from the lack of financial resources and inability to find employment that can sufficiently cover their needs. Most of the victims did not conduct a preliminary research on potential employers or conditions of work. None of the above have ever sought an advice of governmental or non-governmental organizations about employment abroad or considered a risk of human trafficking.

In 2020-2021 victims of human trafficking that have contacted WICC reported that COVID-19 restrictions caused loss of their jobs in Ukraine, forced them into credit obligations, increased expenses on medical supplies, prevented them from seeing family members. 6 out of 8 victims that we were working with in 2020-2021 found "employment" abroad via the internet, 2 persons were tricked into forced pornography via social media platforms. Hence, the Internet became the main tool for traffickers to find victims. Therefore, current approaches to human trafficking prevention and elimination need to be revised and redirected mainly to the digital space.

Analysis of the internal reports of the Coalition and WICC let us to the conclusion that the consequences of COVID-19 for the situation of human trafficking in Ukraine might be pretty severe. Most common of them are:

- increased number of complaints from trafficking victims;
- aggravation of the victims' need for social support, financial, medical and psychological assistance;
- limited capacity of NGOs to provide assistance to victims due to quarantine restrictions;
- limited opportunities for law enforcement agencies to carry out investigative and operational activity to identify crimes, criminals and victims, gather evidence, prepare cases for trial, which will result in the effectiveness reduction of the law enforcement system in combating human trafficking;
- increased xenophobia and discrimination in foreign and domestic labor markets;



- reduction in the number of criminal proceedings and court decisions against human traffickers;
- increased level of re-victimization;
- increased victimization of the general population due to the economic crisis;
- reduction of NGOs' funding as a result of the transfer of public funds to the medical sector;
- reduction of the number of private grants and programs of IOM, OSCE, UN due to the global economic challenges, complicated migration procedures and reduction of the demand for legal migrant workers, which increases the risk human trafficking.

The WICC NGO, with which the author constantly cooperates, reports that due to the COVID-19 pandemic, more and more people find themselves in a difficult economic situation and are forced to look for ways to earn a living, which leads to additional risks. The majority of victims (93%) among those identified by IOM in the first six months of 2021 were in labor exploitation. Three quarters of them are men. More than 80% of victims have technical or higher education. For the first time since IOM began providing reintegration support to victims of trafficking, Poland topped the list of countries where Ukrainians are most likely to be trafficked (38%), while the Russian Federation (36%) and Ukraine proper (18%) were second and third. places [5].

The Coalition analysis of the state of human trafficking in Ukraine in the context of the COVID-19 pandemic, proposes to take the following measures to minimize the risks arising from changes in migration policy and curtailment of official employment programs Ukrainians abroad:

- under the conditions of quarantine restrictions, it is necessary to continue to provide constant individual online and telephone counseling for persons who intend to go abroad for employment;
- to intensify and systematically disseminate information on the rules of safe employment, entry, stay and transit in the countries to which the largest migration flows are directed;
- organize informational campaigns on new fraudulent schemes and risks of human trafficking on social networks, on the web portals of public authorities and local governments, embassies and consulates, as well as on the websites of NGOs - members of the Coalition;
- to place clear and understandable information about the rules of stay, official employment, procedures for issuing a work visa, an open list of businesses that hire foreigners on the websites of embassies and consulates;
- to resume the practice of cooperation with the migration service and the state enterprise "Document", which will issue leaflets containing the rules of safe migration and contacts of hotlines when issuing foreign passports;
- to systematically work with social services in order to detect and prevent human trafficking [2, p.9].

According to the monitoring conducted by the Coalition for January 2019 - June 2020, there have been no changes in the regulatory framework for combating trafficking in human beings at the state, regional and district levels. Only in two oblasts, Ternopil and Cherkasy, specific anti-trafficking programs for the period up to 2020 are being implemented (expired), and no

new ones have been adopted. In other oblasts, anti-trafficking measures are equated to general social measures and included in regional integrated social programs. And only in four oblasts of Zhytomyr, Odesa, Poltava and Kherson the anti-trafficking components were included in the regional development programs.

One of the main components in the mechanism of human trafficking prevention is a proactive cooperation between governmental and non-governmental actors on the local/regional level and effective regional normative frame. WICC reports that the "Regional Program for the Prevention and Combating of Domestic Violence and Trafficking in Human Beings for 2021" (hereinafter the Program) in Zhytomyr Oblast has been adopted with most of the recommendations of the local NGOs on combating trafficking in human beings and is a kind of achievement in the situation with the COVID-19 pandemic and shifting the focus (especially human resources and funding) of all the government activities to the virus combating.

According to the Program, the problem of human trafficking and protection of victims of it is supposed to be solved by:

- improvement of the procedure of interaction of law enforcement bodies with other state authorities in terms of combating trafficking in human beings;
- ensuring the development and approval of criteria for the identification of victims of trafficking;
- carrying out preventive work aimed at preventing the fight against human trafficking, especially among internally displaced persons;
- further informational and educational activities to inform the public about the prevention of risks of human trafficking and the possibility of obtaining comprehensive assistance from the actors who carry out activities in the field of combating trafficking in human beings;
- strengthening coordination of work on detection and identification of victims of trafficking in human beings at all levels with a clear definition of the powers of coordination councils on combating trafficking in human beings and conducting multidisciplinary exercises at the regional and district levels on assistance to such persons;
- providing systematic training of specialists in the field of combating human trafficking;
- taking into account the new challenges of human trafficking that have arisen as a result of the armed conflict in eastern Ukraine;
- ensuring the proper application of legal norms regulating the criminal law counteraction to human trafficking.

During the implementation period of the Program it is provided:

- conducting large-scale information campaigns among the population, including internally displaced persons, to prevent the risks of being trafficked and receiving assistance;
- conducting trainings for employees of state institutions in contact with victims of trafficking in human beings on the issues of identification and interaction of subjects conducting measures in the field of combating trafficking in human beings;



- strengthening cooperation between social services and law enforcement agencies in combating trafficking in human beings and providing assistance to victims of trafficking in human beings;
- providing a range of services to victims of trafficking, facilitating their employment and other activities.

Even though the Program financing is approved for 2021 [4, p.9-11], no specific sum was finalized, which leaves uncertainty in the actual implementation of the proposed measures.

According to WICC as of November 2021, the following feedback was received on the effectiveness of the Program. It is reported that only 40% of the planned activities were carried out, most of the activities were limited to online conferences, round tables and counseling due to the periodic introduction of strict quarantine restrictions. A large-scale action "Walk for Freedom" was held with the participation of all participants of the National mechanism of cooperation of subjects carrying out functions in the area of counteraction to human trafficking (hereinafter the Mechanism).

However, in comparison with previous years, preventive activities have significantly intensified, more information is posted on the official websites of public authorities and local governments, regional and local media, an effective regional working group of the Mechanism has been established, and the coordination role of the Department of Labor and Social Affairs has increased [3, p.12].

The WICC notes that a number of working meetings have been held with representatives of the Mechanism on the scope and control over the provision of state-guaranteed free assistance to victims of trafficking: medical, psychological, legal, social, temporary residence for the period of rehabilitation. In particular, WICC experts focused on the effectiveness of rehabilitation of 8 victims of human trafficking, identified in 2020, receiving a range of services in Zhytomyr [6]. NGO activities include: seminars on combating trafficking in human beings in the oblast, meetings with state bodies, local governments and local communities, and training with representatives of local communities on mechanisms for identifying and referring victims of trafficking.

Our research led us the conclusion that COVID-19 seriously worsened human trafficking situation in Ukraine. Analysis of the collected information and experience working with anti-human trafficking NGOs let us propose further recommendation to influence current human trafficking situation and improve it.

#### Recommendations:

- simplification of procedures for international transportation of victims to countries of origin;
- increase funding for rehabilitation and reintegration measures and services for victims of trafficking;
- introduction of new programs and grants aimed at ensuring the economic stability of the victims;
- development of information-educational and training programs to ensure safe employment abroad and prevent re-victimization;

- promoting the creation of new jobs in the domestic labor market.
- strengthening cooperation of NGOs with state bodies, local self-government bodies, especially with territorial communities as the representative bodies closest to the population.

Based on the results of our research of anti-human trafficking NGOs' activity, their effectiveness, achievements and challenges we believe that the role of NGOs is much underestimated in Ukraine. Being a first point of contact for human trafficking victims NGOs have not just conquered people's trust and respect, but they possess unique and valuable data that can be used by government and international community to address human trafficking problem.

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# MATHEMATICAL SCIENCES

## RECOGNIZING RAMANUJAN'S HOUSE NUMBER PUZZLE

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### Abstract

Srinivasa Ramanujan, the most celebrated mathematician from India is remembered today by mathematical community for various reasons. His formulas and ideas were spell bounding and continue to inspire everyone to this day. There is an interesting puzzle that was posed by a friend which Ramanujan solved effortlessly. In this paper, I will explore the puzzle and explain how Ramanujan could have expressed the solution.

**Keywords:** House Number Puzzle, Pell's Equation, Square – Triangular Numbers, Continued Fraction, Convergents

### 1. Introduction

When Srinivasa Ramanujan was staying at England during the period from 1914 to 1919, Prasanta Chandra Mahalanobis an eminent Indian statistician became his close friend helping him to cope with English conditions. On one day when Mahalanobis visited Ramanujan in his room, he saw Ramanujan was busy in preparing lunch for them. Ramanujan welcomed Mahalanobis and asked to relax until he could complete his work. Suddenly Mahalanobis mentioned about a puzzle which appeared in Strand magazine the previous day. When Ramanujan heard the puzzle, he could provide the solution almost in a flash. In this paper, I will describe the puzzle in the historical context and provide the way of solving it as was guessed by Ramanujan.

### 2. Description of the Puzzle

The Strand Magazine, a local London publication in England, used to run a regular column called "Perplexities". In the December of 1914, this column featured a puzzle titled "Puzzles at a Village Inn", which an Indian student then in Cambridge, Prasanta Chandra Mahalanobis, brought to the attention of his friend and compatriot, Ramanujan.

The original version of the puzzle as appeared in December 1914 issue is the following:

"I was talking the other day," said William Rogers to the other villagers gathered around the inn fire, "to a gentleman about the place called Louvain, what the Germans have burnt down. He said he knew it well — used to visit a Belgian friend there.

He said the house of his friend was in a long street, numbered on this side one, two, three, and so on, and that all the numbers on one side of him added up exactly

$$1 + 2 + 3 + \dots + (m-1) = (m+1) + (m+2) + (m+3) + \dots + n \quad (1)$$

Now we can re-write (1) and simplify as show below

$$1 + 2 + 3 + \dots + (m-1) = [1 + 2 + 3 + \dots + m + (m+1) + (m+2) + (m+3) + \dots + n] - [1 + 2 + 3 + \dots + m]$$

$$\frac{m(m-1)}{2} = \frac{n(n+1)}{2} - \frac{m(m+1)}{2}$$

$$m^2 = \frac{n(n+1)}{2} \quad (2)$$

the same as all the numbers on the other side of him. Funny thing that! He said he knew there was more than fifty houses on that side of the street, but not so many as five hundred. I made mention of the matter to our parson, and he took a pencil and worked out the number of the house where the Belgian lived. I don't know how he done it."

Dr. P.C. Mahalanobis is supposed to have figured initial solution to the puzzle in a few minutes by a trial and error method but could not get the required solution. He then posed the puzzle to Ramanujan, who was cooking a meal when he heard this question. Much to his friend's surprise, who did not have to wait long, Ramanujan asked him to take down the solution. Amazed at the spontaneous answer, Mahalanobis asked him how he did it: Ramanujan says that as soon as he heard the problem, he knew that there should be a continued fraction; and that when he asked himself which one it was, the answer apparently just came to his mind!

So, what could be Ramanujan's solution? What *continued fraction* that he might have thought in his mind to provide the solution in a flash? In this paper, I will discuss the answers to these questions.

### 3. Mathematical Description of the Puzzle

Let us try to put the Strand Magazine house number puzzle mentioned above in mathematical perspective. Let  $n$  be the total number of houses on either side in the big street. Let the house number where Belgian lived be  $m$ . Then clearly  $m < n$ . Since the sum of house numbers before the Belgian's house on one side is equal to sum of all house numbers on the other side of the long street, we have

Equation (2) conveys that the fact that the solutions to the house number puzzle must be a square – triangular number. Ramanujan had worked out ways in his young days to solve such equations. Recognizing that the given puzzle reduces to the problem of determining square – triangular numbers, Ramanujan could recall his methods which ultimately led him to provide the solution in flash. The method that Ramanujan used to solve equation of the form (2) was using continued fractions, an idea in which he produced extra ordinary formulas.

$$\begin{aligned}
 3 - 2\sqrt{2} &= \frac{1}{3 + 2\sqrt{2}} = \frac{1}{6 - (3 - 2\sqrt{2})} = \frac{1}{6 - \frac{1}{6 - (3 - 2\sqrt{2})}} = \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - (3 - 2\sqrt{2})}}} \\
 &= \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - (3 - 2\sqrt{2})}}}} = \dots = \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - \dots}}}}}}
 \end{aligned}$$

He thus could obtain the following continued fraction

$$2\sqrt{2} = 3 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - \dots}}}}} \quad (4)$$

Considering the successive convergents of the continued fraction from (4), we obtain

$$\frac{3}{1}, 3 - \frac{1}{6} = \frac{17}{6}, 3 - \frac{1}{6 - \frac{1}{6}} = \frac{99}{35}, 3 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6}}} = \frac{577}{204}, 3 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6 - \frac{1}{6}}}} = \frac{3363}{1189}, \dots \quad (5)$$

The successive convergent values in (5) obtained from the continued fraction given by (4) will indeed provide the solution to the house number puzzle posed in Strand Magazine.

In particular, the house number of the Belgian namely  $m$  are given by denominators of each rational number and the numerators represent  $2n + 1$ , where  $n$  is the total number of houses on either side on the big street. Thus the solutions of the equation (2) are given by

$\frac{3}{1} \Rightarrow m = 1, 2n + 1 = 3 \Rightarrow m = 1, n = 1$  which is a trivial solution

$\frac{17}{6} \Rightarrow m = 6, 2n + 1 = 17 \Rightarrow m = 6, n = 8$  which forms the second solution to the puzzle. From

#### 4. Solution to the Puzzle

In this section, I will provide the solution to the house number puzzle, as Ramanujan could have arrived originally. For this, we consider the following calculations.

First, Ramanujan recognized that

$$(3 - 2\sqrt{2}) \times (3 + 2\sqrt{2}) = 1 \quad (3)$$

Using (3), he could manipulate the following computations

this, we note that the Belgian lived at house number 6 and there were totally 8 houses in the big street. We notice that,  $1 + 2 + 3 + 4 + 5 = 7 + 8$ . This initial solution was supposed to be known to P.C. Mahalanobis but unfortunately this cannot be the required value, since the puzzle clearly states that “there was more than fifty houses on that side of the street, but not so many as five hundred”. This means that the house number where Belgian lived must be somewhere between 50 and 500. We now consider the third convergent of the continued fraction from (5).

$$\frac{99}{35} \Rightarrow m = 35, 2n + 1 = 99 \Rightarrow m = 35, n = 49.$$

This means that the Belgian lived at house number 35 and there were totally 49 houses in the big street. Also,  $1 + 2 + \dots + 34 = 36 + 37 + \dots + 49$ . Again this is

not the required solution to house number puzzle because of the restriction that the house number of Belgian must be between 50 and 500.

Considering the next convergent from (5),  
 $\frac{577}{204} \Rightarrow m = 204, 2n + 1 = 577 \Rightarrow m = 204, n = 288$

. Now we note that house number of Belgian is 204 which lies between 50 and 500 and the total number of houses in the big street would be 288. We also note that  $1 + 2 + \dots + 203 = 205 + 206 + \dots + 288$ . Thus according to the conditions stated in the puzzle,  $m = 204, n = 288$  is the required solution.

We note that

$\frac{3363}{1189} \Rightarrow m = 1189, 2n + 1 = 3363 \Rightarrow m = 1189, n = 1681$

is the next possible solution to the house number puzzle. Continuing to extract more convergents from the continued fraction (4), we can get infinitely many solutions to the puzzle. Thus Ramanujan not only solved the problem with the required solution but his continued fraction paved way for generating infinitely many solutions at one stroke. This reflects the genius quality of Ramanujan and explains why he is considered to be such a precious mathematician.

### 5. Conclusion

In this paper, I have introduced the original version of the famous house number puzzle published in Strand Magazine during December 1914. It was often mentioned in several sources that Ramanujan obtained the solution in very quick time with the aid of a continued fraction. This can be possible, only because Ramanujan immediately recognized that the posed puzzle ul-

timately reduces to solving for square-triangular numbers as given in (2). He also knew from his notebook jottings that the continued fraction corresponding to generating square – triangular numbers was the one obtained in (4) in this paper. Hence, Ramanujan could have thought this continued fraction and obtained not just the required solution but also could generate infinitely many solutions. This single incident is more than enough to prove how quick Ramanujan's mind was in connecting mathematical concepts, which was the main reason for him to produce more than 3000 outstanding formulas in his short life span of about 32 years. I am quite excited to read Ramanujan's mind in the way probably he could have thought in solving this puzzle. I dedicate this paper to Ramanujan commemorating his 134<sup>th</sup> birth anniversary.

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# MEDICAL SCIENCES

## PREVENTION OF ISCHEMIC DISEASE IN THE ELDERLY

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## ПРОФИЛАКТИКА ИШЕМИЧЕСКОЙ БОЛЕЗНИ У ПОЖИЛЫХ

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### Abstract

Cardiovascular diseases (CVD) are the leading cause of death in the world.

The World Health Organization has concluded that approximately 31% of the population dies from these diseases [1, p. 38; 2, p. 9].

One of the risk factors for their development is old age. Thanks to advances in medicine and improved quality of life, life expectancy has increased, which has led to an increase in the number of elderly people [3, p. 158].

CVD in such patients have their own characteristics - a more severe course of the disease, complications, etc. According to statistics, with increasing age, mortality from these diseases increases, for people over 65 years of age, the cause of death in 50% of cases is complications of cardiac ischemic disease [4, p. 22].

In these circumstances, the importance of preventing cardiac ischemic disease is growing, which can significantly reduce the risk of developing the disease.

### Аннотация

Сердечно-сосудистые заболевания (ССЗ) занимают лидирующее место в мире, являясь одной из главных причин смертности. Всемирная организация здравоохранения пришла к выводу, что от данных заболеваний умирает приблизительно 31 % населения [1, с. 38; 2, с. 9]. К одному из факторов риска развития ССЗ относится пожилой возраст. Благодаря достижениям в медицине и улучшению качества жизни увеличилась продолжительность жизни, что стало причиной роста числа лиц пожилого возраста [3, с. 158]. ССЗ у подобных больных имеют свои особенности - более тяжелое течение болезни, осложнения и т.д. Согласно статистике с увеличением возраста растет смертность от данных заболеваний, для лиц старше 65 лет причина смерти в 50% случаев - осложнения ишемической болезни сердца [4, с. 22].

В данных обстоятельствах растет значение профилактики ИБС, которая способна значительно снизить риск развития заболевания.

**Keywords:** ischemic disease, old age, risk factors, prevention.

**Ключевые слова:** ишемическая болезнь, пожилой возраст, пожилые, факторы риска, профилактика.

**ВВЕДЕНИЕ.** В настоящее время наблюдается тенденция роста числа людей, страдающих кардиологическими заболеваниями. Среди них главное место занимает ишемическая болезнь сердца. Со-

гласно прогнозам ВОЗ, данное заболевание и инсульт к 2030 году станут основными причинами инвалидности и смертности по всему миру [5, с. 23; 6].

Ишемическая болезнь сердца представляет собой патологическое состояние, при котором кровоснабжение миокарда нарушается. Это происходит вследствие стеноза коронарных артерий [7, с. 11;8, с. 8].

С каждым годом качество жизни улучшается, кроме того, медицина достигла больших успехов, все это стало причиной увеличения продолжительности жизни, что повлияло на возрастную структуру населения, существенно возросло число людей пожилого возраста [9, с. 93-94]. Данная категория населения находится в группе риска развития ИБС. Значительно снизить вероятность появления заболевания может помочь профилактика. Профилактические мероприятия не только помогают предупредить заболевание, но и уменьшают риск развития осложнений.

**МАТЕРИАЛЫ И МЕТОДЫ.** При написании статьи использовался теоретический анализ и обобщение данных научных трудов отечественных и зарубежных ученых по профилактике ишемической болезни у пожилых.

**РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ.** Ишемическая болезнь сердца опасна тем, что ее симптомы не всегда ярко выражены. Однако существует перечень факторов риска развития данного заболевания. Итак, к ним относят:

- возраст. В группе риска находятся мужчины и женщины старше 45 и 55 лет соответственно;
- нарушение липидного обмена, в особенности если при этом происходит повышение холестерина;
- частое повышение артериального давления. При гипертензии риск развития заболевания увеличивается в 2 раза;
- курение. У пожилых людей при курении, в особенности чрезмерном, риск ИБС повышается в 1,4 раза;
- малоподвижный образ жизни.
- повышенная концентрация глюкозы в крови;
- предрасположенность к тромбообразованию;
- избыточный вес. Отрицательно сказывается на сердце и сосудах. Часто у лиц с лишним весом наблюдается тромбоз.
- стресс. Данный фактор в совокупности с другими факторами или заболеваниями может привести к самым тяжелым последствиям;
- генетическая предрасположенность [10, с. 81].

Профилактические мероприятия по предупреждению ИБС можно разделить на первичные и вторичные. В первом случае профилактика направлена на предупреждение появления факторов риска, а вторичная же борется с существующими, способными стать причиной обострения заболевания.

Первичная профилактика заключается в следующих мероприятиях:

- отказ от курения.
- активный образ жизни. Не менее 30 мин в день физических нагрузок, если нет медицинских противопоказаний.
- коррекция лишнего веса. Для этого рекомендуется уменьшить число калорий в рационе и увеличить число аэробных упражнений.

- отказ от алкоголя. Допустимое количество алкоголя для мужчин 20 г / сутки, для женщин 10 г / сутки, при отсутствии заболеваний печени.

- правильное питание: меньше насыщенных жиров, больше овощей и фруктов. Также рекомендовано снижение количества соли в рационе [11, с. 26; 12, с. 361]

Вторичная профилактика:

- избегание стресса. Нервное напряжение может стать причиной спазма коронарной артерии, не допустить это поможет методика самоконтроля.

- лечебная физкультура. Врач внимательно изучает вес пациента, его уровень текущей активности, возраст и другие факторы, после чего дает рекомендации пациенту по занятию спортом.

- лекарственные препараты. В некоторых случаях врач может назначить статины, антиаритмики и препараты, помогающие разжижать кровь [13, с. 26]. Одним из препаратов, часто назначаемых врачами при ИБС является аспирин, его принимают ежедневно при отсутствии противопоказаний [14, с. 86].

Также следует помнить, что людям старше 40 лет следует обязательно посещать кардиолога. Выявление заболевания на ранних стадиях существенно снижает риск развития осложнений. Также к кардиологу следует обращаться если не помогают выписанные лекарства, наблюдаются боли в сердце и т.д. В некоторых случаях для снижения риска осложнения ИБС может потребоваться помощь других специалистов- диетолога, эндокринолога.

**ЗАКЛЮЧЕНИЕ.** Ишемическая болезнь сердца – заболевание, развитие которого в большинстве случаев можно предотвратить. Несмотря на то, что болезнь чаще всего проявляется в среднем и старшем возрасте, привычки способные повлиять на здоровье начинают формироваться в детстве. Детям и подросткам следует объяснять какие последствия для их организма могут иметь вредные привычки. Очень важен пример родителей при этом, так как именно их поведение копируют дети. Здоровый образ жизни, правильное питание, занятие спортом исключают развитие большинства факторов риска ИБС [15, с. 35]. Профилактика ИБС направлена главным образом на борьбу с данными факторами, однако даже при наличии заболевания профилактические мероприятия могут помочь избежать осложнения течения болезни.

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#### ANALYSIS OF MEDICO-SOCIAL AND GENERAL CLINICAL PREDICTORS OF GENERALIZED PERIODONTITIS IN YOUNG PEOPLE WITH GLUTEN INTOLERANCE

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#### АНАЛИЗ МЕДИКО-СОЦИАЛЬНЫХ И ОБЩЕКЛИНИЧЕСКИХ ПРЕДИКТОРОВ ГЕНЕРАЛИЗОВАННОГО ПАРОДОНТИТА У МОЛОДЫХ ЛЮДЕЙ С НЕПЕРЕНОСИМОСТЬЮ ГЛЮТЕНА

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#### **Abstract**

Today, generalized periodontal disease is one of the most common dental diseases that can cause tooth loss in young people. Generalized periodontitis is one of the important medical and social problems of today. According to modern ideas of the etiopathogenesis of generalized periodontitis, this disease is multifactorial. Its progression and development depends on a number of factors. To date, there is a close relationship between the development of generalized periodontitis and systemic diseases

#### **Аннотация**

На сегодняшний день генерализованные заболевания пародонта являются одним из самых распространенных стоматологических заболеваний, что может стать причиной потери зубов у молодых людей. Генерализованный пародонтит является одной из важных медико-социальных проблем современности. Согласно современным представлениям этиопатогенеза генерализованного пародонтита, данное заболевание является мультифакторным. Прогрессирование и развитие которого зависит от ряда факторов. На сегодняшний день доказана тесная взаимосвязь развития генерализованного пародонтита с системными заболеваниями

**Keywords:** periodontal disease, coeliac, gluten intolerance without coeliac

**Ключевые слова:** пародонтоз, целиакия, непереносимость глютена без целиакии.

На сегодняшний день генерализованный пародонтит является одним из наиболее распространенных стоматологических заболеваний, которые могут вызвать потерю зубов у молодых людей [1]. Согласно ряду исследований, проведенных за последние десятилетия, удалось углубить знания и понимание патогенеза генерализованного пародонта, значительную роль в развитии и прогрессировании которых играет микробный фактор, состояние иммунитета и наличие сопутствующих патологий [2,3,4,5]. Целым рядом авторов доказана тесная взаимосвязь между генерализованным пародонтитом и заболеваниями желудочно-кишечного тракта [6,7]. Целиакия – аутоиммунное заболевание, которое поражает слизистую оболочку тонкой кишки при употреблении глютена генетически предрасположенными лицами и сопровождается образованием специфических аутоантител [8,9]. Непереносимость глютена без целиакии (НГБЦ) рассматривается как побочная реакция на применение глютена после исключения аллергического или аутоиммунного генеза [10,11].

