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ARCHITECTURE

BIOCLIMATIC DESIGN AND ENERGY EFFICIENCY AS KEY VECTORS OF SUSTAINABLE DEVELOPMENT OF INDUSTRIAL FACILITIES

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БІОКЛІМАТИЧНЕ ПРОЄКТУВАННЯ ТА ЕНЕРГОЕФЕКТИВНІСТЬ ЯК КЛЮЧОВІ ВЕКТОРИ СТАЛОГО РОЗВИТКУ ПРОМИСЛОВИХ ОБ'ЄКТІ

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Abstract

The article discusses the principles of bioclimatic design of industrial facilities in the context of energy efficiency and adaptability to climate change. The influence of architectural and planning solutions, orientation of volumes, insolation, ventilation, and thermal inertia on reducing energy consumption is analyzed. Particular attention is paid to integrating natural factors and digital tools (BIM, Scan-to-BIM, microclimatic modeling) in reconstructing industrial heritage. Model approaches to forming sustainable and functionally efficient facilities adapted to the Ukrainian climatic context are proposed.

Анотація

У статті розглянуто принципи біокліматичного проєктування промислових об'єктів у контексті енергоефективності та адаптивності до кліматичних змін. Проаналізовано вплив архітектурно-планувальних рішень, орієнтації об'ємів, інсоляції, вентиляції та теплової інерційності на зниження енергоспоживання. Особливу увагу приділено інтеграції природних факторів і цифрових інструментів (BIM, Scan-to-BIM, мікрокліматичне моделювання) у реконструкцію промислової спадщини. Запропоновано модельні підходи до формування сталих і функціонально ефективних об'єктів, адаптованих до українського кліматичного контексту.

Keywords: bioclimatic design; industrial architecture; energy efficiency; ventilation; insolation; adaptive revitalization; digital modeling.

Ключові слова: біокліматичне проєктування; промислова архітектура; енергоефективність; вентиляція; інсоляція; адаптивна ревіталізація; цифрове моделювання.

Постановка проблеми. У сучасних умовах глобального потепління, енергетичної кризи та зростання антропогенного навантаження на довкілля, архітектурне проєктування промислових об'єктів вимагає принципово нових підходів, орієнтованих на енергоефективність, екологічність та адаптивність до кліматичних умов. Традиційні методи проєктування не враховують у повній мірі потенціал природних ресурсів, мікроклімату ділянки та особливості регіонального контексту, що призводить до нерационального використання енергії, надмірних витрат на кондиціювання і опалення, а також підвищеного вуглецевого сліду впродовж життєвого циклу будівлі. Біокліматичне проєктування як інтегрований міждисциплінарний підхід дозволяє забезпечити узгодженість архітектурно-просторових рішень з параметрами зовнішнього середовища, знижуючи енергоспоживання, оптимізуючи теплообмінні процеси та створюючи комфортне внутрішнє середовище без надмірної залежності від техногенних систем.

Особливої актуальності ця проблематика набуває у сфері промислового будівництва, де великі площі, значні теплові навантаження та складні технологічні процеси створюють додаткові виклики для архітекторів і інженерів. Біокліматичні стратегії, зокрема орієнтація будівлі за сторонами світу, використання природної вентиляції, тепла інерційність огорожувальних конструкцій, сонцезахисні екрани, зелені покрівлі та фасади, здатні не лише знизити експлуатаційні витрати, а й підвищити екологічну стійкість об'єктів.

На тлі трансформації нормативної бази у країнах Європейського Союзу та впровадження принципів зеленого курсу, Україна має адаптувати архітектурну практику промислового будівництва до вимог кліматично орієнтованого дизайну. У цьому контексті постає потреба у розробці адаптивних моделей проєктування, які поєднують сучасні цифрові інструменти (BIM, енергомоделювання, симуляції освітлення та вентиляції) з природоорієнтованими рішеннями.

Наукова новизна дослідження полягає у систематизації та критичному аналізі біокліматичних стратегій, релевантних для українських кліматичних зон, а також у визначенні архітектурно-планувальних рішень, що забезпечують енергоефективність промислових об'єктів без втрати функціональної ефективності та експлуатаційної гнучкості. Зважаючи на необхідність скорочення викидів CO₂ та впровадження принципів циркулярної економіки, дослідження біокліматичного проектування у промисловій архітектурі має не лише теоретичну, але й практичну цінність для формування архітектурних стандартів нового покоління.

Метою статті є обґрунтування архітектурних засад біокліматичного проектування промислових будівель як інструменту забезпечення їх енергоефективності та сталого функціонування, з урахуванням кліматичних умов, нормативних вимог і сучасних просторово-технологічних рішень.

Матеріали та методи дослідження. У дослідженні застосовано метод морфологічного аналізу архітектурно-просторових рішень промислових будівель з метою виявлення структурних елементів, які забезпечують біокліматичну адаптацію. Метод функціонально-планувального моделювання використовувався для розробки варіантів конфігурації виробничих об'ємів з урахуванням інсоляції, природної вентиляції та теплового балансу. Також використано метод типологічного узагальнення для класифікації архітектурних рішень відповідно до кліматичних зон, орієнтації на ділянці та характеру технологічних процесів. Застосування цих методів дало змогу сформулювати принципи інтеграції біокліматичних стратегій у сучасне проектування промислових об'єктів з урахуванням енергоефективності, технологічної логіки та умов довкілля.

Результати дослідження та обговорення. Енергоефективність промислових будівель є результатом складної взаємодії зовнішніх кліматичних умов, архітектурних рішень і технічних параметрів об'єкта [4]. Біокліматичне проектування передбачає врахування специфіки мікроклімату території – середньорічної температури повітря, напрямку вітрів, кількості сонячного випромінювання, вологості, наявності природних бар'єрів. Ці параметри визначають логіку розташування об'ємів будівлі, орієнтацію головних фасадів, організацію природного освітлення і вентиляції.

Особливу роль відіграє орієнтація промислового об'єкта за сторонами світу. Наприклад, у кліматичних умовах України доцільно розташовувати робочі зони з переважним освітленням із півдня, що забезпечує оптимальне інсоляційне навантаження в зимовий період. Проте влітку це вимагає застосування сонцезахисних елементів, таких як горизонтальні ламелі, зелений фасад або інерційне скління. Важливо також враховувати сезонну мінливість температур, адже промислові об'єкти часто мають великі об'єми та відкриті простори, де традиційні системи обігріву чи охолодження є малоефективними або енерговитратними.

Іншою критичною умовою є повітрообмін. За біокліматичними принципами в будівлі мають бути передбачені канали природної вентиляції, а також можливість крос-вентиляції через наскрізні прогони, вентиляційні шахти або повітроводи у дахових просторах. Використання ефекту тяги на основі різниці тиску повітря дозволяє значно зменшити витрати на механічну вентиляцію [6]. У теплому кліматі (або в літній період) оптимізується розміщення отворів на висоті, що сприяє ефективному виведенню перегрітого повітря.

Також слід враховувати теплову інерційність огорожувальних конструкцій. Массивні матеріали з високою теплоємністю (наприклад, бетон з вбудованими фазозмінними матеріалами) можуть накопичувати тепло вдень і віддавати його вночі. Це особливо корисно для добового балансу температур у неопалюваних або напівопалюваних виробничих залах. Таким чином, узгодження архітектурної конфігурації об'єкта з кліматичними факторами дозволяє знизити навантаження на інженерні системи, а отже – забезпечити ефективне функціонування з меншими витратами енергії.

Біокліматичні стратегії в архітектурі – це набір просторово-конструктивних рішень, що забезпечують мінімальне використання енергоресурсів через адаптацію до кліматичних умов. У контексті промислової архітектури особливо важливо розробити системний підхід до впровадження таких стратегій, які враховують специфіку технологічних процесів, великі об'єми будівель, потреби в інсоляції, вентиляції та тепловому захисті [5].

Одна з ключових стратегій – інтеграція буферних зон: тамбури, теплові шлюзи, перехідні простори, які зменшують теплові втрати на межі «зовнішнє середовище – внутрішнє середовище» [5]. Також важливо застосовувати зелені дахи та фасади, які знижують температуру покрівлі, захищають від ультрафіолетового випромінювання, затримують дощову воду, а також сприяють мікрокліматичній стабілізації.

Організація природного освітлення – ще одна стратегія, що поєднує функціональну та енергетичну ефективність. Застосування світлових ліхтарів, верхнього освітлення, світловідбивних поверхонь і напівпрозорих матеріалів (наприклад, ETFE-мембран) дає змогу мінімізувати використання штучного освітлення протягом дня. Разом з тим такі рішення вимагають зонального контролю та захисту від перегріву влітку.

Особливе значення має стратегія акумулювання та перерозподілу тепла: застосування стін з термомасою, вентиляційних камер у підлозі, накопичувачів тепла в міжповерхових перекриттях, а також використання геотермальних каналів (ground cooling tubes) для охолодження повітря до його потрапляння у виробничу зону [3].

Не менш важливу роль відіграє і форма будівлі: компактність об'єму (відношення площі зовнішньої оболонки до об'єму будівлі), аеродинамічна оптимізація форм, захист від вітру за рахунок ландшафтного моделювання або зовнішніх елементів – усе це забезпечує зниження втрат енергії.

За допомогою типологічного аналізу можна виокремити найбільш ефективні морфологічні моделі: павільйонна забудова з буферними коридорами, об'єми з патіо, напіввідкриті промислові галереї тощо.

Отже, систематизація біокліматичних стратегій дозволяє створити адаптивну модель промислового об'єкта, що відповідає кліматичним умовам, сприяє підвищенню стійкості системи і водночас зберігає функціональну ефективність.

Впровадження біокліматичного підходу у практику промислового проектування вимагає не лише теоретичних обґрунтувань, але й розробки конкретних архітектурно-планувальних рекомендацій, адаптованих до українського будівельного контексту. Враховуючи зміни клімату, деградацію інфраструктури внаслідок війни та актуальні вимоги до енергоефективності, доцільно сформулювати модельні рішення, які можуть бути інтегровані у нове будівництво або реконструкцію промислових об'єктів.

Насамперед, при формуванні архітектурно-планувальних рішень доцільно передбачати високу варіативність просторових структур. Зокрема, впровадження секційної організації, базованої на принципах модульного проектування, створює передумови для гнучкого реагування на зміну мікрокліматичних параметрів окремих функціональних зон. Такий підхід забезпечує не лише комфортні умови перебування, але й енергоефективність за рахунок локального регулювання теплових режимів. Виробничі приміщення, відповідно, мають проектуватися з урахуванням поділу на зони з різним рівнем теплового навантаження, що уможливує використання комбінованих вентиляційних систем: природної вентиляції у буферних або перехідних просторах, а також механічної вентиляції – у зонах з високими технологічними вимогами до повітрообміну.

Додатково, доцільним є впровадження архітектурних елементів з функцією регульованої інсоляції, зокрема адаптивних фасадних систем, що включають рухомі ламелі, сонцезахисні кілеподібні структури, а також скляні поверхні з електрохромним покриттям, здатні змінювати ступінь прозорості залежно від інтенсивності сонячного випромінювання. Інтеграція таких рішень повинна здійснюватись на стадії передпроектного аналізу, що передбачає детальне дослідження сонячної експозиції ділянки, побудову сонячної карти, аналіз кута падіння прямих променів та моделювання річного балансу інсоляції.

Окрему увагу варто приділити використанню елементів ландшафтного моделювання як складової біокліматичного підходу до проектування. До таких елементів належать насадження листяних і хвойних дерев для організації затінення в літній період, штучні або природні водні поверхні (дзеркала) для охолодження мікроклімату, а також ґрунтові насипи та рельєфні бар'єри, що забезпечують вітрозахист у зимовий період. Всі ці компоненти повинні бути частиною єдиної інтегрованої си-

стеми, яка об'єднує архітектуру, інженерію та елементи урбаністичного середовища, забезпечуючи цілісність енергоефективного рішення на всіх рівнях проектування [2].

У контексті реконструкції наявних промислових об'єктів радянського періоду, що значною мірою формують індустріальний фонд сучасної України, особливо важливим є закладення етапів комплексного енергоаудиту та реалізації принципів адаптивної ревіталізації [1]. Сучасні цифрові інструменти, зокрема інформаційне моделювання будівель (BIM), технології тривимірного сканування з подальшим трансфером у BIM-моделі (Scan-to-BIM), а також програмні засоби для симуляції мікрокліматичних процесів, надають змогу ефективно інтегрувати біокліматичні стратегії у простір без втрати функціонально-експлуатаційної цінності об'єкта. Це відкриває нові горизонти для сталого переосмислення промислової архітектурної спадщини.

Отже, запропоновані архітектурно-планувальні рекомендації формують підґрунтя для створення адаптивних, енергоефективних і сталих промислових об'єктів, які відповідають потребам національної економіки та викликам ХХІ століття.

Таким чином, біокліматичне проектування у промисловій архітектурі виступає ключовим інструментом забезпечення енергоефективності та сталого розвитку в умовах зростаючих кліматичних і ресурсних викликів. Проведене дослідження засвідчило, що інтеграція архітектурно-кліматичних стратегій – таких як орієнтація будівель, природна вентиляція, інсоляційний захист і використання термоінерційних матеріалів – дозволяє суттєво знизити експлуатаційні витрати й підвищити якість середовища. На основі аналізу запропоновано типові архітектурно-планувальні рішення для промислових об'єктів у помірному кліматі України.

На нашу думку, на етапі передпроектного аналізу обов'язково враховувати мікроклімат ділянки та використовувати цифрові інструменти для моделювання енергетичної поведінки об'єкта. В умовах реконструкції радянських промислових будівель доцільним є поступове впровадження біокліматичних елементів через ревіталізацію оболонки, модернізацію вентиляції та використання природного освітлення. Варто також переглянути нормативну базу з урахуванням принципів адаптивності, екологічності й кліматичної стійкості.

Подальші дослідження доцільно спрямувати на типологізацію біокліматичних рішень для різних галузей промисловості та інтеграцію біоархітектурних принципів у державні стандарти енергоощадного будівництва.

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ECONOMIC SCIENCES

PROBLEMS OF ASSESSING THE STATE OF ORGANIZATION AND IMPLEMENTATION OF HIGHER EDUCATION IN THE REPUBLIC OF AZERBAIJAN BASED ON INTERNATIONAL AND NATIONAL CRITERIA

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Abstract

The purpose of the study is to assess the status of the implementation of the obligations undertaken by the Republic of Azerbaijan in the field of organization of higher education within the framework of the Bologna process and its adaptation to the European model in 2005-2025. **The relevance** of the study is determined by the need to modernize the national higher education system in the near and medium term and increase its competitiveness. The methods of logical analysis, identification, and critical comparative analysis were used in the study of the problems of assessing the state of organization of higher education. The necessity of resolving the contradictions between the current and future state of higher education in the Republic of Azerbaijan is revealed with the help of the scientific-regulatory construction of the assessment of the state of organization and implementation of higher education in the Republic of Azerbaijan according to international and national criteria. Strengthening state control over the quality of education has acquired special importance in order to bring higher education in the Republic of Azerbaijan into line with the principles of the international and pan-European education system. Thanks to the institutional measures taken, illegally operating universities, branches of national and foreign universities have been liquidated, and low-quality personnel training in private universities in the field of law has been terminated. The study confirms the necessity of adding norms defining indicators of competence of faculty deans and teachers of specialized departments to the Bologna Declaration and national legislation in order to improve the quality of education in political, law, economics, sociology specialties in higher education institutions. **The practical significance of the study** is determined by the possibility of assessing the quality indicators of the organization of higher education in any specialty with the help of the regulatory structure proposed by the author.

Keywords: higher education, Bologna Declaration, requirements, obligations, quality.

Introduction

After the official document on joining the Bologna Process was signed by the Minister of Education of the Republic of Azerbaijan on May 19, 2005, favorable conditions were created for the modernization of the national education system, especially the integration of higher education institutions into the European Higher Education Area. The main goal of modernization of higher education is to integrate it into the European educational space by preserving the values inherent in the national and spiritual traditions of the country's higher education system, establish its content in accordance with the principles of the Bologna process, ensure its attractiveness and competitiveness, meet the emerging demand for highly educated personnel in accordance with the development requirements of the country's economy, as well as create human resources potential in accordance with the requirements of the information society and knowledge-based economy and form an economically and socially efficient higher education system in order to provide the population with opportunities to receive higher education that meets modern requirements [1]. The following goals have been set to justify institutional measures to ensure the implementation of this goal:

- Integration of Azerbaijani higher education into the European Higher Education Area;
- Improving the quality of higher education;
- Alignment of the organizational and legal foundations of higher education with the requirements of the Bologna system;
- Mutual recognition of qualifications and diplomas;
- Introduction of the credit system;
- Facilitation of mobility and employment of student and teaching staff between countries joining the single European Higher Education Area;
- Ensuring the attractiveness of higher education institutions.

The research problem.

The problems of implementing the goals that ensure the modernization of higher education in the daily activities of higher education institutions in the Republic of Azerbaijan are in the focus of attention of state authorities. The provision put forward by the President of the Republic of Azerbaijan Ilham Aliyev in the content "We must transform our material values, economic potential into human capital" is of great importance for assessing the decisive role of education in the formation of highly intelligent human capital and

building a strong economy in the 21st century, as declared by the UN. In 2005-2025, a national legal framework was created within the framework of the state's institutional and legal policy, ensuring the alignment of the activities of higher education institutions with the requirements of the Bologna process; international conventions on the protection of human rights and freedoms, cooperation in the fields of culture, education, science and information were approved. In modern times, the issue of establishing direct relations by higher education institutions with scientific and educational institutions, organizations, international organizations and funds of foreign countries on the basis of international agreements to which the Republic of Azerbaijan is a party, concluding bilateral and multilateral agreements on cooperation, as well as implementing other forms of cooperation, is reflected in the Law of the Republic of Azerbaijan "On Education".

The directions for solving problems related to the development of the higher education system in the near and medium term are substantiated in the "State Program on Increasing the International Competitiveness of the Higher Education System in the Republic of Azerbaijan for 2019-2023" (approved by the Decree of the President of the Republic of Azerbaijan dated November 16, 2018), the "State Program on Youth Education in Prestigious Higher Education Institutions of Foreign Countries for 2022-2028" (approved by the Decree of the President of the Republic of Azerbaijan dated February 28, 2022), and "Azerbaijan 2030: National Priorities for Socio-Economic Development" (approved by the Decree of the President of the Republic of Azerbaijan dated February 2, 2021). Thanks to the application of national education legislation norms, which are based on international conventions on human rights and other international treaties to which the Republic of Azerbaijan is a party, and which envisage integration into the world education system based on the priority of national-moral and universal values in the field of education, a number of achievements have been achieved in the field of adapting the higher education system of Azerbaijan to the education of European countries. In accordance with the requirements of the Bologna process, the European Credit Transfer System is applied in higher education institutions; three-level training of specialists, scientific and scientific-pedagogical personnel (bachelor's degree, master's degree, doctoral degree) is implemented; student exchange is carried out within the framework of internationally accredited educational programs, including the TEMPUS, ERASMUS programs of the European Union and the Mevlana programs of the Republic of Turkey, and the knowledge and experience of students in the field of mastering and applying digital technologies are expanded.

In order to assess the results of the modernization of higher education in the Republic of Azerbaijan in 2005-2025 based on the Bologna process, it is necessary to study the status of the implementation of the obligations undertaken by our republic by joining the Bologna system, such as improving the quality of

education and adapting it to the European education model. The Bologna Declaration confirms the implementation of European cooperation in ensuring the quality of education and the necessity of its assessment based on comparative criteria and methodologies [7]. According to Article 9 of the Law of the Republic of Azerbaijan "On Education", the quality level of education is determined in accordance with the principles of the international and pan-European education system based on the state educational and professional standards adopted in the country and in accordance with the relevant quality indicators system for educational levels (educational programs, level of preparation of applicants, material and technical base, infrastructure, information resources, professionalism and scientific and pedagogical level of educators, progressive educational technologies, etc.). From the comparative scientific analysis of the article of the law determining the quality level of education, it is possible to see that the effectiveness of personnel training in educational institutions directly depends on the professionalism and scientific-pedagogical level of educators, and the competitiveness of graduates in the national and international labor market. The "Action Plan" on the implementation of the "State Strategy for the Development of Education in the Republic of Azerbaijan" (approved by the Decree of the President of the Republic of Azerbaijan dated January 19, 2015) considered the application of higher education standards that support the transformation of higher education institutions into education-research-innovation centers and ensure the training of competitive specialists as a strategic goal.

The practical implementation of the norms of the Bologna Declaration, the Law "On Education" and the State Strategy for the Development of Education on improving the quality of higher education creates a basis for adapting the activities of higher education institutions to European education. If we pay attention to the content of the indicated norms, thanks to their implementation, it may be possible to increase the international competitiveness of the higher education system in the republic and implement international dual diploma programs. However, it is impossible to achieve the application of generally binding legal norms established in the legislation without creating appropriate implementation mechanisms.

Main issues of research

Critical assessment by experts of institutional measures implemented within the framework of the concept of internationalization of higher education in the Republic of Azerbaijan attracts attention. Professor of Baku State University Mammadov J. believes that this is a system that requires too much labor and too many staff. The Bologna education model did not bring any innovations to the high level of education and knowledge of students [14].

Factors that negatively affect the quality of higher education:

- the lack of compliance of teaching staff with modern educational requirements;

- the obsolescence of educational materials and their failure to meet modern requirements;
- the lagging behind of educational programs and their failure to meet real requirements;
- the existence of serious discrepancies and differences in content between theoretical education and the future practical activity of a specialist;
- the absence of advanced world practice in the scope of education;
- the lack of a sufficiently clear understanding of the requirements of the general labor market in society, including among the educational community;
- the inadequacy of the process of modernization of education to the changes taking place in socio-economic life;
- the failure to completely solve the problems of financing educational activities;
- the slow process of forming a real competitive environment in higher education [15]. According to official data, the diplomas of about half of Azerbaijani citizens studying abroad are not recognized in our republic. Recognition of diplomas of Azerbaijani

universities abroad and diplomas of foreign universities in our country still remains one of the main problems related to higher education [8].

In order to study the situation in the higher education system, taking into account the above-mentioned provisions requires the existence of problems that need to be solved in the field of adapting higher education to the requirements of the Bologna process. When clarifying the reasons for the emergence of these problems, it is necessary to conduct a comparative analysis of the legislation of the Republic of Azerbaijan on higher education and legal documents regulating the Bologna process, and in particular, the recommendations of the Bologna Process Monitoring Group. The table below presents statements adopted at the meetings of the ministers of education of the member states on the areas of activity implemented in accordance with the requirements of the Bologna process in 2005-2024 and information on institutional reform measures implemented in the Republic of Azerbaijan.

Table 1

Assessment of the state of organization and implementation of higher education in the Republic of Azerbaijan on international and national regulatory and legal bases

Advisors to the Ministers of Education of the Member States		Institutional reforms and measures implemented in the Republic of Azerbaijan within the framework of the Bologna Process
Conference communiqués, declarations	Basic provisions on the organization of the Bologna educational process	
1	2	3
Sorbonne Declaration (1998)	- Encouraging mobility for the improvement of the qualifications of students, graduates, and staff; - Adapting qualifications to the requirements of the modern labor market.	- Thanks to the implementation of the norms of the Law "On Education" in force from 1993 to 2009 regarding the structure of the education system, levels and degrees of higher education, and international cooperation in the field of education, the foundation of an education system in line with international standards has been laid in Azerbaijan. - On May 19, 2005, the Bologna Declaration was signed and adopted by the Republic of Azerbaijan. - The Law "On Education" (June 19, 2009) established the norms for the organization of higher education, including specialization, education system, quality level of education, educational program, and higher education, thus creating an institutional basis for the modernization of the national education system based on the principles of the Bologna process. - The action plan for the implementation of the provisions of the Bologna Declaration in the higher education system in 2006-2010 was approved (Order of the Minister of Education No. 15, January 16, 2006) - The structure of the minimum state requirements for the content and level of bachelor's training was approved (Order of the Minister of Education No. 251, April 18, 2006) - The model Regulation on the organization of education in higher education institutions with a credit system was approved (Order of the Minister of Education No. 264, April 20, 2006) - New generation state standards have been introduced for directions (specialties) in accordance with the minimum state educational requirements for the content and level of bachelor's training
Bologna Conference (1999)	- The use of a clear, transparent and comparable degree system with diploma supplements; - The introduction of a three-cycle higher education system; - The adoption of the credit system as a means of increasing mobility; - Encouraging mobility for the free movement of students and teachers - The development of European cooperation in the field of quality assurance with a view to developing comparable criteria and methodologies; - Strengthening the European dimension of higher education	
Prague Communiqué (2001)	- Lifelong learning; - Recognition of students as active and equal partners at all stages of the Bologna process; - Taking into account the social aspects of higher education; - Implementation of joint degree programs of new perspectives and profiles of cross-border education; - Organization of continuous work of the accreditation-quality assurance mechanism.	

Berlin Communiqué (2003)	-Ensuring the quality of education: program evaluation, external expertise, student participation in procedures and publication of results, the existence of an accreditation system, international partnerships, cooperation and participation in networks. - Degree structure: adoption of a two-cycle system, introduction of a credit system, recognition of degrees; - Expanding the participation of students as equal partners in the management of higher education; - Developing the dimensions of European higher education; - Lifelong learning; - Improving the attractiveness of the European Higher Education Area; - Monitoring the progress of the implementation of the parameters of the Bologna Process	(Order of the Minister of Education No. 639, September 4, 2006) - Amendments have been made to the Model Regulation on the organization of education in higher education institutions using the credit system, and this document was approved by the Order of the Minister of Education dated August 23, 2007. - Decree of the President of the Republic of Azerbaijan on some measures related to the integration of higher education institutions into the European Higher Education Area (January 31, 2008). - The Ministry of Education, the European Education Rights Association and the Azerbaijan University of Languages held an international seminar on "Quality Assurance in Higher Education" (April 10, 2008). - The sample of the Diploma Supplement "On Higher Education" (Bachelor/Master) was approved (August 8, 2008) based on the model of the "Diploma Supplement" developed by the joint working group established by the Council of Europe, the European Commission and UNESCO/CEPEC.
Bergen Communiqué (2005)	-Implementation of a three-cycle structure of academic degrees - bachelor's, master's and doctoral; - Ensuring quality through the systematic application of internal mechanisms of higher education institutions; - Adoption of standards and guiding principles of quality assurance in the European Higher Education Area; - Approval of European ideas on quality assurance based on national expertise; - Recognition of degrees and periods of study, joint degrees; - Harmonization of doctoral level qualifications with the Common Framework of Qualifications of the European Higher Education Area - supporting student mobility based on outcomes in education.	- State accreditation of higher education institutions continued and 11 higher education institutions were accredited in 2007-2008. - Serious changes were made in the stages of implementation of the first and second cycles of higher education and in the field of implementation of the third cycle of higher education, and the regulatory and legal framework was updated. - In 2007-2009, conceptual provisions were developed on the recognition of degrees and qualifications, the introduction of the Diploma Supplement, the national application of the principles of the Lisbon Recognition Convention on the Recognition of Diplomas, the introduction of the European Credit Transfer System, and lifelong learning in the field of institutional measures, measures are being taken to develop and recognize joint degrees and remove obstacles to the mobility of students and academic staff. - Activities in the field of employment of graduates and cooperation with employers are regulated.
London Communiqué (2007)	-Integrating a broad base of European research based on higher education; - The link between higher education and scientific research should be the hallmark of European higher education. - Providing great education to a large number of people; - Recognizing the responsibility of universities to society; - Preparing to cope with global challenges.	- An internal and external assessment mechanism has been established to ensure the quality of higher education. - The Rules on the mutual recognition of diplomas "Recognition and determination of equivalence of qualifications of foreign states in the field of higher education" (nostrification) are being developed and applied. - "State Program on increasing the international competitiveness of the higher education system for 2019-2023" (approved by the Decree of the President of the Republic of Azerbaijan dated November 16, 2018)
Leuven Communiqué (2009)	-Achieving equality in higher education; - Lifelong learning; - Graduate employability; - Student-centered learning; - Linking higher education with research and innovation;	- Regulations of the Management Group of the "State Program on increasing the international competitiveness of the higher education system for 2019-2023" (approved by the Resolution of the Cabinet of Ministers of the Republic of Azerbaijan dated November 20, 2019).

	- International openness of European higher education; - Expanding the mobility of students and scholars; - Collecting information and ensuring its transparency; - Improving public funding and finding new sources; - Improving the organizational structure of the Bologna process management.	- Rules for the selection of specialty programs and education levels of foreign partner higher education institutions where international dual diploma programs will be implemented within the framework of the "State Program on Increasing the International Competitiveness of the Higher Education System for 2019-2023" (approved by the Resolution of the Cabinet of Ministers of the Republic of Azerbaijan dated November 20, 2019). - Selection Rules for Azerbaijani citizens studying at the doctoral level in higher education institutions of a foreign country within the framework of the "State Program on Increasing the International Competitiveness of the Higher Education System for 2019-2023" (approved by the Resolution of the Cabinet of Ministers of the Republic of Azerbaijan dated November 13, 2019). - Rules for financing the implementation of international dual diploma programs within the framework of the "State Program on Increasing the International Competitiveness of the Higher Education System for 2019-2023" (approved by the Resolution of the Cabinet of Ministers of the Republic of Azerbaijan dated November 20, 2019). - Resolution of the Cabinet of Ministers of the Republic of Azerbaijan on determining priority specialization areas and specialties for doctoral level education of citizens of the Republic of Azerbaijan abroad (May 27, 2019). - The Ministry of Science and Education of the Republic of Azerbaijan has prepared a contract form between a citizen of the Republic of Azerbaijan who has obtained the right to study for a doctorate at a prestigious foreign higher education institution within the framework of the "State Program on Increasing the International Competitiveness of the Higher Education System for 2019-2023" and a higher education institution of the Republic of Azerbaijan that has agreed to conclude an employment contract with the citizen upon completion of the education. - Action Plan on the implementation of the "State Strategy for the Development of Education in the Republic of Azerbaijan" (approved by the Decree of the President of the Republic of Azerbaijan dated January 19, 2015). - "State Program for 2022-2028 on the Education of Young People in Prestigious Higher Educational Institutions of Foreign Countries" (approved by the Decree of the President of the Republic of Azerbaijan dated February 28, 2022). - Rules on the criteria and procedures for selecting young people to study abroad within the framework of the "State Program for 2022-2028 on the Education of Young People in Prestigious Higher Educational Institutions of Foreign Countries" (approved by the Resolution of the Cabinet of Ministers of the Republic of Azerbaijan dated June 1, 2022). - Rules for financing education in foreign higher education institutions within the framework of the "State Program for 2022-2028 on the education of young people in higher education institutions of foreign countries" (approved by the Resolution of the Cabinet of Ministers of the Republic of Azerbaijan dated June 1, 2022).
Budapest-Vienna Declaration (2010)	- Creation of the European Higher Education Area	
Taraz Declaration (2011)		
Bucharest Communiqué (2012)	- Ensuring the quality of higher education for a large number of students, as well as better preparation of graduates for work; - Increasing student mobility; - Adopting a new European Strategy for mobility in 47 countries, with a goal of at least 20% of graduates returning to Europe by 2020 to study or do an internship abroad	
Yerevan Communiqué (2015)	- Development of cooperation in the field of national qualifications frameworks and quality assurance; - Mutual recognition of qualifications; - Expansion of cooperation in the field of development and implementation of the credit transfer system.	
Astana Declaration (2017)		
Paris Communiqué (2018)	- A three-level system comparable to the European Credit Transfer System for 1st and 2nd cycle degrees within the framework of the European Higher Education Area; - Compliance with the Lisbon Convention on Recognition; - Quality assurance in accordance with the standards and principles of the European Higher Education Area	
Rome Communiqué (2020)	- Every learner will have equal access to higher education and will receive comprehensive support in completing their education and training; - The introduction of new methods, practices, learning and assessment of education closely linked to research; - Common frameworks and tools will facilitate and expand international cooperation and reforms, knowledge exchange, and staff and student mobility.	

Tirana Communiqué (2024)	- Strengthening academic freedom and institutional autonomy of educational institutions; - Ensuring the participation of students and staff in the governance of higher education; - Responsibility of states for higher education; - Social responsibility of higher education.	- Rules for organizing education in main (basic) medical education at the bachelor's and master's levels of higher education institutions using the credit system (approved by the Resolution of the Cabinet of Ministers of the Republic of Azerbaijan dated December 24, 2013).
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Source: 1. <https://enic-kazakhstan.edu.kz/ru/bologna-prosess/documents>

2. <https://edu.goo.az/upload/file/boloniya-milli-hesabat.pdf>

The main purpose of the comparative scientific analysis of the state of higher education organization in the Republic of Azerbaijan based on international and national legislative provisions is to determine the adequacy of institutional reforms and measures implemented in the Republic of Azerbaijan within the framework of the Bologna process to the requirements of the Bologna Declaration. The effectiveness of the organizational and legal measures indicated in Table 1 can be determined only by their compliance with the following requirements arising from the Bologna Declaration:

- 1) Adaptation to the requirements of the Bologna system;
- 2) Introduction of the credit system (European Credit Transfer System);
- 3) Strengthening the quality control of education;
- 4) Expanding the mobility of students and teachers between countries joining the single European higher education area;
- 5) Mutual recognition of qualifications, diplomas and degrees;
- 6) Adaptation of diploma supplements to the relevant documents on higher education of European countries;
- 7) Achieving employment of graduates;
- 8) Increasing the international competitiveness of the higher education system [7].

It is impossible to deny that the solution of the above tasks within the framework of the Bologna process plays an exceptional role in eliminating the factors that negatively affect the quality of higher education in Azerbaijan. Let us consider the compliance of the institutional measures implemented in the Republic of Azerbaijan in 1993-2023 with the main provisions on the organization of the Bologna educational process.

Results of logical analysis

The requirement of the Declaration to adapt it to the requirements of the Bologna Process was realized through the establishment of norms related to the levels of higher education, degrees of specialization, quality level of education, and international cooperation of higher education institutions in the laws of the Republic of Azerbaijan "On Education" (October 7, 1992) and "On Education" (June 19, 2009), which came into force in 1993-2009, the signing of the Bologna Declaration by the Minister of Education of the Republic of Azerbaijan on May 19, 2005, as well as the approval and implementation of the action plan for the implementation of the provisions of the Bologna

Declaration in the higher education system in 2006-2010.

In order to fulfill the obligation of the Republic of Azerbaijan to implement the credit system (European Credit Transfer System), a model regulation on the organization of education with a credit system in higher education institutions (April 20, 2006) was adopted, later improved and applied in universities.

In line with the Declaration's requirement to strengthen control over the quality of education, measures taken to establish and implement an internal and external evaluation mechanism to ensure the quality of higher education should play an exceptional role in the modernization of higher education at the national level.

In accordance with the requirement to expand mobility, measures are being implemented in the Republic of Azerbaijan to integrate higher education institutions into the European Higher Education Area, as well as long-term state programs for young people to study at prestigious higher education institutions in foreign countries, and a legal framework is being created to eliminate obstacles to the mobility of students and educational staff.

In order to comply with the Declaration's requirement on mutual recognition of qualifications, diplomas and academic degrees, the recognition of degrees and qualifications, the application of the Diploma Supplement, the application of the principles of the Lisbon Recognition Convention on mutual recognition of diplomas at the national level have been ensured, and organizational and legal measures are being taken to develop and recognize joint degrees.

In order to increase the international competitiveness of the higher education system, the State Program on Increasing the International Competitiveness of the Higher Education System in 2019-2023 was implemented, serious changes were made in the stages of implementation of the first and second levels of higher education and the implementation of the third level of higher education, and the regulatory and legal framework was updated. All of this is of great importance for increasing the international competitiveness of higher education.

From the above research, it is possible to conclude that it is appropriate to assume that the institutional reforms and organizational and legal measures implemented in the Republic of Azerbaijan in 2005-2025 comply with the requirements of the Bologna Process. It should be borne in mind that the norms regulating institutional reforms and measures are

established by the Law "On Education", decrees, orders of the President of the Republic of Azerbaijan and decisions of the Ministry of Education. Therefore, in the future, it is not excluded to conduct an expanded comparative analysis by assessing the requirements of the Bologna Declaration and the norms of national legislation using the authentic interpretation method.

From the preliminary information presented above, it can be seen that the structure of Table-1 is characterized by the equivalence of the organizational and legal measures implemented in the field of higher education regulation in the Republic of Azerbaijan with the requirements of the Bologna Declaration. It should be noted that it is impossible to accept the equivalence of requirements and obligations in the national higher education system organized within the framework of the Bologna process in an absolute form. Therefore, it should not be considered unusual that the necessary organizational and legal measures related to the elimination of obstacles that slow down the development of the educational process do not comply with the provisions of the Bologna Declaration and subsequent communiqués. It should be borne in mind that any requirement for the organization of education is satisfied in the manner of fulfilling the obligations of the other party (i.e., the implementation of organizational and legal measures). Based on the latter provision, it is possible to divide all requirements and obligations related to the organization and implementation of higher education into two groups:

1. Requirements and obligations based on the declaration (communiqué);
2. Requirements and obligations outside the declaration (communiqué).

The Prague Communiqué (2001) established the requirement for the organization of continuous work of the accreditation-quality assurance mechanism in the Bologna process. In order to solve the problems related to strengthening the prestige and attractiveness of higher education institutions in European countries, the systematic application of internal mechanisms of quality assurance in higher education institutions, the adoption of standards and guiding principles of quality assurance in the European Higher Education Program, and the approval of European ideas on quality assurance on the basis of national expertise were reflected in the Bergen Communiqué (2005). Within the framework of the Bologna process, the issues of organizing the continuity of the quality assurance mechanism in the higher education system of the Republic of Azerbaijan were resolved at the legislative level. According to Article 9.1 of the Law of the Republic of Azerbaijan "On Education" (June 19, 2009), the quality level of education is determined in accordance with the principles of the international and pan-European education system based on the state educational and professional standards adopted in the country and in accordance with the relevant quality indicators system for educational levels (educational programs, level of preparation of applicants, information resources, professionalism and scientific pedagogical level of educators, progressive educational technologies, etc.).

The Agency for Quality Assurance in Education and the Accreditation Commission, a responsible body ensuring the implementation of its main functions, were established to carry out tasks in the field of assessing the compliance of the activities of higher education institutions and the implementation of educational programs with state educational standards. In the Republic of Azerbaijan, with the exception of state higher education institutions, private higher education institutions operate on the basis of a license in accordance with the procedure established by the Law of the Republic of Azerbaijan "On Licenses and Leases" (March 15, 2016).

State control over the quality of education, assessment of the quality level of science and education is one of the main areas of activity of the Ministry of Science and Education. Within the framework of its powers, the Ministry ensures the implementation of control over the quality of education and the educational process in higher education institutions, as well as the organization of education in accordance with relevant state standards [1]. Assessment of the compliance of the activities of higher education institutions with the adopted state educational standards and the requirements of other legal acts in the form of accreditation allowed the Ministry of Education to take administrative measures in 1999 to close 18 branches of various private higher education institutions operating illegally and to invalidate the diplomas issued by these branches that had not passed state registration. In addition, 16 branches and educational centers of foreign educational institutions that were illegally established and operated in Azerbaijan were liquidated by the Ministry of Education [3].

In the accreditation process carried out by the Ministry of Education in 2010-2017 in order to strengthen the mechanisms for ensuring the quality of education in higher education institutions, non-compliance with the requirements of regulatory documents, improper organization of the work of faculties and departments, giving lectures to teachers without academic degrees, formally filling out educational journals, forging teachers' signatures, conducting mass admissions outside the State Student Admissions Commission, and violating the principle of financial autonomy were revealed in a number of universities, and Azerbaijan International University, Independent Azerbaijan University, Azerbaijan Social and Political University, Baku Asia University, Tafekkur University, and Qafqaz University were closed [3]. In order to improve the quality of education in the field of personnel training in the field of law, which is extremely important for the political and economic life of the state and society, the training of legal personnel (bachelor's and master's degrees) was terminated in private higher education institutions where lectures and training classes were given to teachers without legal education.

Above, the provision on the emergence of non-declaratory (non-communicable) requirements and obligations related to the organization and implementation of higher education has been substantiated. It should be borne in mind that the

requirements expressed in the infinitive form of the verb in the Bologna Declaration and the communiqués of the Ministers of Education are of a general nature (for example, ensuring the quality of higher education, equality in obtaining higher education, mobility of students and teachers, etc.). Different approaches are applied in the partner countries that signed the declaration to the substantiation of the procedures for specifying and implementing these requirements. The text of the Bologna Declaration and the communiqués of the ministers does not disclose what specific tasks and implementation procedures are to be fulfilled in the partner country for any requirement specified, for example, ensuring the quality of higher education. It should be noted that when solving the issues of ensuring and improving the quality of higher education, the development characteristics of the types of specialties and scientific fields covered by education should be taken into account. It is unlikely that differences will be found between higher education programs and textbooks of different countries for specialties corresponding to the exact sciences. From an analysis of the content of the Bologna Declaration and ministerial communiqués, it is possible to conclude that the highest quality higher education is available only at well-known universities in the United States, Great Britain, France, Germany, and Italy. The high prestige of these universities is considered a key factor in the policies of states, strong advertising campaigns, as well as in securing employment for graduates in any country in the world. Taking this into account, wealthy citizens of partner countries (about 50) prefer to receive highly paid bachelor's and master's degrees and diplomas at universities in Western Europe and North America. It should be especially noted that the ranks of students from Eastern Europe, Asia and Africa in the fields of economics, law, politics and sociology in Western Europe and North America are expanding year by year. Thus, the policies implemented by states in the direction of the development of higher education contribute to an increase in the number of foreign students in the European and American educational space, to strengthening the authority of educators representing that space, and to meeting the labor market demand for highly educated personnel in partner countries.

The study shows that the failure to provide for the requirements reflecting the internationalization of teaching of political, law, economics, sociology, etc. subjects in higher education institutions in the Bologna Declaration and ministerial communiqués leads to endless difficulties in the regulation of the educational process in universities of partner countries. The requirements related to quality in the Declaration and communiqués cover the modernization of the organization of higher education at the university level in general. When assessing the quality of education at the university level, the performance indicators of deaneries and departments of faculties are taken into account. Ensuring the quality of education is the main task of the deaneries of faculties and specialty departments. There is a need to establish in the Bologna Declaration and national legislation not in a general

manner, but in a specific norm the requirements that determine the quality indicators of the dean managing the faculty and the teaching staff of the departments.

As mentioned above, as a result of the control measures taken by the Ministry of Education in 2008-2016 to bring the practice of training specialists with higher education in the specialty "Law" into line with the requirements of the Bologna process, it became possible to suspend the education of bachelors and masters of law in private universities and to abolish law departments. The usefulness of this measure and its compliance with the interests of the state cannot be denied. Using the experience of regulating the teaching of legal sciences, let us consider the issues of assessing the state of organization of higher education in the specialty of accounting within the group of specialties "Economics".

The need to improve the quality of accounting education in Azerbaijani higher education institutions within the framework of the Bologna process is justified by the following provisions:

Firstly, commercial and non-commercial organizations with the status of legal entities registered in the state, in order to fulfill their obligations to the state and partners (banks, insurers, sellers, intermediaries), conduct accounting of income and expenses based on international standards and present financial statements to users in accordance with the procedure established by law. Taxes and fees paid by commercial organizations constitute the main source of income of the state budget. Public sector organizations are responsible for the use of funds received from the state budget for their intended purpose. From this it can be seen that the state of creation and use of the financial potential of the state largely depends on the proper organization of accounting work in enterprises and organizations.

Secondly, the relations related to accounting, preparation and presentation of financial statements in enterprises, institutions and organizations were regulated taking into account international standards in 2008-2025. In the modern era, in accordance with the requirements of economic development and the trends of increasing the financial potential of the state, the demand for qualified accounting personnel in the labor market is constantly increasing.

Thirdly, the training of qualified accounting personnel is provided by higher education institutions of Azerbaijan and foreign countries. However, it is observed that the majority of graduates who receive higher education in accounting do not have the necessary knowledge and skills to perform the duties of an accountant in enterprises and organizations. The main reason for this is that, with the exception of UNEC-State University of Economics, the teaching load on accounting and auditing subjects in the remaining universities is assigned to teachers who do not have the specialty "Accounting". These teachers give lectures by memorizing outdated subject materials and force students to memorize rather than to acquire real knowledge. According to Professor Gazanfar Abbasov, in universities, as a rule, specialists with a

Ph.D. or a Sc.D. degree in accounting can teach specialized subjects. [4, p.27]

Fourthly, it is necessary to critically assess and regulate the issues of compliance of teachers of accounting departments of universities with professional and qualification standards, whether they have a scientific degree and competence in the accounting specialty. The legal basis for the implementation of this requirement, which is put forward outside the Bologna Declaration, is established in national legislative acts. In paragraph 6.1 of the "State standard and program of higher education" (approved by the decision of the Cabinet of Ministers of the Republic of Azerbaijan dated April 23, 2010), the quality indicators of educators include:

- to use innovative training, information and telecommunications, modern equipment, new production and pedagogical technologies in their activities;

- to have a higher education, as well as a relevant scientific degree;

- to regularly improve their scientific level, knowledge and skills. It is possible to reveal the facts of non-compliance at universities with the requirements for the application of specialty names and codes approved by the Resolution of the Presidium of the Higher Attestation Commission under the President of the Republic of Azerbaijan dated 28.02.2017, Protocol No. 3-R, "On Amendments to the Nomenclature of Specialties for Awarding Scientific Degrees to Scientific and Scientific-Pedagogical Workers in the Republic of Azerbaijan". The same Resolution distinguishes specialty codes and academic degrees for 12 specialty types of the "Economics" specialty group. However, in many universities, regardless of specialty and code, teaching of Accounting and Audit subjects is assigned to teachers with academic degrees in other specialties. A similar situation has arisen in universities that train personnel in the "Finance" specialty. Lectures and training classes on Accounting and Audit subjects at universities should be conducted only by specialists with an academic degree in Accounting with code 5303.01. At the same time, it should not be excluded that a decision on termination of bachelor's and master's training in accounting and audit specialties should be made in universities where there are no specialists with academic degrees in Accounting in the departments.

Overall results of the study

The study of the problems of assessing the state of organization and implementation of higher education in the Republic of Azerbaijan according to international and national criteria can be summarized with the following provisions:

1. The main goal of the accession of the Republic of Azerbaijan to the Bologna Declaration is to ensure the modernization of higher education.

2. The assessment of the state of organization and implementation of higher education according to international and national parameters:

- a) confirms the need to improve the regulatory structure of higher education based on the Bologna Declaration and communiqués of the ministers of

- b) the legislation of the Republic of Azerbaijan on the organization of higher education.

3. In order to improve the quality indicators of higher education, it is proposed to add requirements (norms) determining the competence compliance indicators of faculty deaneries and teachers of specialized departments in universities to the Bologna Declaration and national legislation.

4. The proposal to reorganize higher education in accounting, taking into account international criteria, entrust the teaching load of accounting and auditing subjects only to specialists with a scientific degree in the specialty "Accounting", and at the same time terminate the training of personnel in the specialty "Accounting" in universities where there are no such specialists, is justified.

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HISTORICAL SCIENCES

A COMPARATIVE STUDY OF THE LEADERSHIP TRAITS OF CHINGGIS KHAN AND MODERN MANAGERS"

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Ph.D

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Abstract

"This study explores how the leadership of Chinggis Khaan, the founder of the most powerful empire in human history, has been examined within the field of management science. The study aims to identify leadership traits and skills to be learnt from him.

Keywords: Chinggis Khaan, leadership, leadership traits, frequency, comparison, results

Introduction

Many studies have been proved the remarkable success of Chinggis Khaan achieved in a wide range of policies and actions across various fields, including politics, society, economy, trade, governance, law, justice, human rights, family and child protection, military affairs, armed forces, foreign relations, and diplomacy during establishment and strengthening the Great Mongol Empire. Based on it, it needs to clarify or study in

details of highlighted leadership traits of Chinggis Khaan compared to skills of modern managers.

"Characteristics of a Modern Leader: Situational theory suggests that effective leadership depends on the specific situation, the chosen leadership approach, and the characteristics of the followers. Over time, scholars have identified a wide range of leadership traits and skills through their research works. These are summarized in below Table 1.

Table 1.