Данный фрагмент исследования проводился в рамках НИР кафедры стоматологии «Научное обоснование ранней диагностики генерализованных заболеваний пародонта: хронического и обостренного течения» (№ государственной регистрации НИР 0118U100471). С целью определения медико-социальных факторов, способствующих развитию ГП у пациентов с различными формами непереносимости глютена, проанализирован ряд общемедицинских и социальных факторов. В обобщенном виде вышеуказанные элементы можно определить

как неспециализированный (медицинский, социальный и общеклинический) аспект программы скрининга.

Основой изучения факторов риска явилось комплексное исследование, включавшее следующие элементы: медицинские осмотры для выявления признаков генерализованного пародонтита с проведением рентгенологического исследования при наличии показаний для постановки заключительного диагноза и анкетирования для выявления прогностически значимых факторов риска формирования патологии.

Поскольку контрольная группа формировалась по принципу копи-пары, это позволило сформировать сравнительные ( $p > 0,05$ ) по числовым и половозрастным характеристикам группы. Результаты анализа приведены в таблице 3.1.

Несмотря на молодой возраст исследуемой группы, возрастной фактор является значимым для развития генерализованных поражений пародонта, частота которых возрастает в старших возрастных группах  $\chi^2 = 0,404$  (0,29-0,52)  $p = 0,0001$  в раз больше шансов развития генерализованного пародонтита по сравнению с более молодыми возрастными группами.

Полученные результаты свидетельствуют о том, что половой фактор не является статистически значимым для прогностической оценки генерализованных форм пародонтальной патологии ( $\chi^2 = 1,7$ ,  $p = 0,20$ ) на фоне НГ. Мужчины с непереносимостью глютена имеют практически те же шансы развития генерализованного поражения пародонта что и женщины (0,95 (0,6-1,2)), что, вероятно, связано с почти такой же частотой вредных привычек и других неблагоприятных факторов сегодня.

Таблица 3.1

**Прогностическая оценка медико-социальных факторов риска развития генерализованных форм пародонтита**

Параметры	Прогностическая эффективность, % (DI)	Коэффициент на илиотношение, (DI)	$\chi^2$	Оценка p
Курение табака	70,0 (66,8-73,0)	5,8 (4,3-7,7)	147,6	0,0001
Употребление алкоголя (3 и > раз в неделю)	63,7 (60,5-66,9)	3,1 (2,3-4,1)	68,7	0,0001
Возраст (> 30\до 30)	60,6 (55,3-64,6)	2,4 (1,8-3,1)	40,1	0,0001
Отягощенный наследственность	60,0 (56,7-63,2)	2,3 (1,7-3,0)	35,6	0,0001
Нарушения сна и пищевого поведения	59,2 (55,9-62,5)	2,1 (1,6-2,7)	30,6	0,0001
Стрессовые факторы	56,7 (53,4-60,0)	1,7 (1,3-2,2)	16,0	0,0001
Резус-фактор (+/-)	52,2 (48,9-55,3)	1,2 (0,9-1,3)	1,8	0,18
Производственные неблагоприятные факторы(работа с компьютером и сидячий образ жизни)	51,8 (47,6-54,3)	5,2 (1,7-15,3)	10,9	0,0009
Пол (мужской/женский)	48,3 (44,9-52,6)	0,95 (0,6-1,2)	1,7	0,20
Высшее образование	45,8 (43,2-49,6)	0,9 (0,6-1,1)	1,5	0,11

На достаточно высоком прогностическом уровне определяется фактор отягощенной наследственности – при наличии непереносимости глютена у родителей и близких родственников вероятность развития генерализованных форм пародонтита в молодом возрасте возрастает в 2,3 раза ( $p = 0,0001$ ).

Стрессовые факторы играют несколько меньшую роль, увеличивая риск в 1,7 раза ( $p = 0,0001$ ).

Влияние факторов окружающей среды в данном случае не может быть оценено из-за отсутствия индивидуального мониторинга состава и длительности факторов окружающей среды. Однако наличие профессиональных вредных факторов на производстве, которые являются более устойчивым



компонентом и встречаются в основном среди обследуемых профессий (работа с компьютером более 7-8 часов в сутки и сидячий образ жизни) статистически влияют на частоту развития генерализованного пародонтита ( $\chi^2=10,9$ ,  $p=0,0009$ ), увеличивая вероятность его развития в 5,2 раза.

Систематические расстройства пищевого поведения, особенно нарушения безглютеновой диеты, приводят этот фактор к одному из ведущих мест: увеличение шансов на 2,1 (1,6-2,7),  $\chi^2=30,6$ .

Рассмотренный уровень образования, ресурс-фактор является статистически незначимыми факторами для прогностических оценок риска генерализованных заболеваний пародонта у людей с непереносимостью глютена, в то время как такие факторы, как курение табака и употребление алкоголя, являются важными факторами риска. Частое употребление алкоголя (3 и более раз в неделю) увеличивает шансы развития патологии в 3,1 раза по отношению к группе с отсутствием или эпизодическим употреблением алкоголя ( $p=0,0001$ ).

Курение табака повышает шансы генерализованного патологического процесса в 5,8 раза ( $p=0,0001$ ). Но эта зависимость проявляется не у всех обследованных с этой вредной привычкой, а определяется интенсивностью курения табака – коэффициентом корреляции  $r=0,41$  (0,34-0,46). Ввиду этого мы провели анализ для определения порога непереносимости глютена (количество сигарет в сутки) на вероятность развития генерализованного пародонтита у лиц с непереносимостью глютена. Учитывая существующий риск генерализованного пародонтита при повышении интенсивности курения, мы провели анализ для определения критических уровней, которые являются пороговыми с точки зрения увеличения риска осложнений развития пародонтита на фоне непереносимости глютена. Оценка данной модели статистически значима при высоком коэффициенте  $AUC=0,84$  ( $p=0,001$ ).

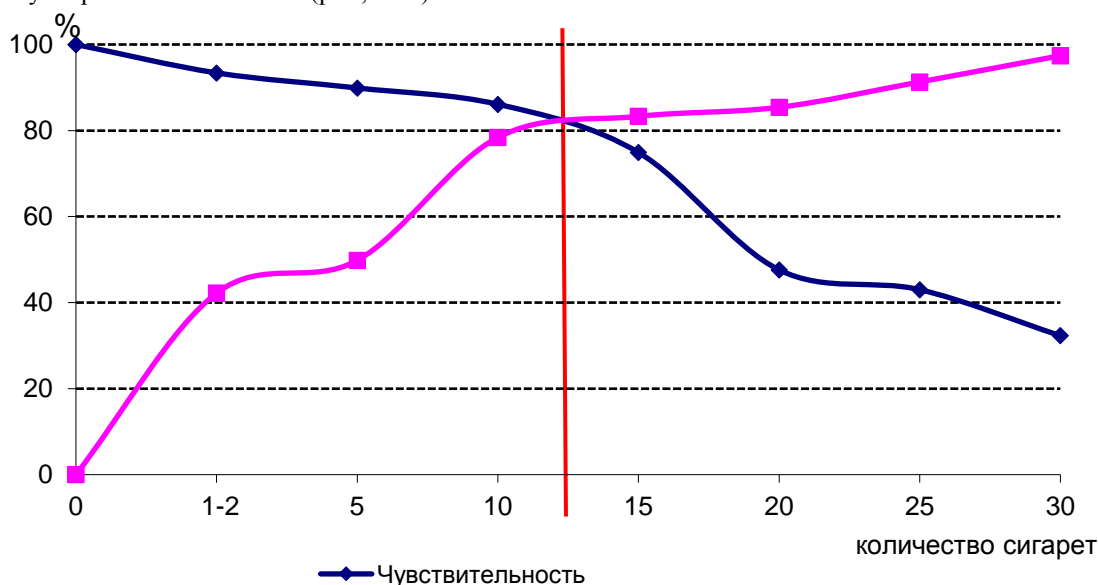


Рис. 1. Анализ прогностической эффективности путем оценки чувствительности и специфичности для исследуемых групп лиц с различной интенсивностью курения для прогнозирования риска развития генерализованного пародонтита на фоне непереносимости глютена.

Следовательно, критическим прогностическим уровнем для оценки риска генерализованного пародонтита у людей с непереносимостью глютена является интенсивность курения 10-15 сигарет в день.

Важным аспектом в прогнозе развития пародонтита, связанного с непереносимостью глютена, является общеклиническая оценка здоровья человека, где хроническая патология имеет первостепенное значение. Проведенный нами анализ по данному аспекту исследования приведен в таблице 3.2

В молодом возрасте частота выявления большинства хронических заболеваний незначительна,

поэтому по результатам анализа сделаны лишь статистически значимые оценки ( $p<0,05$ ). Установлено, что наиболее значимым фактором, наличие которого повышает вероятность развития генерализованных форм пародонтита на фоне непереносимости глютена, являются хронические заболевания ЖКТ – соотношение шансов  $OR=6,1$ ;  $p=0,0001$ , несколько меньшая прогностическая значимость выявляется при заболеваниях ЛОР-органов –  $OR=3,7$  (2,8-4,9) и патологии щитовидной железы –  $OR=2,6$  (2,0-4,3), церебро-сосудистая патология (АГ) также выявляет значительный прогностический потенциал –  $OR=1,8$  (1,3-2,3);  $p=0,0002$ .

Таблица 1

**Прогностическая оценка клинических факторов риска развития генерализованного пародонтита**

Параметры	Прогностическая эффективность, % (DI)	Соотношение шансов OR ,	$\chi^2$	Оценка p
Заболевания дыхательных путей	71,1 (68,0-74,1)	6,1 (4,5-8,1)	160,4	0,0001
Заболевания ЛОР-органов	65,8 (62,3-68,9)	3,7 (2,8-4,9)	89,7	0,0001
Патология щитовидной железы	61,9 (58,6-65,1)	2,6 (2,0-4,3)	51,0	0,0001
Цереброваскулярная патология (АГ)	57,2 (53,9-60,2)	1,8 (1,3-2,3)	18,7	0,0002

Определение перечня прогностически значимых медицинских, социальных и общеклинических факторов риска генерализованных заболеваний пародонта у лиц с непереносимостью глютена легло в основу разработки скрининговой модели, основанной на логистической регрессии. С помощью метода бинарной логистической регрессии можно исследовать зависимость дихотомических переменных (да/нет) от независимых переменных, представленных в виде любой шкалы.

В случае дихотомических признаков речь идет о событии, которое может произойти, а может и не произойти, и бинарная логистическая регрессия в этом случае вычисляет вероятность наступления события в зависимости от значений исследуемых факторов. Вероятность отнесения в группу, где бу-

дет развиваться генерализованное поражение пародонта – генерализованный пародонтит определяется по формуле:

$$p = e^{-z} / 1 + e^{-z},$$

где  $z = b_1 \cdot x_1 + b_2 \cdot x_2 + \dots + b_n \cdot x_n$  – стандартизированное уравнение регрессии,

$X_1$  – значение независимых переменных,

$b_1$  – коэффициенты, расчет которых является задачей бинарной логистической регрессии,

$e$  – экспонента (2,718282).

Если значение меньше 0,5 для  $p$ , то можно предположить, что событие (развитие генерализованного пародонтита на фоне непереносимости глютена) не произойдет. В противном случае предполагается событие с соответствующим уровнем вероятности ( $p$ ) (список факторов дается согласно рейтингу уровня значимости) (табл. 3.3).

Таблица 2.

**Распределение факторов риска развития общего пародонтита у пациентов с непереносимостью глютена согласно рейтингу уровня значимости**

Факторы, включенные в уравнение регрессии	Стандартизированные коэффициенты регрессии	Уровень значимости ( $p$ )
Заболевания дыхательных путей	0.253	0.0826
Заболевания ЛОР-органов	0.353	0.0464
Нарушения сна и пищевого поведения	0.252	0.0394
Отягощенная наследственность	0.214	0.0312
Патология щитовидной железы	0.184	0.0299
Стрессовые факторы	0.298	0.0199
Курение табака	0.368	0.0191
Употребление алкоголя (3 и > раз в неделю)	0.428	0.0099
Цереброваскулярная патология	0.235	0.0062
Производственные неблагоприятные факторы	0.125	0.0001
Возраст	0.094	0.0001

Результат оценки « $z$ » при проведении скрининговой оценки с использованием логистической регрессии для обследуемого пациента в возрасте 30 лет, наличие отягощенности наследственности, курение 1 пачки в день (20 сигарет) и наличие заболеваний пищеварительного тракта будет выглядеть так:

$$z = 0,094 \cdot 30 + 0,298 \cdot 1 + 0,235 \cdot 20 + 0,378 \cdot 1 = 0,820.$$

Подставив значение  $z$  в формуле  $p = e^{-z} / 1 + e^{-z}$ , мы получаем вероятность развития патологии  $p = 0,694$ .

Проведена оценка между фактически выявленными и прогнозируемыми случаями генерализованного пародонтита, которая отражает особенности прогностической силы модели, скрининговая адекватность модели и ее параметров, а также высокий уровень ассоциативного коэффициента Сомера ( $D=0,83$ ) свидетельствует о значительной прямой корреляции параметров модели с результатами

оценки вероятности развития генерализованного патологического процесса в тканях пародонта, развивающегося в условиях непереносимости глютена.

Следовательно, проведенным исследованием установлены медицинские, социальные и общеклинические факторы риска развития генерализованного пародонтита у лиц с непереносимостью глютена, на основании которых определяются критерии формирования групп высокого риска по данной патологии.

Полученные данные стали научной основой для дальнейших исследований по разработке стратегии профилактики генерализованного пародонтита, связанного с непереносимостью глютена, на популяционном уровне и разработке системы первичного скрининга данной патологии.

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## EVALUATION OF ANTIMICROBIAL-PEPTIDE EXPRESSION IN PATIENTS WITH GENERALISED PERIODONTITIS ASSOCIATED WITH GLUTEN INTOLERANCE

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### Abstract

Generalized periodontal disease is one of the most common dental diseases. It's known that generalized periodontitis is considered a multifactorial disease in the progression and development of which a number of factors play an important role. An important role in the progression of generalized periodontitis belongs to the microbial factor and the state of innate and acquired immunity. It should be noted the importance of the presence of concomitant somatic pathologies in the development of generalized disease

**Keywords:** gluten related disorder, coeliac, non celiac gluten sensitivity, antimicrobial peptide

### Introduction

Generalised periodontitis is one of the most common dental diseases. Thus, according to multicentre epidemiological studies, chronic generalised periodontitis affects more than 60% of young people [1,2]. It is well known that generalised periodontitis is a polyetiologic disease, the development and progression of which play a significant role in local and systemic health factors. According to modern pathogenesis paradigms, the generalised periodontitis microbiocenosis of the oral cavity and the formation of microbial biofilm is significant [3]. Periodontopathogenic microorganisms cause a cascade of immunopathological reactions in the oral cavity, particularly in the alveolar tissue. The acute inflammatory process that arises as a result of the action of microorganisms is a manifestation of a physiological protective reaction. As a result, there is a migration of

immune cells and a release of pro-inflammatory cytokines and hemokines [4]. More than 20 types of microorganisms are associated with periodontal diseases, but *Actinobacillus actinomycetemcomitans*, *Porphyromonas gingivalis*, *Tannerella forsythia* and *Treponema denticula* are the most associated with the development and progression of periodontitis. Due to the action of periodontopathogens in the gum, pH changes occur which significantly affects the composition of pathogen bioplates. In the process of colonisation, the co-adhesion (the fixation of microorganisms to microorganisms of the same type) and co-aggregation (the fixation of microorganisms of another species to already-fixed microorganisms) of microorganisms are noted.

One of the current pressing issues is the study of the components of congenital immunity – antimicrobial peptides. Numerous researchers believe that there is a

close relationship between the increase of antimicrobial peptides and the severity of chronic generalised periodontitis [6]. Antimicrobial peptides also mediate the relationship between congenital and acquired immunity. The two most studied types of antimicrobial peptides – defensins and cathelicidins – can disrupt the permeability of the membrane of fungi and viruses and cause inhibiting effects on the intracellular functions of the pathogenic organism [7, 8]. Defensins are basic antimicrobial cationic peptides that can impair the permeability membranes of fungi and viruses and cause an inhibitory effect on the intracellular functions of the pathogenic organism. The main source of antimicrobial peptides in the oral cavity is the epithelium of gum and neutrophils, although the salivary glands also secrete some defensins. In recent years, further research has been conducted on the role of antimicrobial peptides in maintaining oral homeostasis. To date, two main types of antimicrobial peptides are defined in the oral fluid: alpha human  $\alpha$ -defensins (HNPs) and beta-defensins (Human  $\beta$ -defensins (hBDs)) [8]. Antimicrobial peptides have a mediated effect on the stimulation of acquired immunity, contribute to the increase of IgA and IgG products and prevent the formation of a microbial film on the surface of the tooth. Many authors consider antimicrobial peptides markers of periodontitis development.

It should be noted that systemic factors play significant roles in the development and progression of generalised periodontal disease, among which are important comorbid pathologies [9]. According to multicentre epidemiological studies, the most common chronic pathology of the intestine is gluten enteropathy [10]. Due to the rapid increase in the number of diagnosed cases of coeliac disease and NCGS, the study of this type of pathology is important. It is known that coeliac disease is a chronic autoimmune disease, which occurs in genetically predisposed individuals due to the rejection of cereal derivatives that contain gluten and leads to atrophic changes in the mucous membrane of the small intestine [12]. The range of clinical manifestations of coeliac disease and NCGS is varied due to the atypical symptoms of the disease. Thus, in adulthood, patients have a variety of clinical manifestations. According to this literature, quite often in patients with coeliac and non-coeliac gluten sensitivity (NCGS), the manifestations in the oral cavity can also be noticed – namely, aphthosis stomatitis, chelates, defects of hard tissues of the tooth, periodontal disease, etc. [14, 15].

**Aim.** This paper aims to conduct a situational analysis of the expression of antimicrobial peptides of oral fluid in patients with gluten-related diseases and a spectrum of periodontopathogenic microorganisms.

**Materials and methods.** Accordingly, the aim of the research and the criteria of inclusion and exclusion were formed. The design of the study uses three investigated groups to investigate periodontitis of the initial first degree against the background of NCGS.

The first research group (group GP + C) included 30 patients with generalised periodontitis (initial, stage I) with a background of coeliac disease. The second group (group GP + NCGS) included 30 patients with generalised periodontitis in the initial stage I with a

background of NCGS. Group III included 30 patients with generalised periodontitis at the initial stage I with no concomitant pathology. The control group (C group) included 30 patients with clinically intact periodontium without signs of gluten intolerance.

The exclusion criteria were: patients under the age of 19 and over 35 years; pregnant and lactating patients; the presence of severe, decompensated concomitant pathologies of internal organs and systems (except gluten-related diseases); malignant formations; the presence of acute inflammatory diseases (acute bronchitis, pneumonia, etc.); alcohol or drug addiction; patients who, at the time of the study or in the last four weeks before the start of the study, took antibiotics or anti-inflammatories; and patients who refused to participate in the study.

The verification of the nosological form of enteropathy was performed by a gastroenterologist according to the generally accepted protocol. The oral-cavity examination and the investigation of periodontal status were carried out using a generally accepted unified protocol. Periodontal disease is used for the classification of N. F. Danylevsky. Studies of the microflora of periodontal pockets were performed by a polymerase chain reaction (PCR) in real-time. The material was collected in the morning on an empty stomach, without a prior performance of hygienic treatment of the oral cavity, with a sterile paper probe inserted into the area of the deepest periodontal pockets. The material obtained by the above method was placed in a sterile 1.5-ml Eppendorf tube. Genetic and molecular studies determined the presence of markers of the following periodontopathogenic microorganisms: *Prevotella intermedia*, *Bacteroides forsythus*, *Treponema denticula*, *Actinobacillus actinomycetem comitans*, and *Porphyromonas gingivalis*. Additionally, in the course of the study, analyses were performed on LL-37 (cathelicidins) and HNP 1-3 ( $\alpha$ -defensins) in the alveolar fluid using the immunoassay method on the RIDER ANTHOOS 2020 device and using the Kit Human LL-37 ELISA, Human HNP 1-2 ILISA (Hycult Biotech). The resulting material was diluted with a buffer solution 2000 times before the ELISA. Results were evaluated using spectrophotometry. According to the study design, we analysed the expression of antimicrobial peptides of oral fluid in 60 patients with generalised periodontitis against the background of coeliac and NCGS. The basis of this fragment is the assumption of probable correlations of antimicrobial-peptide expression with the detection of unconditionally pathogenic microflora – periodontopathogens and the decisive role of their presence in the pathogenesis development of generalised periodontitis and the antimicrobial oral peptides LL-37 (cathelicidins) and HNP 1-3 ( $\alpha$ -defensins). The control group comprised 30 clinically somatically healthy patients with generalised periodontitis of a similar age. IBM SPSS Statistics 20 software was used for statistical processing. Statistically reliable values were considered, where  $p = \text{the level} \leq 0.05$ .

**Results and discussion.** The research group were comparable in age (the average age was  $28.03 \pm 3.3$  years) and were of uniform gender distribution.

The results of the study of the level of expression of antimicrobial peptides HNP 1-3 ( $\alpha$ -defensin) and LL-37 (cathelicidin) in the mouth fluid of patients with

generalised periodontal diseases with a background of gluten intolerance are given in Table 1.

Table 1.

**The level of expression of antimicrobial peptide HNP 1-3 ( $\alpha$ -defensin) and LL-37 (cathelicidin) in the oral fluid of patients with generalised periodontal diseases with a background of gluten intolerance (ng/ml,  $M \pm m$ ,  $p \leq 0.05$ ).**

Indicator	Group			
	I n=30	II n=30	III n=30	C n=30
LL-37, ng/ml	0,66 $\pm$ 0,19	0,55 $\pm$ 0,18	0,81 $\pm$ 0,08	0,98 $\pm$ 0,03
HNP 1-3, ng/ml	5,87 $\pm$ 0,91	4,68 $\pm$ 0,28	6,14 $\pm$ 1,01	7,31 $\pm$ 0,18

In Group I patients, the level of HNP 1-3 ( $\alpha$ -defensin) in patients with initial and stage I of GP was 1748.6 $\pm$ 1037 ng/ml. In Group II patients, it was 0.55 $\pm$ 0.18 ng/ml, which is reliably lower than the indicators in Groups III (0.81 $\pm$ 0.08 ng/ml) and C (0.98 $\pm$ 0.03 ng/ml) ( $p \leq 0.05$ ). There was no reliable difference between the studied groups of persons with gluten intolerance ( $p \geq 0.05$ ).

The level of expression of the antimicrobial peptide HNP 1-3 ( $\alpha$ -defensin) in the oral fluid of Group I was 5,87 $\pm$ 0,91 ng/ml. In Group II, it was 4,68 $\pm$ 0,28 ng/ml; thus, no reliable discrepancies were found ( $p \geq 0.05$ ). At the same time, in Group III and the control group, levels of HNP 1-3 ( $\alpha$ -defensin) were 6.14 $\pm$ 1.01 ng/ml and 7.31 $\pm$ 0.1801 ng/ml, respectively, showing a reliable deviation of the study indicator in patients with gluten intolerance.

To understand the probable factor influencing the level of expression of antimicrobial peptides in the mouth fluid of patients with generalised periodontitis of the initial and first degree with a background of gluten intolerance, genetic-molecular studies of periodontopathogenic microorganisms were analysed in research-group patients. Frequently, periodontopathogens of the 'red complex' (according to the classification proposed by Socransky and Haffajee, 2005) were detected. Thus, these were the common findings in the periodontal pockets of patients with coeliac disease: *P. Gingivalis* was detected in 76% of cases, *Treponema denticula* was detected in 64% of cases and *Bacteroides forsythus* in 44% of patients. *P. Gingivalis* was found in 52% of patients with NCGS, *Treponema denticula* in 52% and *Bacteroides forsythus* in 48%. In the control group, *P. Gingivalis* was found in 72% of cases, *Treponema denticula* in 36%, and *Bacteroides forsythus* in 32%. *Prevotella intermedia*, which belongs to the 'orange complex', was found in 56% of patients with coeliac disease, in 44% of patients with NCGS, and in the control group in 32% of cases. The study found a strong correlation and relationship between the expression of the antimicrobial peptide LL-37 and *P. Gingivalis* ( $r=0.93$ ). During the study, a moderately pronounced correlation between the expression of HNP 1-3 and the content of periodontopathogenic microorganisms such as *P. gingivalis*, *T. forsythia* and *T. Denticola* ( $r=0.67$ ) was found.

## Conclusions

In the study of periodontal pocket microbiocenosis, a high degree of prevalence of periodontopathogenic microorganisms is noted, with a trend towards increasing their number with the development of GP in patients with gluten intolerance. However, when comparing the obtained data on the expression of this antimicrobial peptide, its level in patients with gluten-related diseases is somewhat lower compared to the control group. A correlative relationship between the expression of antimicrobial peptide LL-37 and *P. Gingivalis* was detected. The data obtained indicate the possibility of using the expression values of antimicrobial peptides as predictors of the development of GP in persons with gluten intolerance.

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### NSC631570 – A PROMISING CANCER CURE (SEMISYNTHETIC COMPOUND FROM THE ALKALOIDS OF *CHELIDONIUM MAJUS L.*)

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#### **Abstract**

NSC631570 (Ukraine) is an anticancer medical preparation on the basis of the extract of the plant *Chelidonium majus* L. and Thiotepa. Numerous pre-clinical and clinical studies seem to suggest that NSC631570 is pharmacologically active and clinically effective. It has curative effects on a range of cancer types. Thus, it has a big potential as an anticancer drug. The studies on this preparation started about 40 years ago. Meanwhile, numerous in-vitro studies, animal experiments and case reports have emerged. All these data suggest that NSC631570 has a strong anticancer activity in a wide range of cell lines.

**Keywords:** cancer, NSC631570, *Chelidonium Majus L.*, alkaloids, selective action, cancer cells, healthy cells, clinical study, research, cancer patients, autofluorescence, patient cases, results.

Malignant tumors belong to the greatest problems of our present. The number of cancer diseases with a fatal end is constantly increasing. According to the European Commission, every fourth person living in the European Union is dying of cancer (each year – 837,000 Europeans), and in the world about 4 million new cases of oncological diseases are recorded. This kind of the disease is diagnosed in all groups of population: men, women, elderly people and children. The most common among the oncological diseases are: cancer of lungs, skin, breast, gastrointestinal tract, prostate, ovaries, cervix of the uterus and thyroid gland. Among malignant tumors in children prevail leukemia, malignant tumors of the brain and lymphoma. ([www.unicef.org/ukraine/ukr/onko.pdf](http://www.unicef.org/ukraine/ukr/onko.pdf)). And every year, these statistics are getting worse.

With this illness all over the world doctors fight primarily with help of surgical operations but also with

radiation therapy and chemical preparations that exhaust the immune system and negatively affect healthy cells.

However, there is an alternative treatment of cancer diseases.

It is an effective anticancer preparation NSC631570 (Ukraine) developed in 1976 by Dr. Wassil Nowicky, an Austrian scientist of Ukrainian origin. This anticancer drug is based on the extract of the plant *Chelidonium majus* L. and Thiotepa. Numerous pre-clinical and clinical investigations seem to suggest that NSC631570 is pharmacologically active and clinically effective. This drug destroys only cancer cells, leaving healthy cells undamaged. This means that the NSC631570 has a selective effect, confirmed by a number of scientific studies.

**Cancer cells can be killed without harming healthy ones**

At the 13th International Congress for Chemotherapy in Vienna in August-September 1983, a new agent – thiophosphoric acid derivative of the alkaloids from celandine (NSC631570) was presented (35). The development of this preparation was the first and very important step on the way to the development of a preparation that kills only cancer cells, but not healthy ones.

The *in vitro* investigations confirmed a different oxygen consumption in normal liver cells and cancer cells: after an initial increase, the oxygen consumption in the tumor cells fell to zero. In normal liver cells, oxygen consumption normalized and they remained undamaged (6). This study provided initial indications that NSC631570, in contrast to its starting materials Thiotepe and celandine alkaloids, is actually only toxic to cancer cells and not to normal cells.

The second indication was achieved from clinical use, where NSC631570 caused no significant side effects (31). Besides, this preparation improved the general condition of patients and their immunological status, which was damaged as a result of the previous chemotherapy (10).

The third sign came from the study from the University of Miami (USA). In this study the therapeutic index of NSC631570 was calculated – 1250 (41). That's unusually high for a cancer drug. Therapeutic index (TI) is the ratio of the toxic dose to the therapeutic and reflects the safety of a drug. The therapeutic index of conventional cytostatic preparations, to which Thiotepe also belongs, is in the range 1.4-1.8 and therefore overdosing it can have fatal consequences. Because of the very high TI value of 1250, there is no risk of overdosing with the NSC631570.

After that many well-known research institutions, e.g. the National Cancer Institute (USA), EORTC, University of Miami (USA), Rochester University (USA), University of Tübingen (Germany) have started to test the preparation in order to better understand its unique properties and therapeutic potential. In contrast to conventional cytostatic preparations, NSC631570 has all 60 cancer cell lines tested, which represent 8 important human tumors, were killed (32), including those cell lines which were resistant to the then strongest known cytostatic agent Cisplatinum.

This has arisen even more interest in the scientific community. Leading scientists tested NSC631570, each group using the method available to them. Thanks to this variety of experiments, the fine mechanisms of the action of NSC631570 could be deciphered at different levels: at the cellular level with oxygen consumption, at the level of the chromosomes, cell organelles and molecules. These studies have brought extremely interesting results and not only confirmed the selective effect of NSC631570 several times, but also thoroughly eliminated any doubts that it only kills cancer cells but does not harm healthy cells in any way. This means that NSC631570 can differentiate between healthy and malignant cells – this property is not available to the other cancer drugs developed to date. Scientific interest in NSC631570 is growing and research continues (39; 47; 40; 13; 14; 15).

In the study on the effect of NSC631570 carried out at St. John's Memorial University (Newfoundland, Canada) under the direction of Prof. Andrejs Liepins, it was found that this preparation causes bimodal cancer cell death. (27).

In 1998, Anne Panzer's group (University of Pretoria, South Africa) demonstrated the selective effect of NSC631570 at the molecular level. The scientists investigated that NSC631570 is selectively toxic to cancer cells by causing a metaphase block. The normal cells were not affected (37).

In 2000, the Ulm researchers found that 10 µg / ml NSC631570 after 24 hours causes a significant accumulation of cancer cells in phase G2/ M. The authors showed that NSC631570 blocks pancreatic cancer cells in prophase by inhibiting tubulin polymerization (16). This work confirmed that NSC631570 does not affect normal cells.

Normal human fibroblasts were later used in their experiments by the scientists at the Eberhard-Karls-Universität Tübingen (Germany) and the Instituto Nacional de Cancerologia (Mexico City, Mexico) (9; 30). Neither research group found any toxic effects of NSC631570 on these normal cell lines.

In 2002, the scientists at the Eberhard Karls University of Tübingen (Germany) examined the effect of NSC 631570 alone or combined with radiation on cell survival, the modification of the cell cycle and the induction of apoptosis in the exponentially growing human tumor cell lines MDA-MB-231 (Breast cancer), PA-TU-8902 (pancreatic cancer), CCL-221 (colon cancer), U-138MG (glioblastoma), and in human skin fibroblasts HSF1, HSF2 and lung CCD32-LU. Without irradiation, NSC 631570 caused time- and dose-dependent cytotoxic effects, which were more pronounced on cancer cells than on normal cells. Combined with radiation, NSC 631570 caused increased cytotoxicity to colon cancer and glioblastoma cell lines, but not to the breast cancer and pancreatic cancer cell lines. Using flow cytometry, NSC 631570 was shown to modulate the toxic effects of radiation on these human cancer cell lines by inducing their accumulation in the G2/ M phase of the cell cycle. Its protective effect on normal human fibroblasts suggests that it can be used in combined radio- and chemotherapy (9).

These innovative openings have caused even greater interest in the scientific world:

Until now, to the NSC631570 their works have devoted more than 260 scientists from 24 countries in 60 universities and research institutes. Their work was described in more than 300 scientific publications, majority of which are available on the [www.pubmed.org](http://www.pubmed.org)

#### **First patients and clinical use**

Dr. Prof. J.-A. Musianowycz from Paris (France) in 1977 was the first who applied the NSC631570 in the treatment of incurable patients. In 1979 he presented 17 patients cases of clinical use. He prescribed to the NSC631570 to incurable cancer patients, primarily with breast and skin cancers. In some of them Prof. Musianowycz noted the decline in the growth of metastases, and in some even their disappearance. Patients put on weight and pain decreased. Prof. Musianowycz noted that this medicine deserves a deeper scientific

study and conduct of experiments. ([https://ukrin.com/docs/Musianowycz\\_1979.pdf](https://ukrin.com/docs/Musianowycz_1979.pdf)).

### Doctors reports

Here are some quotes from the reports of the treatment of cancer patients with NSC631570 (<https://www.ukrin.com/docs/erfahrungsberichte.pdf>).

In 1996 Dr. Alois Denk wrote: *"From a medical view it would be preferably to investigate the action of NSC631570 and tell the wider public about the relevant results."*

In the same 1996, Associate Professor of the University of Dr. Hubert Denz informed: *"In one case of pancreas cancer with the help of computer tomography, we established a temporary decrease of the tumor (...) Side effects were insignificant, namely there was a light feeling of heat, but in general the treatment was carried out simply great (...) It is worth to plan and to carry out appropriate clinical studies of the medicine, which will provide the standardized dosage, application form, duration of treatment and documentation with results. (...) First of all, it seems to be appropriate to use the NSC631570 in the treatment of pancreatic cancer, since by this time, the results after chemotherapy are very modest, and in the most weakened patients there are significant side effects. In addition, there are some more positive reports on the therapy with NSC631570 of this type of tumor."*

Dr. Siegfried Wagner: *"The preparation NSC631570 has been in my ordination for about 2 years. (...) So far, 40-50 patients with various tumor diseases and of different ages have been treated with it. Depending on the initial position of the disease process, success could be recorded in every case of the treatment with NSC631570, whereby the growth stagnation and remission-like conditions of the tumor were also recognizable. No undesirable side effects whatsoever were observed during treatment with NSC631570"*.

The Chief Doctor Hans-Jörg Klein: *"In the majority of my cases, NSC631570 is an adjunct therapy to chemotherapy and/ or radiation therapy. Particularly noticeable successes were achieved with it as monotherapy in around 10% of cases. In adenocarcinomas, for example, remission-like stages and considerable metastasis regressions were observed. (...) In all cases of NSC631570 therapy there was a significant improvement in the quality of life of cancer patients"*.

Dr. Uta Konstantopulos stated: *"One patient with an inoperable carcinoma of bile duct and metastases in the liver after a small surgical intervention (artificial outflow of bile) without further treatment in February 1996, was sent home. Since March 1996, we began to administer her NSC631570. The general condition of the patient is simply wonderful. (...) In some patients, I saw a definitely positive impact on the course of the disease in the progressive stage."*

Dr. Omar Abu-Dayeh informed: *"In my observations, I noticed that the preparation NSC631570 is really a significant help and a positive application to other types of treatment. Along with remissions, that we achieved, it should be noted that during and after treatment, patients feel well, and the quality of their life is significantly improved."*

Dr. Grazyna Nowicki: *"In my practice I applied NSC631570 for seven years. Most of the 15 patients who were treated personally by me, were recognized as incurably ill (...). First, it should be noted that after the first injections with the preparation in all these patients, an unexpected subjective and objective improvement of both physical and mental state was achieved, which I can not call the effect of placebo effect. They have improved sleep and appetite, facilitated pain, in connection with which in many cases, no strong analgesics were needed."*

### Phase I Clinical Study

The phase I clinical study was performed on 19 healthy volunteers on the out-patient basis. Beside general clinical condition, following parameters were evaluated: blood count, clinical chemistry, immune values, electrolytes, microelements, neopterin. NSC 631570 was administered intramuscularly or intravenously daily, on the alternate days or every third day at a daily dose of from 5 up to 50 mg for 7-40 days. In a special case, the medicine was administered during three years at a total dose of 3500 mg divided into several therapy courses. No significant changes in clinical status were revealed at the examination. In the case of intramuscular administration, volunteers reported local pain, sometimes sleepiness, increased thirst and polyuria. In some cases, a light non-significant increase of the body temperature and minor blood pressure decrease were observed. The authors concluded NSC 631570 at single doses of 5, 10, 20 and 50 mg were well tolerated, also at prolonged administration. (11)

### The Dose Finding Study (Phase II)

To find out the correct dosage for NSC 631570 a phase II clinical study was performed on 70 end stage cancer patients. NSC 631570 was administered intramuscularly or intravenously daily, on the alternate days, every third, every forth, or every fifth day. Single doses were 2.5, 5, 10, 15, 20, or 25 mg in ascending order (from 2.5 up to 25 mg), descending from 25 mg to 2.5 mg, or 5, 10, 15, 20 or 25 mg constantly. The duration of a therapy courses was 10-90 days. Breaks between courses varied from seven days up to three months. In all cases the therapy with NSC 631579 was well tolerated. In some patients the analgesics dosage could be reduced. The quality of life improved in the most cases. Subjective as well as objective symptoms and signs were observed like headache, dizziness, thirst, sweating, polyuria, fever (with the body temperature increase of 1-2 °C), and pain at the tumor and/or metastases area. Increased temperature at the tumor area was observed also. Temporary tumor swelling, increased heart beat rate and minor blood pressure decrease were observed as well. The intensity of such concomitants correlated with the response to the therapy. After full remission these concomitants were not anymore observed (31; 28).

In healthy volunteers, such concomitant events are observed not so extensively or not observed at all. It can be suggested they are triggered by the tumor degradation products. The intensity of these concomitants can be decreased with the detoxification measures.

### Phase III Clinical Trials

NSC631570 can cause the full regression of the



main tumor and also of metastases. In the treatment of advanced tumors NSC631570 can improve the quality of life and prolong survival. Many clinical studies have proved this, such as those of the work groups led by Prof. Beger in Germany and of Prof. Zemskov in Ukraine with pancreatic cancer (17; 64; 18; 19; 20; 21; 61), as well as groups led by Prof. Susak and Prof. Bondar in Ukraine with colon cancer (45, 62, 63, 5). Neoadjuvant (before surgery) use of NSC631570 can induce encapsulation of tumors as revealed the studies by the researchers of Grodno Medical University (Grodno, Belarus) in breast cancer (49; 8; 53; 50; 51; 52, 55, 58; 59; 34).

In an open study total 203 advanced cancer patients were treated with NSC 631570 and partially with local hyperthermia (37.4%) after all conventional treatment modalities had failed and the disease progressed or relapsed. Full remission was achieved in 41 cases (20.2%), partial remission – in 122 cases (60.1%). Seminoma and prostate cancer responded especially well with remission rate of more than 75% (1; 2.).

#### **Pancreatic carcinoma**

In a controlled randomized study by Prof. H. Beger et al. in the Ulm University Hospital, Germany, the therapy with NSC 631570 and Gemcitabine doubled the survival rate in the patients with inoperable advanced pancreatic cancer (17). The longest survival was 19 months in the group treated with gemcitabine alone, 26 months in the combined group, and in the NSC 631570 alone group two patients were alive after 28 months. NSC 631570 was well tolerated. The study authors consider further evaluation of NSC 631570 as justified whereas the quality of life of the patients improved (18).

#### *Adjuvant therapy in pancreas cancer: comparison of three studies*

Author	Neoptolemos	Kurosaki	Gansauge
Year	2001	2004	2007
Number of patients	238	16	30
Therapy	5-FU/FS	Gemcitabine	NSC 631570/ Gemcitabine
Relapse free survival	k. A.	16,8 Mo.	26 Mo.
Median survival	19,7 Mo.	20,4 Mo.	37,6 Mo.

Again, this publication supports the efficacy (and safety) of the use of NSC631570 as it demonstrates a considerable prolongation of survival compared to what is known from other clinical studies (21).

Other researcher confirmed the efficacy of NSC 631570 in pancreatic carcinoma (20; 24; 26), while the partial remission rate was as high as 85.7% in one study (3). The longest survival in palliative therapy was more than six years (64; 18).

Histological changes caused by the treatment with NSC 631570 in the pancreatic tumor and in the surrounding tissue were profoundly studied. NSC 631570 has been revealed to bring about the fibrotic and sclerotic transformation of the tumor. Perivascular sclerosis has also occurred (46).

#### **Colorectal cancer**

In a controlled randomized clinical study by the National Medical University (Kyiv, Ukraine) colon cancer patients were treated with NSC 631570 or with 5-fluorouracil and x-ray therapy. The survival rate after 21 months was 78.6% in the NSC 631570 group and

Patients were further observed after the conclusion of the study and it was noted that NSC631570 was well tolerated and could be administered without problem to all patients. NSC631570 brought about a significant increase in survival time in comparison to therapy with gemcitabine alone. Combination therapy with gemcitabine and NSC631570 showed no advantage over monotherapy with UKRAIN. The longest survival in the gemcitabine group was 19 months, 21 months in the Gemcitabine+NSC631570 group, and in the NSC631570 group a patient was still alive after 28 months. The authors concluded: 'As a result of this study we highly recommend the treatment of patients suffering from advanced pancreatic cancer with NSC631570 (19)

2007 the results of another clinical study by the same research team were published. This time the efficacy of the adjuvant therapy with NSC 631570 has been demonstrated in the patients with advanced pancreatic cancer after surgery. The patients were treated with a combination of NSC 631570 and Gemcitabine.

The median survival was 33.8 months and the 5-year survival rate was 23.3% which is clearly better than results reported in the earlier studies without NSC 631570, with the median survival of 20.1 months and the 5-year survival rate was 21% (<https://www.nejm.org/doi/full/10.1056/NEJMoa032295>). Moreover, NSC 631570 at therapeutic dose range has only minimal adverse effects, improves the quality of life of patients and can be administered also on out-patient basis. All these features distinguish this drug favorable compared to the standard cytostatic agents.

33.3% in the group treated with 5-FU and radiotherapy (45).

Within a randomized study in the Donezk Regional Cancer Center (Ukraine) rectal cancer patients received either high-dose radiotherapy and 5-FU before surgery, or the therapy with NSC 631570: one course before surgery (10 mg every second day up to 60 mg) and another course afterwards (up to 40 mg). During following 14 months, relapses occurred in six patients (25%) from the combined group and in 2 patients (8.3%) in the NSC 631570 group. Two year relapse rate was 33.3% (8 patients) in the combined group and 16.7% (4 patients) in the NSC 631570 group (112). Now, 11 years after this publication 18 from 24 patients (75%) in the NSC 631570 group are still alive.

#### **Prostate cancer**

The efficacy of NSC 631570 in prostate cancer has been confirmed in a controlled clinical study. In the study patients, all standard treatment modalities had been exhausted. The cancer relapsed and/or progressed and no therapy protocol was available. The patients

were treated with NSC 631570 and partially with local hyperthermia. Following results were achieved: full remission in 54 patients (73%), partial remission in 16

patients (22%). Only in 4 patients (5%) the therapy did not affect the course of the disease (4).

Total number of patients	Full remission	Partial remission	Disease progression
74	54	16	4
100%	73%	22%	5%

The good efficacy of NSC 631570 in prostate cancer has been confirmed in another study (57).

#### **Breast cancer**

In a controlled clinical study conducted at the University Grodno (Grodno, Belarus), after the therapy with NSC 631570 the hardening of the tumor, a slight increase in the tumor size (5-10%) and proliferation of connective tissues were observed. The tumors appeared harder and slightly enlarged after NSC 631570 therapy, and were easier to detect by ultrasound or radiological examination. Metastatic lymph nodes were also hardened and sclerotic (fibrous). Tumors and metastatic lymph nodes were clearly demarcated from healthy tissue and therefore easier to remove. Based on the results of this study the scientists from Grodno recommended the use of NSC 631570, at the higher dosage, in all breast cancer operations (7, 49, 8, 53, 55).

In a series of articles the researchers have studied the effect of NSC 631570 on various parameters in breast cancer patients (58, 59, 34, 60). Best results were achieved with higher dosage of NSC 631570. Almost every patient noted the improvement of the general well-being, sleep and appetite. During the surgery, the tumors as well as involved lymph nodes were presented sclerotic and well demarcated from the surrounding tissue. This alleviated the surgical removal of the tumor considerably (59). In the tumor tissue, increased concentration of the amino acid proline was revealed indicating augmented production of connective tissue that demarcates the tumor from surrounding tissue (34). NSC 631570 improved also the amino acid balance of patients (60).

#### **Bladder cancer**

In a study NSC 631570 caused full remission in three patients for six months (56, 54).

Biochemical evaluation revealed NSC 631570 had favorably affected the amino acid metabolism (33).

#### **Malignant melanoma**

The first publication on the using NSC 631570 in malignant melanoma describes the full remission in a patient with metastases to the lung (42).

A long lasting remission (more than 10 years without recurrence) has been observed in a patient with malignant nodular melanoma after the treatment with NSC 631570. At the beginning of the NSC 631570 therapy liver metastases were present and melanin was excreted with urine (22).

The effects of NSC 631570 alone and in combination with the pathogen associated molecules (PAM) on the cell cycle and apoptotic induction were compared in two melanoma cell lines MM-4 and MM-4M2 with different metastatic properties (cell division rate, hematogenous metastasizing, sensitivity to the TNF-induced apoptosis).

Apoptosis induction and cell viability were analyzed using trypan blue exclusion test, morphological

criteria, DNA gel electrophoresis, and flow cytometry. Cell cycle distribution of tumor cells was estimated by flow cytometry. The therapy with NSC 631570 induced apoptosis in both melanoma cell lines in a dose-dependent manner. The cell line with higher metastatic potential was more sensitive to NSC 631570. In the cell line with low metastatic potential, combined use of NSC 631570 and PAM induced apoptosis more effectively (39).

#### **Brain tumors**

NSC 631570 has been successfully used in the treatment of brain tumors (43);

44). In a review on the clinical studies with NSC 631570 performed so far the researchers from the Universities of Exeter & Plymouth suggested this agent to have potential as an anticancer drug (12).

#### **Malignant gynecologic tumors**

Earlier, there was a report on the successful using NSC 631570 in the treatment of ovarian cancer (29). Also in the tests of National Cancer Institute (Bethesda, Maryland, USA) NSC 631570 was toxic against all ovarian cancer cell lines tested (32) Other authors reported on good results in the therapy of cervical cancer (38, 25).

#### **Autofluorescence of NSC 631570 in the tumor area**

The selective effect of NSC 631570 on cancer cells has been confirmed due to its autofluorescence under UV light (36). First time this feature of NSC 631570 was presented 1983 at 13th International Congress of Chemotherapy in Vienna. It has been confirmed in this work NSC 631570 to selectively accumulate in cancer cells. The accumulation of NSC 631570 in cancer cells correlates with the efficacy of the drug. With the elimination of the preparation from the body the intensity of the fluorescence decreases also (35).

At this congress, the first reports on the successful using NSC 631570 in the treatment of the end-stage cancer patients were presented, where all standard therapy modalities had failed. Though poor prognosis, NSC 631570 brought about full remission in a part of the patients and some of those are still alive.

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# PHILOLOGICAL SCIENCES

## USING AUTHENTIC MATERIALS DURING A READING LESSON – CELTA CASE STUDY

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## ИСПОЛЬЗОВАНИЕ АУТЕНТИЧНЫХ МАТЕРИАЛОВ ДЛЯ ЧТЕНИЯ В ПРОЦЕССЕ ОБУЧЕНИЯ – ПРАКТИЧЕСКИЙ ПРИМЕР CELTA

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### Abstract

The following paper is aimed at explaining the need to use authentic materials in reading lessons designed for students with the level B1-B2. The topic of the authentic reading has been selected not only to practice language skills but also to bring cultural awareness on how to start a new life in the UK, taking into consideration the essential aspects and some legal peculiarities of how to be a good citizen. In this way a thorough analysis of how the reading lesson has been built. Additionally, in order to tailor the 90-minute lesson to the current learners' needs, appropriate receptive and productive skills tasks have been recommended.

### Аннотация

Данная работа нацелена на то, чтобы объяснить необходимость использования аутентичных материалов для чтения для обучения студентов с уровнем B1-B2. Тема чтения оригинальных текстов была выбрана не только для отработки языковых навыков, но и для того, чтобы привнести понимание культурных и правовых особенностей жизни в Великобритании. В представленной работе будет проведен детальный анализ того, как построен урок чтения, какие задания на развитие рецептивных и продуктивных навыков рекомендуется использовать, чтобы адаптировать 90-минутный урок к текущим потребностям учащихся.

**Keywords:** authentic reading, gist reading, intensive reading, productive skill task, open discussion feedback

**Ключевые слова:** чтение аутентичных текстов, чтение для понимания сути, интенсивное чтение, задание на развитие продуктивных навыков, обратная связь в процессе открытого обсуждения

The subject of the investigation is how the authentic material can be used in the reading lesson designed for an upper class (B1 - B2 level) to 'equip students to deal ultimately with the authentic language of the real world' [4, p. 67].

The first stage of the lesson is presented by a lead-in 'used by teachers at the beginning of a presentation to prepare students to learn and establish a communicative link between the learners and the information about to be presented [1, p. 240].' Topic-related pictures meet all requirements to draw students into the lesson and help students get a clear idea of what they are going to learn. Afterwards, it is suggested to narrow down the preliminary introductory discussion to exact bullet points presented in the reading section for anticipation reasons. Students look at the provided list of problems they might come across and compare them to those of their own. Then open discussion feedback takes place to elicit students' ideas and share their experiences.

Prior to the reading stage, pre-teaching of new vocabulary takes place. It helps students in recalling prior knowledge of terms they may already know or creates a foundation for them by introducing them to the new

words they will come across during the reading itself [8]. The pre-teaching of vocabulary will be conducted in an elicitation, context-setting manner, followed by numerous concept-checking questions to clarify all vocabulary units.

As the lesson aim is to focus on one of the language skills that is reading in our case, the PTV stage is followed by several receptive skills tasks. The first one is represented by a **gist reading** where students skim through the article to get a general idea of what it is about and whether their predictions were right or wrong. This type of general comprehension reading is 'a skill that involves absorbing only the main points of a text' [3, p. 167]. Students work in groups of 2 after they compare their answers with their peers and finally the teacher initiates a general feedback discussion.

The second receptive skill task for the article is reading for detail or **intensive reading**. Scrivener defines intensive reading as 'reading texts closely and carefully with the intention of gaining an understanding of as much detail as possible' [7, p. 188]. After reading the article for the first time the students start performing

a more detailed comprehension task which is about focusing on details of the article. Students need to identify which statement is true, false, or not given by finding the proof in the article to support their opinion. In order to increase the student talking time, they are again asked to compare their answers with the fellow students and finally bring it to open class discussion.

The final lesson stage is represented by a **productive skill task**. The teacher asks students to discuss

topic-related questions to personalize the topic and to work on speaking fluency. Additionally, this closing exercise can bring a meaningful end to the lesson and review the key vocabulary points of a lesson. This idea is supported by Phillips in his article 'Closure: The Fine Art of Making Learning Stick' where he notes that 'closure helps learners know what they learned, why they learned it, and how it can be useful' [6, p. 37].