Study findings of leadership traits and skills

Year	Scholars	
1929	A. Bowden, Prof of South California University	Hair and eye colors, voice, body height and weight are very important to become a leader (Bowden, 1929)
1935	Ordue Tead, Scholar	It is believed that a great leader can be defined by five characteristics: being energetic, courageous, friendly, sociable, and disciplined (Tead, 1935)
	Charles Bird, Prof of Minnesota University	79 traits and skills of leader have been determined in about 20 previous studies done since year of 1904 (Charles Bird)
1948	Rulp Stogdill, Prof of Ohia University, USA	32 personal characteristics of a leader have been identified through the summary of 124 similar nature studied conducted on years between 1904 and 1948 (Stogdill, 1948)
1955	R. Stogdill and S. Shartle	Stogdill and Shartle are jointly defined 10 leadership traits in year of 1955
1974	R. Stogdill	The additional traits were defined through summary of 163 studies conducted between years of 1949 and 1970 (Stogdill, 1974)
1987	G. Kausis and B. Posner	Their study presents that people are likely follow up 7 leadership traits in most cases.
1987	Keit Simonton, psychologist from USA	He said all presidents of America have had about 100 leadership characteristics and 115 characteristics owned by Napoleon Bonapart (Simonton, 1987)
1999	Brosnahan	Special attention is paid on development of particular 7 leadership traits (Brosnahan, 1999)
2001	Tom Peters	Determined 50 leadership traits and skills (Tom Peters, 2001)
2009	Warren Bennis	Mentioned about 90 traits in own study (Warren Bennis, 2009)

Among these, the version described by Stanford University Professor Tom Peters was selected for this study because it was conducted in 2001—a relatively recent timeframe. This version not only integrates the findings of previous research but also presents a broader set of leadership characteristics and skills that align more closely with the demands of modern scientific, technological, and social development. These skills can be considered as representing the

essence of effective leadership. In this respect, they offer certain advantages over the characteristics and skills proposed by Professor Warren Bennis in 2009

Tom Peters identified 50 leadership characteristics¹ and skills within the personality approach. He suggests that by grouping these traits into related categories, we can better understand the common qualities of modern leaders.

Table 2.

Common traits of Modern Leaders			
	Common Traits	Meaning and Content	50 characteristics and skills of leader proposed by Tom Peters
1	Vision and Strategy	1. Great idea Vision 2. Strategy thinking 3. Change management 4. Non sustainability management 5. Build networking 6. Trust to change the universe	1. Vision and Strategy. 5. Leader changes the chaos into the possibility. 12. Leader manages uncertainty. 13. Leader builds the networking. 42. Leaders are confident that they can change the world.
2	Leading skills of others	1. Charismatic Leadership 2. Accept the diversity 3. Build team 4. Build trust 5. Assign power 6. Motivation	2. The strong admiration or devotion to a single leader is often seen as a mark of their success 9. A leader succeeds because of the support and strength of the people behind them. 10. A leader recognizes the importance of interdependence. 16. A leader relies on trust. 17. he leader holds the position as powerful representative 21. Leaders enjoy collaborating with other leaders. 27. For truly pragmatic reasons, leaders like all the colors of the rainbow. 45. Leaders willingly surround themselves with individuals who are smarter than they are. 49. A leader encourages you to think independently.
3	Personal characters	1. Self-development 2. Self-management 3. Ethics 4. Flexibility 5. Belief and trust 6. Intuition 7. Humility 8. Humor	3. Leadership may be a mystery. 4. Leadership does not diminish talent 8. A leader creates himself. 11. A leader performs several tasks at the same time. 15. A leader believes in a sixth sense. 18. A leader can forget. 22. A Leader has humor senses. 25. Leaders focus on the "intangible". 41. Leaders focus on the "intangible" 46. Great leaders are also great politicians. 48. Leaders are easy learners.
4	Making decision and problem settlement	1. Based on available information 2. Fast 3. Flexible 4. Pragmatic 5. Risk responsibility 6. Always learn from mistakes	20. Leaders don't repeat their mistakes. 29. True leaders never prepare for the last war." 31. Leaders promote murderers within their organizations.
5	Innovation and adaptability	1. Open for new ideas 2. Use technology 3. Continues improvement 4. Promote the changes 5. Combining tradition with innovation.	14. Leadership is the art for improvement. 23. Leaders like design references. 24. Leaders better knows when design should be reconsidered. 32. Leaders love the technology.
6	Communication and impacts	1. Productive relations 2. Motivation 3. Listening skill 4. Persuasion	33. Leaders radiate inspiration. 39. Leaders like the history. 40. Leaders find ways to make people go far. 43. Leaders need to talk more. 44. Leaders are a good listener.
7	Organization and management	1. Structure and organization 2. Human resource management 3. Concentrate on outcomes	6. Leaders are rarely the best performers. 7. A leader increases results. 19. Leaders involve people from all walks of life in the work. 28. True leaders are driven by purpose, not just achievements

		4. Information management 5. Resource management 6. Quality management	30. Leaders must achieve results. 35. Leaders manage the communities. 38. Leadership is the performance. 47. Leaders perform meaningful work.
8	Ethics and Values	1. Justice 2. Respect 3. Loyalty	36. Leaders prefer the respect. 37. Leaders keep their word and deliver on their promises. 50. Leaders know when they leave.
9	Strength and endurance	1. Perseverance 2. Vigor 3. Patience	34. Leaders knows better that power supporting them.
10	Train incomers	1. Train the incomers 2. Sustainability	26. Leaders always educate and train their disciples.

Source: produced by author

In addition to personal characteristics, effective leadership encompasses key qualities such as the ability to manage people and organizations, solve problems, make decisions, innovate, implement vision and strategy, prepare successors, and demonstrate ethics, commitment, and energy. This demonstrates that a modern leader must be multifaceted, possessing a diverse range of characteristics and skills, while also being well-rounded enough to effectively engage and influence every aspect of the organization..

Leadership traits of Chinggis Khaan. Many studies have been proved the remarkable success of Chinggis Khaan achieved in a wide range of policies and actions across various fields, including politics, society, economy, trade, governance, law, justice, human rights, family and child protection, military affairs, armed forces, foreign relations, and diplomacy during establishment and strengthening the Great Mongol Empire. Therefore, it is required to analyze,

summarize, and clarify the leadership qualities and skills of Chinggis Khaan based on the findings of proper studies accordingly.

Chinggis Khaan's leadership skills, as defined by foreign scholars: The larger companies recognize that navigating globalization is the number one challenge for business leaders in the 21st century where multinational corporations operate without borders and globalization is reshaping business dynamics.

This highlights the urgent need for leaders with a Chinggis Khaan-style approach. As a result, his leadership style and skills have garnered significant attention from scholars and have been extensively studied.

Modern management science has analyzed Genghis Khan's leadership from various angles, leading to several key conclusions, which are summarized in the table below.

Table 3.

Leadership traits and skills of Chinggis Khaan as defined by foreign scholars

<u>1997 - Blenheim Partners:</u> Leadership skills and methods of Chinggis Khan ²	<u>1999 – Kim Jong Rae:</u> Leadership Techniques of Chinggis Khan ³	<u>2007 - Mike Yates:</u> 4E's Leadership Framework of Chinggis Khan ⁴	<u>2018 - Forbes Magazine:</u> Seven lessons of Chinggis Khan from Weatherford's book ⁵
1. Open-mindedness	1. Practicality	1. Envision – Ability to foresee	1. Not to control, but to lead
2. Speed and Strength	2. Speed	2. Enable – Ability to implement	2. Care for others, not just yourself
3. Building a System of Trust within the Team	3. Adaptability and Strength	3. Energize – Energy to achieve goals	3. Be visionary
4. New Ideas and Solutions	4. System for Replenishing Capability	4. Empower – Granting appropriate authority to subordinates	4. Believe only in yourself
	5. Trust Built on Sharing Hardships and Joys		5. Be humble
	6. Risk-Taking Attempt		6. Avoid excessive luxury
			7. Change the world, but do so gradually

Source: produced by author

As seen from the table, modern management scholars have thoroughly examined Chinggis Khaan's leadership process, identifying key lessons to be learned. These studies have also quantified the frequency with which Genghis Khan's leadership skills are mentioned, emphasizing the characteristics and skills that appear more than twice.

Table 4.

Leadership Traits and Skills of Chinggis Khaan Frequently Mentioned by Foreign Scholars

	Trait/Skill Studied Scholars	Blenheim Partners	Kim Jong Rae	Mick Yates	Forbes	Frequency
1	Building trust within the group	3	5	4		4→3
2	Vision	4	—	1	3	4→3
3	Caring for others	4	—	1	3	4→3
4	New ideas and solutions	—	4	2	1	4→3
5	Knowledge and skills	2	2, 3, 4	3	—	4→3
6	Speed and strength	—	5	—	2	4→3
7	Self-confidence	—	6	—	4	4→2
8	Simplicity, openness, humility	1	—	—	5, 6	4→2
9	Empowering subordinates	—	—	4	1	4→2
10	Adaptability	—	3	—	—	4→1
11	Risk-taking attempts	—	6	—	—	4→1
12	Changing the world	—	—	—	7	4→1

Source: produced by author

The table findings are represented in Figure as below:

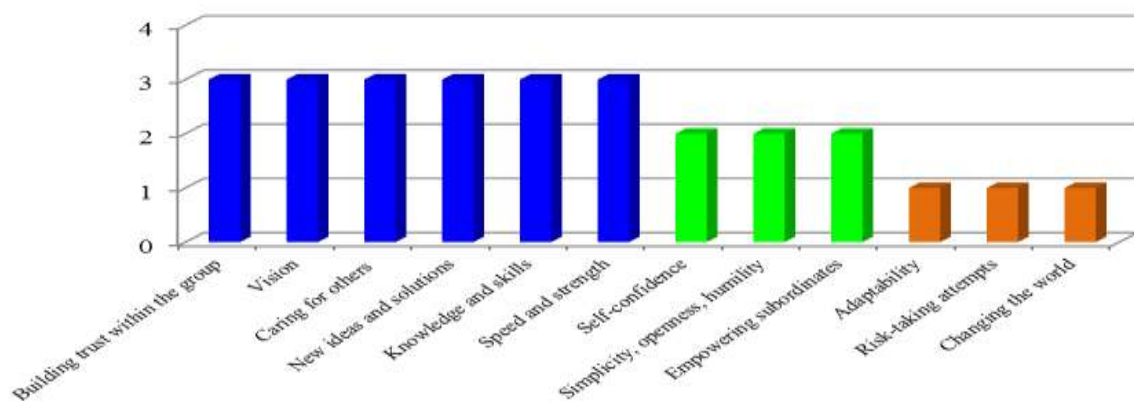


Figure 1. Leadership Traits and Skills of Chinggis Khaan Frequently Mentioned by Foreign Scholars

Red color presents of the highest frequency, blue higher, green fair while brown shows of lowest frequency of leading traits and skills in the figure respectively.

From this, it becomes clear that the most frequently mentioned traits include: vision or goal-setting, the knowledge and skills required to achieve those goals, the ability to generate new ideas and solutions, caring for others, building trust within a team, and the speed and strength needed to accomplish these goals.

The leadership traits of Chinggis Khaan as defined by national scholars: The works of our respected scholars have contributed specific findings about Genghis Khan's leadership abilities. For example, in his book 'The Art of Leadership of Mongolian Kings and Leaders' (2009), Dr. Professor D. Lkhaashid highlighted five

key leadership traits of Genghis Khan⁶. In another example, Dr. Professor H. Purevdagva, in his work 'A Brief Guide to Genghis Khan's Management' (2004), listed nine leadership traits that developed in him up until the age of 18⁷. In addition, academician S. Naran-gel, in 'The Ethics and Religion of Genghis Khan' (2013), outlined 28 ethical traits and behaviors that shaped him⁸. In studying the historical events mentioned in the Secret History of the Mongols, English scholar G.Batkurel (2011) identified 37 traits and skills that he called the 'Secrets of Genghis Khan's Leadership'⁹. Likewise, academician T. Dorj, in his work 'The Secret of Genghis Khan's Leadership Wisdom' (2016), defined 10 key traits and abilities¹⁰. All of these findings are summarized in the table below

Table 5.

Characteristics and Skills of Chinggis Khaan's Leadership Most Frequently Mentioned by National scholars

	Trait/Skill Studied by Scholar	Doctor, Professor D. Lkhaashid (1999)	Doctor, Professor Kh. Purevdavga (2004)	Doctor, Professor G. Batkhurel (2011)	Academician S. Narangerel (2014)	Academician T. Dorj (2016)	Frequency
1	Wise	1	8	9	18, 20, 22, 23	5	5→5
2	Empathetic	2	4	21			5→3
3	Collaborates with others		5, 9	5	6	6	5→4
4	Flexible	4	5			7	5→3
5	Strategic foresight	5		3	18	8	5→4
6	Caring for people		2	7	2, 4, 6, 16, 17, 20, 26	2, 4	5→4
7	Resilient spirit		1		1, 10		5→2
8	Attracts others through compassion		2			10	5→2
9	Hiring the best people	3	4	14		5	5→4
10	Truthfulness			4	1, 8	2	5→3
11	Developing others		4, 7, 8	18		5	5→3

Source: produced by author

The table findings are represented in Figure as below:

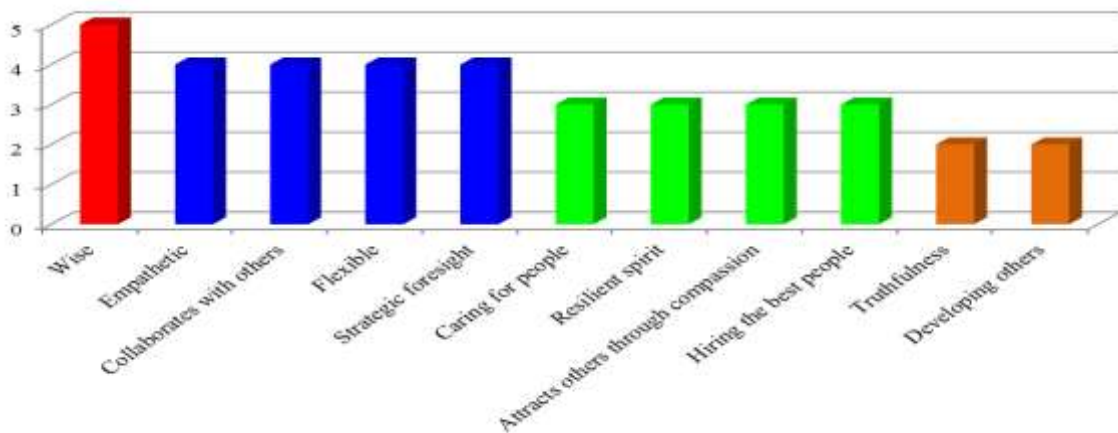


Figure 2.

Characteristics and skills of Chinggis Khaan's leadership most frequently mentioned by national scholars

Skills marked in red have the highest frequency, skills marked in blue have a high frequency, skills marked in green have a medium frequency, and skills marked in brown have a low frequency. Skills marked in red and blue will have the highest frequency.

In the figure: the attribute 'Wise' is the most frequently mentioned attribute in all scholars' research,

while 'Strategic thinking', 'Hiring the best', 'Caring for people', and 'Collaborating with others' are attributes with a high frequency.

Comparative results: Now, compared analysis of the leadership traits and skills of Genghis Khan, which are frequently mentioned in the research of both internal and external scholars.

Table 6.

Comparative Results of the Leadership Traits and Skills of Genghis Khan Frequently Mentioned by both foreign and National Scholars

	Research by foreign scholars	Frequency	Research by domestic scholars	Frequency
1			Intelligent	5→5
2	Building trust within the team	4→3	Collaborating with others	5→4
3	Vision	4→3	Strategic thinking	5→4
4	Caring for others	4→3	Caring for people	5→4
5	Knowledge and skills	4→3	Hiring the best people	5→4
6	New ideas, solutions	4→3		
7	Speed, strength	4→3		
8	Simplicity	4→2		
9	Empowering subordinates	4→2		
10	Self-confidence	4→2		
11			Empathetic	5→3
12			Flexible	5→3
13			Developing others	5→3
14			Truthfulness	5→3
15			Resilient spirit	5→2
16			Attracting others through compassion	5→2

Source: Produced by author

The table findings are represented in Figure as below:

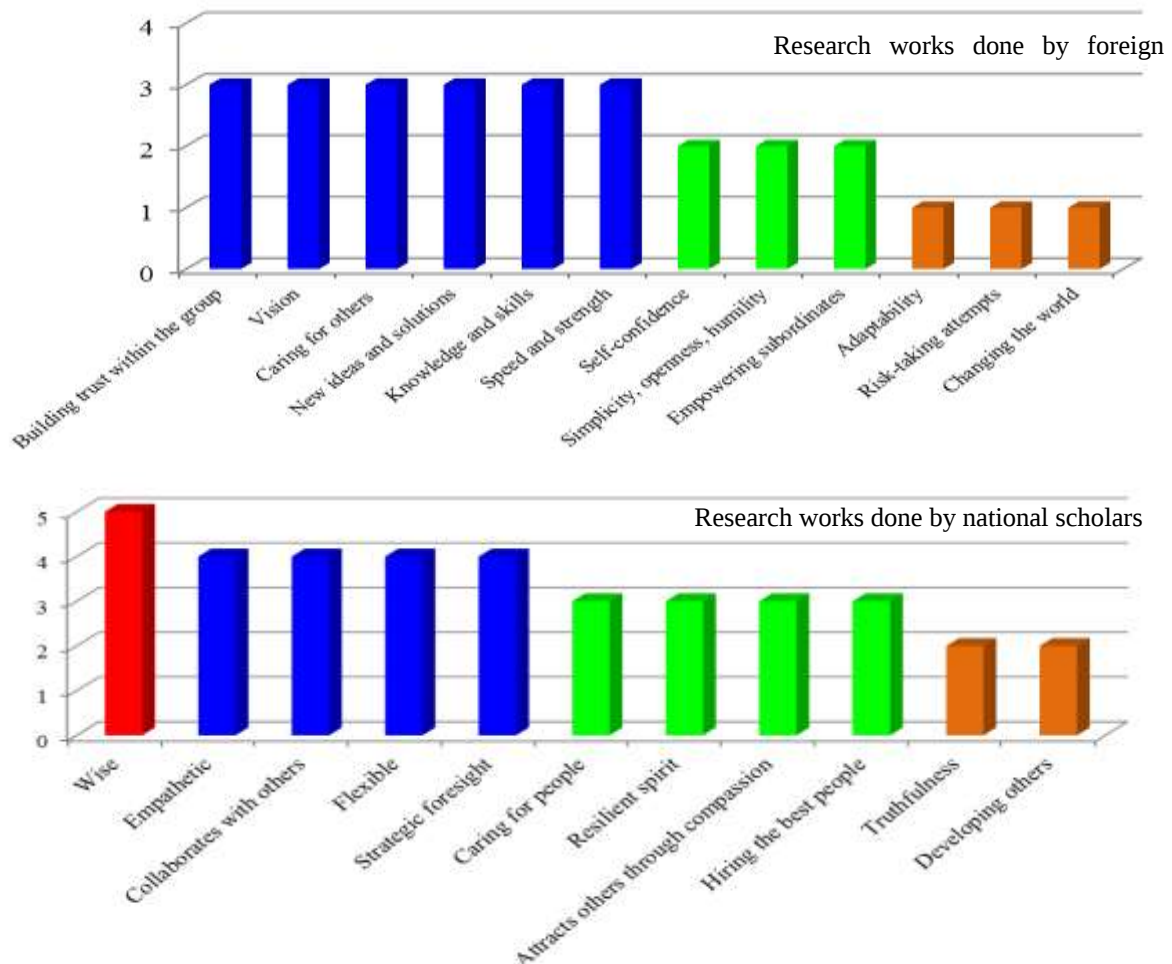


Figure 3. Comparative results of the characteristics and skills of Chinggis Khan's leadership most frequently mentioned by both foreign and National Scholars

When summarizing the characteristics and skills of Chinggis Khan's leadership most frequently mentioned in foreign and domestic scholars' research: the indicator **"Being intelligent"** appears with the highest frequency. Furthermore, the following attributes show both high frequency and overlap between the two groups:

- **Visionary thinking** (or strategic foresight)
- **Knowledge and competence, new ideas and solutions** (or recruiting the best talent)
- **Caring for others** (or valuing people)
- **Building trust within the team** (or cooperating with others).

From these results, it can be observed that both foreign and domestic scholars generally emphasize,

alongside vision and goals, the importance of intellectual (IQ) attributes such as the knowledge, skills, and innovative solutions needed to achieve them. In addition, they highlight emotional (EQ) attributes such as caring for others, collaborating, and building trust within teams, which also show high frequency and overlap. This indicates that emotional intelligence or spirituality in the workplace was a predominant aspect of Chinggis Khan's leadership. Thus, it is reasonable to conclude that Chinggis Khan was a leader of great intellect and spirit.

Comparative analysis on leadership traits and skills of modern leaders and Chinggis Khaan . At the conclusion of this article, we will compare the leadership characteristics of Genghis Khan, as identified by scholarly research, with those of modern leaders, aiming to clarify the extent to which they align."

Table 7.

Comparative analysis results

	Common characteristics of Modern leaders (by Tom Peters)	Leadership traits of Chinggis Khaan defined by scholars	Concurrence
1	Personal characters	- Wise - Sensitive - Open-minded - Flexible - Humility - Simple	✓
2	Vison and Strategy	- Vision -long-term policy	✓
3	Managing skills	- Cooperating with others -build trust among colleagues	✓
4	Communication and impacts	- Caring for others – love others - Attracting others through kindness	✓
5	Innovation and adaptability	- New ideas and solution - Hire the best one-knowledge and competence	✓
7	Managing the organization	- Develop out others and assign power to low level people	✓
	Making decision -problem solving	- Self- trust	✓
8	Ethics and Values	- To be honest	✓
9	Strength and endurance	- Speed and power - Patience	✓
10	Train the incomers		

Source: Produced by author

As the table shows, Chinggis Khaan's leadership traits align approximately 90% with those of modern leaders.

Conclusion: The findings indicate that the leadership traits of Chinggis Khaan, a leader from over 800 years ago, are largely consistent with those of contemporary leaders.

Additionally, the characteristics of a leader in a nomadic civilization are fundamentally similar to those of a leader in a settled civilization. This situation:

- Demonstrates that Chinggis Khaan was a leader capable of adapting to any era or lifestyle, meeting the management and societal needs of his time.
- Shows that true leadership transcends time and lifestyle, depending instead on the leader's mindset and level of development.

Chinggis Khaan possessed a diverse range of leadership skills: he was not only intelligent, sensitive, disciplined, energetic, resilient, open, flexible, simple, and humble, but also a visionary leader who successfully implemented his grand strategy. He achieved this by continuously training, empowering, and developing himself, his followers, his team, and his nation.

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MEDICAL SCIENCES

ASSOCIATION OF METABOLIC SYNDROME COMPONENTS WITH INTERVERTEBRAL DISC DEGENERATION: REVIEW

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Abstract

Objective

The objective of the present study was to examine the associations between metabolic syndrome (MS) components, such as overweight (OW), hypertension (HT), dyslipidemia (DL), and impaired glucose tolerance (IGT), and intervertebral disc degeneration (DD).

Design

The present study included 928 participants (308 men, 620 women) of the 1,011 participants in the Wakayama Spine Study. DD on magnetic resonance imaging was classified according to the Pfirrmann system. OW, HT, DL, and IGT were assessed using the criteria of the Examination Committee of Criteria for MS in Japan.

Results

Multivariable logistic regression analysis revealed that OW was significantly associated with cervical, thoracic, and lumbar DD (cervical: odds ratio [OR], 1.28; 95% confidence interval [CI], 0.92–1.78; thoracic: OR, 1.75; 95% CI, 1.24–2.51; lumbar: OR, 1.87; 95% CI, 1.06–3.48). HT and IGT were significantly associated with thoracic DD (HT: OR, 1.54; 95% CI, 1.09–2.18; IGT: OR, 1.65; 95% CI, 1.12–2.48). Furthermore, subjects with 1 or more MS components had a higher OR for thoracic DD compared with those without MS components (vs. no component: OR, 1.58; 95% CI, 1.03–2.42; 2 components: OR, 2.60; 95% CI, 1.62–4.20; ≥ 3 components: OR, 2.62; 95% CI, 1.42–5.00).

Conclusion

MS components were significantly associated with thoracic DD. Furthermore, accumulation of MS components significantly increased the OR for thoracic DD. These findings support the need for further studies of the effects of metabolic abnormality on DD.

Keywords: metabolic syndrome, intervertebral disc degeneration, overweight, hypertension, dyslipidemia, glucose tolerance.