Lesson plan "Top tips to get your new life in the UK off to a flying start"

Timing	Stage/activity	Rationale	Interaction
10 min	<b>Lead-in (part 1)</b> - Pictures ICQs	to share ideas, to elicit the general topic of the lesson	T-SS S-S SS-T
10 min	<b>Lead-in (part 2)</b> , ICQs  If you decide to start your new life in the UK, what problems can you come across/find, what do you have to think about? Make a list of it.	to anticipate the topic details, to share ideas	T-SS S-S SS-T
	<b>Paircheck</b>	to increase confidence	
	<b>Feedback</b>	to share information	
10 min	Look at the list of problems and things you have to come across in the UK. What do you know? Do you have any of them on your list? What can each point mean? Discuss them in small groups. ICQs		T-SS S-S SS-T
	<b>Paircheck</b>	to increase confidence	
	<b>Feedback</b>	to share information	
15 min	<b>PTV, CCQs</b> ( <i>to sort out, get off to a flying start, apply for sth., property, tenancy agreement, GP, driving licence, designated countries, bill, time-consuming, confusing, pricing package</i> )	to input unknown vocabulary, practice pronunciation	T-SS SS-T
5 min	<b>Reading for gist</b> , ICQs	to skim a text for the overall meaning, the core idea of the article, to check predictions	S S-S
10 min	<b>Paircheck</b> - Exchange the information with a partner from the other group.	to increase confidence	SS-SS
	<b>Feedback</b>	to share information	SS-T

Timing	Stage/activity	Rationale	Interaction
10 min	<b>Intensive reading</b> , ICQs Look at the sentences below, mark them as 'True', 'False' or 'Not given' relying on the information from the article. Find the proofs in the article.	to look for specific information to answer true/false/not give	S
	<b>Paircheck</b>	to increase confidence	S-S
15 min	<b>Discussion phase</b>	to exchange opinions, to share personal experience	SS-SS
	<b>Feedback</b>		S-T

Lesson worksheet:

**'Top tips to get your new life in the UK off to a flying start'**

**1. Talk to you partner.**

Discuss the pictures in your pairs.

What do you see in the pictures?

What is the topic of today's lesson?



**2. If you decide to start your new life in the UK, what problems can you come across/find, what do you have to think about? Make a list of it.**

**3. Look at the list of problems and things you have to come across in the UK. What do you know? Do you have any of them on your list? What can each point mean? Discuss them in small groups.**

- ☒ a place to live
- ☒ getting a job
- ☒ National Insurance Number (NINO)
- ☒ UK's social security system
- ☒ council tax
- ☒ council tax account
- ☒ GP
- ☒ medical care
- ☒ personal account

**4. Read the article quickly to find out if you were right in your predictions.**

Group A

**Top tips to get your new life in the UK off to a flying start**

The list of things to do when moving to the UK is a long one. From making sure that you have everything you need for your travel to finding a place to live and getting a job; there's a lot of stuff you need to consider and get ready before the big move.

However, there are some key things that you won't be able to sort out until you are in your new home. But



that is just as important and will help you get off to a flying start.

### Getting a National Insurance Number

A National Insurance Number (NINo) is part of the basic documentation you should have when living and working in the UK. It will help you ensure that all of the National Insurance contributions and taxes you pay are registered under your name. Your NINo will also be your personal reference number within the UK's social security system.

Getting a National Insurance Number can take a few weeks so you should apply for one as soon as you arrive in the UK. It is possible for you to start work before having your NINo, as long as you can prove that you have the right to work in the UK and let your employer know that you are waiting for it to arrive.

### Setting up a council tax account

You will need to pay council tax if you are an adult, are not in full-time education, and own your home. If you rent the property you live in you will need to check your tenancy agreement to find out who is responsible for paying council tax.

To set up a council tax account you should contact your local authority, who will help you get registered. They will also send you a council tax bill and advise how, when and how much you will need to pay.

### Group B

#### Registering with a GP

Registering with a GP is important to ensure that you receive medical care whenever you need it.

It is very common for people to register with a GP that's near to their home. However, you can choose any GP practice that best suits your needs.

The best way to register is by visiting the practice you've chosen and requesting a registration form there and then. Some GP practices may ask for proof of ID, especially if you are registering any children, so make sure to bring one with you.

#### Getting a Driving License

If you have a driving license that was issued in your native country, you might be able to use it to drive in the UK but only for a limited time. This applies mainly to people from outside the EU and other designated countries.

If you don't currently have a driving license you will need to pass both a theory and a practical driving test in order to be able to apply for one.

#### Opening a Personal Account

Once you start working and earning you will need a safe place to keep your money. That's why opening a personal account is a good idea. Having an account will also make paying your rent and bills much easier.

Opening an account with a high street bank can be difficult, time-consuming and expensive with all their paperwork, credit checks, and confusing pricing packages. But there are other options that can help you get a personal account quickly and easily, like Arro Early Access.

#### 5. Exchange the information with a partner from the other group.

#### 6. Look at the sentences below, mark them as 'True', 'False' or 'Not given' relying on the information from the article. Find the proofs in the article.

- It is easy to change the place of living, just be open to everything new.
- You can prepare yourself for a new life beforehand.
- You need to have a National Insurance Number to know how much taxes you have to pay.
- If you want, it is possible not to pay council tax.
- In case you have a health issue, your GP can solve this problem.
- All people in the UK should have driving license.
- It is better to pay your rent and bills by cash.

#### 7. Discussion.

1. Would you like to live in the UK? Why/Why not?
2. Are you a British citizen? What is it like to have this status?
3. How long have you been living in the UK?
4. What problems did you have when you arrived here?
5. Is it difficult to become a British citizen?
6. Have you ever experienced a cultural shock in Britain?
7. What procedures mentioned in the article have you come through?
8. Give advice to those who are planning to start his/her life in the UK.
9. What British holidays do you like?
10. What do you think of the British Queen?
11. Would you like to speak with a British accent?
12. Does your country have good relations with Britain?
13. What would you like to do and see in Britain on a three-week holiday?

#### Conclusion

The creation of the above presented lesson plan proves the fact that authentic materials can and should be used at different levels when mastering English. In this respect, a reading lesson may be organized in the following way. At the first stage of the lesson, a teacher should establish a communicative link between the learners and the information to be presented. Before the reading stage itself, the teacher should introduce new vocabulary that students may come across during the reading stage. This PTV (pre-teaching of vocabulary)

stage is followed by several receptive skills tasks, such as gist and intensive reading. The final lesson stage is represented by a productive skill task. Following the above mentioned steps may help students to both cope with an authentic reading and understand cultural aspects of the UK.

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### ANTONYMY OF ADVERBS IN THE EVEN LANGUAGE

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### АНТОНИМИЯ НАРЕЧИЙ В ЭВЕНСКОМ ЯЗЫКЕ

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### Abstract

The relevance of the research is connected with the insufficient study of the phenomenon of antonymy in the Even language, although there are separate articles and general remarks in a number of textbooks on this problem, most of them superficial in nature. Nevertheless, it should be noted that there is still no special monographic study devoted to the complex nature of antonyms in the Even language. The scientific novelty lies in the fact that the article for the first time examines the antonymous pairs of adverbial antonyms in the Even language, united by the same conceptual sphere. The aim of this research is to identify productive groups of synonymous adverbs; to determine the peculiarities of transferring semantic connotations by them and to establish the antonymic connection between emotional and expressive adverbs.

### Аннотация

Актуальность исследования связана с недостаточной изученностью явления антонимии в эвенском языке, хотя имеют место отдельные статьи и общие замечания в ряде учебников по этой проблеме, большинство своем, поверхностного характера. Тем не менее, следует заметить, что специального монографического исследования, посвященного сложной природе антонимов, в эвенском языке до сих пор нет. Научная новизна заключается в том, что в статье впервые рассматриваются антонимичные пары наречных антонимов в эвенском языке, объединённые одной понятийной сферой. Цель данного исследования – выявление продуктивных групп синонимических наречий; определение особенностей передачи ими смысловых оттенков, установление антонимической связи между эмоционально-экспрессивными наречиями.

**Keywords:** lexicology, even language, antithesis, antonymy, adverbs.

**Ключевые слова:** лексикология, эвенский язык, противоположность, антонимия, наречия.

Антонимия – это одна из сложнейших категорий в лексикологии. Этот интересный раздел науки, который непосредственно связан с познанием человека противоположных явлений реальной действительности. Противоположность существует в отражаемом нашим сознанием мире именно как существенное различие, которое можем быть выражено в языке особыми словами – антонимами. Изучение различных вопросов антонимии внесли Введенской Л.А. [2], Новикова Л.А. [5], Апресяна М.Р. [1], Миллера Е.Н. [3], Шанский Н.М. [8] и др.

Изучение проблемы антонимии по характеру противоположности в английском языкознании отражено в трудах целого ряда ученых, таких как Лайонз Д. [12], Круз Д.А. [9], Джонс С., Липка Л. [10], Мерфи М. [13], А. Лехер А. [11] и др.

По мнению Введенской Л.А. «образование антонимических отношений между словами парадигмы зависит от ряда факторов: во-первых, от характера смысловых различий, заключенных в словах каждого ряда; во-вторых, от словообразовательной структуры соотносимых слов; в-третьих, от стилистической характеристики; в-четвертых, от дистрибуции слов с соотносительно противоположными значениями и, наконец, от объема синонимических рядов» [2, с.22-23].

В эвенском языке в антонимические отношения могут вступать и наречия, хотя и не все наречия имеют антонимичные пары. Антонимичными бывают лишь те наречия, которые дают качественную обстоятельственную характеристику действия. Определительные наречия выражают качество действия или состояния, различные их свойства или признак признака. Они вносят в их значения новые добавочные признаки или же выражают качественную характеристику в различных оттенках действия.

Наречия не имеют форм словоизменения, то есть они не изменяются ни по лицам, ни по числам, ни по падежам. Наречия служат различными обстоятельствами, примыкая к глаголу, причастию, деепричастию, отглагольному существительному, прилагательному, иногда к самим наречиям [4, с.186].

Наречия, как и прилагательные, имеют антонимические пары: *бадикар* 'утром' ~ *хисэчин* 'вечером'; *инэң* 'днем' ~ *долба* 'ночью'; *тек* 'теперь' ~ *тадук* 'потом'; *элэ* 'здесь' ~ *тала* 'там' и т.д.

Антонимичные пары наречий в зависимости от их лексических значений подразделяются на

подгруппы: а) антонимы, обозначающие время и способ действия; б) антонимы, обозначающие место и направления действия; в) антонимы, обозначающие количество и меры, способ состояния совершения действия; г) различного рода психологические и физические характеристики человека и его состояние.

а) антонимы, обозначающие время и способ действия. Наречие образа действия указывают на качественный признак глагола: *аич* 'хорошо' ~ *кэнелич* 'плохо'; *игэч* 'громко' ~ *тивсэнэ* 'тихо'; *энтэкэе* 'изо всех сил' ~ *энтукун* 'чуть-чуть'; *энтукукэн* 'медленно' ~ *хинмач* 'быстро'; *тэрэкэлди* 'одинаково' ~ *онтаканыч* 'по-разному'; *амалтач* 'последовательно' ~ *таваски-авуски* 'беспорядочно'; *курэнэ* 'нарочно' ~ *хотарам* 'нечаянно'; *халгань* 'пешком' ~ *бабудай* 'верхом'; *далила* 'рядом' ~ *горла* 'далеко'; *таваски* 'наизнанку' ~ *дойдади* 'лицевым'; *одяпки* 'вкось' ~ *нунэч* 'прямо'; *бөкчэпки* 'ничком' ~ *итий ойдэтки* 'навзничь'; *небатич* 'набело' ~ *хакаринь* 'начерно'; *көчикэтэлди* 'помаленьку' ~ *эгдетылди* 'побольше'; *аич* 'безупречно' ~ *будули* 'шероховатый'; *хатарсиду* 'впотмах' ~ *нэринду* 'при свете'; *эрэв инэңу* 'сегодня' ~ *тинив* 'вчера'; *бадикар* 'утром' ~ *хисэчин* 'вечером'; *түгэниду* 'зимой' ~ *дюганиду* 'летом'; *тек* 'сейчас' ~ *амарла* 'потом'; *хисэчиклэн* 'допоздна' ~ *бадик* 'спозаранку'; *укал* уже ~ *унэт* еще и т.д.

б) антонимы, обозначающие место и направления действия. Наречия места обозначает место действия, например: *эртэки* 'сюда' ~ *тартаки* 'туда'; *ангидала* 'направо' ~ *дэвынгидэтки* 'налево'; *амаски* 'назад' ~ *дюлэски* 'вперед'; *өгэски* 'вверх' ~ *хэссэки* 'вниз'; *дэски* 'вверх по склону' ~ *нески* 'вниз по склону'; *холаки* 'вверх по реке' ~ *эки* 'вниз по реке'; *төлэски* 'на улицу' ~ *доски* 'внутри'; *гортаки* 'далеко' ~ *далитки* 'близко'; *амаргиг* 'сзади' ~ *дюлгич* 'спереди'; *өгич* 'сверху' ~ *хэргич* 'снизу'; *амаргич* 'сзади' ~ *дюлин* 'впереди'; *тэгэлэ* 'далеко' ~ *далила* 'близко' и т.д.

в) антонимы, обозначающие количество и меры, способ состояния совершения действия. Наречия меры и степени выражают интенсивность действия. Они близки к качественным наречиям,

например: *эюмкунь* 'легко' ~ *хилусэч* 'трудно'; *энтукун* 'тихо' ~ *уруня* 'шумно'; *кэнели* 'плохо' – *аич* 'хорошо'; *хадун* 'редко' ~ *инэнтэнь* 'часто'; *эгдепчи* 'крупно' ~ *көчүкэнди* 'мелко'; *нонамди* 'длинно' ~ *урумкун* 'коротко'; *аран - аран* 'эле-эле' ~ *хинмач* 'запросто'; *хоч* 'очень' ~ *энтукун* 'немножко'; *тачин-та* 'весьма' ~ *эсни-дэ хавра* 'незначительно'; *тэндун* 'совсем' ~ *эснидэ тачи-кан* 'совсем не'; *төли* 'чересчур' ~ *абал* 'недостаточно'; крайне, *дагрит* 'чуть-чуть' ~ *хояв* 'много' и т.д.

г) различного рода психологические и физические характеристики человека и его состояние, например: весело грустно; весело скучно; радостно горестно; грубо вежливо; грубо нежно; сильно слабо; умно глупо, гордо стыдливо и др.

Итак, антонимы-наречия одинаково характеризуются по семантике, как в эвенском, так и в русском языках. В данной статье рассмотрены разнокорневые антонимы на примере наречий, в эвенском языке разнокорневая антонимия, как замечено, пронизывает важнейшие лексико-грамматические классы слов. Вокруг подобных наречных образований группируется огромное количество антонимов. Все это является живым источником пополнения и тем самым обогащения лексического состава эвенского языка. В данной статье подверглись анализу лишь наиболее типичные и продуктивные наречные антонимы.

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# PHYSICAL SCIENCES

## EXPERIMENTAL REFUTATIONS OF THE SRT VERSION contained IN PHYSICS TEXTBOOKS AND CONFIRMATIONS OF THE TRUTH OF ITS ALTERNATIVE VERSION<sup>1</sup>

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### Abstract

The article presents experimental proofs<sup>2</sup> of falsity of the generally accepted version of the SRT studied in physics textbooks and truth of its alternative version. It is shown that there would be no radio engineering, electrical engineering, Ohm's law in Steinmetz's interpretation or physical phenomenon of resonance, we would neither hear bell ringing or piano music, as well as no tsunami or Indian summer or other things would ever exist, if the generally accepted version of the SRT were correct. Even children's swing wouldn't sway after being pushed by parents. Therefore, it is concluded that the sections of physics textbooks related to relativistic physics, astronomy and astrophysics require correction.

**Keywords:** Imaginary numbers; Special theory of relativity; Ohm's law; Resonance; Transient processes; Dark matter; Dark energy; Invisible universes; Multiverse; Portals; Anomalous zones.

### 1. Introduction

The relativistic formulas given in the version of the special theory of relativity (SRT) presented for study in physics textbooks are known to be its main scientific result. However, in cases a physical body moves at superluminal speed, the formulas take on imaginary values, physical sense of which could not be explained by authors of the SRT. And this is not surprising, since no one has known so far how to explain physical sense of imaginary numbers discovered 400 years before creation of the SRT. Indeed, everyone knows what, for example, 3 kg, 2 sec or 7 km is, but no one, including even physicists, knows what 3 kg, 2 sec or 7 km, where  $i$ , is. Actually no one needs such knowledge in our everyday human life. This knowledge is useless even when solving quadratic equations at school algebra lessons.

However, authors of the SRT really needed that knowledge, as they had to completely explain relativistic formulas, the result obtained in this theory. Otherwise, no one would have needed a theory, which couldn't be explained even by its authors. And the solution to this issue was found. It turned out to be elementary simple and seemingly obvious. It is as follows: if results of any measurements are never expressed by imaginary numbers, then imaginary numbers doesn't exist.

And this was the concern of mathematicians, not physicists, that mathematicians invented some operational calculus and some theory of functions of a complex variable. Mathematicians didn't mind. But they didn't even need to know physical sense of imaginary numbers. This is how the postulate (that is, an unproven assumption), called the principle of light speed non-exceedance, appeared in the SRT.

Nevertheless, there remained some doubts about the truth of the principle of light speed non-exceedance due to the lack of its proof and/or experimental validation.

In particular, the doubts were raised by the discovery of Cherenkov radiation, emitted when charged particles are moving through a transparent medium faster than the speed of light in that medium [1]. In 1958, its authors Pavel Alekseevich Cherenkov, Igor Evgenievich Tamm and Ilya Mikhailovich Frank even received the Nobel Prize for their discovery. However, later confidence in the SRT was restored by specifying that the principle of light speed non-exceedance implies movement of a physical body only in a vacuum.

In 2011, the principle of light speed non-exceedance was just about refuted again. This time it was OPERA experiment [2] at the Large Hadron Collider. But six months later the OPERA experiment was refuted by the ICARUS experiment [3], which, however, neither confirmed nor refuted the principle of light speed non-exceedance. It only revealed some errors in the OPERA experiment and demonstrated how extremely complex the experiment was. Thus, it was shown that the issue was very difficult to solve and therefore there were doubts about whether it needed to be solved at all.

### 2. Experimental proofs of falsity of the version of the SRT presented for study in physics textbooks

Around the same time, in 2008-2010, there were publications about the results of radio engineering experiments [4]-[8] that successfully proved physical reality of imaginary numbers and therefore made the question of truth of the principle of light speed non-exceedance and the OPERA experiment unnecessary.

<sup>1</sup> This is reprint of the article "Antonov A.A. Experimental proofs of falsity of the version of the special theory of relativity presented for study in physics textbooks and truth of its alternative version. 80 International scientific conference of Eurasian Scientific Association "Development of science and education in the context of global instability". Moscow. ESA. 2021. 8-17. (in Russian) <https://esa-conference.ru/wp-content/uploads/2021/esa-october-2021-part1.pdf>

<sup>2</sup> In the Thirty Years' War Cardinal Richelieu, prompted by similar considerations, ordered to inscribe upon cannons the following text: "Ultima ratio regum". And the last argument of scientists is experiments.

Since existence of multiplicity of sciences is explained only by limited intellectual capacity of people, then different sciences should not refute each other. After all, Nature is integral. Therefore, Science is also integral. And mathematics is the single universal language of all exact sciences. Thus, correct mathematical interpretation of radio engineering and any other experiments is indisputably convincing for all other exact sciences, including physics. Norbert Wiener wrote in this regard: "Important work is sometimes delayed by the unavailability in one field of results that may have already become classical in the next field".

However, since the principle of physical reality of imaginary numbers proved by radio engineering experiments [4]-[20] in physics refuted the principle of light speed non-exceedance and thereby refuted the generally accepted version of the SRT [21]-[23], physical community wasn't satisfied with this result. And therefore, students have still studied an outdated and erroneous version of the SRT [24]-[33] presented in physics textbooks and based on the refuted principle of light speed non-exceedance.

In order to substantiate this statement and to gain the moral right to propose replacing the erroneous version of the SRT built on the postulates in physics textbooks with the alternative version confirmed experimentally, let's give a description of the experiments.

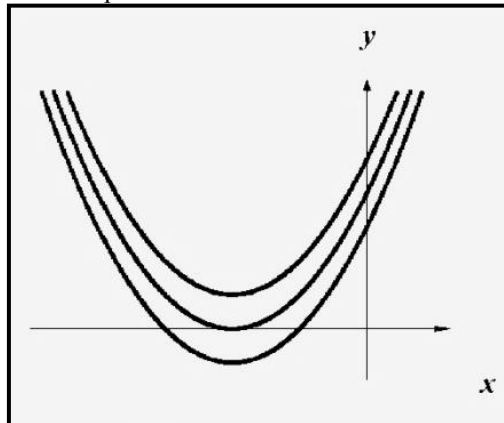


Fig. 1. Graphical solution to the equation (2) on the set of real numbers corresponding to the intersection points of the line  $y=0$  and the parabola  $y=ax^2+bx+c$

Analysis of transient processes in linear LCR-circuits allowed solving this issue in the following way. Processes occurring in the electric circuits are known to be described by linear differential equations usually of not higher than the second order. Their solution contains two components

$$y(t) = y(t)_{\text{forc}} + y(t)_{\text{free}} \quad (1)$$

where  $y(t)_{\text{forc}}$  is the forced component of response (or output signal);

$y(t)_{\text{free}}$  is its free (or transient) component;

$t$  is the time.

In this case, the transient component  $y(t)_{\text{free}}$  that is of interest to us is found as a result of solving an algebraic characteristic equation of the same order (for example, second) as the original differential equation

## 2.1. Proof of physical reality of imaginary numbers as a result of study of transient processes in linear electric circuit's proofs of falsity of the version of the SRT presented for study in physics textbooks

Since power is the energy derivative with respect to time, energy stored in inductors and capacitors cannot change instantly in electric LCR circuits, when changing their operating mode (for example, switching them). Consequently, infinitely large power that actually doesn't exist might correspond to an instantaneous change in energy. And therefore, transient processes always arise in such electric circuits, if no special measures are taken to suppress them. These processes are usually regarded as unwanted. And therefore, ways of suppressing rather than using them are studied.

However, studying transient processes in this article, we shall try to solve a very important scientific issue – to find out whether the above-mentioned version of the SRT implying that imaginary numbers are not physically real is true. That is, we shall try to solve a mathematical issue – to prove or refute physical reality of imaginary numbers – that couldn't be solved for 500 years, by radio engineering experiments. This physics issue turned out to be so important that the Large Hadron Collider was even used in the OPERA experiment to solve it. But this proved a failure.

$$ax^2 + bx + c = 0 \quad (2)$$

where  $x$  is the additional variable that is called a complex frequency in radio engineering, if it is actually a complex number.

And then, depending on the result of solving the equation (2), the function  $y(t)_{\text{free}}$  corresponding to this solution shall be found.

In algebra, solutions to the equation (2) can be on the set of both real and complex numbers. In the first case, the equation (2) can have either no or one or two real solutions (see Fig. 1) depending on the value of the coefficients  $a, b, c$ . In the second case, there are always only two solutions (see Fig. 2). Moreover, the two roots are different in Fig. 2a and 2c, and equal in Fig. 2b.

However, this case defies common sense, since two different decisions cannot be simultaneously true.

One of them must be false. So where is the truth?

Which of these solutions is true?

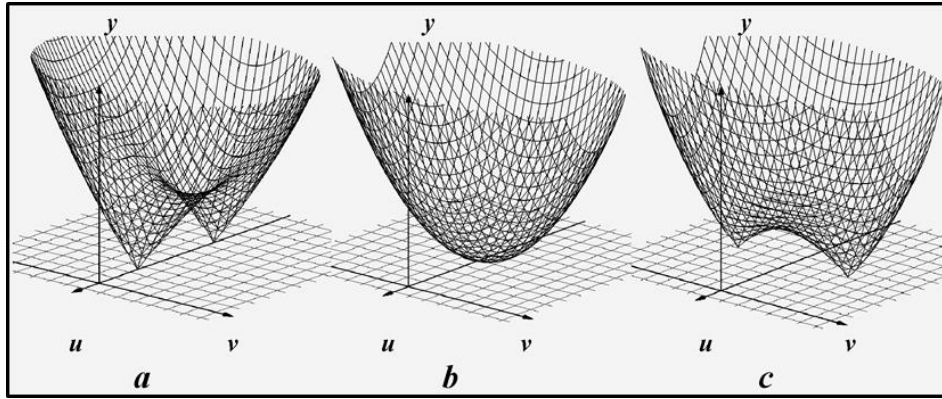


Fig. 2. Graphical solution to the equation (2) on the set of imaginary numbers, corresponding to the tangent

$$\text{plane point } |y| = 0u + i0v \text{ and tangent surface point } |y| = |ax^2 + bx + c| = |a(u+iv)^2 + b(u+iv) + c|$$

Mathematics could not answer this question. Therefore, let us turn back to the analysis of transient processes in radio engineering. The following facts are well known in radio engineering:

- when the discriminant  $b^2 - 4ac$  is positive, and therefore the roots of the characteristic equation (2) are real and different, the transient process is aperiodic;
- when the discriminant  $b^2 - 4ac$  is equal to zero, and therefore the roots of the characteristic equation (2) are real and equal, the transient process is critical;
- when the discriminant  $b^2 - 4ac$  is negative, and therefore the roots of the characteristic equation (2) are different and complex-conjugate, the transient process is oscillatory.

As can be seen, radio engineering claims that transient process always exists. But this situation takes place only for solutions to the characteristic equation (2) on the set of complex numbers. For solutions on the set of real numbers, there can be a result in the form of complex conjugate numbers. Thus, if the solutions on the set of real numbers were correct, and therefore, if the principle of light speed non-exceedance were true, then oscillatory transient processes would not exist. That is, there would be no tsunami and Indian summer; no church bells and grand pianos would sound; children's swings would not sway after being pushed by parents and no shock oscillations would exist at all.

Therefore, we have to conclude that the only correct solution to algebraic equations (not only characteristic, but to all) are solutions in the form of complex numbers. In that case complex (and, therefore, imaginary) numbers have to be recognized as physically real.

## 2.2. Proof of physical reality of imaginary numbers as a result of study of linear electric circuits using Ohm's law in the interpretation of Steinmetz

In accordance with Ohm's law in the interpretation of Steinmetz, not only resistors, but also inductors and capacitors have electrical resistance. However, unlike the value of resistors  $R$  that does not depend on the frequency of voltage applied to them and is measured by real numbers  $R$ , the value of reactance of inductors  $L$  and capacitors  $C$  is measured by imaginary numbers  $X_L = j\omega L$  and  $X_C = 1/j\omega C = -j/\omega C$  opposite in sign and depends on the frequency  $\omega$  of voltage applied to them. Imaginary unit is designated here as  $j$ , since designation  $i$  in the theory of electrical circuits is used for electric current.

Therefore, in accordance with Ohm's law in the interpretation of Steinmetz the value of current  $i(t)$  flowing through  $LCR$ -circuit of any configuration, to which an alternating voltage  $u(t)$  is applied, would be equal to  $i(t) = u(t)/|Z(j\omega)|$ , where  $Z(j\omega)$  is the complex resistance of the electric circuit under study. However, it wouldn't depend on the frequency  $\omega$  of this voltage, if the so-called imaginary reactances  $X_L$  and  $X_C$  do not physically exist. Otherwise it would. Any experiment can confirm this dependence, and, thereby, physical reality of imaginary physical entities – imaginary values of reactances of inductors and capacitors.

So, resonance and various electrical filters can exist due to physical reality of imaginary values of reactances of inductors and capacitors in electric circuits. Therefore, *if the generally accepted version of the SRT and its statement about physical unreality of imaginary numbers were true, existence of television, radiolocation, GPS trackers, mobile phones, or radio equipment in general would be impossible.*

Thus, the evidence of physical reality of imaginary numbers that couldn't be obtained by physicists within the framework of the OPERA experiment at the Large

Hadron Collider turned out to have been de facto obtained<sup>3</sup> long ago by millions of radio engineers all over the world and is daily confirmed by their practical activities in all radio electronic laboratories. Notably, this plain evidence of the principle of physical reality of imaginary and complex numbers that is possible due to measuring the value of resistance of electrical circuits with devices available in any radio engineering laboratory – for example, testers (see Fig. 3), oscilloscopes, frequency-response analysers, etc. – is the most convincing.

After all, it is exactly the ability to register by devices X-ray, radioactive, ultraviolet and infrared radiation, infra and ultrasound, magnetic field, atoms and subatomic particles, as well as many other physical entities that are not registered by the human senses, proves their physical reality. Therefore, to prove physical reality of imaginary numbers there is no need to conduct the unique and expensive OPERA and ICARUS experiments at the Large Hadron Collider involving a large number of professors of physics instead of a simple and cheap radio engineering experiment using a tester (see Fig. 1) and involving only one engineer.

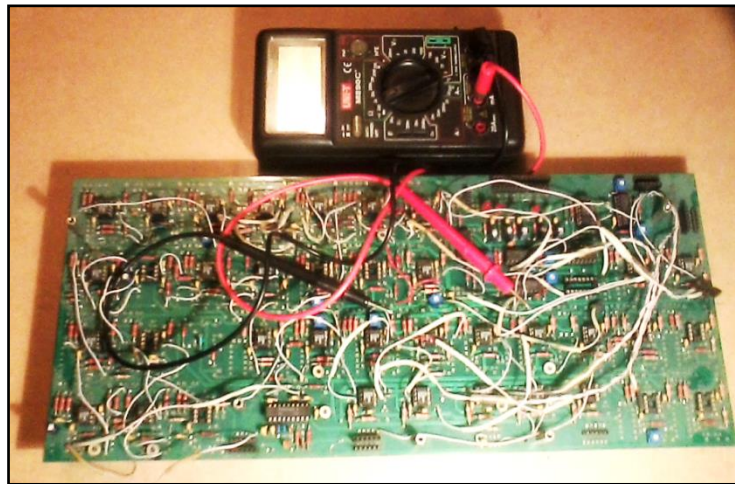


Fig.3. This is all that is needed instead of the Large Hadron Collider for the experimental proof of physical reality of imaginary numbers.

Thus, since the principle of physical reality of imaginary numbers in the SRT has been experimentally proved, there's no longer any necessity for the postulated principle of light speed non-exceedance, but it becomes necessary to correct relativistic formulas that allow explaining the SRT at superluminal velocities.

### 3. Alternative version of the SRT

Thus, the principle of physical reality of imaginary numbers can be considered proven and the principle of light speed non-exceedance can be considered refuted as it is useless. What have we achieved by this? What new knowledge have we received? To answer these questions, let's analyze a relativistic formula graph. For example, the graph of the Lorentz-Einstein formula

$$m = \frac{m_0}{\sqrt{1 - (v/c)^2}} \quad (3)$$

where  $m_0$  is the rest mass of a moving body (e.g. elementary particle);

$m$  is the relativistic mass of a moving body;

$v$  is the velocity of a body;

$c$  is the speed of light.

As can be seen, the section  $0 \leq v < c$  of the graph of function (3) in Fig. 4a corresponds to our visible universe, and the section  $c \leq v$  of the same graph – in accordance with the principle of physical reality of imaginary numbers – corresponds to some other invisible universe, since it is beyond the event horizon. However, this invisible universe does not exist, because the process  $m(v)$  corresponding to the formula (3) is unstable at the section  $c \leq v$ . Actually, if we assume that velocity  $v$  of a moving body has increased, for some reason, in the section  $c \leq v$  of the graph in Fig. 4a, then this should lead to a decrease in its mass  $m$ , and a decrease in mass  $m$  should lead to a further increase in velocity  $v$ , and so on. If we assume that velocity  $v$  of a moving body has decreased, for some reason, then this should lead to an increase in its mass  $m$ , and an increase in mass  $m$  should lead to further decrease in velocity  $v$ , and so on. Consequently, there can be no physical content in the section  $c \leq v$  of the graph in Fig. 4a. And that's why the relativistic formula (3) is incorrect, since its derivation has not been completed.

<sup>3</sup> Consequently, the generally accepted version of the SRT could have been refuted back in the 19th century, i.e. before its creation



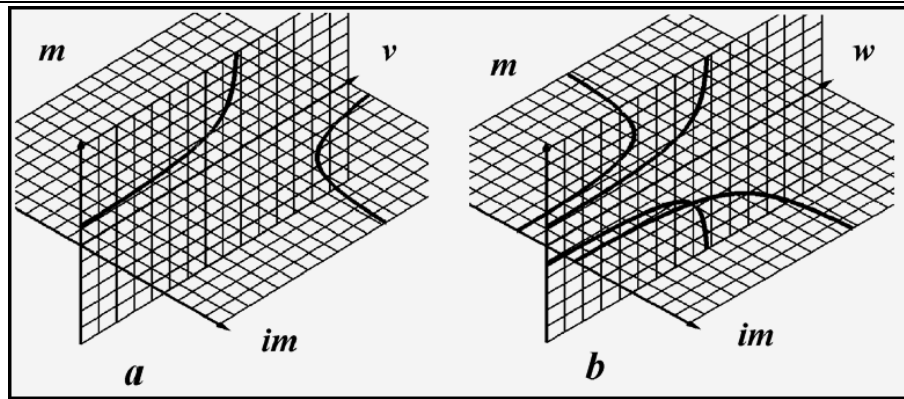


Fig. 4. Graphs of functions  $m(v)$  corresponding to the formulas (3) and (4)

To complete its derivation, we should reason as follows. Invisible universes together forming the hidden Multiverse could exist in the section  $c \leq v$  of the graph in Fig. 4a, if the graph of function  $m(v)$  had many intervals  $c \leq v < 2c, 2c \leq v < 3c, 3c \leq v < 4c$ , etc., on each of which it would take the same form as on the interval  $0 \leq v < c$ . Therefore, for the hidden Multiverse the graph of function  $m(v)$  should generally have the form shown in Fig. 4b. Hence, the function can be written as follows

$$m = \frac{m_0 i^q}{\sqrt{1 - (v/c - q)^2}} = \frac{m_0 i^q}{\sqrt{1 - (w/c)^2}} \quad (4)$$

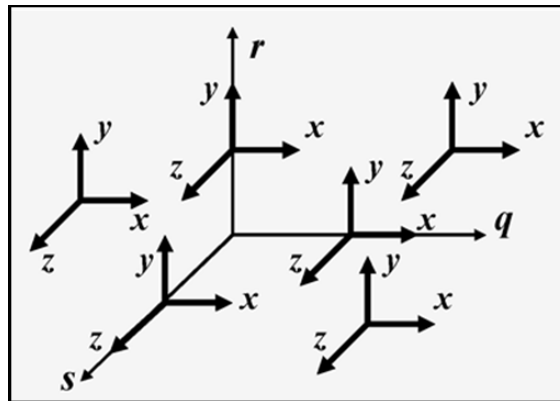


Fig. 5. Six-dimensional space of the hidden Multiverse

However, as shown in [34], [36], the six-dimensional metric of the hidden Multiverse (see Fig. 5) is more complex than the three-dimensional metric of our visible universe. And therefore, the Lorentz-Einstein formula ultimately takes the following form

$$m = \frac{m_0 (i_1)^q (i_2)^r (i_3)^s}{\sqrt{1 - [v/c - (q + r + s)]^2}} = \frac{m_0 (i_1)^q (i_2)^r (i_3)^s}{\sqrt{1 - (w/c)^2}} \quad (5)$$

where  $i_1, i_2, i_3$  are the imaginary units in hyper-complex numbers [37] called quaternions;

$q, r, s$  are the extra dimensions;

$v$  is the velocity measured relative to our visible tardyon universe;

where  $q = \lfloor v/c \rfloor$  is the “floor” function of argument  $v/c$  in discrete mathematics; its integer values<sup>4</sup> correspond to different mutually invisible parallel<sup>5</sup> universes;

$w = v - qc$  is the local velocity for each parallel universe that can take values only in the range  $0 \leq w < c$ ;

$v$  is the velocity measured relative to our visible universe.

$c$  is the speed of light;

$w = v - (q + r + s)c$  is the local velocity of the universe corresponding to the coordinates  $q, r, s$ , that can take values only in the range  $0 \leq w \leq c$ .

Other relativistic formulas can be corrected in a similar way. **The corrected relativistic formulas allows for creating a version of the SRT [38]-[50] alternative to the incorrect version presented in physics textbooks.**

#### 4. Experimental proofs of truth of the alternative version of the SRT

<sup>4</sup> It takes non-integer values in the portals considered below, where the value  $q$  varies by one from a portal entry to its exit under the influence of physical factors that haven't yet been studied

<sup>5</sup> Called as such because they never intersect despite their infinity

In order to substantiate this statement and to gain the moral right to propose replacing the erroneous version of the SRT built on the postulates in physics textbooks with the alternative version confirmed experimentally, let's give a description of the experiments.

#### **4.1. Dark matter and dark energy phenomena prove existence of invisible universes**

The phenomenon of dark matter was discovered by Jan Hendrik Oort and Fritz Zwicky in 1932-33, and the phenomenon of dark energy was discovered by Saul Perlmutter, Brian P. Schmidt and Adam G. Riess, who received the Nobel Prize for this discovery, in 1998-99.

These phenomena [51]-[53] are referred to as such for their incomprehensibility. It is unclear why they are invisible and neither emits nor reflect nor absorb nor refract electromagnetic oscillations in any range and therefore can be detected only indirectly by their gravitational manifestations. It is even more incomprehensible why any molecules, atoms or subatomic particles haven't yet been found in dark matter and dark energy, although their total mass is more than twenty times greater than the mass of all objects of our visible universe. This circumstance even raises doubts about correctness of modern understanding of the term 'matter'. And the subsequent long-term and very intensive studies of the phenomena of dark matter and dark energy have not brought scientists closer to understanding their sense.

Albert Einstein explained the reason for incomprehensibility of the phenomena of dark matter and dark energy in the existing version of the SRT very clearly: "Insanity: doing the same thing over and over again and expecting different results". That is, astrophysicists themselves have created all these incomprehensibilities by wrong statement of the task. They sought explanation for the phenomena that should certainly correspond to the version of the SRT presented in physics textbooks. This version of the SRT implies that we live in the Monoverse. However, since no macro-objects corresponding to the concepts of dark matter and dark energy were found in the Monoverse, it was quite logical to seek an explanation for these phenomena in the microcosm. And they failed again. Nevertheless, scientists considered any alternative explanations for the phenomena irrelevant. And therefore, even those few hypothetically possible structures of the Multiverse published in [54]-[61] have always been commented on as fundamentally unverifiable.

However, if we change the statement of the task and seek an explanation for the phenomena of dark mat-

ter and dark energy in the invisible universes of the hidden Multiverse existing along with our visible universe, explanation becomes obvious [62], [63]:

- Dark matter and dark energy are merely certain images (rather gravitational, than optical and still less electromagnetic), a kind of a shadow, of invisible universes of the hidden Multiverse, rather than some real physical entities located in the microcosm or in the macrocosm;

- Dark matter is evoked by invisible parallel universes of the hidden Multiverse adjacent to our visible universe;

- Dark energy is evoked by the rest of invisible parallel universes of the hidden Multiverse, which are more distant from our visible universe;

- Notably, images corresponding to dark matter and dark energy do not contain any chemical substances. This alone suggests and proves existence of the Multiverse, rather than the Monoverse.

This explanation meets the Occam's razor criterion and therefore is quite plausible. And since, in accordance with this explanation, the phenomena of dark matter and dark energy are evoked by existence of invisible universes, it can be assumed that experimentally registered dark matter and dark energy are experimental evidence of existence of invisible universes, which proves the truth of the alternative version of the SRT.

#### **4.2. How to see invisible universes?**

The truth of the alternative version of the SRT can also be confirmed by direct astronomical observation of constellations that have never been seen in the starry sky of Earth [64], [65]. Moreover, this is the only way to reliably identify invisible universes (like people by ID photos), since stars in the skies of different universes are obviously spread in extremely different ways. It is also obvious that these other constellations can only be seen in these other universes, which are invisible from our universe on most of the Earth's surface.

However, it turns out that our Earth has numerous areas called anomalous zones [66]. At least some of them are entrances to passages to other universes, called portals [67]. These passages are analogous to the passages in our dwellings that lead from one room to another. We can usually see only one of the rooms entirely, the room we are in now. Any other room can also be partially visible, if we adjourn to it or at least look inside through an open door.



Fig. 6.

*Main Astronomical Observatory of the National Academy of Science of Ukraine located in an anomalous zone*

Therefore, an adjacent invisible universe can be looked into from any portal of our visible universe in a similar way. Entering a portal one can observe as the star map of one universe is gradually replaced by the star map of the adjacent universe. And it would seem to the observer moving along the portal that these are constellations of our starry sky moving, disappearing and appearing. Moreover, the deeper one enters the portal, the more changes one actually sees. But people avoid visiting anomalous zones and try not to enter deep into the portals, and rightly so. Portals are labyrinths invisible to us and once you are in, it is easy to get lost and not to find the way back. Therefore, in order to safely perform astronomical observations in portals, first it is

necessary to create portal orientation devices (similar to marine compass).

Even with a slight penetration into a portal, while still remaining at its entrance in an anomalous zone, one can observe some changes in the constellations known to astronomers. This would also be an irrefutable experimental proof of existence of other universes that are invisible outside the portals. Moreover, *such an experiment, similar to the experiment conducted by Sir Arthur Stanley Eddington [68] in 1919, would be quite low-cost and simple*, since the main thing required is to place a telescope in an anomalous zone, all the rest is available.

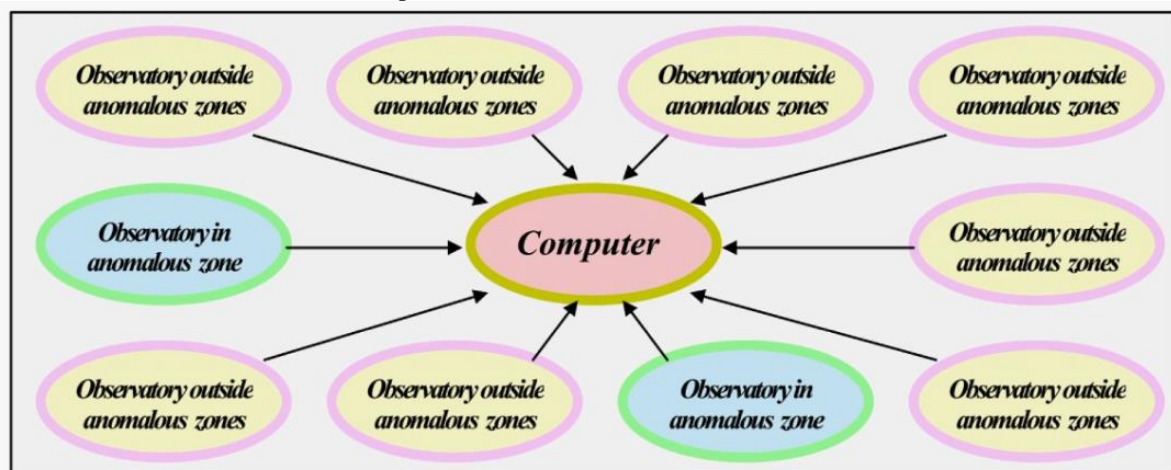


Fig. 7. Scheme of an experiment in detecting invisible universes

And since constellations observed in the starry sky using such a telescope may sometimes differ very slightly from constellations observed using other telescopes placed outside the anomalous zones, some astronomical observatories could already have been, by chance, located in anomalous zones. For example, the Main Astronomical Observatory of the National Academy of Sciences of Ukraine located in the Holosiivskyi Forest, just 12 km from the centre of Kyiv, the capital of Ukraine. This means that the whole experiment would involve comparing, and detecting differences in, positions of stars located at the same fragment of the starry sky observed by different observatories. This

presupposes that the information obtained should be transferred by observatories of the same region to a single computing centre (Fig. 7) and processed to detect the differences.

## 6. Conclusion

Let's summarize. All the experiments described above refute the generally accepted version of the SRT. This occurs in a different way. Collectively all these refutations are even more convincing. Thus, the proofs of physical reality of imaginary numbers given in sections 2.1 and 2.2 undoubtedly refute the principle of light speed non-exceedance and thereby the whole ex-

isting SRT. Section 4.2 offers a description of an experiment that has not yet been performed, but is very demonstrative. The experiment allows discovering invisible universes. Section 4.1 mentions the experiments that were conducted in the last century. They allowed discovering the phenomena of dark matter and dark energy that are actually evoked by invisible universes.

Although one experimental proof is usually enough to refute other theories, the existing version of the SRT has not been refuted. The erroneous version of the SRT is even presented for study in physics textbooks, which must contain only unconditionally correct theories. Hence, authors of the textbooks create the impression that the generally accepted version of the SRT is also unconditionally correct, although there already have been published dozens of articles, proving that it can be refuted by existence of television and radiolocation, GPS and mobile telephony, musical instruments and children's swings created by humans, as well as tsunami and 'Indian summer' created by nature, resonance, Ohm's law in the interpretation of Steinmetz and many other things.

For all that, why then the incorrect version of the SRT hasn't still been refuted? Why, for example, decisions on banning criticism of the SRT were made by Soviet Government three times: in 1934, 1942 and 1964? It hasn't still been criticized. The author of the article does not know answer to these questions. However, authors of the textbooks might not have read my articles. Or, if they have read, they haven't believed and verified it. Anyway, this needs to be done. And textbooks need to be corrected, because it is immoral to provide outdated and unimproved knowledge to students [24]-[33]. After all, Albert Einstein wrote: "There is no single idea, which I would be sure that it will stand the test of time".

An alternative version of the SRT confirmed experimentally is described in publications [38]-[50].

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## TO THE THEORY OF SIZE QUANTIZATION IN A QUANTUM WELL OF p-Te

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## К ТЕОРИИ РАЗМЕРНОГО КВАНТОВАНИЯ В КВАНТОВОЙ ЯМЕ p-Te

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ул. Турон 19, 150700, Коканд, Узбекистан***Abstract**

The wave functions and the energy spectrum of holes in a gyrotropic crystal, where the valence band consists of two branches, are calculated. In this case, a term linear in the wave vector in the effective Hamiltonian of holes was taken into account and it was shown that the wave function has two terms, one of which has damping, and the second describes the de Broil wave of holes. The calculation was carried out in the approximation of the Schredenger equation using the perturbation theory.

**Аннотация**

Рассчитаны волновые функции и энергетический спектр дырок в гиротропном кристалле, где валентная зона состоит из двух ветвей. При этом учтен линейное по волновому вектору слагаемое в эффективном гамильтониане дырок и показан, что волновая функция имеет две слагаемое, одно из которых имеет затухание, а второе описывает де Бройловскую волну дырок. Расчет проведен в приближении уравнения Шредингера с применением теории возмущения.

**Keywords:** wave function, energy spectrum, holes, gyrotropic crystal, valence band, effective Hamiltonian

**Ключевые слова:** волновая функция, энергетический спектр, дырки, гиротропный кристалл, валентная зона, эффективный гамильтониан.

**I. Введение**

В последнее время привлекают значительное внимание на размерное квантование (РК), которое имеет применение в оптоэлектронике [1]. Для полупроводников с простой зонной структурой исследование межуровневых оптических переходов в структурах для произвольного потенциала было проведено в [2,3]. В то же время межуровневые оптические переходы в полупроводниковых структурах дырочной проводимости представляют интерес из-за ненулевого поглощения для света произвольной поляризации, которые имеют практическое

применение [4]. Теоретическое исследование такого рода задачи затруднено сложностью зонной структуры кристалла.

В частности, в [5-7] такая задача в случае прямоугольной РКЯ фиксированной толщиной решена численно. Однако даже малая вариация толщины или глубины РКЯ может сильно изменить конечный результат, что затрудняет анализ промежуточных расчетов. В работе [8] на основе теории возмущения получены аналитические выражения [9] исследовано энергетический спектр, волновая функция дырок межподзонное поглощение поляри-



зованного излучения в бесконечно глубокой квантовой яме полупроводника. Расчеты проведены в приближении Латтинжера-Кона [10, 11] для полупроводников с решеткой цинковой обманки.

Однако теоретическое исследование размерного квантования в потенциальной яме (РКЯ), выращенной на основе гиротропного кристалла (например, *p-Se* или *p-Te*), остается открытым, к чему посвящено настоящее сообщение.

Отметим, что исследование ряда явлений, в частности оптических или фотогальванических эффектов в размерно-квантованных структурах (РКЯ) требует знания энергетического спектра и волновых функций носителей тока электронов.

## II. Basic relations

Для квантовой ямы с потенциалом  $U(z)$  эффективный гамильтониан для квантовой ямы с потенциалом  $U(z)$  эффективный гамильтониан электронов в *p-Te* представляем в виде

$$\Psi_{M'_1} = \sum_{m_z=\pm 3/2} C_{m_z}^{(I)} |m_z\rangle, \quad (3)$$

где  $C_{3/2}^{(1)} = C_{-3/2}^{(2)} = C_1 = \sqrt{(1+\eta)/2}$ ,  $C_{-3/2}^{(1)} = -C_{3/2}^{(2)} = C_2 = \sqrt{(1-\eta)/2}$ ,  $\eta = \beta k_z (\Delta^2 + \beta^2 k_z^2)^{-1/2}$ .

Спектр дырок в валентной зоне в объемном гиротропном кристалле имеет вид

$$E_l(k_x, k_y, k_z) = Ak_{\perp}^2 + Bk_z^2 - (-1)^l (\Delta^2 + \beta^2 k_z^2)^{1/2} \quad (l=1,2). \quad (2)$$

Здесь  $A = \hbar^2 / (2m_{\perp})$ ,  $B = \hbar^2 / (2m_{\parallel})$ ,  $m_{\perp}$  и  $m_{\parallel}$  - поперечные и продольные эффективные массы дырок в подзонах  $M'_1$  и  $M'_2$ , равные с обратным знаком эффективным массам электронов.

Тогда выбирая осью размерного квантования  $Oz$  и считая, что  $k_z = \frac{1}{i} \frac{\partial}{\partial z}$  из (1) имеем

$$\hat{H} = \hat{H}_0 + \hat{R}_2 k_{\perp}^2, \quad (3)$$

где

$$\hat{H}_0 = \Delta \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} - B \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \frac{\partial^2}{\partial z^2} - i\beta_V \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \frac{\partial}{\partial z} + U(z), \quad \hat{R}_2 = A \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} k_{\perp}^2, \quad (4)$$

## III. Hole wave functions in a quantum well of hole conduction tellurium

Невозмущенные уровни энергии  $E_{\xi}(0)$  и волновая функция дырок  $\psi_{\xi}^{(0)} = \begin{bmatrix} \psi_2^{(0)} \\ \psi_1^{(0)} \end{bmatrix}$  в подзонах зоны проводимости  $M'_{\xi} (\xi=2,1)$  в *p-Te* определяются из следующего матричного дифференциального уравнения с зонными параметрами  $A, B$ :

$$\hat{H}_0 \hat{\psi}_{\xi}^{(0)} = \hat{E}_{\xi} \hat{\psi}_{\xi}^{(0)}, \quad (5)$$

где  $\hat{E}_{\xi} = \begin{bmatrix} \tilde{E} & 0 \\ 0 & \tilde{E} \end{bmatrix}$ . Тогда имеем

$$\left\{ \frac{\Delta}{2} \begin{bmatrix} \psi_2^{(0)} \\ -\psi_1^{(0)} \end{bmatrix} - \frac{\partial^2}{\partial z^2} \begin{bmatrix} A_3 \psi_2^{(0)} \\ A_1 \psi_1^{(0)} \end{bmatrix} + U(z) \begin{bmatrix} \psi_2^{(0)} \\ \psi_1^{(0)} \end{bmatrix} \right\} = \begin{bmatrix} \tilde{E} \psi_2^{(0)} \\ \tilde{E} \psi_1^{(0)} \end{bmatrix}, \quad (6)$$

Для упрощения задачи считаем, что  $U(z) = U_0 = const$ . Тогда последнее уравнение будет иметь вид

$$\begin{cases} \frac{\partial^2 \psi_2^{(0)}}{\partial z^2} - \frac{1}{B} [U(z) - \tilde{E}] \psi_2^{(0)} + i \frac{\beta_V}{B} \frac{\partial \psi_2^{(0)}}{\partial z} - \frac{\Delta}{B} \psi_1^{(0)} = 0, \\ \frac{\partial^2 \psi_1^{(0)}}{\partial z^2} - \frac{1}{B} [U(z) - \tilde{E}] \psi_1^{(0)} - i \frac{\beta_V}{B} \frac{\partial \psi_1^{(0)}}{\partial z} - \frac{\Delta}{B} \psi_2^{(0)} = 0 \end{cases} \quad (7)$$

$$\hat{H} = \hat{H}_0 + \sum_{\alpha=x,z} A_{\alpha} \sigma_{\alpha}, \quad (1)$$

где  $\hat{H}_0 = Ak_{\perp}^2 + Bk_z^2$ ,  $A_x = \Delta$ ,  $A_z = \beta k_z$  и предполагается, что фазы функции  $M'_{1,2}$  выбраны так, что коэффициент при  $k_z$  вещественен,  $2\Delta$  - спин-орбитальное расщепление валентной зоны в точке  $M(P)$  зоны Бриллюэна),  $k_{\perp}^2 = k_x^2 + k_y^2$ ,  $A, B, \beta_V$  - зонные параметры *p-Te*,  $\vec{k}_{\perp} = k_{\perp} (\sin \varphi, \cos \varphi)$  - двумерный волновой вектор, направленный по интерфейсу.