Introduction

Intervertebral disc degeneration (DD) is generally considered as the first step of spinal change and undergoes destructive changes with age. It is typically followed by the loss of water and proteoglycan content of the nucleus, annulus tears, gradual formation of osteophytes, disc narrowing, and spinal canal stenosis (1, 2), and low back pain (3–6), is a major public health problem that negatively influences activities of daily living and quality of life in those affected. The number of patients with degenerative disease of the spine is increasing [6], thereby causing medical expenses to rise. In spite of these situation, the cause of DD is not fully understood. Because the etiology of DD exclude aging remains poorly understood. Accordingly, the study needs to clarify which risk factors promote DD to establish preventive measures against DD. In the present study,

the study focused on metabolic syndrome (MS) component, such as overweight (OW), hypertension (HT), dyslipidemia (DL), and impaired glucose tolerance (IGT), because MS component has some influence on atherosclerosis (7) and accumulation of MS component increase the risk of atherosclerosis events (8). MS may increase not only the risk of cardiovascular events but also the risk of DD in the whole body (9), because intervertebral discs, which are structures with precarious nutrient supply at tissue level throughout the whole body, may suffer and gradually degenerate as a consequence of failure of nutrient supply to disc cells (10–11). However the association between MS component and DD remains controversial (9). In some previous epidemiologic studies, OW (6, 12–16), DL (16), and IGT (17) were found to be associated with DD in the lumbar region. Other studies, however, have found no clear associations between hypertension (HT) (9), IGT (9, 16),

and DL (9, 18), and DD in the lumbar region. This may be due to the limitation of potential biases related to patient selection and the consequences of disease on behavior. Furthermore, the majority of epidemiologic investigations have focused only on the lumbar spine. The researchers believe that analysis of DD in the entire spine would provide more useful data than that of DD in only the lumbar region. Since the cervical and lumbar regions comprise mobile segments, the intervertebral discs in these regions are easily affected by mechanical and motion stress; thus, the effects of certain factors imposed on all intervertebral discs equally, such as age and endogenic factors, might be masked. In contrast, the thoracic region is stabilized by the thoracic cage, which reduces mechanical stress imposed on the intervertebral discs. The researchers conducted a thorough literature review and found no studies of associations between component of MS and DD that focused on a population-based analysis using whole-spine magnetic resonance imaging (MRI).

The purpose of the present study was to examine the association of each MS component, such as OW, HT, DL, and IGT, with DD in the cervical, thoracic, and lumbar regions of the entire spine in a large population. The researchers also examined the relationship between accumulation of MS components and DD.

Methods

Participants

The present study design was approved by the Wakayama medical university ethics committee. All participants provided their written informed consent. The present study, entitled the Wakayama Spine Study, was a population-based study of DD performed using a sub-cohort of the large-scale population-based cohort study called Research on Osteoarthritis/Osteoporosis Against Disability (ROAD). The ROAD study is a nationwide, prospective study of bone and joint diseases consisting of population-based cohorts established in several communities in Japan (19, 20). A second visit of the ROAD study to the mountainous region of H town and the sea-coast region of T town was performed between 2008 and 2010. From inhabitants participating in the second visit of the ROAD study, 1,063 volunteers were recruited for MRI examinations. Among the 1,063 volunteers, 52 declined to attend the examination; therefore, 1,011 inhabitants were recruited for registration in the Wakayama Spine Study. Among the 1,011 participants, those who had an MRI-sensitive implanted device (e.g., pacemaker) or other disqualifiers were excluded. Consequently, 980 individuals underwent whole-spine MRI. One participant who had undergone a previous cervical operation and 4 participants who had undergone previous posterior lumbar fusion were excluded from the analysis. Whole-spine MRI results were available for 975 participants (324 men, 651 women) with an age range of 21 to 97 years (mean, 67.2 years for men, 66.0 years for women). Thirty participants with incomplete anthropometric measurements and 17 participants without blood measurements were excluded. Finally, the present study comprised 928 participants (308 men, 620 women) with a mean age of 67.4 years.

The participants completed an interviewer-administered questionnaire of 400 items that included life-style information, such as smoking habit, alcohol consumption, family history, past history, occupation, physical activity, and health-related quality of life. Anthropometric measurements included height, weight, and body mass index (BMI) (weight [kg]/height [m]²). An experienced public health nurse measured systolic and diastolic blood pressure (BP) using a mercury sphygmomanometer.

MRI

A mobile MRI unit (Excelart 1.5 T; Toshiba, Tokyo, Japan) was used in the present study, and whole-spine MRI was performed for all participants on the same day as the questionnaire and anthropometric examination. The participants were supine during MRI, and those with rounded backs used triangular pillows under their head and knees. The imaging protocol included sagittal T2-weighted fast-spin echo (FSE) (repetition time [TR], 4000 ms/echo; echo time [TE], 120 ms; field of view [FOV], 300 × 320 mm) and axial T2-weighted FSE (TR, 4000 ms/echo; TE, 120 ms; FOV, 180 × 180 mm).

Sagittal T2-weighted images were used to assess the intervertebral space from C2/3 to L5/S1. C2/3 to C7/T1, T1/2 to T12/L1, and L1/2 to L5/S1 were defined as the cervical, thoracic, and lumbar region, respectively. Grading of DD was performed by a board certified orthopedic surgeon (M.T.) who was blinded to the background of the subjects. The degree of DD on MRI was classified into 5 grades based on the Pfirrmann system (21), with grades 4 and 5 indicating DD. The signal intensity for grade 4 is intermediate to hypointense to cerebrospinal fluid (dark gray), while the structure is inhomogeneous. The signal intensity for grade 5 is hypointense to cerebrospinal fluid (black), and the structure is likewise inhomogeneous. In addition, the disc space is collapsed. It has been reported that loss of signal intensity is significantly associated with morphologic level of DD and also with water and proteoglycan content in a disc (22). Therefore, the researchers used a grading system based on signal intensity and disc height.

For evaluating intraobserver variability, 100 randomly selected whole-spine magnetic resonance images were rescored by the same observer (M.T.) more than 1 month after the first reading. Furthermore, to evaluate interobserver variability, 100 other magnetic resonance images were scored by 2 board certified orthopedic surgeons (M.T. and R.K.) using the same classification system. The intra- and interobserver variability for DD, as evaluated by kappa analysis, were 0.94 and 0.94, respectively.

Blood examination

All blood and urine samples were extracted between 9:00 AM and 3:00 PM. Some samples were extracted under fasting conditions. After centrifugation of the blood samples, sera were immediately placed in dry ice, and transferred to a deep freezer within 24 hours. These samples were stored at -80°C until assayed. For the samples of participants in the baseline study, the following items were measured: blood counts, hemoglobin, hemoglobin A1c (HbA1c), blood sugar, total

protein, aspartate aminotransferase, alanine aminotransferase, γ -glutamyl transpeptidase, high-density lipoprotein cholesterol (HDL-C), total cholesterol, triglycerides (TGs), blood urea nitrogen, uric acid, and creatinine. These analyses were performed at the same laboratory within 24 hours after extraction (Osaka Kessei Research Laboratories Inc., Osaka, Japan).

Definitions of MS components were based mainly on the criteria of the Examination Committee of Criteria for MS in Japan (23). According to the consensus, an abdominal circumference ≥ 85 cm in men and ≥ 90 cm in women is a necessary condition for MS. HT was diagnosed as systolic BP ≥ 130 mm Hg and/or diastolic BP ≥ 85 mm Hg; DL, as serum TG level ≥ 150 mg/dL and/or serum HDL-C level < 40 mg/dL; and IGT, as fasting serum glucose level ≥ 100 mg/dL. Recently, the National Cholesterol Education Program's Adult Treatment Panel III report proposed a new set of criteria to define MS without central obesity, as indicated by waist circumference, as the core feature (24). Furthermore, compared with BMI, measurement of waist circumference is less reproducible due to lack of uniformity in measurement methods (25, 26). By contrast, measurement of BMI is more user-friendly and widely practiced. In this study, the researchers decided to use BMI ≥ 25 kg/m² as an indicator of OW, based on the criteria of the Japan Society for the Study of Obesity (25).

In addition, because not all blood samples were obtained under fasting conditions, we did not use participants' data concerning serum levels of glucose and TGs because of their large variation depending on hours after eating. Instead, we used serum HDL-C level < 40 mg/dL to indicate DL, and serum HbA1c level $\geq 5.5\%$ to indicate IGT (the value for HbA1c (National Glycohemoglobin Standardization Program (NGSP))

(%) is estimated as an NGSP-equivalent value calculated by the formula HbA1c (%) = HbA1c (Japan Diabetes Society (JDS)) (%) + 0.4%) (27). These are indices used in the National Health and Nutrition Survey in Japan, which were adopted as criteria for MS in this national screening based on the difficulty of collecting samples under fasting conditions (28).

Statistical analysis

All statistical analyses were performed using JMP version 8 (SAS Institute Japan, Tokyo, Japan). Differences between the groups depending on the presence or absence of DD were tested using a variance analysis. Multivariable logistic regression analysis was performed to determine the association of OW, HT, DL, and IGT with DD. The DD in the cervical, thoracic, or lumbar region was separately served as an objective variable. Then, to clarify the association between accumulation of MS components and DD, logistic regression analysis was repeated using presence of DD in the cervical, thoracic, and lumbar region, respectively, as the objective variable and number of MS components present as the explanatory variable, after adjusting for age, sex, regional difference, smoking habit, and alcohol consumption. P value of < 0.05 was treated as significant.

Results

Table 1 shows selected characteristics of the participants, including age, height, weight, BMI, systolic and diastolic BP, and serum levels of HDL-C and HbA1c, classified by sex. Table 1 also shows the proportion of subjects who smoked (regularly or more than once a month) and consumed alcohol (regularly or more than once a month), and the prevalence of OW, HT, DL, and IGT. In the total population, the MS component with the highest prevalence was HT, followed by OW, IGT, and DL.

Table 1. Background characteristics of the participants.

	Overall	Men	Women
No. of participants	928	308	620
Mean (SD) selected characteristics			
Age (years)	67.4 (12.3)	68.5 (12.4)	66.8 (12.2)
Height (cm)	155.8 (9.4)	160.5 (8.0)	153.4 (9.1)
Weight (kg)	56.7 (11.5)	60.2 (11.4)	55.0 (11.2)
Body mass index (kg/m ²)	23.3 (3.6)	23.7 (3.3)	23.1 (3.7)
Systolic BP, mmHg	139.5 (19.6)	141.3 (18.5)	138.7 (20.0)
Diastolic BP, mmHg	76.0 (11.5)	78.1 (12.5)	74.9 (10.9)
Serum levels of HDL-C, mg/dl	63.2 (16.2)	56.0 (14.8)	66.8 (15.7)
Serum levels of HbA1c, %	5.3 (0.7)	5.3 (0.9)	5.2 (0.6)
Prevalence of selected characteristics, %			
Smoking habit	10.1	23.3	3.5
Alcohol consumption	31.2	57.5	18.2
Prevalence of each metabolic abnormality, %			
Obesity	29.4	32.5	27.9
Hypertension	74.7	78.9	72.6
Dyslipidemia	4.5	10.1	1.8
Impaired glucose tolerance	23.3	27.3	21.3

Values are the means $\pm$ standard deviation. HDL-C = high density lipoprotein cholesterol, HbA1c = glycosylated haemoglobin, ABI = ankle brachial index, SD = standard deviation.

Table 2 shows the mean value of each MS component according to absence and presence of DD in the

cervical, thoracic, and lumbar region, respectively. Mean values of age, BMI, systolic BP, and HbA1c were significantly higher, while those of HDL-C were significantly lower, in subjects with DD than in those without DD.

Mean value (SD) of each demographic characteristics and measurements in the absence and presence of disc degeneration in the cervical, thoracic, and lumbar region, respectively.

Table 1. Background characteristics of the participants.

	Overall	Men	Women
No. of participants	928	308	620
Mean (SD) selected characteristics			
Age (years)	67.4 (12.3)	68.5 (12.4)	66.8 (12.2)
Height (cm)	155.8 (9.4)	160.5 (8.0)	153.4 (9.1)
Weight (kg)	56.7 (11.5)	60.2 (11.4)	55.0 (11.2)
Body mass index (kg/m ²)	23.3 (3.6)	23.7 (3.3)	23.1 (3.7)
Systolic BP, mmHg	139.5 (19.6)	141.3 (18.5)	138.7 (20.0)
Diastolic BP, mmHg	76.0 (11.5)	78.1 (12.5)	74.9 (10.9)
Serum levels of HDL-C, mg/dl	63.2 (16.2)	56.0 (14.8)	66.8 (15.7)
Serum levels of HbA1c, %	5.3 (0.7)	5.3 (0.9)	5.2 (0.6)
Prevalence of selected characteristics, %			
Smoking habit	10.1	23.3	3.5
Alcohol consumption	31.2	57.5	18.2
Prevalence of each metabolic abnormality, %			
Obesity	29.4	32.5	27.9
Hypertension	74.7	78.9	72.6
Dyslipidemia	4.5	10.1	1.8
Impaired glucose tolerance	23.3	27.3	21.3

DD = disc degeneration, BMI = body mass index, BP = blood pressure, HDL-C = high density lipoprotein in cholesterol, HbA1c = hemoglobin A1c, SD = standard deviation

Differences between the groups depending on the presence or absence of DD were tested using a variance analysis.

To determine the associations of DD with OW, HT, DL, and IGT, multivariable logistic regression analysis was performed (Table 3). OW was significantly associated with presence of DD in the cervical, thoracic, and lumbar regions. In addition, HT, DL, and IGT were significantly associated with presence of DD in the thoracic region, but not with DD in the cervical and lumbar regions.

Table 3. Association of OW, HT, DL and IGT in cervical, thoracic and lumbar region, respectively.

		Cervical		Thoracic		Lumbar	
		OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value
Overweight	Yes vs no	1.28 (0.92–1.78)	0.1397	1.75 (1.24–2.51) *	0.0016	1.87 (1.06–3.48) *	0.0306
Hypertension	Yes vs no	1.19 (0.85–1.66)	0.286	1.54 (1.09–2.18) *	0.0138	0.88 (0.52–1.45)	0.6189
Dyslipidemia	Yes vs no	1.06 (0.49–2.17)	0.8853	0.42 (0.21–0.86) *	0.0176	0.87 (0.34–2.70)	0.7963
Impaired Glucose Tolerance	Yes vs no	1.27 (0.88–1.85)	0.1943	1.65 (1.12–2.48) *	0.0115	1.48 (0.80–2.95)	0.2211
Age	over 65 vs under 65	2.98 (2.16–4.11) ***	<0.0001	5.76 (4.10–8.16) ***	<0.0001	4.72 (2.47–9.69) ***	<0.0001
Sex	Women vs men	1.32 (0.92–1.90)	0.1342	1.02 (0.70–1.48)	0.9198	0.95 (0.56–1.66)	0.8691
Regional difference	Mountainous town vs seacoast town	1.75 (1.13–2.78) *	0.012	1.20 (0.77–1.89)	0.4353	0.14 (0.07–0.27) ***	<0.0001
Smoking habit	Yes vs no	0.88 (0.54–1.44)	0.6002	0.90 (0.54–1.49)	0.6707	0.56 (0.29–1.12)	0.0984
Alcohol consumption	Yes vs no	0.94 (0.67–1.33)	0.7332	0.96 (0.67–1.37)	0.8332	0.92 (0.55–1.55)	0.7456

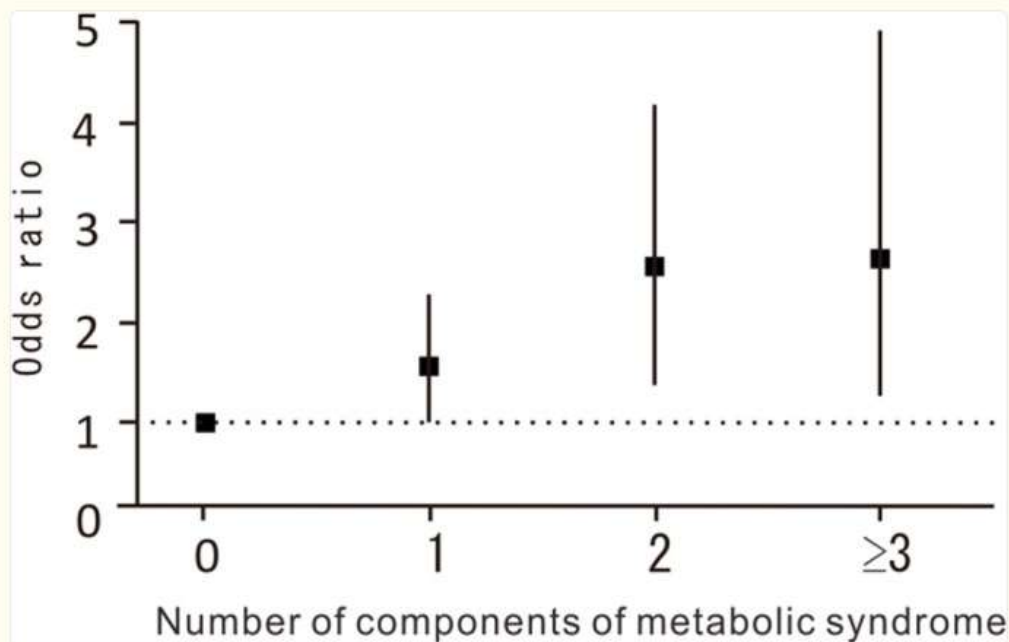
***p value < 0.0001

Multivariable logistic regression analysis was performed to determine the association of OW, HT, DL, and IGT with DD. The DD in the cervical, thoracic, or lumbar region was separately served as an objective variable. DD = disc degeneration, OW = Overweight, HT = Hypertension, DL = Dyslipidemia, IGT = Impaired Glucose Tolerance. Overweight was diagnosed as BMI ≥ 25 , Hypertension was diagnosed as systolic BP ≥ 130 mm Hg and/or diastolic BP ≥ 85 mm Hg, DL was diagnosed as serum HDL-C level < 40 mg/dl, Impaired Glucose Intolerance was diagnosed as serum HbA1c level $\geq 5.5\%$

OR = odds ratio, 95% CI = 95% confidence interval

*p value < 0.001

Next, to determine the effect of accumulation of MS components on DD in the thoracic region, the researchers examined the association of number of MS components present with DD after adjusting for age, sex, regional difference, smoking habit, and alcohol consumption. Fig 1. shows the odds ratio (OR) of number of MS components for presence of DD in the thoracic region. Subjects with 1 or more MS components had a higher OR for presence of DD compared with those without MS components (vs. no component; 1 component: OR, 1.58; 95% confidence interval [CI], 1.03–2.42; $p = 0.0353$; 2 components: OR, 2.60; 95% CI, 1.61–4.20; $p < 0.0001$; ≥ 3 components: OR, 2.62; 95% CI, 1.42–5.00; $p = 0.0021$).

Fig 1. ORs of the number of MS components for the presence of DD in the thoracic region, compared with no components present.

Subjects with 1 or more MS components had a higher OR for presence of DD compared with those without MS components.

Subjects with 1 or more MS components had a higher OR for presence of DD compared with those without MS components.

Discussion

The present study was the first to determine the associations between MS components and DD in the entire spine using whole-spine MRI in a large population. The researchers elucidated that OW was significantly associated with presence of DD in the entire spine, including the cervical, thoracic, and lumbar regions. HT, DL, and IGT were significantly associated with presence of DD in the thoracic region, but not with DD in the cervical and lumbar regions. Furthermore, the study also found that accumulation of MS components was significantly associated with presence of DD in the thoracic region.

Regarding the association between degenerative musculoskeletal disease and metabolic risk factors, Yoshimura et al. clarified the association between accumulation of metabolic risk factors and presence and occurrence of knee osteoarthritis (OA) (29, 30). Hart et al. found that metabolic risk factors, such as high blood glucose level, hypercholesterolemia, and even treated HT, were associated with development of knee OA (31). Furthermore, Anekstein et al. clarified the association between diabetes mellitus and lumbar spinal stenosis in the patients (32). However, to our knowledge, there has been no report concerning the association between MS components and DD in the spine, especially the entire spine, using whole-spine MRI in a large population.

In the present study, OW was significantly associated with presence of DD in the cervical, thoracic, and lumbar regions. The association between OW and DD has been previously reported, and Liuke et al. found that past OW was more strongly associated with DD than present OW (13). Samartzis et al. reported that DD in the lumbar region was significantly associated with OW and obesity (14). On the other hand, according to Okada et al. and Matsumoto et al., DD in the cervical and thoracic regions did not have significant correlation with BMI (32, 33). Therefore, the association remains controversial. The present study is the first to determine the association of OW with DD in the entire spine using a population-based design, and found that OW was significantly associated with DD in not only the lumbar region but also the cervical and thoracic regions. DD is influenced by inflammatory cytokines, such as adipokines, known as key metabolism mediators (34-37). Inflammatory cytokines, such as leptin, adiponectin, and resistin, have more addressed in body fat (34, 38). Thus, OW may lead to an increase in adipokine secretion of proinflammatory cytokines and metabolic mediators; thus, all intervertebral discs in the entire spine may be influenced by inflammatory cytokines. Further research is needed to elucidate the mechanism through which OW affects DD since both direct mechanical stress and indirect factors affect the intervertebral discs.

To our knowledge, there has been less report regarding the association of HT with DD or lumbar spinal

stenosis as spinal disorder (9, 39). HT is a well-known risk factor for development of atherosclerosis (40). Thus, HT might lead to vascular insufficiency to the disc, due to atherosclerosis, which can affect nutrient and metabolite transport into the disc.

The present study also confirmed the significant association between IGT and DD. In one study, it was reported that diabetic sand rats had more dehydrated discs compared with a control group (17). In the Nurses' Health Study, IGT increased the risk of lumbar disc herniation (41). However, several previous reports on DD also showed a weak association with IGT (9, 16, 42); this may be due to their investigation of DD in only the lumbar region. In this study, the researchers found an association between IGT and presence of DD in the thoracic region. Therefore, IGT, which is well known for causing microangiopathy throughout the whole body, also might be a predisposing factor for development of DD. Furthermore, advanced glycation end products accumulate in the intervertebral discs with aging, particularly when the concentration of serum glucose is high, such as in IGT (43). Therefore, IGT might be associated with DD.

The study founds a negative association between DL and DD. The association of DL and DD also remains controversial in previous reports (9, 18, 44). DD might be the result of decreased blood supply, caused by DL, to the already poorly vascularized discs (45, 46). The mean HDL-C was higher in women than in men, as shown in Table 2. Because women in Japan use health services more frequently compared with men (28), the proportion of patients with DL in women was higher than that in men. This might have influenced the negative association between DD and DL. In a follow-up study, the researchers will further investigate the association between DL and DD.

The study founds no associations of HT, DL, and IGT with DD in the cervical and lumbar regions. Since the cervical and lumbar regions comprise mobile segments, the intervertebral discs are easily affected by mechanical and motion stress, while the effect of endogenous factors might be masked. In contrast, in the thoracic region, mechanical stress on the intervertebral discs is reduced because the region is stabilized by the thoracic cage. Distinct associations among DD in the cervical, thoracic, and lumbar regions might indicate the effects of HT, DL, and IGT on DD are due to endogenous factors. To clarify risk factors for DD, particularly endogenous risk factors, it may be useful to examine associations in not only the cervical and lumbar regions, but in the thoracic region as well.

Study limitations

This study has several limitations. First, this was a cross-sectional study; thus, the causal relationships between MS components and DD remain unclear. These can only be ascertained by a follow-up study that clarifies the incidence and/or progression rates of DD in the same cohort. Second, the participants included in the present study may not represent the general population since they were recruited from only 2 local areas. To confirm whether the participants are representative of the Japanese population, the researchers compared an-

thropometric measurements and frequencies of smoking and alcohol consumption between the general Japanese population and the study participants. No significant difference in BMI was observed (men: 24.0 kg/m² vs. 23.7 kg/m², $p = 0.33$; women: 23.5 kg/m² vs. 23.1 kg/m², $p = 0.07$). Further, the proportion of men who smoked and who consumed alcohol (those who regularly smoked or consumed alcohol more than once per month) and the proportion of women who consumed alcohol were significantly higher in the general Japanese population than in the study population, whereas there was no significant difference in the proportion of women who smoked (men who smoked: 32.6% vs. 23.3%, $p = 0.015$; women who smoked: 4.9% vs. 3.5%, $p = 0.50$; men who consumed alcohol: 73.9% vs. 57.5%, $p < 0.0001$; women who consumed alcohol: 28.1% vs. 18.2%, $p < 0.0001$). These results suggest the likelihood that, in this study, participants had healthier lifestyles than those of the general Japanese population (28). This “healthy” selection bias should be taken into consideration when generalizing the results obtained from the Wakayama Spine Study. In addition, since the blood samples obtained were not always from participants under fasting conditions, the researchers used serum HDL-C level <40 mg/dL, and not TG level, to indicate DL, and serum HbA1c level $\geq 5.5\%$, and not blood glucose level, to indicate IGT, which are indices used by the National Health and Nutrition Survey in Japan (28). These differences in the definition of MS might have skewed the true association between MS and DD.

Conclusions

The study investigated the associations between MS components and DD in the cervical, thoracic, and lumbar regions in a large population of individuals ranging in age from 21 to 97 years. The researchers revealed that OW was significantly associated with presence of DD in the entire spine, and that HT and IGT were significantly associated with presence of DD in the thoracic region. The researchers also found that subjects with 1 or more MS components had a higher OR for presence of DD compared with those without MS components. The prevention of MS may be useful for avoiding DD. Further investigations, along with continued longitudinal surveys of the Wakayama Spine Study, will elucidate the associations between MS components and occurrence or progression of DD.

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VITAMIN D IN PAIN MANAGEMENT

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Vitamin D is a hormone synthesized in the skin in the presence of sunlight. Like other hormones, vitamin D plays a role in a wide range of processes in the body. Here we review the possible role of vitamin D in nociceptive and inflammatory pain. In observational studies, low vitamin D levels have been associated with increased pain and higher opioid doses. Recent interventional studies have shown promising effects of vitamin D supplementation on cancer pain and muscular pain—but only in patients with insufficient levels of vitamin D when starting intervention. Possible mechanisms for vitamin D in pain management are the anti-inflammatory effects mediated by reduced cytokine and prostaglandin release and effects on T-cell responses. The recent finding of vitamin D-mediated inhibition of Prostaglandin E2 (PGE2) is especially interesting and exhibits a credible mechanistic explanation. Having reviewed current literature, we suggest that patients with deficient levels defined as 25-hydroxyvitamin D (25-OHD) levels <30 nmol/L are most likely to benefit from supplementation, while individuals with 25-OHD >50 nmol/L probably have little benefit from supplementation. Our conclusion is that vitamin D may constitute a safe, simple and potentially beneficial way to reduce pain among patients with vitamin D deficiency, but that more randomized and placebo-controlled studies are needed before any firm conclusions can be drawn.

Keywords: vitamin D, pain, opioid, infections, quality of life, cancer, statins, myopathy

Introduction

Vitamin D is a hormone mainly synthesized in the skin in the presence of sunlight. Oral intake from natural and fortified foodstuffs, as well as from supplementation, adds to vitamin D levels in the individual. Like other hormones, vitamin D plays a role in a wide range of processes in the body. Sufficient vitamin D levels are important not only for a healthy skeleton but also for a healthy immune system (1). Vitamin D has anti-inflammatory effects in the body by reducing the release of pro-inflammatory cytokines and suppressing T-cell responses (1,2). In vitro studies have shown that vitamin D inhibits the synthesis of Prostaglandin E2 (PGE2) (3). Both observational and interventional studies suggest a role for vitamin D in pain intensity and in management of pain in varying clinical settings (4-10). Despite these data, three meta-analyses of randomized and placebo-controlled trials (RCTs) could not establish a correlation between vitamin D supplementation and pain reduction (8, 11, 12). In contrast, a recent systematic review of published RCTs (not included in the three meta-analyses above) concluded that vitamin D supplementation leads to a significantly greater mean decrease in pain score compared to placebo in patients with chronic pain (13). The goal of this review is to examine the evidence to date in the field of vitamin D and pain, and to elucidate whether current knowledge supports vitamin D supplementation in patients with deficient levels of 25-OHD and pain.

The search strategy in PubMed included the MeSH terms “vitamin D” and “pain” and resulted in 347 titles that have been briefly reviewed and relevant articles have been extracted in full text.

Definitions of Pain

The definition of pain, according to the International Association for the Study of Pain, is “... an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.” (14). Physical pain is usually divided into nociceptive, inflammatory and neuropathic pain. During recent years different types of psychological pain has been defined, and “existential pain” is sometimes used to describe this feeling of pain in cancer patients (15). Patients often experience “mixed pain”, where nociceptive, inflammatory and neuropathic components present together with existential pain. Nociceptive pain can be treated with opioids and non-steroid anti-inflammatory drugs (NSAIDs), whereas steroids and NSAIDs are used to treat inflammatory pain. Neuropathic pain can be treated with subgroups of anti-epileptic drugs or tricyclic antidepressants. Studies have shown that vitamin D might influence nociceptive and inflammatory pain mechanisms (4, 6, 9, 16). There are very scarce data on the role of vitamin D in neuropathic pain. One observational study has shown possible associations between vitamin D deficiency and carpal tunnel syndrome (17), and an inter-

ventional study showed positive effect on diabetic neuropathy after a very high single-dose of vitamin D (18). However, in this review we will focus on the role of vitamin D in nociceptive and inflammatory pain.

Vitamin D—Synthesis, Physiological Effects and Pathophysiological Mechanisms

Vitamin D is synthesized in the skin using energy from ultraviolet-B light. Vitamin D is hydroxylated in two steps into the active form 1,25-dihydroxyvitamin D, which binds to the vitamin D receptor (VDR). The activated VDR complex regulates a large number of genes (19). The pro-form 25-hydroxyvitamin D (25-OHD) has a half-life of about 3 weeks and is more stable than the active 1,25 hydroxy vitamin D, with a half-life of four hours (20). Therefore, 25-OHD is used for evaluation of vitamin D status (21). Serum levels of 25-OHD below 50 nmol/L are considered insufficient according to the Institute of Medicine in the US (22).

Vitamin D is needed for a healthy skeleton and plays an important role in calcium homeostasis. During recent years, it has become evident that vitamin D, just like other hormones, affects a variety of functions and processes in the body.

In our research we mainly focus on the role of vitamin D in the immune system. Vitamin D influences both the adaptive and the innate parts of immunity. For example, vitamin D is a potent inducer of antimicrobial peptides (AMPs) on mucosal surfaces and in immune cells (1,2). AMPs constitute the “first line of defense” for invading bacteria and viruses on mucosal surfaces, including the respiratory tract (1,2). In a meta-analysis

comprising 25 randomized, placebo-controlled trials, including 11,321 participants, vitamin D supplementation was shown to reduce the number of respiratory tract infections (23). This meta-analysis also showed that the protective effect of vitamin D was evident only in studies using once-daily dosage, whereas bolus doses did not work. Moreover, the positive effect was more pronounced in patients with serum levels of 25-OHD below 25 nmol/L. Importantly, vitamin D supplementation was generally well tolerated and not associated with any adverse events in any of the included studies.

In addition to the induction of AMPs, vitamin D also affects T-cell responses and suppresses inflammation (24). Under conditions of vitamin D insufficiency, the immune system will favor a more inflammatory immune response involving Th1 and Th17 cells rather than Th2 and Tregulatory cells (Treg) (24). On the contrary, adequate levels of vitamin D lead to less inflammation and lower levels of inflammatory cytokines and prostaglandins (6). Indeed, vitamin D deficiency has been reported as a risk factor for different forms of inflammatory diseases, such as rheumatic diseases (16, 25) and multiple sclerosis (26-28). Effects of vitamin D on both B- and T-cell responses have been suggested to be involved in controlling inflammatory diseases (16,27). Colotta et al. recently published a valuable overview of the effects of vitamin D on immune and inflammatory cells and of epidemiological studies in the field (29). The effects of vitamin D in the immune system that may influence pain management are listed in Table 1.

Table 1.

Actions of vitamin D in the immune system that may influence pain management [1,2,6,24,29].

Actions of Vitamin D in the Immune System		
Antimicrobial peptides		↑
Inflammation	↓	
Th1 cells	↓	
Th17 cells	↓	
Th2 cells		↑
T-regulatory cells (Treg)		↑
Prostaglandin E ₂ (PGE ₂)	↓	
Tumour Necrosis Factor α (TNF α)	↓	
Leukotriene B ₄ (LTB ₄)	↓	

T-helper cells (Th); arrow up = increased levels; arrow down = decreased levels.

The physiological mechanism linking vitamin D to pain is not yet fully elucidated. Evidence from both clinical and animal studies suggest that insufficient levels of vitamin D affect both peripheral (30, 31) and parasympathetic nerve function (32). Presence of vitamin D receptors (VDR) and vitamin D activating enzymes in the central nervous system (CNS) as well as effects of vitamin D on neurotransmitters have been suggested to explain the link between pain and vitamin D in patients with fibromyalgia (33).

However, the most probable mechanism of Vitamin D in pain management involves its anti-inflammatory effects. As mentioned above, vitamin D shifts the T-cell responses resulting in higher levels of Th2 and Treg cells instead of the pro-inflammatory Th1 and Th17-cells (24). In addition, in vitro studies have shown that vitamin D inhibits the synthesis of PGE2 in fibroblasts (3). In a small study on 36 healthy women, vitamin D supplementation led to decreased levels of prostaglandins in a dose-dependent fashion (34). Interestingly, in a clinical study where vitamin D supplementation reduced musculoskeletal pain, the effect was associated with decreased levels of inflammatory cytokines including prostaglandin E2 (PGE2) (6). PGE2 is an important factor in inflammatory pain (35). Thus, the suppression of inflammation in general and of PGE2 especially exhibits credible mechanistic explanations for the effect of vitamin D in pain.

Nevertheless, it can also be argued that vitamin D does not have any direct or causal role in pain. In fact, a recent article suggested that UVB light has strong analgesic effects by induction of endogenous opioid-like substances (endorphins) in the skin (36). In this model, vitamin D levels would only serve as a marker for UVB exposition. Thus, it is possible that findings in observational studies of a clear association between vitamin D levels and pain can be fully or partly explained by exposure to the sun and endogenous synthesis of endorphins. However, if UVB light constituted the only association between vitamin D deficiency and pain, it would be hard to explain the positive effect on pain management reported during vitamin D supplementation (9, 37-40).

Vitamin D and Chronic Pain

Chronic pain is generally described as pain experienced on a majority of days for at least three months. Several observational studies have shown that patients with different forms of chronic pain have low 25-OHD levels in the circulation (41-44). This has led to that several randomized controlled trials in different populations of chronic pain patients have been conducted. In 2015, a Cochrane review was published with the aim to assess the efficacy and safety of vitamin D supplementation in patients with chronic pain. In the final analysis 10 studies, comprising a total of 811 patients, were included. In these studies vitamin D was compared to placebo or active comparators (12). However, the studies were very heterogeneous regarding doses used, included patients and co-interventions. The authors of the Cochrane review concluded that there was no consistent pattern that vitamin D supplementation was associated with greater efficacy than placebo. However, it should be noted that vitamin D supplementation was

considered safe and well tolerated, since the numbers of adverse events were the same between placebo groups and vitamin D-treated groups (12). A recent review discussing the role of vitamin D in the treatment of chronic pain arrives at the same conclusion as the Cochrane review, arguing that in the absence of a mechanistically explanation for the causal relationship between vitamin D and chronic pain, clinical data from interventional studies do not support vitamin D supplementation as an independent treatment in this patient group (45). The most promising results from clinical studies in patients with chronic pain were reported in patients suffering from fibromyalgia (9) or nonspecific musculoskeletal pain with insufficient 25-OHD levels at baseline (39), discussed further below. In contrast, in the study where the included patients had high/sufficient 25-OHD levels from the beginning (100 nmol/L), no effect of vitamin D supplementation was evident (46).

Vitamin D in Musculoskeletal Pain

Observational studies have indicated that sufficient vitamin D levels are important for normal muscular function and strength (47). In addition, several studies have shown an association between vitamin D levels and neuromuscular coordination (47). However, the presence of the vitamin D receptor (VDR) in adult skeletal muscle cells has been debated. Studies from VDR knock-out mice have shown that the muscle fibers were small and variable in size, although overall myocyte differentiation occurred normally (48). Recently it was shown that the vitamin D-activating system can be detected in human muscle precursor cells, but is low or non-detectable in adult skeletal muscle (49). Neither did a review of bioinformatics approaches in analyzing VDR signaling reveal a significant role for VDR in muscle tissue (50).

Fibromyalgia is a disease associated with chronic muscular pain (9). In a small, randomized, placebo-controlled study ($n = 30$) vitamin D supplementation of 50,000 IU/week for 20 weeks showed statistical significant improvement in pain and quality of life (9). The included patients had mean 25-OHD levels of 50 nmol/L at baseline. In a more recent, small, non-controlled interventional study ($n = 58$) on patients with chronic nonspecific and widespread musculoskeletal pain and mean 25-OHD levels of 20 nmol/L at baseline, vitamin D supplementation with the same dose, 50,000 IU/week for three months, also showed a statistical significant improvement in pain and quality of life (51). In contrast, in a study on patients with diffuse musculoskeletal pain with sufficient 25-OHD levels (mean 72 nmol/L) at baseline, no effect could be observed (52).

In a randomized, placebo-controlled study on 80 patients with musculoskeletal pain, 4000 IE vitamin D/day for 3 months resulted in improvement of symptoms recorded as decline in visual analogues scale (VAS) score (6). The included patients had mean 25-OHD levels of 55 nmol/L at baseline. Interestingly, this study also showed that vitamin D supplementation resulted in decreased levels of inflammatory and pain-related cytokines in plasma, such as Prostaglandin E2 (PGE₂), TNF α and Leukotriene B₄ (LTB₄) (6).

Low vitamin D levels have been linked to an increased risk for statin induced myalgia in several observational studies (7, 53, 54). Interventional studies have shown that supplementation with vitamin D with 50,000 IU/week, may have protective effects against myalgia in statin treated patients (55, 56). However, these studies were not randomized or placebo controlled, compromising the validity of the data. Notably, several observational studies have failed to establish a relationship between low vitamin D levels and myalgia (57-59). Thus, the picture is far from complete and further research is highly warranted.

Vitamin D in Cancer Pain

Several observational studies show that cancer patients generally have lower vitamin D levels than healthy controls (60-63). According to two small pilot-studies, vitamin D supplementation might reduce pain in prostate cancer patients with bone metastases (37, 40). The association between vitamin D deficiency and musculoskeletal symptoms induced by aromatase inhibitor treatment in breast cancer patients has also been studied in different settings (64-66). However, in a recent randomized, placebo-controlled trial on 160 breast cancer patients treated with aromatase inhibitors (the VITAL study) vitamin D supplementation was not associated with any clear beneficial effects on musculoskeletal symptoms (67).

In an observational study in palliative cancer patients in Stockholm, we noted an association between low 25-OHD levels and high opioid doses (4). In a follow-up study, vitamin D supplementation was given in a dose of 4000 IE/day to palliative cancer patients with 25-OHD levels <75 nmol/L (38). In this study we could show that the vitamin D-supplemented patients had significantly decreased fentanyl doses compared to untreated controls already after one month. The mean difference in fentanyl dose was 46 µg/h; (95% confidence interval 24–78 µg/h) between the groups after one month ($n = 39$) and increased even further at three months to 91 µg/h (95% CI 56–140 µg/h) ($n = 26$) (38). In addition, there was a decrease in infections after three months of vitamin D supplementation as well as an increase in self-assessed quality of life. The results from this pilot study were used for the power-calculation of a future randomized, placebo-controlled, double-blind study called “Palliative-D” that will start in November 2017 and will include $n = 254$ palliative cancer patients (68). The primary endpoint in that study will be “change in opioid dose” between placebo and vitamin D-treated patients. The study will proceed for two years and end in December 2019.

Which Dose Should Be Given to the Vitamin D-Deficient Patient?

When evaluating results from clinical vitamin D trials, it might be of value to consider the five rules for optimizing individual clinical studies of nutrient effects that Heaney et al. proposed in 2014, namely that both the basal and the change in nutrient status be measured so that a change in nutrient status produces the effect tested in the hypothesis, and that the intervention must be large enough to change nutrient status (69). Also, changes in conutrient status should not influence the results of the study. Not all performed studies fulfill these

rules—most often by not recording the individual patient’s baseline levels of 25-hydroxyvitamin D (25-OHD) (70). If patients with sufficient vitamin D levels at baseline are included in an intervention study, they will not benefit from supplementation. This is often forgotten when vitamin D studies are evaluated and compared. Thus, the goal of vitamin D supplementation should be to achieve sufficient levels of 25-OHD in the circulation.

Serum levels below 50 nmol/L are considered to be insufficient according to the Institute of Medicine in the US (22). However, based on the findings from recent clinical studies, it has been suggested that levels above 75 nmol/L might be the goal of supplementation (71-73). Levels above 125 nmol/L probably add no more benefit, and levels above 250 nmol/L are considered as potentially harmful (74).

The recommended dietary intake (from both food-stuffs and supplementation) of vitamin D from all sources varies between 400–600 IU/day in different countries (74). However, when supplementing individuals with vitamin D deficiency, a total oral intake in this range does not result in a quick change in vitamin D status. In accordance with Heaney’s principles mentioned above, the intervention needs to be large enough to change nutrient status. In individuals with serum levels of 25-OHD <30 nmol/L we therefore suggest supplementation with 4000 IE /day for at least three months, or until the levels are >50 nmol/L. This dose has been shown to be both effective and safe in clinical studies (23, 38, 75). This dose has also been stated as safe in adults according to guidelines from expert groups (74). The safety issue has been further addressed in a large meta-analyses including 11,321 and 821 participants respectively; vitamin D supplementation was never associated with more adverse events than in the placebo groups (12, 23).

Summary and Conclusions

To summarize, there are several observational studies showing an association between vitamin D deficiency and different pain conditions, but a causal relationship is not obvious. Some, but not all, randomized controlled trials have shown positive effect of vitamin D supplementation on pain management. A recent systematic review of published RCTs concluded that vitamin D supplementation leads to a significantly greater mean decrease in pain score compared to placebo in patients with chronic pain. Importantly, patients with sufficient 25-OHD levels from the beginning do not benefit from treatment. The suppression of inflammation in general and of PGE2 especially exhibits credible mechanistic explanations for the effect of vitamin D in pain. Vitamin D supplementation has not shown adverse effects in any studies reviewed here and is also easy to administer.

Today, the evidence is too weak for making general recommendations for vitamin D in pain management and more randomized and placebo-controlled studies are needed before any firm conclusions can be drawn. However, current knowledge allows us to conclude that patients with deficient levels, defined here as 25-OHD <30 nmol/L, are most likely to benefit from

supplementation, while individuals with 25-OHD levels >50 nmol/L probably have little benefit from supplementation. Vitamin D might therefore be offered as independent therapy to vitamin D-deficient patients with chronic pain. Further clinical studies in this field should focus on patients with 25-OHD <30 nmol/L at baseline, and offer intervention that raises the individual's 25-OHD levels to >50 nmol/L.

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A COMPARATIVE STUDY OF THE ANTIMICROBIAL PROPERTIES OF ESSENTIAL OILS OBTAINED FROM LEMON, FENNEL AND PINE**Suleymanova T.***Azerbaijan Medical University, Department of Medical Microbiology and Immunology, Baku***СРАВНИТЕЛЬНОЕ ИССЛЕДОВАНИЕ АНТИМИКРОБНЫХ СВОЙСТВ ЭФИРНЫХ МАСЕЛ ПОЛУЧЕННЫХ ИЗ ЛИМОНА, ФЕНХЕЛЯ И СОСНЫ****Сулейманова Т.Х.***к.б.н.**Азербайджанский медицинский университет, кафедра медицинской микробиологии и иммунологии, Баку*<https://doi.org/10.5281/zenodo.15879892>**Abstract**

The article presents the effects of lemon, fennel and pine oils on some microorganisms, which consist human normal microflora. From normal flora and pathogens of human organism were used museum cultures of Azerbaijan Medical University. It was shown that bactericide effect of fennel oil was more, than lemon and pine oil/ Limon oil was shown more antifungicide effect, but pine oil was show little bactericide and fungicide effect.

Аннотация

В статье представлено влияние масел лимона, фенхеля и сосны на некоторые микроорганизмы. Во время исследования было обнаружено, что лимонное масло обладает довольно сильно фунгицидным действием (зона лизиса вокруг колонии гриба *C.albicans* ≤ 39 mm). Масло фенхеля, свою очередь обладало высоким бактерицидным действием на некоторые тест культуры, такие как, *E.coli*, *K.pneumonia*, *B.antrocoides* (зона лизиса вокруг колоний этих культур варьировала от 25 до 29 mm). Сосновое масло в данным случае, оказало низкий эффект (зона лизиса во всех тест культурах варьировала от 3 до 7 mm). Таким образом, сосновое масло не обладало в результате экспериментов, ни бактерицидным, ни фунгицидным действием.

Keywords: lemon oil, fennel oil, pine oil**Ключевые слова:** тасло лимона, масло фенхеля, масло сосны

Введение. Применение эфирных масел лимона, фенхеля и сосны известно с античных времен. Эфирные растительные масла— это сложные по химическому составу смеси различных низко- и высокомолекулярных соединений, основную группу которых составляют вещества с изопреновой структурой. Из эфирных масел выделено и идентифицировано свыше 500 органических веществ, образованных углеродом, водородом и кислородом. Эти соединения относятся к различным классам, преимущественно терпеноидам (кислотосодержащим), реже — к ароматическим и алифатическим. В них присутствуют монотерпены, сесквитерпены. Терпеноиды, содержащиеся в эфирных маслах, представлены альдегидами, кетонами, спиртами, фенолами, эфирами, лактонами, кислотами и другими соединениями.

Масло лимона очень широко применялось в древнем мире, родиной которого являлся Египет. Лимонное эфирное масло, получаемое из плодов лимона методом холодного прессования (*lemen Oil Expressed*) или паровой перегонкой (*lemen Oil Distilled*), как и другие эфирные масла, представляет не одно химическое соединение, а смесь природных летучих ароматных веществ (ЛАВ), прежде всего лимонена и линалилацетата. Лимонное масло

широко применяется в медицине, пищевой промышленности, парфюмерии. Лимонное масло, полученное методом холодного прессования, положительно влияет на функциональное состояние сердечно-сосудистой системы, тонизирует нервную систему, снимает утомление, повышает умственную работоспособность. Помимо бактерицидных свойств оно обладает и вируцидным действием, в связи с чем используется для профилактики ОРЗ и гриппа. Как антисептик оно применяется при бактериально-вирусных высыпаниях на коже, трещинах, нарывах. Широко используется в косметической промышленности: нормализует секрецию жирной кожи, результативно при целлюлите, перхоти, ломкости волос и ногтей, применяется в качестве ароматизатора напитков, кондитерских изделий [1,2,3].

В свою очередь, масло фенхеля, полученное по новым технологиям помимо свойств известных с древних времен — одно из самых популярных специй, которое активно применяют для придания горячим блюдам глубокого, насыщенного аромата. Но его можно использовать не только как пряную добавку: фенхель обладает широким спектром антисептических, противовоспалительных, регулирующих свойств, которые передаются и эфирному

маслу. Одно из главных воздействий – это болеутоляющий и снимающий спазм эффект, облегчает воспалительные процессы при невритах, артритах, остеохондрозе, способствует нормализации работы желудка. В качестве антисептического масла его активно применяют при инфицированных повреждениях кожи и фурункулезе, а также для улучшения деятельности сердечно-сосудистой системы, кровяного давления. Масло фенхеля часто включается в перечень препаратов для борьбы с заболеваниями желудка, а также с гнойно-воспалительными заболеваниями верхних-дыхательных путей [2,3,4].

Сосновые масла, полученные из молодых побегов и шишек разных видов сосны, содержат главным образом сесквитерпеновые спирты, терпеновые углеводороды, простые и сложные эфиры. Спектр действия соснового масла также многогранен: оно обладает антисептическим, дезинфицирующим, восстанавливающим, противовоспалительным, мочегонным и др. действием. Сосновое масло за целый перечень универсальных лечебных свойств, помогающих справиться с различными заболеваниями, издавна ценится, но, пожалуй, основным свойством считается помощь при заболеваниях верхних дыхательных путей [2,5,6].

Материалы и методы исследования. В качестве изучаемых материалов исследовались, синтезированные по новейшим технологиям эфирные масла: лимона, фенхеля, сосны. Изучались их антибактериальные и антифунгальные свойства.

Для изучения этих свойств в качестве тест-культур были использованы основные возбудители гнойно-воспалительных заболеваний: грамположительные кокки (*Staphylococcus aureus*), обладающий большим комплексом факторов патогенности. Наличие капсулы вызывает у этого микроорганизма широкий спектр устойчивости к химическим препаратам.