Волновые функции в верхних валентных зонах ( $M'_1$  и  $M'_2$ ) являются суперпозицией состояний с проекцией момента количества движения на ось  $Z$  ( $m_z = \pm 3/2$ )



или

$$\frac{\partial^2 \psi_+^{(0)}}{\partial z^2} - \kappa_E^2 \psi_+^{(0)} + i\kappa_{\beta_V} \frac{\partial \psi_-^{(0)}}{\partial z} - i\kappa_{\Delta}^2 \psi_-^{(0)} = 0, \quad (8)$$

где  $\kappa_E^2 = \frac{1}{B}(U_0 - \tilde{E})$ ,  $\kappa_{\Delta}^2 = \frac{\Delta}{B}$ ,  $\kappa_{\beta_V} = \frac{\beta_V}{B}$ ,  $\psi_{\pm}^{(0)} = \psi_2^{(0)} \pm i\psi_1^{(0)}$ .

Будем искать решение (8) в трех приближениях, которых более подробно анализируем ниже.

**1 -приближение.** Из (8) нетрудно получить следующую систему уравнений

$$\begin{cases} \frac{\partial^2 \psi_+^{(0)}}{\partial z^2} - \kappa_E^2 \psi_+^{(0)} = 0, \\ \frac{\partial \psi_-^{(0)}}{\partial z} + \frac{\kappa_{\Delta}^2}{\kappa_{\beta_V}} \psi_-^{(0)} = 0, \end{cases} \quad (9)$$

решение которых пишем виде

$$\psi_{\pm}^{(0)} = D_{\pm} \exp(\kappa_{\pm} z) + C_{\pm} \exp(-\kappa_{\pm} z), \quad (10)$$

где  $\kappa_+ = \kappa_E$ ,  $\kappa_- = \kappa_{\Delta}$ , неизвестные величины  $D_{\pm}$ ,  $C_{\pm}$  определяются из граничных условий задачи, о которой будет идти речь в дальнейшем. Отметим, что параметр  $\kappa_-$  реальная величина,  $\kappa_+$  может быть как реальной (при  $U_0 > \tilde{E}$ ), так и мнимой (при  $U_0 < \tilde{E}$ ) величиной. Тогда волновая функция в первом случае будет экспоненциальной  $\psi_+^{(0)}$ , а во втором случае-тригонометрической. Если величина  $\kappa_{\pm}$  реальная, тогда можно считать, что  $D_{\pm} = 0$ . Это означает, что носители тока (дырки в  $p$ - $Te$ ) с энергией  $\tilde{E} < U_0$  будут вести себя как де Бройлевская (плоская волна), а в остальных случаях – нет.

Далее считаем, что дырки находятся в потенциальной яме. Тогда

$$\psi_+^{(0)} = D_+ \exp(ikz) + C_+ \exp(-ikz), \quad \psi_-^{(0)} = C_- \exp\left(-\frac{\kappa_{\Delta}^2}{\kappa_{\beta_V}} z\right), \quad (11)$$

где учтено, что  $U_0 = 0$ ,  $\kappa_+ = i\sqrt{\frac{\tilde{E}}{B}} = ik$ . Тогда из условий ортонормированности и конечности волновых функция дырок в интерфейсах ямы имеем,

$$\psi_+^{(0)}(z) = 2\kappa^{1/2} \frac{\cos(\kappa z)}{[2\kappa a + \sin(2\kappa a)]^{1/2}}. \quad (12)$$

Из следующего граничного условия получим выражения для размерно-квантованного энергетического спектра дырок

$$\tilde{E} = B \frac{(2n+1)^2}{4a^2} \pi^2 \quad (n = 0, 1, 2, \dots) \quad (13)$$

**2 -приближение.** Теперь решение уравнения (8) ищем в виде

$$\psi_+^{(0)} = D \exp(\kappa z) \quad \psi_-^{(0)} = D^* \exp(\kappa^* z), \quad (14)$$

где  $\kappa^*$  и  $D^*$  - комплексно-сопряженный волновой вектор и параметр, аналитический вид которого можно определить из вышеуказанных граничных условий. Тогда нетрудно получить следующие полезные, для дальнейших расчетов соотношения

$$D_{im} = i \cdot \frac{\left[(-\kappa^2 + \kappa_E^2) + i(-\kappa^* \kappa_{\beta_V} + \kappa_{\Delta}^2)\right]^2}{(-\kappa^2 + \kappa_E^2)^2 + (-\kappa^* \kappa_{\beta_V} + \kappa_{\Delta}^2)^2} D_{re}, \quad (15)$$

где  $D_{re}$  и  $D_{im}$ -реальное и мнимое значения величины  $D$ . Из (15) видно, что вид волновой функции (14) зависит от физической природы волнового вектора  $\kappa$ . Поэтому рассмотрим следующие случаи:

а) пусть волновой вектор реальная величина, тогда

$$D_{im} = -2 \frac{\zeta_{re}}{\zeta_{re}^2 + 1} D_{re}, \quad (16)$$

где  $\varsigma_{re} = (-\kappa^2 + \kappa_E^2) / (-\kappa\kappa_{\beta_V} + \kappa_\Delta^2)$ . Тогда волновые функции дырок принимают вид

$$\psi_{\pm}^{(0)}(z) = \frac{\varsigma_{re}^2 + 1 \mp 2i\varsigma_{re}}{\varsigma_{re}^2 + 1} D_{re} \exp(\kappa z). \quad (17)$$

Тогда энергетический спектр носителей тока определяются из следующего трансцендентного уравнения

$$\left( \frac{\tilde{E}}{B} \right)_{\pm} = \frac{\varsigma_{re}}{\varsigma_{re}^2 + 1} \kappa_{\beta_V} \pm \left[ \left( \frac{\varsigma_{re}}{\varsigma_{re}^2 + 1} \kappa_{\beta_V} \right)^2 + 4 \left( \frac{\tilde{E}^2}{B^2} - \frac{2\varsigma_{re}}{\varsigma_{re}^2 + 1} \kappa_\Delta^2 \right) \right]^{1/2}. \quad (18)$$

Из (18) видно, что энергетический спектр принимает реальные значения при выполнении следующих неравенств

$$\tilde{E} \geq \frac{B}{2} \left[ \frac{2\varsigma_{re}}{\varsigma_{re}^2 + 1} \kappa_\Delta^2 - \left( \frac{\varsigma_{re}}{\varsigma_{re}^2 + 1} \kappa_{\beta_V} \right)^2 \right]^{1/2}, \quad \frac{2\varsigma_{re}}{\varsigma_{re}^2 + 1} \kappa_\Delta^2 \geq \left( \frac{\varsigma_{re}}{\varsigma_{re}^2 + 1} \kappa_{\beta_V} \right)^2; \quad (19)$$

б) пусть волновой вектор мнимая величина, тогда взаимосвязь величин  $D_{im}$  и  $D_{re}$  описывается как

$$D_{im} = -2 \frac{\varsigma_{im}}{\varsigma_{im}^2 + 1} D_{re}, \quad (20)$$

а волновые функции дырок определяются как

$$\psi_{+}^{(0)}(z) = \frac{2D_{re}}{1+b_2^2} (1+ib_2) \exp(\kappa z), \quad \psi_{-}^{(0)}(z) = D_{re} \left( 1 - \frac{(1+ib_2)^2}{b_2^2} \right) \exp(\kappa z), \quad (21)$$

где  $\varsigma_{im} = (\kappa^2 + \kappa_E^2 - \kappa\kappa_{\beta_V}) / \kappa_\Delta^2$ .  $b_2 = \frac{\kappa_\Delta^2 - \kappa^* \kappa_{\beta_V}}{\kappa_E^2 - \kappa^2}$ .

Теперь попытаемся решить систему уравнений (7) в общем виде. Для этого проведя преобразование в (7) нетрудно получить уравнение Шреденгера в виде

$$\frac{\partial^4 \psi_2^{(0)}}{\partial z^4} - \frac{1}{B} \left( U_0 - \tilde{E} - \frac{\beta_V^2}{B} \right) \frac{\partial^2 \psi_2^{(0)}}{\partial z^2} - \frac{1}{B^2} \left\{ \Delta^2 - (U_0 - \tilde{E})^2 \right\} \psi_2^{(0)} = 0. \quad (22)$$

Рассмотрим следующие случаи:

а) для дырок, находящихся в яме ( $U_0 = 0$ ) уравнение (22) принимает вид

$$\frac{\partial^4 \psi_2^{(0)}}{\partial z^4} + \aleph_1^2 \frac{\partial^2 \psi_2^{(0)}}{\partial z^2} - \aleph_0^4 \psi_2^{(0)} = 0, \quad (23)$$

решение которого ищем в виде

$$\psi_2^{(0)} = B_2 \cdot e^{-\alpha_1 \cdot z} + B_2 \cdot e^{\alpha_2 \cdot z} + B_3 \cdot e^{-\alpha_2 \cdot z}, \quad (24)$$

где  $\aleph_1^2 = B^{-1} (\tilde{E} + B^{-1} \beta_V^2)$ ,  $\aleph_0^4 = B^{-2} (\Delta^2 - \tilde{E}^2)$ ,  $\alpha_1 = \aleph_-$ ,  $\alpha_2 = i\aleph_+$ ,

$\aleph_{\pm} = \sqrt{\frac{1}{2} \left[ \pm (\aleph_1^2) + \sqrt{(\aleph_1^2)^2 + 4\aleph_0^4} \right]}$  и, в дальнейшем будем учесть, что  $(\aleph_1^2) \ll \sqrt{(\aleph_1^2)^2 + 4\aleph_0^4}$ . Тогда

из условий конечности волновых функций на границах интерфейса имеем

$$\psi_2^{(0)}(z) = \frac{B_2}{2} \left[ \frac{e^{(2i\aleph_- + \aleph_+)a} - e^{-\aleph_+ \cdot a} - 2i \sin(\aleph_- \cdot a)}{ch(\aleph_+ \cdot a) - \cos(\aleph_- \cdot a)} \cdot (e^{-\aleph_+ \cdot z} - e^{-i\aleph_- \cdot z}) + 2(e^{i\aleph_- \cdot z} - e^{-\aleph_+ \cdot z}) \right]. \quad (25)$$

где  $B_2$  определяется из условия нормировки  $\psi_2^{(0)}(z)$ .

Энергетический спектр дырок в потенциальной яме определяется соотношением

$$\sin(\mathfrak{N}_- \cdot a) - \cos(\mathfrak{N}_- \cdot a) + \frac{\mathfrak{N}_-}{\mathfrak{N}_+} \exp(-\mathfrak{N}_+ \cdot a) = 0 \quad (27)$$

б) для дырок, находящихся вне ямы ( $U_0 \neq 0$ )

волновая функция дырок определяется выражением (25) и энергетический спектр соотношением (27), но при этом надо произвести следующие замены:  $\mathfrak{N}_1 \leftrightarrow \wp_1$   $\mathfrak{N}_0 \leftrightarrow \wp_0$ , где

$$\wp_0^4 = \frac{1}{B^2} \left\{ \Delta^2 - (U_0 - \tilde{E}_2)^2 \right\},$$

$$\wp_1^2 = \frac{1}{B} \left( U_0 - \tilde{E} - \frac{\beta_V^2}{B} \right);$$

с) в случае резонанса, т.е. когда энергия дырок численно равно высоте потенциального барьера, тогда волновая функция дырок определяется выражением (25) и энергетический спектр соотношением (27), но при этом надо произвести следующие замены:  $\mathfrak{N}_1^2 \leftrightarrow \mathfrak{N}_{01}$   $\mathfrak{N}_0 \leftrightarrow \mathfrak{N}_{00}$ , где

$$\mathfrak{N}_{01} = \frac{\beta_V}{B}, \quad \mathfrak{N}_{00}^4 = B^{-2} (\Delta^2 - \tilde{E}^2).$$

Из соотношения (22) видно, что волновая функция дырок в потенциальной яме имеет два слабое, одно из которых экспоненциально затухающее, а остальные являются осциллирующими.

Таким образом, показали, что размерно-квантованный спектр дырок в гиротропных кристаллах имеет сложный вид и зависит от отношения энергии дырок к высоте потенциального барьера. В частности энергетический спектр дырок в яме состоит из набора размерно-квантованных уровней, не пересекающиеся между собою из-за наличия энергетической щели между подзонами  $M'_1$  и  $M'_2$ .

Получены выражения волновых функций и энергетических спектров электронов для различных случаев, различающиеся друг от друга соотношениями для характеристических волновых векторов, которые, в свою очередь, зависят от зонных параметров полупроводника и от энергетической щели между подзонами валентной зоны гиротропного кристалла/

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## ABOUT THE ORBIT OF MERCURY. EXTENSION OF KEPLER'S FIRST LAW.

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## ОБ ОРБИТЕ МЕРКУРИЯ. РАСШИРЕНИЕ ПЕРВОГО ЗАКОНА КЕПЛЕРА.

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**Abstract**

Discrepancies in the rotation of the orbit of Mercury are considered and methods for their elimination are proposed. The reason for the precession of the orbits is explained.

**Аннотация**

Рассматриваются нестыковки во вращении орбиты Меркурия и предлагаются методы их устранения. Объясняется причина прецессии орбит.

**Keywords:** Mercury, precession of Mercury, precession, Kepler's first law.

**Ключевые слова:** Меркурий, прецессия Меркурия, прецессия, первый закон Кеплера.

В своё время Тихо Браге (астроном учитель Кеплера) собрал много астрономических данных, после его смерти Кеплер обработал их и методом последовательного приближения получил законы движения космических тел для солнечной системы, названные в его честь «законами Кеплера». Попробуем сделать то же самое для орбиты Меркурия, одной из самых загадочных планет вследствие своей непонятной прецессии. Сейчас точность измерений возросла.

Известно, что все планеты солнечной системы вращаются по эллиптическим орбитам[1-4, 9-12]. Но так ли это?

Если все планета вращаются по эллиптическим орбитам, то для них должно выполняться правило для эллипсов. Радиусы окружностей при вращении вокруг их центров должны совпадать (быть равными  $R_1 = R_2$ ) Как показано на рис. 1.

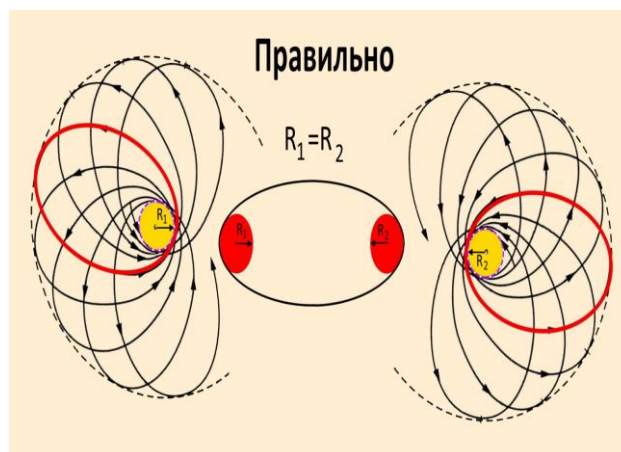


Рис. 1. Правильные эллипсы

При исследовании орбиты Меркурия было выявлено не совпадение, нестыковка. Радиусы окружностей центров вращения эллипсов не совпадают  $R_1 \neq R_2$ , как показано на рис. 2. Радиус возле солнца оказывается меньше, получается неправильный эллипс, что и вызывает прецессию. Но при

этом закон, что за равные промежутки времени  $\Delta t_1 = \Delta t_2$  замечаются равные площади,  $\Delta S_1 = \Delta S_2$  сохраняется, так как отображает закон сохранения энергии.

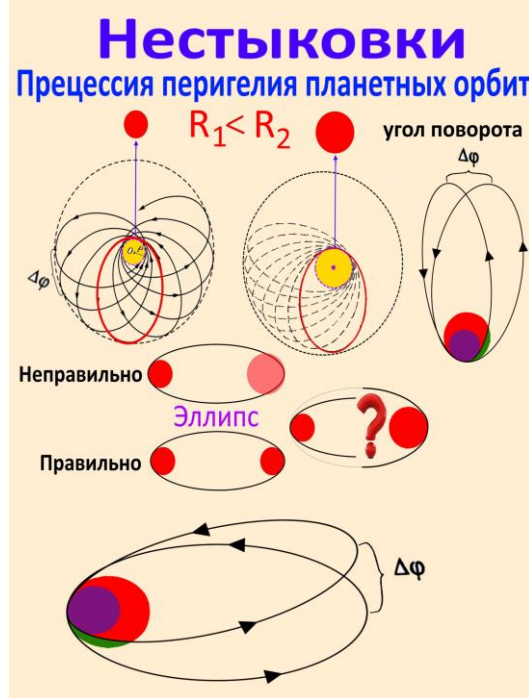


Рис. 2. Неправильные эллипсы

Данная нестыковка объясняется тем, что в законе Ньютона не хватает экспоненты рис. 3, как показывалось в работах автора [5-9] (рис. 4).

### Нарушение закона Кеплера

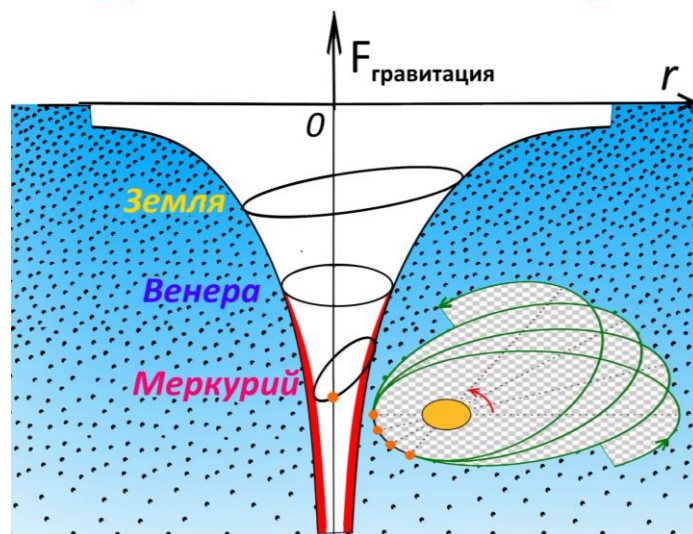


Рис. 3. Нестыковки в орбитах





При введении экспоненты в формулу Ньютона и ограничение на предел сжатия  $\Delta r_{\text{предельное}}$  мы получаем срезы не по конусу, а по конусу гиперболоида вращения, что объясняет неправильные эллипсы, полученные при экспериментах – это устраняет возникшие противоречия в опытах (рис. 5).



Рис. 5. Законы Кеплера. Компенсация неправильных эллипсов

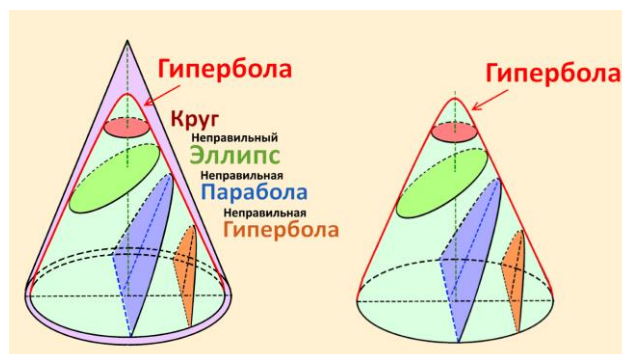


Рис. 6. Законы Кеплера. Коррекция законов Кеплера

В рисунках 5, 6 срезы плоскостями дают неправильные эллипсы, параболы, гиперболы с коррекцией вызванной экспонентой при введении в закон Ньютона [5-9].

Законы Кеплера ранние выводились автором из закона сохранения энергии [5-9].

Отметим, что ранее законы Кеплера уже корректировались и расширялись. Так к соотношению квадратов периодов вращения добавилась соотношение суммы масс планет:

$$\frac{T_1^2}{T_2^2} = \frac{a_1^3}{a_2^3}, \text{ переход на формулу}$$

$$\frac{T_1^2(M+m_1)}{T_2^2(M+m_2)} = \frac{a_1^3}{a_2^3}.$$

Сейчас в данной работе происходит замена правильных эллипсов на неправильные эллипсы. Это вызвано теоретическими нестыковками (противоречиями) при подходе к вершине конуса (рис. 5, 6) , что отвечает прохождению от радиуса

Шварцшильда (радиуса чёрной дыры) к точке сингулярности – вершине конуса. Замена конуса на гиперболоид вращения (рис. 5,6) позволяет устранить эти противоречия и состыковать эксперименталь-

ные данные с теоретическими данными. Первый закон Кеплера переписывается (расширяется) как: «Каждая планета Солнечной системы обращается по неправильному эллипсу, в меньшем из фокусов которого находится Солнце» (рис. 7).



Рис. 7. Закон Кеплера расширенный

В данной формулировке Солнце обладает приоритетом. Такой подход расширяет наши представления об окружающем мире.

Наши познания окружающего нас мира, продолжают.

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# SOCIAL SCIENCIES

## TRANSFORMATION OF BUSINESS EFFICIENCY WITH THE LEAN MANAGEMENT

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*Perfection may not be attainable, but if we chase perfection  
we can catch excellence*

*- Vince Lombardi*

### Abstract

Organizations have been practicing Lean practices for years, but many have found improvements to be fleeting - often because they focus on small, individual improvement projects. By changing the way managers manage and workers work, Lean Management has a systemic impact. Lean Management helps organizations optimize processes by addressing the root causes of organizational inefficiency, building management systems and capabilities to support new ways of working, and engaging leaders and staff to continually improve part of everyone's day-to-day work. This method makes it possible in a short time to master and at the same time apply in practice effective tools of lean management.

**Keywords:** Lean management, business efficiency, transformation.

### INTRODUCTION.

Organizations have been practicing Lean practices for years, but many have found improvements to be fleeting - often because they focus on small, individual improvement projects. By changing the way managers manage and workers work, Lean Management has a systemic impact. Lean management helps businesses optimize processes by addressing the root causes of organizational inefficiency, building management systems and capabilities to support new ways of working, and engaging leaders and staff to continually improve part of everyone's day-to-day work.

### THEORETICAL ASPECTS OF RESEARCH.

The concept of lean management originated in automobile factories in Japan after World War II. In the conditions of a destroyed economy, industrialists experienced an acute shortage of resources, so the task of minimizing losses and costs came to the fore. The market also dictated new conditions. Low purchasing power of the population and the need to rebuild the national economy created a demand for practical car models that rarely break down (Вялов 2014).

At the same time, in order to stay afloat, Japanese companies had to compete with the thriving American auto industry. The quality of the products played a decisive role. Under such conditions, at the beginning of the 50s of the last century, a special enterprise management system was born at the Toyota Motor plant, which today is known throughout the world as lean (Мельников, Ларионов, and Ганькин 2016). This

system is based on the idea of continuous improvement of work processes in order to eliminate all types of losses while maximizing production orientation to consumer demand. The main component of lean management is the concept of customer value creation (G. Bekimbetova 2020). Value arises from actions that are important to the customer, such as direct manufacturing, processing and product improvement. All actions that are not directly related to the production process and are important only for the manufacturer (elimination of defects, storage and transportation of products, etc.) are attributed to losses.

### METHODOLOGICAL ASPECTS OF RESEARCH.

To follow lean principles in enterprise management, special lean manufacturing tools are used. This is a set of rules and methods that have been found to be effective in many companies around the world. Some lean concept tools have evolved into standalone management techniques. The kaizen system from an element of a lean methodology has evolved over time into a kind of enterprise management philosophy based on the idea of continuous improvement of the company's activities (Maria Goreti usboko 2018). The management concept of kaizen includes actions to improve product quality, constantly update production technologies, increase personnel competence and improve corporate culture. In modern management, kaizen (Kandeeva 2015) is used both within lean production and independently.



Another direction in Japanese management that relates to lean manufacturing tools is the kanban method. This tool is used in enterprises to eliminate waste associated with excess inventory. In companies that practice kanban, material resources are purchased in limited quantities and delivered directly to the production halls, bypassing the warehouse (Brans and De Smet 2016). The supply volumes are regulated solely by the number of orders for the production of products, which makes it possible not to store excess stocks.

A similar mechanism has the Just in Time (JIT, just in time) system, which avoids losses associated with overproduction. The essence of the method lies in the manufacture in a certain period of time only the volume of products provided by orders at each stage of the technological chain (M. Milan and J. Krlik 2009). The second name of the JIT method is pull production. In the process of manufacturing parts and finished products, the required volumes are "pulled out" by the needs of the internal customer - the next production stage, and the external customer - the end user.