Грамотрицательные палочки (*Escherichia coli*), являющиеся нормальной микрофлорой организма, что обосновывает необычайную важность этого микроорганизма в желудочно-кишечном тракте. *Pseudomonas aeruginosa* микроорганизм, устойчивый к ультрафиолетовому облучению, а также к антисептикам применяемым в медицине. Наличие капсулы у *P.aeruginosa* приводит к мощной устойчивости этих микроорганизмов ко многим эфирным маслам. *K.pneumonia* обладает фактором множественной лекарственной устойчивости и занимает ведущее место среди возбудителей ВБИ. *B.antracoides* образует капсулу и продуцирует супероксиддисмутазу, защищая эти бактерии от бактерицидного действия антибиоти-

ков и эфирных масел, а также *Candida albicans* составляющая нормальную микрофлору ротоглотки и желудочно-кишечного тракта.

Для изучения механизма действия эфирных масел использовали диск – диффузный метод. При диск-диффузном методе из суточной культуры микроорганизмов приготавливается суспензия, состоящая в 1 мл. 1 млрд. микробных тел, которая готовится следующим образом: стерильной бактериологической петлей с поверхности скошенного агара с суточной бактериальной культурой берут небольшое количество микроорганизмов и растворяют в физиологическом растворе. Далее полученный раствор по консистенции сравнивают с стандартом, содержащем также в 1 мл. 1 млрд. микробных тел. Посев производится полученной суспензией на чашки Петри с мясо-пептонным агаром (МПА) и среду *Сабуро* следующим образом. Приоткрывая крышку чашки Петри добавляют 2-3 капли приготовленной суспензии на середину и при помощи шпателя рассеивают по всей поверхности приготовленную суспензию. После этого стерильные диски в течение 3-5 минут, пропитанные в маслах: лимона, фенхеля и сосны, ставятся на поверхность чашек Петри с микробной культурой. Чашки с бактериальной культурой помещаются в термостат при температуре 37°C, чашки с грибной культурой на среде *Сабуро* содержатся при температуре 28°C, в течение 24-48 часов. Через 2-3 суток чашки вытаскивались из термостата и результаты фиксировались.

В качестве контроля использовались чашки Петри с МПА и средой *Сабуро* без дисков, смоченных в масле фенхеля, лимона и сосны.

Результаты исследований как видно из результатов, показанных в таблице лимонное масло оказало сильный эффект на грибы рода *Candida*, где зона стерильности вокруг колоний этого гриба показала 39 mm. Капсулообразующие микроорганизмы рода *K.pneumonia* 22 mm и спорообразующие микроорганизмы рода *B.antracoides* 21mm, *S.aureus* 14 mm, на *E.coli* 19 mm. В случае с *P.aeruginosa* эффект масла лимона составил 12 mm, что свидетельствует о среднем и слабом эффекте, масла на перечисленные выше тест культуры, кроме условно патогенных грибов, где наблюдался высокий результат. Масло фенхеля оказало сильный эффект на представителей рода *E.coli* 29 mm, на капсулообразующие *K.pneumonia* 25 mm и спорообразующие *B.antracoides* 29 mm, о чем свидетельствует диаметр стерильной зоны вокруг этих колоний. Средний эффект оказало масло фенхеля на условно патогенные грибы рода *Candida* 19 mm, слабый эффект показало данное масло на микроорганизмы рода *S.aureus* 11 mm и *P.aeruginosa* 11 mm.

Таблица 1.

Тест-культура	Масло лимонное	Масло фенхеля	Сосновое масло
<i>S.aureus</i>	14 *	11	3
<i>E. coli</i>	19	29	8
<i>P. aeruginosa</i>	12	11	3
<i>C. albicans</i>	39	19	13
<i>K.pneumoniae</i>	22	25	5
<i>B.anthracoidea</i>	21	29	6

*Цифры обозначают диаметр стерильных зон в мм. Эксперименты повторялись 3 раза.

Сосновое масло оказало слабый эффект на грибы рода *Candida* и на другие микроорганизмы использованные в данной работе в качестве тест культур.

ВЫВОДЫ

Таким образом, из полученных результатов следует, что наиболее сильным действием обладало лимонное масло, проявившее высокий эффект на условно патогенные грибы рода *Candida*, тогда как на остальные тест культуры, был оказан средний эффект. Из чего следует что лимонное масло обладает больше фунгицидным эффектом.

Масло фенхеля оказало в свою очередь сильный эффект на кишечную палочку *E.coli*, на капсулообразующие *K.pneumonia* и спорообразующие *B. anthracoides*, что указывает на бактерицидный эффект этого масла. Сосновое масло обладало слабими как антибактериальными, так и антифунгальными свойствами. Стерильные зоны вокруг колоний из перечисленных тест культур образовывали зоны от 3 до 7 mm.

Изучение антимикробного и антифунгального действия эфирных масел лимона, фенхеля и сосны на группу микроорганизмов, составляющих тест культуры, показало полное соответствие полученных результатов с их микробиологическими особенностями.

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PEDAGOGICAL SCIENCES

AN EXPLORATION OF THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN JUNIOR HIGH SCHOOL MATHEMATICS CLASSROOM TEACHING

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Abstract

Artificial intelligence (AI) is profoundly transforming the teaching model of junior high school mathematics classrooms, opening up new avenues for personalised learning, classroom interaction, and improved teaching effectiveness. This paper first discusses the necessity of applying AI to junior high school mathematics teaching, then analyses the current issues in teaching, and finally focuses on exploring specific application strategies for AI in classroom teaching, with the aim of providing references for enhancing teaching effectiveness.

Keywords: artificial intelligence; junior high school mathematics; classroom teaching; application exploration

1 The necessity of applying artificial intelligence in junior high school mathematics teaching

In the digital age, the rapid development of artificial intelligence technology has brought unprecedented opportunities to the field of education. As a key component of basic education, the quality of junior high school mathematics teaching directly affects students' mathematical literacy and future learning abilities. The application of AI in junior high school mathematics teaching can not only effectively improve teaching efficiency, but also significantly optimise the learning experience of students. Through data analysis and intelligent algorithms, AI can accurately identify students' learning needs and weaknesses, thereby generating personalised learning plans. This model effectively compensates for the shortcomings of traditional teaching, enabling each student to learn at their own pace and in their own way. At the same time, AI-assisted teaching tools can create complex mathematical problem scenarios to help students understand and master abstract concepts more intuitively.

2 Current issues in junior high school mathematics teaching

(1) Lack of practicality and innovation in teaching content

Teaching content is disconnected from practical application, making it difficult for students to transfer knowledge to real-life situations and future career scenarios. Traditional teaching methods not only weaken

students' interest in learning, but also constrain the development of their practical skills and innovative thinking.

(2) Teaching methods are monotonous and lack diversity and interactivity

The traditional lecture-based teaching model places students in a passive role, depriving them of opportunities for active thinking and exploration. This one-way method of imparting knowledge fails to stimulate students' interest and enthusiasm for learning, often resulting in a dull classroom atmosphere and poor learning outcomes.

(3) Incomplete evaluation system, emphasising grades over ability

The current evaluation system relies too heavily on exam results and lacks effective assessment of students' comprehensive qualities and practical abilities. This single evaluation method cannot fully reflect the learning situation and is likely to induce students to focus on exam-oriented learning, neglecting the cultivation of mathematical thinking and problem-solving abilities.

3 Practical Application of Artificial Intelligence in Junior High School Mathematics Teaching

Currently, various AI-based math teaching tools and platforms (such as smart classroom platforms, online tutoring systems, adaptive learning software, etc.) are widely used in teaching practice. These tools rely on algorithms to provide students with customized

learning content and difficulty levels, and adjust teaching strategies in real time based on learning progress and feedback.

3.1 Intelligently generate learning content to stimulate intrinsic motivation to learn

Interest is a key motivator for learning mathematics. Teachers should fully consider students' interests and use AI technology to dynamically generate learning content tailored to the classroom, allowing students to enhance their motivation to learn and improve the quality and effectiveness of learning in an interesting context.

Case Study: In teaching 'linear equation with one unknown', teachers discovered that students were very interested in the market economy and used AI to introduce relevant case studies to design application questions:

The school bookstore plans to purchase best-selling books, with each book costing 20 yuan to purchase and selling for 30 yuan. The monthly fixed costs (such as rent) amount to 1,000 yuan. Question: If 300 books are sold this month, what will be the profit? If the target profit for this month is 5,000 yuan, how many books need to be sold?

This case study integrates students' interests, effectively stimulating their enthusiasm for learning and encouraging them to make connections. Through analysing the case study, students master mathematical knowledge and its application methods, improving their mathematical modelling and problem-solving abilities. At the same time, the case study involves economic concepts such as 'cost, selling price, sales volume, and profit,' which helps students understand business logic and market rules, cultivates their economic awareness and comprehensive literacy, and provides an opportunity for interdisciplinary knowledge integration. Teachers can tailor learning content based on students' diverse interests using AI to continuously design and adjust materials, guiding efficient exploration.

3.2 Innovative teaching methods promote open inquiry-based learning

Traditional teaching methods focus on imparting knowledge and skills, often neglecting to stimulate interest. AI can use gamified learning, virtual experiments, interactive question-and-answer sessions, and other methods to make abstract mathematical concepts vivid and interesting, allowing students to actively acquire knowledge in a relaxed atmosphere. This fun and educational approach not only improves learning outcomes but also cultivates interest in learning and a spirit of inquiry.

(1) Transform the teaching model: teacher-led, student-centred

To motivate students and clarify the application of knowledge, a new teaching model can be constructed:

First, use artificial intelligence to recreate the knowledge being taught in a real-world context. Then, establish a mathematical model to derive a formula or property. Next, prove or derive the conclusion. Finally, expand the application through numerical simulation or case analysis. This teaching model can be summarised as: create a scenario (AI recreates the real-world context) → establish a mathematical model → derive and

deduce → expand the application (AI-assisted numerical simulation/case analysis).

(2) Enhancing interactivity and collaboration

AI technology can significantly enhance the interactive experience of mathematics learning. Students participate in virtual experiments (such as tossing a virtual coin 100 times and observing the frequency of heads), gamified learning (such as solving quadratic equations through a 'challenge-based quiz'), and real-time Q&A sessions through intelligent teaching systems, thereby stimulating interest and increasing engagement. Additionally, AI facilitates collaborative learning among students (such as online discussions and collaborative problem solving), fostering teamwork and communication skills.

(3) Personalised teaching based on intelligent systems

Before class, teachers can use the app to post relevant questions so that students understand the focus of the next day's learning, thereby improving the effectiveness of their preparation through targeted previewing. In practice, teachers can use the app to send specific questions to students' smart devices. Students use this device to complete their pre-class assignments and submit them via a mobile app. The system automatically evaluates and provides feedback on their pre-class results. Teachers can conduct a comprehensive analysis of these results to identify areas where students need improvement during pre-class preparation, enabling them to adjust the focus of classroom instruction and allocate teaching time appropriately across different sections. This approach facilitates the implementation of personalised teaching strategies. For example, when teaching the section on 'Fractions and Their Applications', teachers can set different questions for students and guide them to complete corresponding exercises. During classroom teaching, teachers can flexibly adopt a variety of teaching methods and techniques based on students' listening and interaction, such as adding group competition sessions to enhance students' participation and interaction.

3.3 Specific Application Scenarios for Technical Support

(1) Intelligent Diagnosis

Artificial intelligence collects and analyses students' answer data and learning behaviour patterns in real time to construct a multidimensional profile of their learning situation, enabling accurate diagnosis of their knowledge mastery and cognitive characteristics. The system not only automatically generates personalised learning path recommendations to help students form a clear self-awareness, but also provides teachers with class-wide learning situation reports and individual difference analyses to assist them in dynamically adjusting their teaching strategies. Specific application scenarios include:

Implementation of differentiated instruction: Teachers can use the learning reports generated by the system to set differentiated tasks (such as basic, advanced, and extension groups) in classroom exercises and push smart exercise sets that match students' abilities after class to achieve precise teaching.

Wrong Question Management System: The system automatically collects wrong questions and labels the types of errors (such as conceptual, computational, or comprehension errors). After completing a unit, it generates a review manual of wrong questions, and teachers can guide students to conduct targeted intensive training.

Dynamic difficulty adjustment: Based on students' real-time performance, the difficulty level of questions is intelligently adjusted to ensure that exercises remain within the 'zone of proximal development'. Adaptive training continuously improves learning efficiency.

(2) Building personalised learning paths

AI-based personalised learning paths are built using intelligent algorithms to create learning trajectories tailored to students' cognitive characteristics and development needs. The system mainly performs the following functions:

Learning diagnosis: Real-time monitoring of key indicators such as students' answering speed and accuracy, and intelligent identification of error types (e.g. calculation errors, conceptual confusion, logical deviations).

Precise intervention: Push customized learning resources (such as micro-lesson videos, specialised exercises, and error analysis) targeting knowledge gaps.

Path optimisation: Recommend the optimal learning sequence based on students' interests and cognitive styles.

(3) Visualisation of abstract concepts

Use AI-driven dynamic geometry tools (such as the GeoGebra AI plugin) to generate function images or geometric transformation animations via voice commands (e.g. demonstrate the effect of moving the vertex of a quadratic function on the image).

(4) Real-time monitoring and early warning of student learning situations

Combining cameras and AI to analyse students' expressions in class (such as confusion or concentration) and remind teachers to adjust the pace of teaching in a timely manner. Based on historical data, predict students' academic risk points (such as weak areas in mid-term exams) and push review materials in advance for intervention.

Conclusion

Artificial intelligence has profound practical significance and broad development prospects in junior

high school mathematics education. Through means such as personalised learning, intelligent tutoring, and data analysis, AI can significantly improve student learning effectiveness and teacher teaching efficiency. However, its application still faces challenges such as insufficient teacher knowledge and skills, room for improvement in the practicality of tools, and varying levels of student acceptance. In the future, with the continuous advancement of technology and deeper exploration of practical applications, artificial intelligence will undoubtedly play a more central role in junior high school mathematics education, providing strong support for the cultivation of high-quality talent.

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PHILOLOGICAL SCIENCES

METAPHOR AS A FIGURATIVE DEVICE AND ITS MAIN TYPES IN ENGLISH

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Abstract

The article investigates some types of metaphors. The article writes that metaphor is a natural element of language and one of the main tools that shape human thinking and communication. It states that this tool makes language more effective, understandable and creative.

Metaphor is reported to be a natural element of language, and it plays an important role in the system of human thinking and communication. The article highlights that modern linguistic studies show that this figure of speech is widely used not only as a literary stylistic device, but also in everyday speech, mass media and scientific writings. It shows its importance in the process of creating meaning in language and in the formation of human thinking.

Metaphor is also meant to be an integral part of creative strategies for creating meaning, especially in world languages such as English. This makes it necessary to study and research it, because its use is of great importance in terms of revealing hidden meanings in the text and correctly understanding the context.

Keywords: device, metaphor, meaning, types, structure, figurative

Metaphor, as a linguistic unit, is an effective linguistic device that creates new meanings by establishing a figurative connection between two different concepts or objects. Metaphor is known to be an important linguistic structure for thought and communication in English. This linguistic device creates new shades of meaning by metaphorically applying the properties of one concept to another concept, which ensures a better understanding of that concept. Metaphor is explained as "the expression of one concept in terms of another concept" and this process is a natural part of language. The main goal is to better explain one object or concept through another. According to the conceptual metaphor theory proposed by J. Lakoff and M. Johnson, metaphor is not only an aesthetic tool of language, but also a part of the human cognitive system. In their opinion, through metaphors, people shape their experiences by creating figurative connections and create complex meaning structures [11, p.46]. For example, the phrase "Life is a journey" embodies the main principle of this theory. Here, the concept of life is explained through the more concrete and structured term "journey", which creates a metaphorical connection to understand the different stages of life and the challenges encountered. According to J. Lakoff and M. Johnson, people tend to understand abstract concepts through such more concrete and recognizable experiences [11, p.53].

Metaphors occupy an important place in the structure of human thought in cognitive linguistics. According to the theory proposed by J. Lakoff and M. Johnson, abstract concepts in the human brain are explained by concrete experiences, and this is at the heart of the cognitive thinking system. According to this theory, metaphor through language reorganizes the thinking system and creates new connections between concepts.

As noted in J. Lakoff and M. Johnson's "Metaphors We Live By," conceptual metaphors are formed on the basis of human experience and help people understand their world. For example, the expression "time is money" describes time as a specific and limited resource, explaining the management of time in an economic sense [11, p.8]. Such metaphors change a person's view of the world and make abstract concepts concrete. Metaphor is considered to be one of the main tools of both poetic and descriptive language in literature. According to literary researchers, metaphor creates conditions for the creation of new meanings through "representing one object in the name of another object," which enriches the aesthetic side of language. For example, W. Shakespeare's famous phrase "All the world is a stage" emphasizes the metaphorical connection by comparing life to a theatrical stage [14]. This metaphor reflects the temporary and theatrical nature of human life, creating a new and deeper layer of meaning in the reader.

The effect of metaphor on perception is one of its most important functions. Through metaphor, people reorganize reality through the point of different concepts and renew their perceptions. Comparing an object or concept with another object or concept provides a new perspective on that object. For example, the phrase "love is war" shows that love relationships are full of conflicts and changes men's understanding of the relationship [].

Researches in psychology and cognitive science show that metaphors play a key role in human understanding of abstract concepts and have a significant impact on perceptual processes [10, p.207]. Thus, the human brain perceives and structures figurative relationships more deeply based on concrete experiences. The

different use of metaphors from culture to culture reveals differences in their perception and worldview. Different cultures form metaphorical structures in different contexts, and this is reflected in their language and thinking. For example, the metaphor “time is money” is widespread in Western culture, but in some other cultures time is perceived more as a cyclical or fluid concept, and therefore metaphors are formed differently [12, p.178].

This is based on the different experiences that cultures have in metaphorical thinking and language systems, and people shape the conceptual structures of that culture through these metaphors.

Metaphors play an important role in the development and expansion of language. They expand the semantic field of language and create new layers of meaning in the description of various concepts. Along with the development of technology, new metaphors are created, and they are widely used in the language of technology in modern times. For example, the metaphor “cloud” was created to describe the concept of storing data over the internet, adding new layers of meaning to the language of technology. Such metaphors not only expand language, but also introduce new concepts to society through language [13, p. 90].

Thus, metaphor in English is not only considered to be an artistic and descriptive language tool, but also a central element of the human thought and perception system [9, p. 45]. Metaphors play an important role in the creation of meaning in language, in the organization of perception, and in the representation of culture. They facilitate perception by explaining abstract concepts in concrete, recognizable, and experience-based terms. Metaphor plays a key role in the development of language and human thinking, and influences the development of language as well as the thought process [8, p.40].

Metaphors play a fundamental role in both speech and thought in English. Through metaphors, people understand and interpret abstract concepts based on more concrete experiences. There are different types of metaphors, and each affects the structure of language and thinking in different ways.

We find it necessary to give some information about the main types of metaphors in English and their characteristics, examples, and detailed explanations based on scientific theories.

Conceptual metaphor is based on the conceptual metaphor theory of J. Lakoff and M. Johnson, and this type of metaphor occupies a central place in the system of human thought and experience. Conceptual metaphor ensures that an abstract concept is understood through a concrete concept. This idea is explained in detail in the work of J. Lakoff and M. Johnson “Metaphors We Live By”.

Conceptual metaphor is the representation of one concept by another concept, which ensures that people understand abstract thoughts with more concrete and familiar concepts. Conceptual metaphors organize human thought structures and thereby shape experiences in a conceptual framework. For example, the metaphor “Time is money” emphasizes the economic value of

time and allows people to understand their activities in life in the context of economic models [11, p.8].

These metaphors play a central role in everyday speech and our thought systems because they shape how we understand and interpret the world. Conceptual metaphors may take different forms in different cultures, but their function remains the same: to shape our thought systems by making abstract concepts more concrete and understandable. Each metaphor provides a way to relate a concrete concept to certain abstract concepts, making complex concepts such as emotions, time, and social relationships more easily understood. These types of metaphors provide people with deeper insights by relating the structure of one concept to the context of another.

Characteristics of conceptual metaphors can be defined as following:

- These metaphors structure human thought and frame experiences in a conceptual framework.
- The connection of abstract concepts, especially experiences such as emotions, time, life, and social relationships, with more concrete experiences.
- Conceptual metaphors are widespread in everyday language and speech, as people use these metaphors intuitively.
- Conceptual metaphors may appear in different forms in different cultures, but their function remains the same.
- Conceptual metaphors help people express their emotional and social experiences in a more concrete way.
- These metaphors structure language and influence how expressions in speech are formed.

Some examples of conceptual metaphors:

“Time is money” (Here, time is described as a resource, and this metaphor allows for the explanation of activities in life through economic models).

“Argument is war” (Debate is described as war, which emphasizes the winning and losing aspects of arguments) [1, s.4].

Structural metaphor is a subtype of conceptual metaphor, where one concept is structured by another. In this type of metaphor, we see that one concept is represented by another concept as a whole structure. Structural metaphor is a concept in which one concept is formed by the properties of another concept; it is a mechanism that people use to transform abstract concepts into a more concrete, understandable form. These metaphors allow abstract concepts (such as life, love, or time) to be explained in more concrete terms, which makes people’s experiences more understandable. Structural metaphors provide a framework that helps people understand their thought processes and daily lives; this allows them to simplify and understand complex concepts [3]. Structural metaphors organize the language structures that are essential for people to understand the world; thus, understanding the structure of language allows people to describe the world they think about more clearly. The widespread use of these metaphors also affects the development of people’s thought systems; because they create the basis for creating new concepts and reformulating old concepts [2].

Some features of structural metaphors:

- A concept is formed as a whole by the features of another concept.
- This usually provides an explanation of complex abstract concepts in simplified concrete terms.
- Structural metaphors make abstract concepts more understandable and comprehensible by relating them to concrete concepts.
- These metaphors provide a framework for guiding people's thought processes, thus helping to achieve better understanding in everyday life.
- Structural metaphors organize the structure of language and thought and help people understand the world.
- Structural metaphors provide new perspectives by allowing old concepts to be reformulated.

Examples of structural metaphors:

“Life is a journey” (The different stages of life are depicted as different parts of a journey, suggesting that experiences in life develop step by step) [11, s.44].

“Ideas are food” (Describing ideas as food), for example, like in the phrase “I can’t digest that idea”.

An ontological metaphor is a type of metaphor in which abstract concepts are represented as objects, tangible entities, or substances. This approach helps people make intangible concepts more accessible and understandable. The main purpose of ontological metaphors is to objectify intangible concepts or to perceive them as entities. For example, the statement “the mind is a machine” presents thought processes as a mechanical structure.

These metaphors help people perceive complex and non-experienced concepts as simpler objects or entities. In the case of the statement “time is money”, it describes it as a tangible entity, giving it a concrete form. With the help of ontological metaphors, intangible concepts become more understandable in practice. In statements such as “love is a journey”, love, time, and other abstract concepts are depicted as journeys or tangible entities. Studies of how ontological metaphors shape language and thought show that these metaphors form the basis of human thinking and affect how we perceive the world.

An ontological metaphor is a type of metaphor that is used to help people perceive and imagine abstract concepts as objects and tangible entities. Through these metaphors, complex and abstract categories of thought are presented in the form of simpler and more concrete objects, which makes them easier to understand. This concept is explained in detail in the book “Metaphors We Live By” by C. Lakoff and M. Johnson.

Some characteristics of ontological metaphors:

The main feature of ontological metaphors is that abstract concepts are described as objects or tangible entities. This allows people to understand concepts in a more concrete and experience-based way. For example, the phrase “the mind is a container” is an example of an ontological metaphor. Here, the mind, while in fact a complex and abstract concept, is imagined as a container, which leads to its reduction to a more understandable form.

People understand more abstract and complex concepts based on the tangible objects they encounter

in their experiences. For example, the phrase “Time is money” is an example of this, where time is described as a tangible object. Here, time is presented as a resource that is spent or used. People can take control of abstract concepts by explaining the world with ontological metaphors. For example, metaphors such as “ideas are objects” allow ideas to be considered in a concrete way. In this way, people more easily assimilate and manage ideas.

Through ontological metaphors, people transform abstract concepts into tangible entities. For example, the expression “consciousness is a machine” associates the idea of the mechanism of consciousness with the image of a machine. This presents consciousness as a more controllable entity. Ontological metaphors are closely related to container metaphors. For example, the expression “The mind is a container” considers the mind as a specific object, showing that thoughts and feelings are stored in it. This metaphor brings people’s feelings and thoughts into a more understandable form [3, p.25].

Abstract feelings and emotions are also presented through ontological metaphors. For example, the expression “Anger is a boiling liquid” depicts a person’s anger as a liquid container, and this is imagined as a process in which the anger gradually fills up and finally bursts [4].

Examples:

“Mind is a container”: Here, the mind is considered as a container, and thoughts, memories, or information are placed inside it. This explains abstract concepts in a more objective and tangible way.

“Inflation is an entity”: Here, inflation is shown as an independent entity. For example, the phrase “inflation is eating up our savings” creates a description of inflation “eating up” savings as a living entity

Ontological metaphors help people understand complex and abstract concepts more easily. By shaping the structure of language and thought, these types of metaphors allow people to gain a greater sense of control over abstract concepts. The impact of ontological metaphors on both language and thought systems is one of the main topics of scientific debate and has an important role in understanding how language works and how it affects thought. As a result, ontological metaphors play an important role in people’s understanding of the world and abstract concepts. They influence the formation of human thinking as a powerful tool of language and are widespread in culture [5].

There is a number of scientific literature that provides information about orientational metaphors. This type of metaphor is characterized by the association of abstract concepts with physical directions (up-down, in-out, front-back, etc.) [6].

The main essence of orientational metaphors:

Oriental metaphors are a type of metaphor that associates abstract concepts with physical spatial directions. These metaphors help people understand different emotions and experiences through certain directions. For example, “up” represents positive emotions, and “down” represents negative emotions. People apply the physical directions they experience

with their bodies to their thinking. For this reason, expressions such as “happiness is up” and “sadness is down” arise. Our bodily experiences guide our thinking and language [7].

Oriental metaphors relate emotions to space. For example, “up” represents positive feelings and states, while “down” represents negative or distressing states. Examples include “I’m feeling up today” or “He’s feeling down.” Control and management are also represented by orientational metaphors. For example, “control is up, and lack of control is down” are used to emphasize a person’s control over a situation. The phrase “He’s on top of the situation” is an example of this [8].

Difference between ontological and directional metaphors:

While ontological metaphors represent abstract concepts as objects, orientational metaphors are more related to physical spatial directions. Both types of metaphors help people understand abstract concepts, but orientational metaphors are specifically related to space. Oriental metaphors not only express emotions and experiences, but can also have different meanings in different cultures. For example, in some cultures, the metaphors of “right-left” also play an important role. Such metaphors can have different meanings in different societies.

Examples:

1. **“Happy is up, sad is down”** (Happiness is described as “up” and sadness as “down.” The phrase “I’m feeling up” means that a person is feeling good, while “I’m feeling down” means that a person is feeling bad).

2. **“Control is up, lack of control is down”** (Control is shown at the top, and lack of control is shown at the bottom. The phrase “He’s on top of things” means that a person is in complete control of a situation) [11, s.15].

3. **“More is up, less is down”** (This metaphor describes a greater quantity as being higher and a lesser quantity as being lower. For example, the phrase “Prices are going up” means that prices are increasing, while “His energy is low” means that his energy is decreasing).

Characteristics:

- Based on space and physical directions: Oriental metaphors are based on people’s bodies and spatial experiences. For example, people feel more energetic and good when they physically go up, which creates the metaphor “happiness is up.”

- Link abstract concepts to direction: These metaphors link abstract concepts (emotions, control, quantity, etc.) to spatial directions. This makes it easier for people to understand complex feelings and situations.

Polarization by direction: Positive concepts are usually associated with the direction “up,” while negative concepts are associated with the direction “down.” This creates a contrast in human thinking, such that those associated with “up” are good and those associated with “down” are bad.

Literary (poetic) metaphor is a language device widely used in works of fiction, poetry, and other

literary genres. It attempts to explain one concept in terms of the characteristics of the other by establishing a direct connection between two different concepts. The main purpose of literary metaphors is to make descriptions more powerful and emotional by going beyond the limits of ordinary language. These types of metaphors are used to create imagery, creative use of language, and deep meanings. Literary metaphors are a type of metaphor used mainly in works of fiction to create more impact and emotional depth. These metaphors aim for creative use of language, figurative expressions, and a more accurate conveyance of feelings. Literary metaphor is an effective type of metaphor used in works of fiction and literary genres such as poetry. These metaphors emphasize the aesthetic side of language and are more creative and figurative than ordinary communication.

The main purpose of literary metaphors is not only to explain a concept, but also to affect the feelings and thoughts of the reader. These types of metaphors attract the reader’s attention and increase the emotional charge of the work. For example, the expression “My heart is on fire” is not enough to simply explain an emotion, but also creates a strong image in the reader’s imagination. Literary metaphors are often symbolic and create ambiguous expressions that the reader can insert their own thoughts into instead of specific meanings. For example, the expression “Dark nights oppress my heart” is both metaphorical and symbolic, because darkness can represent a person’s distress in addition to being a concept directly related to darkness.

Literary metaphors create new and unique images that deviate from the ordinary use of language. Through these images, authors can evoke special scenes and feelings in the imagination of readers. For example, the phrase “Love is a lighthouse that finds its way by the stars” used in Shakespeare’s works is a figurative and unique metaphor. One of the important characteristics of literary metaphors is to create aesthetic appeal. In creative writing, metaphors are more complex and colorful than ordinary speech. Poets and writers create rhythm, harmony, and beauty in language through metaphors.

Examples:

1. “The world is a stage” [12, s. 15].

W. Shakespeare’s phrase “All the world’s a stage” is one of the most famous examples of this type. Here, life is likened to a theater stage and every person is shown as a performer.

2. “Hope is the thing with feathers” (Hope is depicted as a bird, flying with its wings to bring hope to people. This metaphor symbolizes that hope is fragile but strong).

3. “Shall I compare thee to a summer’s day?” (This metaphor, which compares a lover to a summer day, contains the idea of both beauty and transience).

Features of this metaphor:

- Imagery and creative thinking: Literary metaphors do not always give concrete and clear meanings. They create multi-layered meanings by using figurative expressions and affect the reader’s thinking. These metaphors encourage the reader to think and use their imagination.

– Subjectivity and expression of personal experiences: Literary metaphors are usually used to express the personal experiences and feelings of the author or characters. For this reason, they are also very subjective. For example, a poet may express his sadness and loneliness through images of nature such as the sea or the wind.

– Extensive use of language and literary techniques: Literary metaphors, combined with language techniques, strengthen the structure of the writing. In works of fiction, such metaphors affect the overall flow of the work rhythmically and aesthetically. This feature is more pronounced in genres such as poetry.

– Complex and ambiguous approaches: Literary metaphors are often complex and multilayered. They allow for poetic expression of feelings and situations that are difficult to explain in simple language, which adds ambiguity to literary works.

CONCLUSION

Metaphors are an integral part of human thinking and language comprehension. Metaphors allow us to explain abstract concepts through concrete images and influence a person's perception of the world.

Metonymy increases the efficiency of communication and serves to express ideas more concisely and accurately. Through metonymy, one concept is replaced by another based on proximity or connection, thereby ensuring density of meaning.

Metaphors not only enrich the artistic style of language, but also act as one of the main structural elements of thought and the system of meaning. According to the theory of conceptual metaphor, metaphors play an important role in human understanding of the world and help to figuratively establish connections between experiences.

Different types of metaphors - conceptual, structural, ontological and directional metaphors - perform specific functions in different styles of language and systems of meaning.

Conceptual metaphors help people better understand abstract concepts.

Structural metaphors increase the perceptual power of language by explaining one concept in terms of the properties of another concept.

Ontological metaphors make intangible concepts more understandable by likening them to concrete objects.

Directional metaphors, on the other hand, draw on human bodily experiences to connect emotional and physical states with spatial directions.

Metaphors act as one of the main organizers in the structure of the text. Metaphors shape the structure of

the text, determining its conceptual framework and meaning system. Metaphors enhance the emotional and stylistic characteristics of the text, making it more effective and memorable. They are also widely used in scientific, academic and journalistic texts. In particular, the role of metaphors is indispensable in explaining new concepts and presenting concepts in a more understandable form.

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Pavlodar c., Kazakhstan***КІРМЕ КОНЦЕПТ ЖӘНЕ КІРМЕ СӨЗ ҚЫЗМЕТІ МЕН СИПАТЫ****Шақаман Ы.Б.***Филология ғылымының кандидаты, профессор
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<https://doi.org/10.5281/zenodo.15879898>***Abstract**

The purpose of the study of the topic of the article is to show the difference between the input concept and the input word; to analyze the types of concepts. The article explains that the concept is recognized as a human concept, a national concept depending on the worldview, and the National concept is an input concept for another nation. At the same time, it is reported that the concept has an original and input type, which has not yet been taken into account in the study. A definition of these two concepts is made and their essence is analyzed. The fact that the input concept and the input word are not the same is considered, and the distinguishing features are indicated. As a result of the study, several results were obtained: a scientific definition of the concept was given; disclosure of the nature of the original and input concept; transmission of the difference between the input concept and the input word; easy translation of the input word; the input concept increases the richness of the language; the input concept expands the knowledge, culture of the nation, contributes to spiritual development; the input concept has a positive and negative impact on the language of the nation.

Аңдатпа

Мақала тақырыбының зерттелу мақсаты кірме концепт және кірме сөз туралы айырмашылықты таныту; концепт түрлерін талдау болып табылады. Мақалада Концептінің дүниетанымға қарай адамзаттық концепт, ұлттық концепт болып танылатындығы түсіндіріліп, ұлттық концептінің басқа бір ұлт үшін кірме концепт болатындығы баяндалады. Сонымен бірге концептінің төл және кірме түрі болатыны, олардың әлі де зерттеуде нақты назарға алынбағандығы туралы мәлімет беріледі. Осы екі концептіге анықтама жасалып, олардың мәні талданады. Кірме концепті мен кірме сөздің бір емес екені қаралып, айырмашылық белгілері көрсетіледі. Зерттеу қорытындысында бірнеше нәтижеге қол жеткізілді: концептіге ғылыми анықтаманың берілуі; төл және кірме концепт сипатының ашылуы; кірме концепті мен кірме сөз айырмашылығының берілуі; кірме сөзді аударуға оңай болатыны; кірме концепт тіл байлығын арттыратыны; кірме концепт ұлт танымын, мәдениетін кеңейтіп, рухани дамуға ықпал ететіні; кірме концептінің ұлт тіліне жағымды-жағымсыз әсері болатыны.

Keywords: ethno concept, intro concept, translation, lacuna, inbound word**Түйін сөздер:** төл концепт, кірме концепт, кірме сөз, аударма, лакуна**Kіріспе**

Кез келген тілдің жалаң өзімен өзі болып, дербес дамуы осы заманғы кеңістікте мүмкін емес. Қазіргі өмірлік дамуда жер бетіндегі бар халықтың бір бірімен мәдени, әлеуметтік, экономикалық, ғылыми техникалық, т.б. жақтан араласуы әр ұлттың әлемдік танымын түсінуге, білуге, игеруге, тануға итермелейді. Түрлі қарым-қатынас ықпалынан әр елдің, ұлттың, халықтың танымы, өмірлік ұғымы тіл ғылымында Концепт деген тілдік бірлікпен түсіндіріледі. Жалпы концепт – өмірлік мазмұнның, кіші ұғым-түсініктердің бір тілдік таңбаға жинақталып, шоғырланатын бастапқы **Өзек ұғым**. Дүниені тану арқылы санада өмір, әлем мазмұнының **кіші ұғым** бөліктері, бірліктері тілдік таңбаға жинақталып, шоғырланады да, Өзек ұғымға айналып, **Атау-сөз** пайда болады. Қарапайым тілмен түсіндіргенде, Концепт дегеніміз –

күнделікті тіршілікпен, дағдымен әлемді бағдарлап, бақылап танумен өмір мазмұнының, дүниенің барлық қыр-сипатының, жаратылысының, қозғалысының, т.б. белгілерінің санада, ойда түбегелі ұғымдық, мағыналық жағынан мазмұнды түрде таңбалануы. Содан кейін адам кері әрекетпен санасында таңбаланған дүниесін, ой-мазмұнын (концептіні) сыртқа сөзбен, сөйлеумен шығарып, атау береді. Атау – концептінің санада *«шленіп, иі қанып»*, қарым-қатынаста жарыққа шығатын Сөз. Осыдан кейін Сөз байланыс құралы қызметін атқара бастайды.

Дереккөздер мен әдістер

Мақалалық зерттеуде қазақ тілі ғалымдары мен орыс тіл білімі ғалымдарының тілдік таным, танымдық тіл білімі, мағына, стереотип, концепт, тілдік мәдени тану туралы жазған еңбектері әдіснамалық тұжырым ретінде негізге алынды.

Тақырып бойынша мәселені қарастыруда сипаттау, талдау, мағыналық талдау, салыстыру, жинақтау әдістері қолданылды. Мақала тақырыбының зерттелу мақсаты кірме концепт және кірме сөз туралы айырмашылықты таныту; концепт түрлерін талдау болып табылады.

Қазақ тіл ғылымында Концепт мәселесі ғылыми негіздеу тұрғысынан кейінгі 20 жыл ішінде қарастырылып келе жатыр. Оған дейінгі кезеңде жалпы ұғым (концепт), мағына, туралы тілдік құрылым, ұлттық тілтану (А.Байтұрсынұлы, Қ.Жұбанов, С.Аманжолов, т.б.); тілдік ұғым-бірліктер қызметтік ерекшелігін таныту (Н.Сауранбаев, Ғ.Мұсабаев, М.Балақаев, т.б.); ұлттық тіл білімін ғылыми жақтан дамыту (К.Аханов, Т.Қордабаев, Ы.Маманов, Н.Оралбай, Р.Сыздық, Ә.Болғанбаев, С.Исаев, т.б.) бағытында зерттеулер жүргізілді [9, 60-6.].

XX ғасырдың соңынан бастап қазақ тілінде концепт, тілдік таным, стереотип мәселелері, тілдің генетикалық сипаты (Ш. Бекмағанбетов, Э. Оразалиева, Г. Исиа, Ш. Жалмаханов, Б. Тілеубердиев) жеке тақырыпқа алынып, нақты зерттеу нысанына түсті.

Орыс тіл білімінде Концепт туралы бастапқы түсінік Н. Арутюнова, Е. Кубрякова, С. Аскольдов-Алексеев, Ю. Степанов, Е. Верещагин, А. Вежбицкая, т.б. еңбектерінен басталады. С.Аскольдов-Алексеев, Ю.Степанов, т.б. ғалымдар Концептіні «ойлау жүйесі арқылы жинақталған білім» – деп тұжырымдайды [3]

Талқылау және нәтижелер

Концепт – кешенді ойлау әрекетімен, пайымдау нәтижесінде пайда болатын танымдық бірлік. Елес, болжалды бейне, фрейм, ұғым, гештальт концептіде түйінделіп, өзек құрап, адамның ойлау-үдерісінде де, түрлі адами қарым-қатынаста, сөйлеуде, жазбада танылып жатады. Концепт кең, мағыналы, мазмұнда болса, соған қатысты аталым да көп, ұлтта сөз қоры да мол болады.

Концептінің дүниетанымға қарай жалпы адамзаттық концепт, ұлттық концепт деген түрі танылады. Ұлттық концепт басқа бір ұлт тіліне кірме концепт болып қабылданады. Ұлттың өзіне ғана тән танымы, дүниетаным туралы түсінігі, ұғымы (концептісі) төл концепт болып табылады. Бірақ Концептінің осы екі түрі (*төл және кірме*) әлі күнге дейін зерттеулерде назарға алынып жатқан жоқ.

Төл концепт – ұлт, халық тілінде, санасында, танымында, тіршілігінде, ұлттық мәдениетінде жер бетінде қалыптасқаннан бастап, танылып бекіген ұғымдар жиынтығы. Кірме концепт басқа ұлттың танымымен қалыптасып, қабылданған ұғымдар жиынтығынан тұрады.

Кірме концепт кірме сөзбен бір емес, ол – мүлде басқа қолданыс. Концептінің кірме болуы ұлт тілінің мәдени танымына, түсінігіне байланысты. Бір ұлтта бар концепт екінші бір ұлтта болмауы мүмкін, концептінің болу-болмауы ұлттың, адамның өмір сүру ландшафтысына, ортасына, жеке адами, ұлттық дүниетанымдық

кеңістігіне қатысты болып, сондағы әлемді игеру, тану құзіреттілігіне негізделеді. Кірме концептілі сөздер ел, ұлт арасындағы қарым-қатынасты кеңейтіп, ғылымда, т.б. салада ортақ танымдық түсінікті жеңілдетеді. Сонымен қатар кірме концептімен туындаған сөздер, жаңа тілдік құрылым қарым-қатынаста ой дәлдігін, бейнелілігін, ой ұтқырлығын, тілдік нақтылықты жеткізуге септігін тигізеді.

Бір ұлт тіліне басқа ұлттан енген кірме концепт жағымды, жағымсыз қырларымен екі жақты қызмет етеді. *Кірме концептінің жағымды сипаты* оны қабылдаған ұлт тілінің сөзжасамдық әлеуетін, сөз жүйесін, арттырады, сөздің қорды байытуға ықпал етеді. Сөздік қор тұрғысынан Кірме концептілер мен кірме сөздер басқа ұлт тілінің «бос орнын» толтырып, жаңа таным, ұғым әкеледі, лакуна сөздер пайда болып, сол арқылы төл тілде атауы жоқ, бірақ ұғымы бар зат-құбылыс, әрекет-үдерістерге сыртқы дыбыстық жамылғы береді. Немесе атауы да жоқ, ұғымы да жоқ, бірақ басқа ұлтта бар тың ұғым-түсініктерді, мәдени танымды тудырады. Осындай ерекшелікке байланысты және Концептінің танылуына, түсінілуіне қарай кірме сөздердің өзін, ұлт тілінде ұғымы жоқ болса, *кірме концептілі сөздер*, ал ұғымы бар болып, дыбыстық тұлғасы жоқ болып, шет тілден сөздер алынса, оларды *кірме сөздер* деп атаймыз. Мысалы, қазақ тілі үшін **кірме концепт** болып табылатын сөздерге: *компьютер, сканер, цитрус, менеджмент, бизнес, пицца, донер, коктейль, автомобиль, меню, радио, лифт*, т.б. жатады. Бұларды кірме концептілі сөздер дейміз, өйткені бұларға қазақ тілінде сай келетін нақты атау жоқ. Рас, оларды ішкі ұғымдық мәнін, мағынасын түсініп, түрлі сөзбен талдап жеткізуге болады немесе қолданыста жиі айтылып, әбден қабылданғаннан кейін оларға қазақша «жасанды» атау беріліп жатқаны да бар. Мысалы: *меню – мәзір*. Қазақ тілі үшін кірме сөздерге *йогурт, сыр, самолет, вертолет, трап, фонарь, плинтус, т.б.* саналады.

Кірме концептінің кері әсері де бар. Ол ұлт тілінің табиғи құрылымын өзгертіп, сөздік құрамның, сөз жүйесінің, ұлттық тілдік танымның, грамматикалық құрылысының бұзылуына әкеледі. Өйткені тілдік кірмелілік, кірме концептінің енуі – бөтен тілдік танымды игеру, бөтен дүниетаныммен өз әлемінің негізін «өзгерту» үдерісі.

Сондай-ақ тұлғалық кірме сөздер де, кірме концептілі сөздер де лексикаға, сөйлем мазмұнына ғана емес, фонетикаға, мағынаға, тұтас грамматикаға да әсер етеді. Сондықтан Кірме концептілі сөздерді, кірме сөздерді орынсыз қабылдау ұлт тілінің мазмұнын, жүйесін бұзып, түп тамырымен төл тілде қалыптасқан лексиканы «шайқау, ығыстыру», жасанды түрде «кедейлендіру», жоққа шығару болып табылады.

Кірме сөздерге келсек, олар да кірме концептілік сипатпен енеді. Кірме сөз болып танылу – ұлт тілінде сол кірме сөзге қатысты өзек ұғымның болуы, бірақ ұғымға қатысты атау-сөздің болмауы. Концепт болса да, оған қатысты атаудың

берілмеуі – ұлттың, халықтың, елдің мәдени танымының еніп отырған кірме сөзге байланысты тәжірибелік дағдысының, түсінігін, әрекетінің болмауы. Нақтылап айтсақ, қажеттілік болмағандықтан, әрекет те жоқ, таным да жоқ. **Қажеттілік теориясы** танымды, әрекетті, жоқтан бар жасауды тудырады. *Қажеттіліктің болмауы* сол ұлттағы өмірлік дамуының кенжелеп тұрғанын, концептілік дамудың төмендігін білдіреді. Сөйтіп ұлттың сөздік қоры да кедей болады.

Қазақ тілінің өзінің өмір сүру дағдысы мен тіршілігіне қарай, белгілі бір мәдени бағытында дамуына қарай Концептілік жүйесі толымды әрі бай. Қазақ халқының концептілік жүйесі өзінің стереотипі мен жарытылыс-болмысынан туындайды. Осыған орай қазақ тілінде әлеуметтік, салт-дәстүр, ұлттық мәдениет мәндегі («Атамекен», «Туыс» «Батыр», «Отан», «Достық» концептісі, т.б.) концептілер басым келеді.

Кірме концептіні түсіну сол концепт қалыптасқан ұлт ерекшелігін, дәстүрін, танымын түсіну, білу дегенді білдіреді. Мәселен, ұлт мәдениетінде, дәстүрінде, жалпы танымында адамзаттық ортақ концептіні түсінудің өзі түрліше қабылданады. Адамзаттық ортақ концептінің әр түрлі қабылдануын ғалымдар ішкі құрылымға бөліп түсіндіреді. Ғалым Ю.Степанов концептінің қабылдануын үш түрлі деңгейге бөліп ашады: ұғымның негізгі өзек мәні; қосымша бәсең мәні, ішкі, бірақ сөздік дыбысталуын айтқан кезде ғана танылатын мәні [11]. Осылайша кірме концепт әр тілде аталған үш деңгейдің қай қырынан түсінілуіне қарай қабылданады. Мысалы: қазақ тіліндегі «Қымыз» сөзі – басқа ұлтқа кірме концепт және кірме сөз. *Қымыз* кірме концептілі сөз болғандықтан, басқа ұлт өкілдері бұл сөздің «сүт» дегендегі мәнін бірінші деңгей (өзек мән) ретінде алып қарайды. Ал қазақ үшін бұл сөздің сөздің *өзек мәні* – *ашытылған уыз* екені, «сүт» деген мәні қосымша мән саналады.

Кірме концепт танымдық мазмұнды ашқанмен, оны бір сөзбен жеткізу мүмкін емес. Бір концептінің өзі әр ұлтта бірнеше қырымен танылып, түрлі сөзбен аталады. Сондықтан кірме концептіні де, кірме сөздің ұғымын, мағынасын түсінуде ұлт өзінің алғашқы түсінігіне, өзінің танымына қарай өзіне ыңғайлы жағын танып, қабылдайды да, басқа белгілерін қосымша дерек етіп, сол концептіні, кірме сөзді игеріп, қолдана бастайды. Ал ол концептінің немесе кірме сөздің жалпы шығутегін қарастыру, ол сөз нақты қолданысқа түсіп, толық қабылданғаннан кейін мүмкін болады. Сол кезде концептінің үш деңгейі де толық көрінеді.

Кірме сөздер ұлттың ұғымына таныс болғанмен, қолданыстық атауы (лексемасы) болмағандықтан, кірме, жат сөз болып танылады. Дегенмен кірме сөздерге балама сөз, аударма сөз тез табылады. Мазмұны басқа ұлттық тілдік таныммен қалыптасқан сөздер қазақ тілінің танымына жақын келсе де, айтылатын сөз, атау жоқ болса, біз үшін кірме сөз болдаы, бірақ кірме

концепт болып саналмайды. Сондықтан ғалымдар З. Попова мен И. Стернин кірме сөздің дыбыстық аталымы нақты концептіні білдірмейді немесе концептісі кірме ретінде танылмауы да мүмкін деп түсіндіреді [10].

Қазақ тіліндегі сөздердің концептісі (өзек ұғымы) басқа тілдегі адам үшін оның қазақ халқымен араласу-араласпауына қарай оңай не қиын танылуы мүмкін, соған орай аудармасы да сол концепт бөліктерін қай қырынан тануына қарай жасалады. Мәселен, «Кеспе» концептісі орыс халқы үшін сұйықтық жағымен ғана танылып, «суп» деп қана аударылуы мүмкін, бұл сөз орыс тілділерге кірме сөз болады, ал концептісі таныс (тамақ атауы).