Losses associated with improper workspace organization can be minimized by the 5S method. The name of the system is formed from five words denoting the principles of the most rational organization of the workplace, which in Japanese begin with the letter "C" - improvement, cleanliness (cleaning), sorting, standardization, convenient arrangement of tools.

Productive Maintenance (Maria Goreti usboko 2018). The method provides for regular preventive inspections of tools and equipment to help prevent breakdowns and downtime. Preventive maintenance and equipment maintenance also provides an opportunity to realize the principle of the most efficient use of available resources, which is one of the main principles of the concept of lean manufacturing.

#### ANALYSES AND RESULTS OF RESEARCH.

Whatever you do, implementing lean management in a company will help improve the quality and efficiency of the organization. Well, or at least cut costs. It may seem that the Lean concept is only suitable for industrial giants or large companies with complex structures. In fact, lean principles apply even in a shoe repair shop, where the owner and two other assistants work.

Here are some of the first steps to implementing lean:

Determine which actions are valuable to your customers or customers, and which are important only to you or are done out of habit. For example, for the customers of the same shoe repair shop (G.M. Bekimbetova 2020), it does not matter how long and carefully in the morning the owner and two assistants divide the shoes and heels between to keep things fair, but it's important to get a well-repaired shoe as soon as possible (Bisultanova et al. 2018).

Any activities that do not add value to customers should be taken out of the supply chain or cut back because they incur losses. Think about how this can be done at the management level. The repair shop owner should document that the process of distributing work among employees is a time-consuming activity that is important for his clients (R. Karlibaeva 2021). This

means that it is necessary to clearly regulate the duration of the morning meetings in the workshop (Daft and Weick 1984). This will help save time, which means that you can order orders faster and perform better.

Explain to employees what activities your company considers to be losses and how you propose to restructure work in this regard (Shaturaev and Jumaev 2019). It is important to convey to the team the essence of the concept of "value to the consumer" and teach how to track all possible types of losses. In the case of our workshop, the owner must tell the assistants that they will now work in a new way in order to earn more. Introduce a list of losses - actions that need to be removed or reduced. Explain why this will help increase revenues and attract new customers (Бекимбетова Г.М. 2021). Better yet, if he asks if he has missed something important from the list and asks his employees to join in the search for losses.

Set aside one day a week to discuss with your coworkers the most obvious losses that you or employees have noticed in the process, and adjust the course of the lean strategy in the company.

Track feedback from waste elimination actions. Share your results with your team.

Regulate and standardize all lean concept activities that produce good results.

#### CONCLUSION.

Organizations strive to optimize management, including production management, strive to adjust processes in such a way as to reduce the cost of a product or service, and at the same time not lose, but rather improve quality. The universal recipe in this case is just the implementation of the principles of lean production, they have a simple and understandable logic:

1. Do not do what is not necessary;
2. Efficiency starts with the little things;
3. Efficient process - fast process;
4. Simplify;
5. Teach;
6. The result is valuable, not the process.

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# TECHNICAL SCIENCES

## 3D MODELLING OF UNTWISTED MULTIFILAMENT THREADS, CURVED IN A KNITTED LOOP

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### Abstract

To improve the mathematical software for three-dimensional knitwear modelling systems at the micro-level, an algorithm for shifting filaments within reserved volumes has been developed. The algorithm increases the accuracy of the model of knitwear structures, made of untwisted multifilament threads, considering arbitrary lateral shifts of the filaments within their reserved boundaries.

**Keywords:** Knit, 3D modelling, untwisted multifilament thread, algorithm

**Introduction.** The development of three-dimensional modelling of textile materials is based on algorithmic and mathematical means of describing their form at one of the next levels: fibre – elementary thread – complex thread – fabric – textile shell. The choice of an optimal level of three-dimensional models of textile materials is being discussed both in papers devoted to modelling of textile reinforcement of polymer composites [1-2], and in ones that address the issue of modelling of woven and knitted fabric structures [3-5]. Improving the accuracy of 3D modelling of textile structures can be reached due to a detailed mathematical description of the yarn structure. Description of the geometry of twisted complex threads in the knitted structure is considered in the works [6-7]. An approach to the three-dimensional modeling of woven structures, made of multifilament threads, at the level of separate filaments is examined in [8]. A mathematical software for the description of the geometry of a plain knit stitch, made of twisted ply yarn and wrap spun yarn is suggested in [9].

### Results and discussions.

Considering separate filaments in the three-

dimensional model of a knitted loop becomes possible, provided a mathematical apparatus of description of surfaces, which limits the part of the space, occupied by every individual filament, is elaborated. It is known that the size and shape of the yarn cross-section changes along its axial line. We assume that along the axial line of an untwisted multifilament thread, several segments of decreasing and increasing diameter are present (fig. 1). Let's a part of the thread  $l$ , is divided into  $h$  segments. Points  $t_0, t_1, \dots, t_{j-1}, t_j, \dots, t_h$  – are characteristic points of the axial line of the thread, in which local maximum or minimum values of the thread width are detected. Each segment  $g_j$  is limited by cross-sections  $e_{j-1}$  and  $e_j$ , taken at characteristic points  $t_{j-1}$  and  $t_j$  respectively. The cross-section in characteristic points can be denoted as *characteristic cross-sections*. The length of the segment  $g_j$  is assigned as  $dl_j$ . It's assumed as well, that the thread is composed of  $n$  filaments, that have an unchangeable cross-section with diameter  $d_f$ . Let's assign as  $o_{ij}$  the central point of the  $i$ -s filament in the co-ordinate system of the  $j$ -s cross-section of the thread.

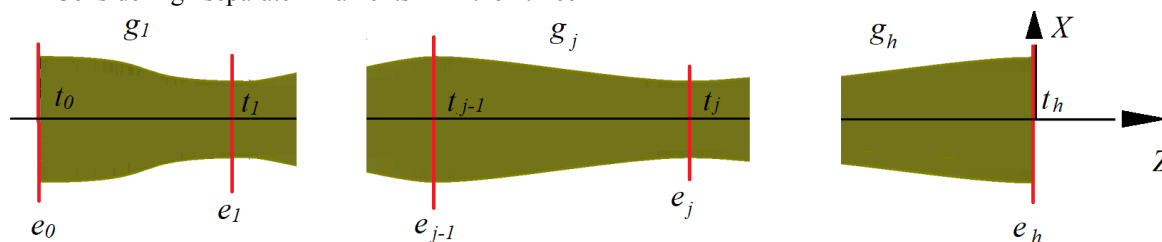


Figure 1. Projection of a part of yarn with a varied cross-section on a plane

Let's suppose that in cross-sections, where the thread has a minimum diameter  $D_{\min}$  – filaments are located as tightly as possible (Fig. 2a). The increase in the diameter may occur unevenly. In general, a cross-section shape of an unfolded multifilament thread can

be approximated by an ellipse with a major  $P_{\text{maj}}$  and minor  $P_{\text{min}}$  axis (Fig. 2b), which can take a form of a circle in particular cases, e.g., in characteristic points of the minimal thread width.

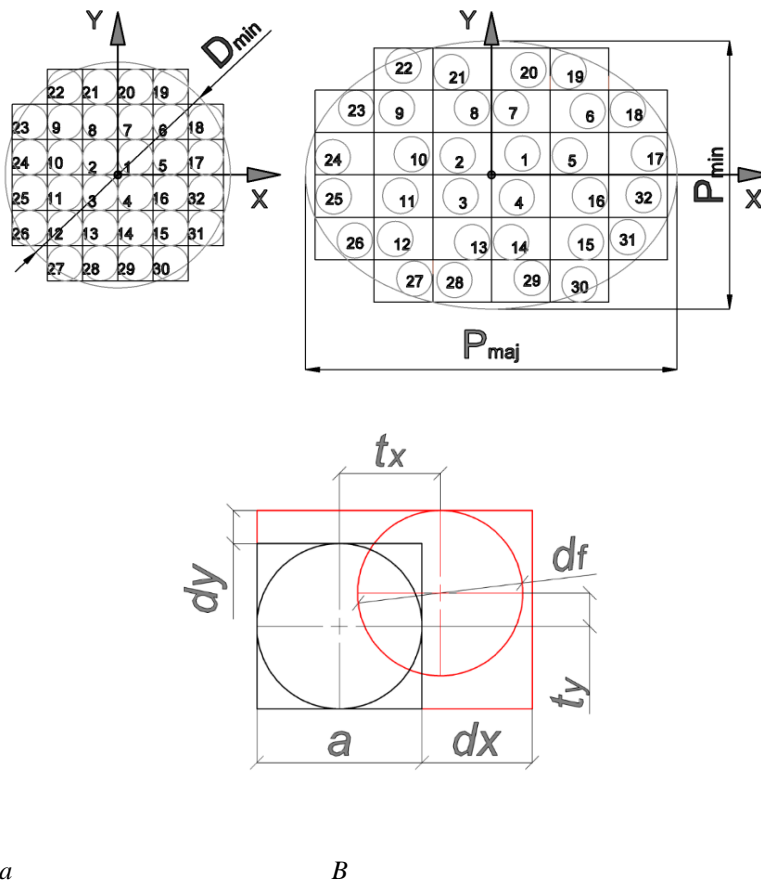


Figure 2. Cross-section of a thread, consisting of 32 filaments, with compact (a) and scattered (b) placement of the filaments; an arbitrary shift of the filament in the limits of its bounding rectangle (c)

The transition from a round to an elliptical form can be realized by increasing the distance between the individual filaments, keeping their mutual position unchanged. If all filaments' axis line traces remain in the central points of their boundaries, optical porosity will be significantly higher than it could be in a real thread. This may lead to discrepancies of the results of permeability simulation and visualization quality. At the points with a loose placement, the filaments' cross section can shift without crossing the boundary as shown in Fig. 2b. Let's determine a *reserved rectangle* as a rectangular area, belonging to the cross section  $e_j$ , which limits a possible displacement of a separate filament  $i$ 's cross-section. It's dimensions  $a_{x_j} \times a_{y_j}$  (Fig 2c) can be assessed as (1) and (2):

$$a_{x_j} = a + dx_j = d_f + dx_j \quad (1)$$

$$a_{y_j} = a + dy_j = d_f + dy_j \quad (2)$$

Then an arbitrary shift of the filament cross-section along the axis of the abscise and the ordinate in the

co-ordinate system of the  $j$ -s cross-section of the thread remains within:

$$\begin{aligned} 0 &\leq t_x \leq (a_{x_j} - d_f) \\ 0 &\leq t_y \leq (a_{y_j} - d_f). \end{aligned}$$

The key assumptions used in this algorithm are:

- all filaments have a round shape of cross-section with a constant diameter;
- tangents to the axis lines of separate filaments, built at the point of their intersection with the characteristic cross-sections, are parallel to the tangent line, built to the axial line of the thread at the appropriate characteristic points.

In Fig. 3 a block diagram of the algorithm is shown. The algorithm collects a set of data, containing coordinates of the centres of the filaments' cross-sections, distributed in the area of the appropriate thread cross-section  $e_j$ , considering an arbitrary lateral shift of the filaments within their reserved boundaries.

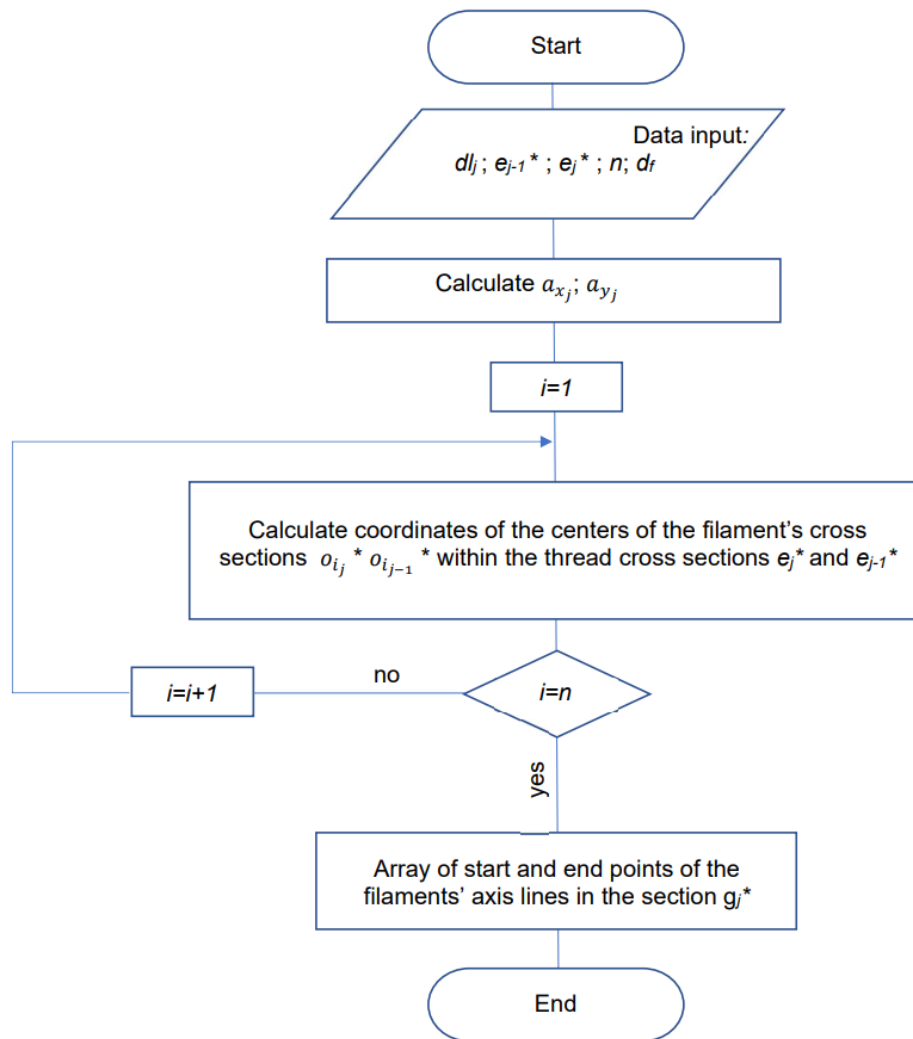


Figure 3. The algorithm of forming a data set, that contains coordinates of the start and end points of the filaments' axis lines, in the  $j$ -s segment of the thread

\* variables, that contain mathematical descriptions of graphical objects

Let's assign the sets of the reserved rectangles in the key cross sections  $e_j$  and  $e_{j-1}$  as:

$$R_j = \{r_{j_1}, r_{j_2}, \dots, r_{j_i}, \dots, r_{j_n}\}, \quad (3)$$

and

$$R_{j-1} = \{r_{j-1_1}, r_{j-1_2}, \dots, r_{j-1_i}, \dots, r_{j-1_n}\}. \quad (4)$$

The elements of these sets are graphical objects, containing their mathematical descriptions. The use of the algorithm increases the realism of the 3D model. This can be seen in Figure. 4.

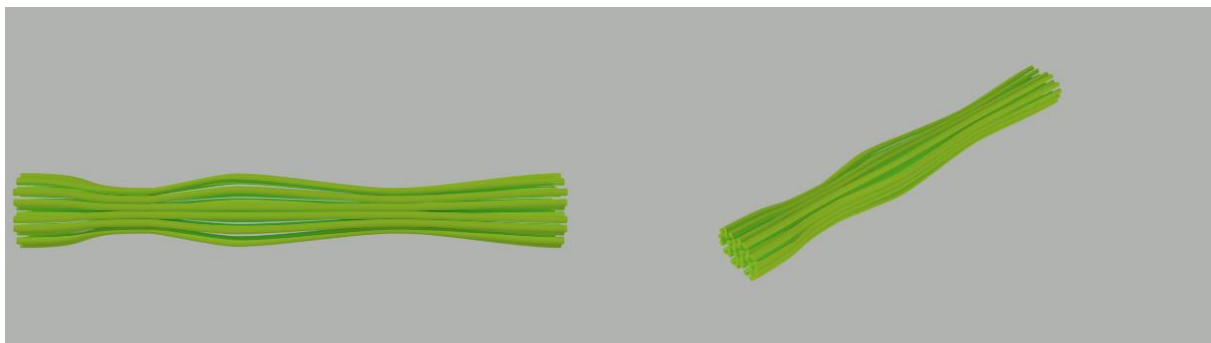


Figure 4. 3D model of a segment of a multifilament untwisted thread, generated with the use of the algorithm

In the structure of the knit, the axial line of thread has a more complicated configuration.

It is possible to assume that there are some characteristic points of a knitted loop, where the thread remains in the most compressed state (points  $C_1$ ,  $C_2$ ,  $C_3$  and  $C_4$  in Fig. 5). The cross sections in these points are marked as  $c_1$ ,  $c_2$ ,  $c_3$ ,  $c_4$  respectively. It is assumed as well, that at these points the filaments are inserted into a circular shape contour. A set of circular shaped cross sections can be described as:

$$C = \{c_1, c_2, \dots, c_k\}, \quad (5)$$

where  $k$  is the number of cross-sections of type  $c$  in a repeated unit of the thread (in the simplest case – in a plain knit loop  $k=4$ ).

There are also characteristic points, in which the

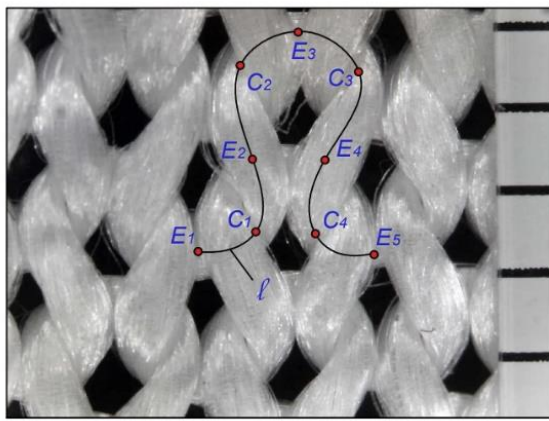
projection of the thread on the fabric plane has the greatest width. In Fig. 5 these are points  $E_1$ ,  $E_2$ ,  $E_3$ ,  $E_4$ ,  $E_5$ . We assume that at these points the filaments are located within elliptical boundary,  $e_1$ ,  $e_2$ ,  $e_3$ ,  $e_4$  and  $e_5$ . Accordingly, we can say, that within a repeated unit, a set of elliptical cross-sections of type  $e$  corresponds to the zones of the sparsest distribution of the filaments.

$$E = \{e_1, e_2, \dots, e_q\}, \quad (6)$$

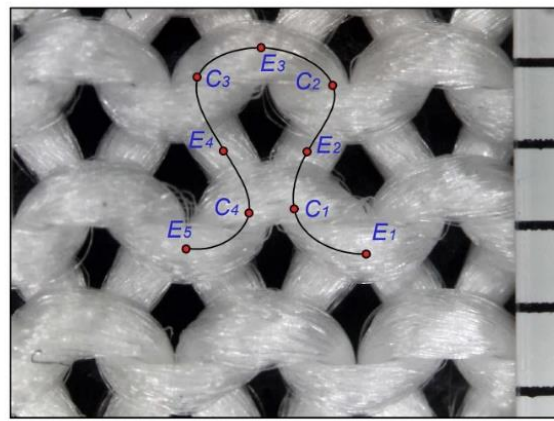
where  $q$  is the number of the cross-sections of type  $e$  in the repeated unit of the thread (for a plain knit loop  $q=5$ ).

The indicated points divide a section of the thread  $l$ , knitted in a plain knit stitch, in  $h$  segments, marked here as  $g_j$ .

$$l \leq j \leq h, \quad h = k + q - 1.$$



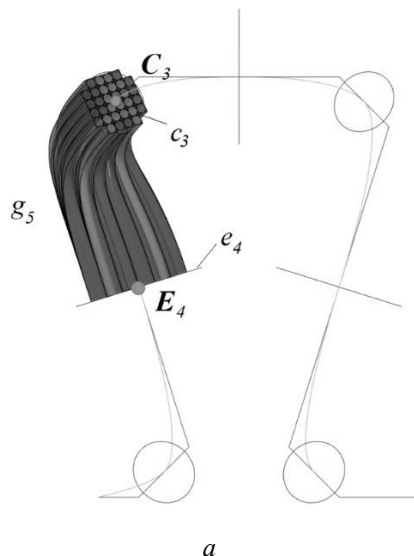
a



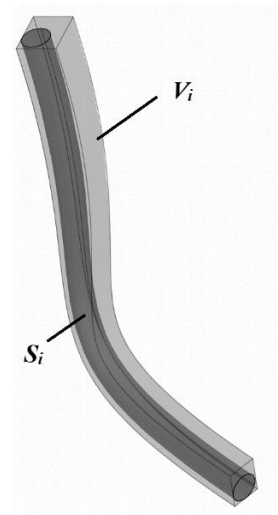
b

Figure 5. Placement of characteristic points on the axial line of a plain knit stitch on the projection of its technical face (a) and technical back (b) to the fabric plane.

In Fig. 6 a 3D model of a thread segment is shown. It consists of 32 filaments, limited by cross sections, built at points  $C_3$  and  $E_4$ .



a



b

Figure 6. 3D model of a multifilament thread section, limited by cross sections, built in adjacent characteristic points (a); a segment of one filament inside its reserved volume (b)

The algorithm of building a three-dimensional model of a plain knit stitch, made of a multifilament thread, is shown in Fig. 7. As the input data for construction, the algorithm uses:

- the equation of the thread axial line;
- coordinates of the characteristic points  $E_1(Xe_1, Ye_1, Ze_1)$ ,  $C_1(Xc_1, Yc_1, Zc_1)$ ,  $E_2(Xe_2, Ye_2, Ze_2)$ ,  $C_2(Xc_2, Yc_2, Zc_2)$ ,  $E_3(Xe_3, Ye_3, Ze_3)$ ,  $C_3(Xc_3, Yc_3, Zc_3)$ ,  $E_4(Xe_4,$

$Ye_4, Ze_4)$ ,  $C_4(Xc_4, Yc_4, Zc_4)$ ,  $E_5(Xe_5, Ye_5, Ze_5)$ ;

- number of filaments  $n$ ;
- and diameter of each individual filament  $d_f$ .

From the input data, the geometric description of the characteristic cross-section of the thread is processed, using standard mathematical formulae and the method, explained in [14].

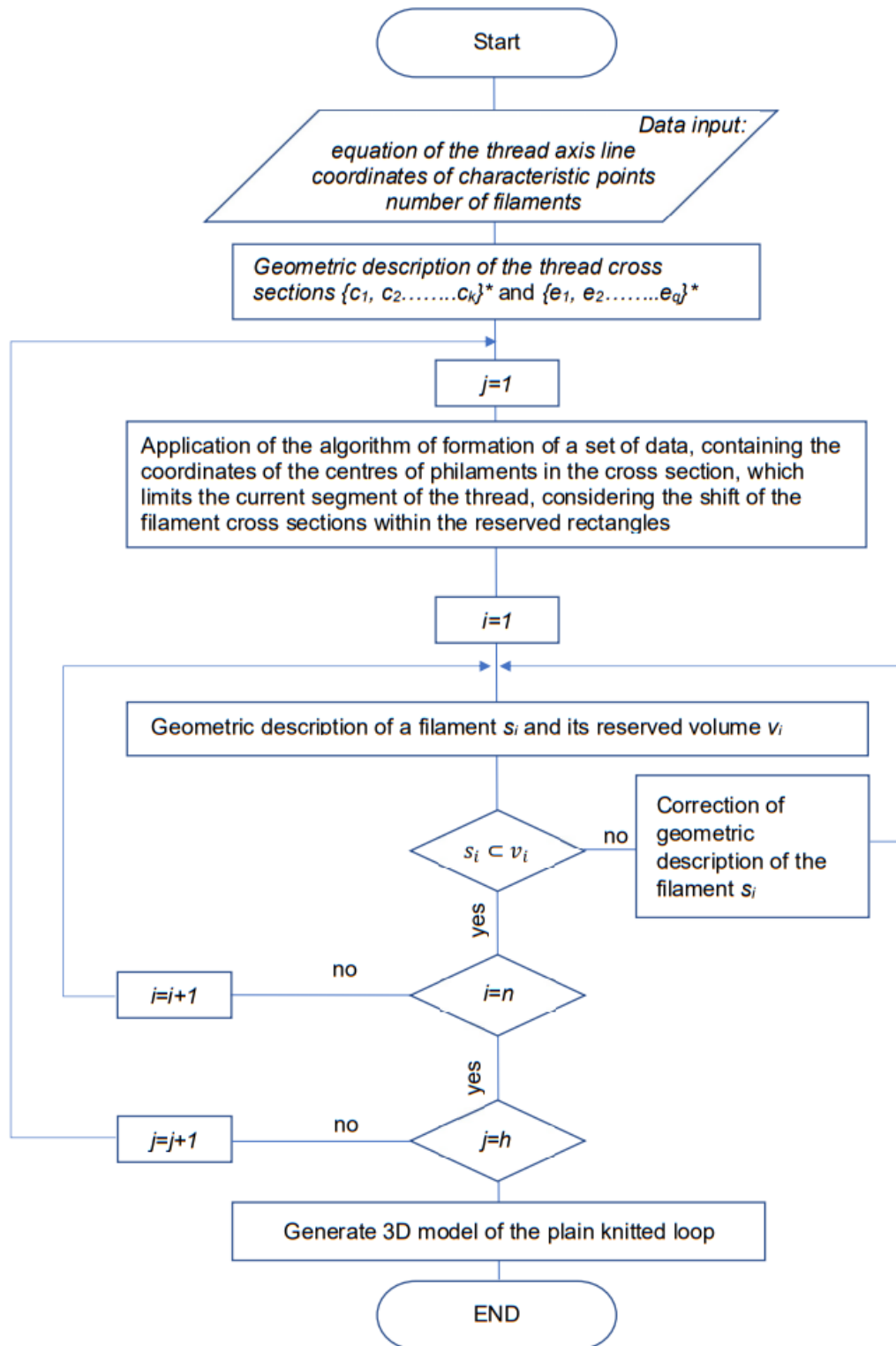


Figure 7.

Algorithm of construction of 3D model of a knitted loop made of a multifilament thread, at the micro-level



For each segment of the thread, the algorithm is executed, and a new cycle begins, where the number of repetitions equals the number of thread filaments. After the completion of the first filament, the transition to the next one is performed. When all the filaments are

checked, the transition to the next segment is performed, and after processing all segments, the model generates.

Fig. 8 represents a 3D model of a plain knit loop, made of multifilament thread. The number of filaments is 420. Diameter of one filament is 0,025 mm.

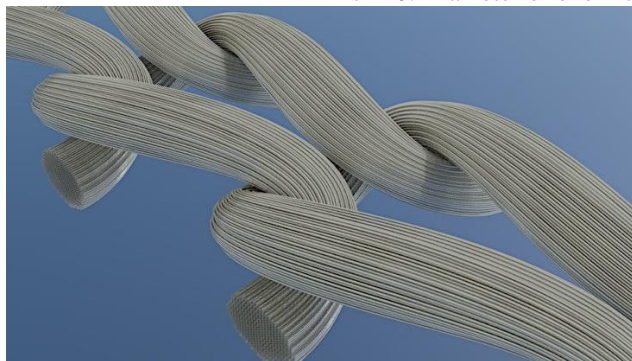


Figure 8. Visualization of a knitted structure at the filament level (micro-level)

Application of the algorithm of 3D modelling of knitted structures, made of untwisted multifilament threads, considering lateral displacement of filaments within the reserved volumes, increases the accuracy and realism of the model and simplifies its processing by the means of CFD analysis.

### Conclusions

During the study, an algorithm of the lateral displacement of filaments within the reserved volumes was developed, intended to increase the accuracy of three-dimensional geometric models of knitted structure, made of untwisted multifilament threads.

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DOI: [10.24412/2701-8369-2021-22-80-84](https://doi.org/10.24412/2701-8369-2021-22-80-84)**ЭКОЛОГИЧЕСКАЯ БЕЗОПАСНОСТЬ НА НЕФТЕПЕРЕРАБАТЫВАЮЩЕЙ  
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**Abstract**

This paper investigates the environmental problems of production and transportation of oil. The basic causes and sources of pollution from the process of development of oil and gas, also, measures to improve environmental safety.

**Аннотация**

В данной статье исследуются экологические проблемы переработки нефти. Выявлены основные причины и источники загрязнения, также меры по улучшению экологической безопасности.

**Ключевые слова:** экологическая безопасность, нефтегазовые ресурсы, загрязнение окружающей среды, утилизация нефтяного попутного газа(ПНГ).

**Keywords:** ecological safety, oil and gas resources, environmental pollution, utilization of associated petroleum gas (APG).

**Введение.** Экологическая безопасность как составная часть национальной безопасности является обязательным условием устойчивого развития и выступает основой сохранения природных систем и поддержания соответствующего качества окружающей среды. На современном этапе взаимодействия общества и природы экологическая безопасность может рассматриваться как качественно новый вид общественной ценности.

Согласно приведенному в Экологическом кодексе Республики Казахстан определению, содержащемуся в подпункте 91) статьи 1 Экологического кодекса РК «экологическая безопасность – это состояние защищенности жизненно важных интересов и прав личности, общества и государства от угроз, возникающих в результате антропогенных и природных воздействий на окружающую среду» [1]. Проблемы охраны окружающей среды занимают все более важное место в системе мировых приоритетов, экологические ценности все более активно и успешно интегрируются в стратегию экономического развития.

К сожалению, на протяжении десятилетий в Казахстане сложилась сырьевая система с преобладанием природопользования, с очень высокой технической нагрузкой на окружающую среду, что

приводит к деградации природных систем, нестабильности биосферы и утрате способности поддерживать качество окружающей среды, необходимое для жизнедеятельности общества.

Особенно неблагоприятна ситуация в нефтегазовой отрасли. Так, по оценкам специалистов, в 3,2 млн тонн вредных выбросов, сжигаемых тяжелых нефтяных остатков, мазута, попутного нефтяного газа, улавливается в лучшем случае около 50% - 65%. Кроме того, все твердые отходы, образующиеся при вышеупомянутой добыче и переработке нефти, могут быть широко использованы в народном хозяйстве Казахстана после глубокой и комплексной переработки.

Негативное влияние предприятий нефтегазовой отрасли на окружающую среду приводит к следующим изменениям ее компонентов: изменение целостности массивов пород, образование техногенных ландшафтов, нарушение земель, загрязнение атмосферного воздуха и водных объектов, образование отходов производства, негативное воздействие на здоровье человека, гибель и повреждение растительного покрова и объектов животного мира, повышение риска возникновения чрезвычайных ситуаций. А для Казахстана, одного из мировых лидеров по нефтедобыче, эти экологические проблемы стоят наиболее остро.

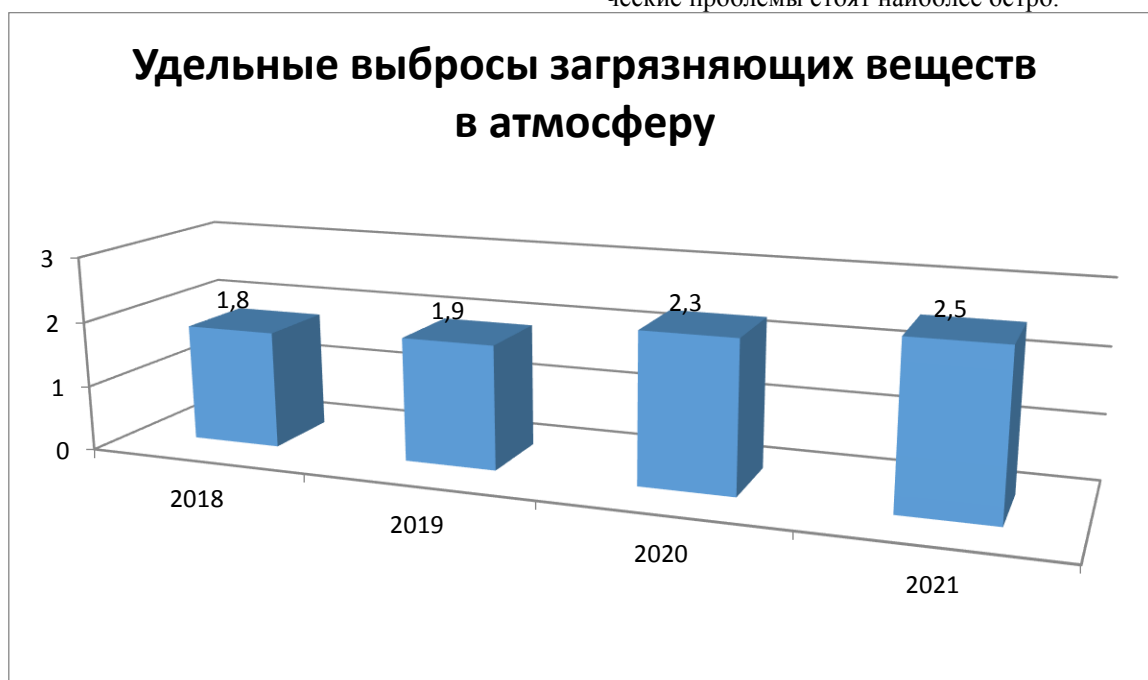


Диаграмма 1. Удельные выбросы загрязняющих веществ в атмосферу от переработанной нефти

В данной диаграмме мы можем увидеть удельные выбросы загрязняющих веществ в атмосферный воздух. С каждым годом содержание загрязняющих выбросов увеличивается 1.2 раз. Причиной повышения удельных выбросов в атмосферы могут послужить увеличение объема переработанной

нефти, также из за сжигаемых тяжелых нефтяных остатков [2].

Процесс переработки нефти сопровождается сотней различных химических веществ, из которых почти каждое третье относится к высшим классам опасности.

Таблица 1.

## Классы опасности вредных веществ в атмосфере

Класс опасности	Вещества	Средняя смертельная концентрация в воздухе
1-й — чрезвычайно опасные	бензапирен, озон, свинец	менее 500 мг/м <sup>3</sup>
2-й — высокоопасные	формальдегид, сероводород, сероуглерод, фенол, фторид водорода, хлорид водорода	500–5000 мг/м <sup>3</sup>
3-й — умеренно опасные	оксид азота, диоксид азота, диоксид серы, углерод (сажа), этилбензол, взвешенные вещества (пыль)	5001–50 000 мг/м <sup>3</sup>
4-й — малоопасные	аммиак, оксид углерода, диоксид углерода	более 50 000 мг/м <sup>3</sup>

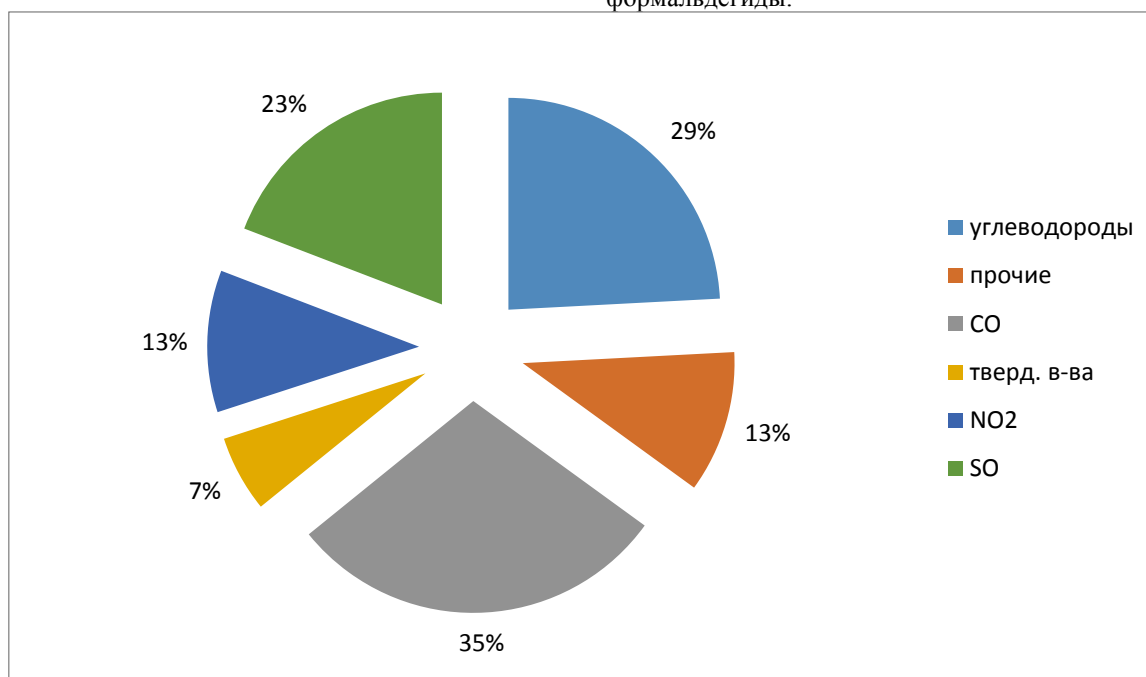
Из приведенных табличных данных можно делать вывод о том, что есть 4 санитарных классификации опасностей химических и токсических веществ.

Те, которые относятся к нижнему классу опасностей, но в больших концентрациях, могут приравниваться к высокоопасным компонентам [3].

Особую опасность представляют отходы нефтепереработки. Степень утилизации отходов нефтепереработки незначительна, и приводит к большому накоплению отходов на территории нашей страны. Для хранения этих отходов предна-

значены полигоны (специальные инженерные сооружения), которые должны соответствовать требованиям экологической безопасности. Эти полигоны являются источниками загрязнения окружающей среды вследствие испарения отходов нефтепереработки, их проникания в грунтовые воды [4].

К основным источникам загрязнения в результате нефтеперерабатывающей деятельности относятся: сероводород H<sub>2</sub>S, оксид углерода CO, диоксид углерода CO<sub>2</sub>, углеводород, диоксид азота NO<sub>2</sub>, сернистый газ SO<sub>2</sub>, канцерогенные вещества, формальдегиды.



Диаграмме 2. Приблизительное процентное содержание вредных веществ в атмосфере от нефтеперерабатывающей промышленности [5].

На данной диаграмме представлена, что 35% выбросов приходится на оксида углерода CO. Продукты горения топлива содержат вредных веществ одним из которых является CO, удаляются с дымовыми газами и оказывают вредное воздействие на атмосферу и окружающую природную среду. CO оказывает вредное воздействие на организм человека (угарный газ). При вдыхании оксид углерода блокирует поступление кислорода кровь и вследствие этого вызывает головные боли, тошноту, а в более высоких концентрациях - даже

смерть. ПДК CO при кратковременном контакте составляет 30 мг/м<sup>3</sup>, при длительном контакте - 10 мг/м<sup>3</sup>. Если концентрация оксида углерода во вдыхаемом воздухе превысит 14 мг/м<sup>3</sup>, то возрастает смертность от инфаркта миокарда. Уменьшение выбросов оксида углерода достигается путем дожигания отходящих газов [6].

Большой процент выбросов приходится на углеводороды. Являясь основными компонентами нефти, природного газа и пестицидов, эти вещества способствуют возникновению парникового эф-

фекта и изменению климата, разрушению озонового слоя, снижению фотосинтетической способности растений, а также увеличению числа случаев раковых заболеваний и респираторных расстройств у человека.

Не менее опасными химическими веществами являются диоксид азота  $\text{NO}_2$ , диоксид серы  $\text{SO}_2$  и диоксид углерода  $\text{CO}_2$ .

При растворении в воде диоксид серы образует кислотные дожди, которые губят растения, закисляют почву, увеличивают кислотность озер. Даже при среднем содержании оксидов серы в воздухе порядка 100 мкг/м<sup>3</sup>, что нередко имеет место в городах, растения приобретают желтоватый оттенок.

Оксиды азота занимают второе место после диоксида серы по вкладу в увеличение кислотности осадков. В дополнение к косвенному воздействию (кислотный дождь), длительное воздействие диоксида азота в концентрации 470-1880 мкг/м<sup>3</sup> может подавлять рост некоторых растений (например, томатов). Значимость атмосферных эффектов оксидов азота связана с ухудшением видимости. Диоксид азота играет важную роль в образовании фотохимического смога.

Затрагивая вопросы экологической безопасности в условиях необходимости комплексного использования углеводородного сырья, нельзя не вспомнить о проблеме утилизации попутного нефтяного газа (ПНГ). Сейчас эта проблема актуальна практически для любой нефтедобывающей компании. Попутный нефтяной газ, залегающий вместе с нефтью, на данный момент не осваивается, утилизация его происходит путем сжигания в факелах. Сжигание попутного нефтяного газа (ПНГ) на факельных установках приводит к значительным потерям ценного химического сырья. Утилизация ПНГ позволила бы ежегодно производить до 5-6 млн. тонн жидких углеводородов, 3-4 млрд. кубометров этана, 15-20 млрд. кубометров сухого газа или 60-70 тысяч ГВт/ч электроэнергии. Расчеты показывают, что упущенная выгода от каждого сожженного миллиарда кубических метров ПНГ эквивалентна потере товарной продукции на сумму 270 млн. долларов, при этом потери бюджета составляют порядка 35 млн. долларов.

Кроме того, сжигание ПНГ приводит к значительным выбросам в атмосферу целого спектра канцерогенных и токсичных продуктов сгорания и парниковых газов. Выбросы, образующиеся при сжигании ПНГ, составляют около 2% от выбросов всех стационарных источников. По разным оценкам, за год в результате сжигания ПНГ в атмосферу выбрасывается 400 тыс. т вредных веществ. В среднем на 1 т добытой нефти приходится около 8 кг вредных атмосферных выбросов, которые локализуются преимущественно в сырьевых регионах. Сжигание ПНГ сопровождается также тепловым загрязнением окружающей среды: вокруг факела радиус термического разрушения почв колеблется в пределах 10-25 метров, растительности – от 50 до 150 метров [7].

Загрязнения атмосферы продуктами горения газа возможно избежать, направив газ на производственные нужды потребителей или самой компании. В последние годы нефтегазовые компании более активно начинают совершать сделки, используя механизмы, предусмотренные Киотским протоколом к Рамочной конвенции ООН об изменении климата, что также может способствовать более эффективному решению задачи утилизации ПНГ за счет получения доступа к иностранным технологиям и оборудованию в результате реализации квот на выбросы.

Также остро стоит вопрос загрязнения гидросферы нефтепродуктами. Эта проблема касается как небольших водоемов и рек, так и вод Мирового океана. Ежегодно происходит около 60 крупных аварий и более 20 тысяч случаев, заканчивающихся значительными разливами нефти. Водоизмещение нефтяных танкеров увеличивается и достигает 700 тысяч т, поэтому катастрофы танкеров оказывают влияние на морские биоценозы всего земного шара.

Нефтепродукты поступают в моря и океаны и через канализационные стоки. На долю предприятий нефтегазового комплекса приходится более 1% объема используемой свежей воды в России и около 13 % сброса сточных вод в водоемы. Со сточными водами предприятий нефтегазовой отрасли в водный бассейн поступают нефтепродукты, хлориды, сульфиды, фенолы, соединения азота, соли тяжелых металлов, взвешенные вещества и др.

Ежегодно в океан сбрасывается более 10 млн. тонн нефти. Уже почти 30 % поверхности океана покрыто нефтяной пленкой. Особенно загрязнены воды Средиземного моря и Атлантического океана. Для гибели большинства видов рыб достаточно концентрация нефти и нефтепродуктов около 0,01 мг на 1 литр воды. Также углеводороды образуют пленку на поверхности воды, тем самым перекрывая доступ кислорода рыбам. Тонна нефти загрязняет 12 км<sup>2</sup> поверхности океана. Литр нефти лишает кислорода, столь необходимого рыбам, загрязняя при этом 40 тыс. л морской воды. Нефтяная пленка уменьшает испарение воды на 60 % [8].

Негативные последствия образования нефтяных пленок носят глобальный характер:

- снижение количества осадков над континентами приводит к увеличению пустынных участков суши;
- более частое возникновение циклонов, изменение метеообстановки;
- сокращение видов и численности морских и пресных рыб;
- массовая гибель птиц и морских млекопитающих.

Мы считаем, что предотвращению загрязнения гидросферы нефтепродуктами могут способствовать следующие мероприятия:

- совершенствование экологического законодательства;
- рациональное размещение предприятий нефтегазового комплекса с учетом особенностей природной экосистемы;

- увеличение инвестиций в инновационные технологии транспорта, добычи и переработки нефти;
- разработка новых способов и методов для очистки поверхности водных объектов;
- повышение эффективности систем очистки сточных вод на предприятиях нефтегазового комплекса.

**Вывод.** В заключение можно сделать вывод, что экологическое состояние окружающей среды при производственной деятельности нефтеперерабатывающих предприятий является серьезной проблемой, который затрагивает всех аспектов окружающей среды, именно поэтому для ее решения нужны кардинальные меры.

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# CHEMICAL SCIENCES

## SYNTHESIS OF A NEW AMINOCOLCHAMINE DERIVATIVE WITH PROPARGYL ALCOHOL

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## СИНТЕЗ НОВОГО ПРОИЗВОДНОГО АМИНОКОЛХАМИНА С ПРОПАРГИЛОВЫМ СПИРТОМ.

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### Abstract

A aminocolchamine derivative with 2-methyl-5-ethynylpyridine from the *Colchicum luteum* baker plant was synthesized. The structure of the synthesized compound was confirmed by the data of IR and PMR spectra. In the IR spectra of compounds with an ester group, absorption bands of the carbonyl group ( $1735-1730\text{ cm}^{-1}$ ) appear, and in the spectra of carbinols of the hydroxyl group ( $3400-3450\text{ cm}^{-1}$ ).

### Аннотация

Синтезировано производное аминоколхамин с пропаргильным спиртом. Строение синтезированного соединения подтверждено данными ИК- и ПМР-спектров. В ИК-спектрах соединений со сложноэфирной группировкой проявляются полосы поглощения карбонильной группы ( $1735-1730\text{ см}^{-1}$ ), а в спектрах гидроксильной группы карбинолов ( $3400-3450\text{ см}^{-1}$ ).

**Keywords:** Aminocolchamine, 2-methyl 5-ethynylpyridine, IR spectroscopy.

**Ключевые слова:** Аминоколхамин, пропаргильный спирт ИК-спектроскопия.

**Введение.** В мире алкалоиды - растительные основания, имея совершенно разнообразные химические строения и физиологическую активность составляют один огромный класс органических соединений. Глубокое исследование их строения и физиологической активности внесло огромный вклад в развитие теоретической органической химии и медицинской практики. В то же время интерес к их исследованию не ослабевает, принося науке и практике все новые результаты. Установление особенностей их строения имеет особое значение.

В мире лекарственных средств созданных на основе алкалоидов групп трополона широко масштабно используется в практике медицины и органического синтеза. К группе алкалоидов относятся трополоновые, продуцентами которых являются безвременники (*Colchicum L.*) и близкие им растения семейства Лилейных. Структурное разнообразие их алкалоидов, важные физиологические свойства и нахождение все новых их представителей был проведен ряд исследовательских работ.

В нашей стране с целью развития химической промышленности разрабатываются эффективные методы извлечения лекарств из растений, отвечающих современным требованиям, особое внимание уделялось выделению эффективных способов растительных лекарственных веществ, были достиг-

нуты определённые успехи в создании лекарственных препаратов. Меры, предпринятые в этом направлении, привели к определенным результатам, в том числе, принимаются обширные меры по выделению физиологически активных веществ из лекарственных растений, по синтезу их малотоксичных продуктов, а также по изучению состава, структуры и свойств синтезированных соединений, для определения зависимости их физиологической активности от структуры. В связи с ростом и развитием разных отраслей хозяйства возрастает потребность в новых классах соединений, особенно содержащих углерод-углеродную тройную связь. Поэтому химическая продукция, полученная на основе ацетилена и его производных, в последние годы стала объектом широкого исследования синтетической химии. Особый интерес к этой проблеме объясняется высокой реакционной способностью и большими перспективами практического использования таких синтетических продуктов, на основе которых возможно получение физиологически активных веществ [1, 2] ингибиторов коррозии металлов [3] и прочее.

Основное исходное соединение для проведения синтеза – аминоколхамин - был выделен из растения *Colchicum luteum* baker, произрастающего в степях Сурхандаринской области Республики Узбекистан [4].

Замечено, что введение в молекулу лекарственных веществ групп, содержащих ацетиленовую связь, заметно снижает их токсичность. В работе синтезированы производные аминоколхамина со 2-метил-5-этинилпиридином.

#### Экспериментальная часть

**Синтез производных аминоколхамина со 2-метил-5-этинилпиридином.** Навеску 1,0 г аминоколхамина растворяли в 17 мл свежеперегнанного и высушенного диоксана, в полученный раствор добавляли 0,12 г параформа, 0,01 г гидрохинона и 0,03 г однохлористой меди. Затем добавляли эквимолекулярное количество 2-метил-5-этинилпиридина. Содержимое в колбе тщательно перемешивали [5-7].

Реакцию конденсации аминоколхамина с ацетиленовыми соединениями проводили по Манниху, в эквимолекулярных соотношениях реагентов.

Полученные вещества представляют собой порошок светло-желтого цвета. Методом тонкослойной хроматографии установлено, что продукты синтеза имеют близкие значения  $R_f$ . В то же время по хроматографической подвижности они сильно отличаются от исходного аминоколхамина, имея высокие значения  $R_f$ .

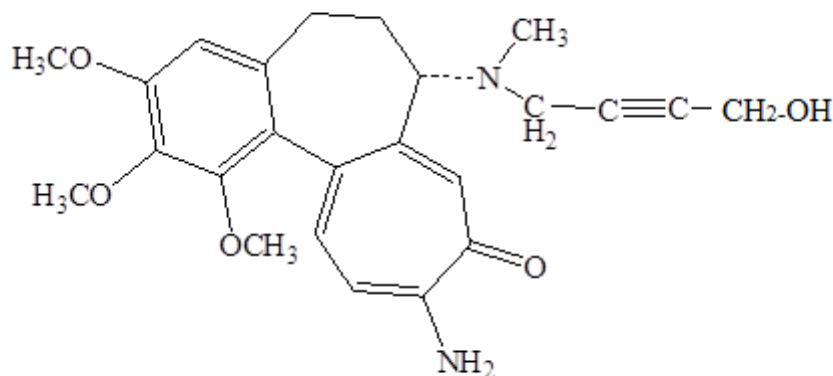
Вследствие алкильного (а не ацильного) харак-

тера вводимых в аминогруппу заместителей, полученные производные сохраняют, в некоторой степени, основность (особенно с пиридиновым кольцом), что затрудняет отделение примеси аминоколхамина от продуктов реакций. Поэтому для этой цели прибегли способу хроматографирования на окиси алюминия (элюенты - смеси эфир-ацетон, ацетон и ацетон-метанол).

**Результаты и их обсуждение.** Строение синтезированных соединений подтверждены данными методов ИК- и ПМР-спектроскопии. В ИК-спектрах соединений со сложноэфирной группировкой проявляются полосы поглощения карбонильной группы ( $1735-1730\text{ см}^{-1}$ ), а в спектрах карбинолов гидроксильной группы ( $3400-3450\text{ см}^{-1}$ ).

Аминоколхаминный фрагмент синтезированного соединений в ПМР-спектрах существенно не различается: сигналы N-метильной группы проявляются при 2,20-2,22 м.д, метоксильных групп - 3,56-3,60 (при C-1) и 3,82-3,85 м.д. (при C-2, C-3 C-10), протона H-4 - при 6,44-6,51 м.д., H-8 - 7,90-7,96 м.д., H-11 - 6,68-6,75 м.д. и H-12 - 7,17-7,22 м.д.

Полученное соединение исследовали спектральными методами и подтвердили, что оно имеет следующую структуру.



#### Выводы

1. Синтезировано новое производное аминоколхамина с пропаргильным спиртом
2. Методами ПМР и ИК спектроскопии подтверждены состав и структура синтезированного соединения

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