Сондай-ақ басқа ұлт өкілдеріне қазақ тілінің «Ет» концептісіне енетін *шұжық*, *қазы*, *қарта* әрі кірме концепт, әрі кірме сөз болады. Себебі бұл сөздер ұғымы жағынан да, дыбыстық тұлғасы жағынан да басқа халық үшін толық аудару мүмкін емес, тек белгілі бір түсінік алғаннан соң, кіші бөлік ұғымдарын аударып, бірнеше сөзбен келтірілуі мүмкін. Мұндай концептісі де, сөзі де аударылмаған жағдайда, басқа ұлт өкілдеріне ол сөздер лакуна болып енеді.

Қорытынды

Сонымен кірме концепт және кірме сөз түсініктерінің сипаты олардың ұлт тіліндегі қолданысқа, қажеттілікке, мәдени танымына байланысты көрініс береді. Нақты концептінің, аталымның болмауы халықтың өміріндегі оған қатысты қажеттіліктің туындамауымен және өмірлік әрекетінде әлеуметтік мәдени қатынастың талабына сай келмеуімен, жаратылысымен байланысты болады. Тілге кірме концепті мен кірме сөздің жиі енуі халықтың бір-бірімен экономикалық, саяси, әлеуметтік, ғылыми техникалық, мәдени жағынан үнемі араласып өмір сүруіне байланысы болады.

Мақала қорытындысында бірнеше зерттеулік нәтиже анықталды:

- Концепт түсінігіне анықтаманың нақтыланып берілуі;
- Концептінің төл және кірме концепт деген түрі болатыны;
- Төл концепт – ұлттың әлемді тануда әуелден бекіп қалыптасқан ұлттық ұғымдар жиынтығы;
- Кірме концепт басқа ұлт, халықтың танымымен қалыптасып қабылданған кірме ұғымдар жиынтығы екені;
- Кірме концепт пен кірме сөздің екі түрлі түсінік екені;
- Кірме концептіге қарағанда, кірме сөздің аударылуы оңай болатыны;
- Кірме концепт тілдік қорды арттыратыны, соның негізінде сөздік қор молаятыны;
- Кірме концепт ұлттың дүниетанымын, мәдениетін кеңейтетіні, рухани, әлеуметтік дамуға әсер ететіні;
- Кірме концептінің жағымды-жағымсыз әсері бары;

• *Кірме сөз ұлт тілі сөзімен қатар қолданылуы мүмкін екені.*

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PHILOSOPHICAL SCIENCES

THE MOTIF OF THE POST-APOCALYPTIC CITY IN THE ARTISTIC PRACTICES OF THE DIGITALIZED SOCIETY: ANTHROPOLOGICAL AND AESTHETIC ASPECTS

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Abstract

Eschatological way of perceiving reality remains an important factor in the existence of modern man in a post-industrial society. In recent decades, the idea of the end of the world has been widely exploited in the non-religious sphere, especially in fiction and popular films. The article deals with the study the Biblical motive of the post-apocalyptic city in the artistic practices of post-industrial society; particularly in popular films; identification of the essential features of the urban space of the post-apocalyptic future.

Keywords: post-apocalyptic city, eschatology, man-made disaster, mass popular cinema, digitalized society.

Introduction. The eschatological way of perceiving reality, having been formed at the level of the mythological worldview and having passed through the dogma of developed religious systems, remains an important factor in the existence of modern man in the digital society. Over the past decades, the idea of the end of the world has been widely exploited in the non-religious sphere, primarily in fantastic literature and popular cinema. The eschatological problem of determining the prospects for humanity's existence remains a source of inspiration for writers, publicists, or filmmakers, as it deals with complex and painful issues for people of every era: concerning the meaning and purpose of life, man's awareness of their own mortality and desire for immortality. At the same time, the determinants of the possible end of the world in the minds of people in a digitalized society are realized in a wide range of apocalyptic scenarios: from a man-made disaster, nuclear military conflict, attack by alien civilizations to the extinction of humanity as a result of genetic experiments and pandemics.

In the context of the accelerated digitalization of many dimensions of human existence, the modern media often over-exploit information about disasters, reinforcing a fatalistic perception of reality and provoking permanent tension and anxiety. Apocalyptic motifs in human experience are directly related to the sense of the ontological value of one's own life. But, unlike previous eras, modern man, instead of experiencing the fullness of his own being in the real world of nature and close social communication, increasingly falls into a state of waiting for the future within the virtual digital space, and this future is often perceived in extremely pessimistic terms.

Eschatological scenarios caused formation of a whole cluster of information and entertainment products in the symbolic production of modern digital

society. Significant interest of many contemporaries in it requires a study of the reasons for demand for such products and inexhaustible interest in it over the last century (as the first disaster film is the science fiction film *Verdens Undergang (The End of the World)* directed by *August Bloom* was released in 1916). Researchers from the European Association of Personality Psychology see the roots of such an interest in one's own religious beliefs, their daily negative experiences and global political shifts. These factors together aggravate the eschatological expectations of man [1].

Reflections on the idea that man-made catastrophes may result in the destruction of mankind were found in the studies of philosophers, theologians, and cultural figures, such as Martin Heidegger, Karl Barth, Rudolf Bultmann, Albert Schweizer, Karl Jaspers, Oswald Spengler, Ernst Mayer, Arnold Toynbee and others. Albert Schweizer states the deep crisis in which modern civilization finds itself, and sees no way out of it, except for human rethinking the principles of their lives in accordance with the idea of 'reverence for life' and the corresponding reformatting of the existence of mankind under the slogan: 'I am life which wills to live, and I exist in the midst of life which wills to live' [2]. Heidegger's ideas are of interest to us primarily in the interpretation of individual eschatological experiences of humanity, escape from the fear of death by immersion in everyday life, the present, without thinking about the future [3, pp.95-115]. After all, otherwise humanity must come to terms with the fact that their being is a being-to-death.

Consequently, in the XXI century, reflections on eschatological issues are widespread, and the very eschatological character of the modern world is getting to be perceived as a permanent state of things, which, however, does not yet show signs of catastrophic global

scale. Such a feature, in our opinion, dissolves the boundaries of understanding eschatology until it acquires the features of a universal concept to denote any radical changes that transform the image of the world known to us in a short time just beyond recognition. At the same time, apocalyptic ideas cultivation in popular films is one of the important means of secularizing eschatology, as many of these scenarios are based on scientific man-made or anthropogenic component as a factor of global eschatological catastrophe. Today we can observe that it is not only religion but also pop culture in particular popular films that participate in eschatological ideas development.

The aim of the article is to study the motif of the post-apocalyptic city in the artistic practices of the digitalized society on the example of popular cinema; to identify the essential features of the city as an urbanized space of the post-apocalyptic future and the society that has been formed in it.

Main Text. Modern popular culture, including literature, journalism, cinema, is closely related to apocalyptic narrative that is varied from potentially possible to frankly fantastic [4]. The apocalyptic films nowadays are characterized by a paradoxical trend, namely, separation from religion, on the one hand, and on the other – the significant influence of the biblical book of Revelation [5], which, however, is consistent with the general trend of eschatology desacralization.

The motives for the desacralization of the eschatological perception of reality as well as the apocalyptic expectations of modern humankind are largely related to the urban space in which at least 70% of modern people live. In the mind of people of the post-industrial era, different aspects of urban environment reflection are combined. They intertwine both mythological images of ancient cities, biblical cities, city-states of antiquity and the middle Ages, and post-apocalyptic cities of popular modern cinema blockbusters. Thus, the motif of the city reflects the realities of different ontological strata of the urban environment, which fully reflect the ideal and material, conscious and unconscious, rational and irrational.

In world culture, the motif of the city contains a dichotomy of rational and irrational perception of reality. Cities are the embodiment of a standardized, geometrically correct space, with clear boundaries. Cities eventually became invariant, archetypal images of the embodiment of order in the world as opposed to another, uncultured area, where natural elements and chaos prevail. However, cities could not completely get rid of the influence of the irrational elemental natural environment. First, the disruption of the order (space) of the urban environment was possible in the process of violating the city's borders, primarily during armed invasions and conquests. This violation was seen in many cultures as the end of the world, as a violation of the divine order and a return to the reign of chaos over the cosmos. In the Middle Ages, this violation became a temporally normalized period, a period of temporary carnivals, during which a person could legitimately depart from social canons, rules, and norms and reveal his or her own unconscious and spontaneous intentions.

There are also other ancient sources in the mythological tradition, which have pessimistic eschatological connotations about the urban space of human existence. We should turn to the Judeo-Christian narrative, which originates in the biblical texts about Cain as the founder of cities on earth. 'And Cain knew his wife; and she conceived, and bare Enoch: and he builded a city, after the name of his son, Enoch' (Gen.4.17) [6]. In this very sense, cities are the creation of the first man on earth who committed the crime of murder and was cursed by God. Consequently, the urban environment emerges as a potential territory for sin and evil. Even the very fact of Cain's creating the city in the biblical tradition is a forced action, because for the murder of his brother, whose blood was shed on the earth, Cain was 'cursed from the earth', and 'it shall not hence force yield unto' him 'her strength' (Gen.4.11-12)[6]. For a tiller of the ground Cain this meant the loss of the very foundations of his existence, an ontological crisis associated with a rethinking of the way of life. Moreover, the creation of urban, detached from the ground environment was the only way out. The creation of the city in the biblical tradition can be regarded as the beginning of a new mode of existence of human society: the departure from the earth, as well as the exit from the Garden of Eden, is due to another fall. So the city from the very beginning is immanently affected by sin, and therefore its final decline is an inevitable prospect.

Eschatological ideas in the context of human existence in the urban environment relate not only to the mythology of Cain, but also to the motif of the Tower of Babel: fratricidal creator and the embodiment of man's attempt to rebel against God are the first biblical symbols of urban space. Besides, in the world cultural tradition the biblical cities of Sodom and Gomorrah have become the embodiment of the habitat of people prone to extreme depravity and debauchery.

The potential sinfulness of any city on earth in the cultural tradition, especially of the Abrahamic religions, correlates with the motif of *the harlot of Babylon*, the source of which is the Revelation of John the Theologian. According to John, an angel approached him and offered to see the judgment 'of the great whore that sitteth upon many waters; With whom the kings of the earth have committed fornication, and the inhabitants of the earth have been made drunk with the wine of her fornication... And the woman was arrayed in purple and scarlet colour, and decked with gold and precious stones and pearls, having a golden cup in her hand full of abominations and filthiness of her fornication; And upon her forehead was a name written, mystery, Babylon the great, the mother of harlots and abominations of the earth' (Revel.17.1-5) [6]. The city of Babylon, according to biblical tradition, was to be destroyed by the prophecies of Isaiah, Jeremiah, and Daniel because of its inhabitants' disregard for faith in the Lord Yahweh, the oppression of Israel, and the denial of God's covenant. The cup of God's patience was overflowing because the city of Babylon got 'the hammer of the whole earth cut asunder and broken! How is Babylon become a desolation among the nations! I have laid a snare for

thee... because thou hast striven against the Lord' (Jerem.50.23-24) [6]. The last straw that caused the destruction of Babylon was that Belshazzar, intoxicated, ordered the use of sacred things from the Jerusalem Temple in orgies (Dan.5.1-4) [6]. It is for this reason that the motif of the whore of Babylon, which rebelled against God and against his covenant, became the personification of sinfulness on earth.

History knows many examples when catastrophic events within the urban space actualized the apocalyptic moods of the population and even the eschatological expectations of humankind. It is difficult to underestimate the role of the media and cinema in these processes. Thus, the events of 9/11 in 2001 are regarded as making '*the Pessimistic Turn of Post-9/11 Apocalyptic Cinema*' [7]. In fact, the events of 9/11 affected all popular culture, starting with newspaper headlines: 'Is this the end of the world?', 'Doomsday America' and simply 'Apocalypse' [7, p. 53]. After the terrorist attack, the number of eschatology-oriented TV shows and movies increased so much that it gave reasons to claim that '*films and television shows seem locked into a perpetual and ever-more-frenzied Dance of Death*' [8, p. 23].

However, despite the eschatological perception of urban space formed in the Christian cultural tradition, in some samples of modern popular cinema the motif of a post-apocalyptic city as the last refuge in which salvation is possible even when such a possibility remains nowhere else is cultivated. The unconditional relationship between saving one's own life and the functioning of the post-apocalyptic community of people in the latter city derives from self-preservation instinct, while survival of a single individual in such conditions is considered impossible. The post-apocalyptic world loses the benefits of civilization, which significantly reduces the chances of survival of an individual. Comprehension of the city as a center of civilization and hence a chance for salvation, correlates with the concept of post-apocalyptic resurrection of humanity in the Christian tradition. This concept is substantiated in the prophecy of John the Theologian, where there are indications of the revival of the New Jerusalem: '*And I John saw the holy city, New Jerusalem, coming down from God out of heaven, prepared as a bride adorned for her husband. And I heard a great voice out of heaven saying, Behold, the tabernacle of God is with men, and he will dwell with them, and they shall be his people, and God himself shall be with them, and be their God*' (Revel. 21.2-3) [6]. '*And the gates of it shall not be shut at all by day: for there shall be no night there*' (Revel. 21.25) [6]. The key indication of the construction of brand new world for humankind after the end of the world is the idea of city limits destruction and the absence of darkness itself.

In the film '*Dark City*' (Proyas, Alex, USA-Australia, 1998), the very color symbolism of the dark city points to deep biblical motifs. Darkness, opaque in various mythological and religious traditions has always correlated with the forces of evil, chaos and destruction. In the text of the Bible, darkness is mentioned about two hundred times. According to the

Bible, darkness is the state of the world before light appeared; it is the state of the world as an abyss, the deep ('*darkness was upon the face of the deep*') (Gen.1.2.) [6]. In this meaning, the transition from darkness to light is the embodiment of victory over the forces of evil and chaos, the victory of the being over non-being. When light overcomes darkness, humanity gets a chance to life and resurrection, because the world and the light have already been created.

Darkness is the realm of sleep as an anabiosis in which people are before their birth and existence in the real world. We can trace the eschatological theme of darkness as '*anthropological space*', darkness as '*the realm of the underworld*', which is stated, in particular, in Psalms 88 and 139. Thus, in *Dark City*, the darkness of night (the period when people fall asleep after 12 o'clock strikes) is the darkness that is nothingness, non-being, and the darkness, which is oblivion, when people lose memory, self-awareness and self-identification. And this very comprehension of darkness correlates with the theme of darkness in Psalm 88, as the one praying it, being in darkness, considers himself dead [9, p. 566].

The walls of a fortified city, which primarily meant to protect the inhabitants from enemies' attacks, can be at the same time its weakest points. The four city walls, oriented according to cardinal directions, not only protect the cosmological order of the city as a place of communion with God and preserve the wealth and well-being of its inhabitants. City walls due to 'open gates' can also become the embodiment of 'maximum openness, weakness... as the walls which turn into solid gates' [10, p.128]. In such a comprehension, the walls become illusory and they let cities open to the influence of the sinfulness of the *broad* world. In this context, borders, walls and ramparts are the defining symbols of the city as a secure space. The walls save the representatives of the tribe, ethnic group, people, and others from the potential dangers of the disordered, non-urbanized space. In this regard, the motif of a woman defender of the city walls (for example, the image of Oranta in the Byzantine and Kyivan Rus' traditions) is repeatedly observed in world culture. In the city of the Eloi ('*The Time Machine*' (Wells, Simon, USA, 2002)) there are no walls. Vertical structure of the city protects its inhabitants: the Eloi live on the sides of cliffs, trying to return to their homes before dark. However, it does not save them. At the same time, the safety of the underground city of the Morlocks is guaranteed by its very location – underground, as well as physical strength of the population and the technologies they use. As a result, they do not consider Alexander Hartdegen a serious threat to their way of life. Similar motives for the presence of walls as the basis of urban security are inherent in the film '*Dark City*' (Proyas, Alex, USA-Australia, 1998). The city itself remains organized in its own way until the moment of the walls destruction by the main character of the film Murdoch.

The *Dark City*, however, leaves room for the biblical motif of the search for knowledge, truth. An analogue of the fruit of the tree of knowledge of good and evil in the film is the hermeneutic circle as a symbol

of the city from which there is no way out, city in which there is no end, and no one knows the way to any destination far from it.

Post-apocalyptic cities in artistic practices in contemporary cinema often have metaphysical, unrealistic boundaries. This can be manifested in the use of a significant number of metallic, mirrored surfaces, in which there is a play of light and darkness, which only enhances the sense of illusion of such cities. The emphasis on irrationality, unreality of the perception of the world using the latest mirror-like man-made designs in cinematic images of the cities of the future is also reinforced by the fact that since ancient times, humanity has perceived the mirror as a boundary between worlds, between order and chaos, between the cognitive and transcendental worlds. In particular, in a dark city, the boundary of urbanized space is destroyed because of the battle between Murdoch's hero and the alien gods. Moreover, it turns out that there is nothing beyond the city wall but the boundless expanse of space. The whole world of the dark city is just the territory of a ship in the middle of endless space. In addition, the entire reality of the city is reduced to consciousness, a set of memories of people transferred to a colony spaceship.

The city as a limited space of safe human existence in the paradigm of modern perception of post-apocalyptic scenarios of the world development is reflected in the already mentioned concept of the last human shelter in the world, which is collapsing or already destroyed. Such a shelter can be represented by a city itself (*'I Am Legend'* (Lawrence, Francis, USA, 2007)), as well as local centers of non-urban environment. The concept of the last shelter is closely linked to the ideas of the potential sinfulness of the first city, as Cain and his descendants created it. Cities in such comprehension are interpreted as centers of concentration of sinfulness and corruption, where man is potentially ready to accept the power of the antichrist.

In contrast to the city as the last refuge, the concept of the last refuge, tied to non-urbanized, rural space, functions in the minds of people in a digitalized society through personal experience and feelings. In this sense, countryside is considered the safe area in which a person can significantly minimize the destructive effects of natural and social troubles and disasters. In this way a kind of 'sacred geography' or 'geography of salvation' is formed. It is based on the belief that there are spaces on earth where it is possible to minimize the manifestations of doomsday cataclysms – climate, technological and geopolitical disasters. The key condition for salvation of a person is the necessity to be at the right time in a sacred place – a temporary space of relative well-being in the sea of eschatological cataclysms. In the film *'Terminator 3: Rise of the Machines'* (Mostow, Jonathan, USA, 2003), John Connor accidentally finds himself in the veterinary clinic of Kate Brewster, who he studied at school with, at the time of the Terminator T-X's attack. And it is this circumstance that brings together the Terminator-Defender T-101, Kate and John, which further allows them to realize the need to protect Kate's father, General Brewster, who in his turn sends them to the

most safe and secure haven for top officials of the state. This makes it possible for the hero-savior to stay alive and lead the resistance against the uprising of the machines. Similar ideas are manifested at the level of public consciousness in the myths about *the country of the blessed* (Eldorado, Shambhala) or in the utopian projects of the *'City of the Sun'* by Tommaso Campanella.

The mythologeme of the last sacred refuge is a component of modern eschatological mythology. It points to the idea that it is possible to avoid and minimize the negative consequences of the end of the world in the post-apocalyptic future within the newest city of refuge. Thus, to a large extent, this mythology is one of the components of the soteriological perception of reality, a kind of extrapolation of the idea of human survival in a (post)apocalyptic reality.

The desacralization and demythologization of eschatology by contemporary cinema, however, does not exclude the symbiosis of the traditionally eschatological and the innovative. On the one hand, cinema actively uses the motif of the New Jerusalem, the city of salvation. On the other hand, all the post-apocalyptic cities that are the centers of the civilization of the saved (the Dark City, the Eloi Village, Wayward Pines) cannot protect the lives of their citizens within their borders, even if they are walled or placed in rock caves. Even when locked at night, they are dangerous to humans. Whereas in the biblical New Jerusalem there will be no night and no need for any closed gates.

Conclusions. If the eschatological doom of humanity in the religious and mythological tradition is mainly due to two factors: the end of the time limits allotted by higher forces for human life on earth (for example, the Mayan calendar) and the punishment of man for an inadequate lifestyle (the fall and degradation of human nature as its consequence in the discourse of Abrahamic religions), the cinematic practice of modern digitalized society focuses mainly on the moral aspects of apocalyptic events. According to the scenarios of popular cinema in recent decades, humanity is losing the world and the possibility of a decent life in it because of the destructive activities of man himself. It is no longer God or gods who appear as a punishing force, but the anthropogenic factor that causes the apocalyptic threat. In post-apocalyptic scenarios of the future, the death of a human being, literally or metaphorically, in a world destroyed by it, looks horrifying but a natural consequence of the development of a digitalized society. The latest technologies (genetic engineering, digitalization, and robotization) allow humans to survive the apocalypse, but only so that humanity has a chance to realize its role in the destruction of the world and to go into oblivion with it, giving way to new civilizations. Thus, the exploitation of a person's immanent fear not only of his or her own death, but also of the threat of the destruction of the entire human world, has become one of the key themes in popular cinema of the digitalized present.

The actualization of the idea of the "end of the world" in cinema in recent decades has influenced the production of a sense of disruption in the normal course

of everyday life, its instability and excessive variability in public opinion and human experience in the digital age. These tendencies are reinforced by the fact that in contemporary cinema the post-apocalyptic motif changes the temporal attachment. The end of the world no longer represents the end of the era of the ordered existence of the human world. In most urban disaster films, we see a post-apocalyptic society that has already experienced the "end of the world" to varying degrees. The apocalypse has happened and the next stage of the world's cyclical existence has already begun.

Motif of post-apocalyptic city as the last refuge of humanity in popular films of post-industrial digital era is interpreted as the last center of order and civilization, a New Jerusalem of post modernity. This is a place where a person can find salvation when there is no salvation anywhere else. The walls or boundaries of the city, both, physical or digital, protect people at the end of times from threats of disappearance or dissolution in non-being. In a broad sense, the post-apocalyptic city is a kind of ark that gives humanity hope for salvation. The key condition of salvation is the ability of the main character to be in the sacred place at the right time, in space of wellbeing among a sea of eschatological cataclysms. However, the walls of the new city not only save but also make humankind of post-apocalyptic era obey new social and natural laws.

Although influence of popular cinema cannot form a holistic eschatological outlook in the minds of modern people, we conclude in the study that excessive exploitation of the idea of the end of the world in post-industrial society enhances anxiety and uncertainty about the future of a significant number of people. The motive of human survival in (post)-apocalyptic city (new civilization) is a call for rethinking the principles of human existence mode in the modern world, as the very idea of the end of the world and extermination of majority of mankind contains hope for contemporary humankind. In a society of mass consumption, many people perceive eschatological threats with hope, as they are extremely dissatisfied with their lives and seek to finish this stage of their existence in the 'unjust' world. They are willing to finish their miserable existence in the world where they have no chance to preserve dignity, so that to get another chance to start a new life in a post-apocalyptic world as if from scratch.

However, in accordance with eschatological cinematic practice, hope for the revival of humanity is possible not so much due to human nature but Divine will.

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THE IMPACT OF TECHNOLOGY ON HUMAN LIFE

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ВЛИЯНИЕ ТЕХНОЛОГИЙ НА ЖИЗНЬ ЧЕЛОВЕКА

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<https://doi.org/10.5281/zenodo.15879902>**Abstract**

This article discusses the positive and negative aspects of technology in human life. In modern times, technology makes human work easier in many areas. People use modern technical means and establish long-distance relationships through social networks. It is well known that artificial intelligence reduces the burden of human thinking. Through technology, people achieve great achievements in education, healthcare, and business life. By ensuring the rapid development of these areas, modern technology provides people with great opportunities to plan their future lives. Although technology improves human life in terms of quality, its excessive use can also destroy human life. As a result, the appropriate use of technology can correctly direct human life and its future plans.

Аннотация

В данной статье рассматриваются положительные и отрицательные стороны влияния технологий на жизнь человека. В наше время технологии облегчают работу человека во многих областях. Люди используют современные технические средства и устанавливают отношения на расстоянии через социальные сети. Хорошо известно, что искусственный интеллект снижает нагрузку на мышление человека. Благодаря технологиям люди достигают больших успехов в образовании, здравоохранении и деловой жизни. Обеспечивая стремительное развитие этих сфер, современные технологии предоставляют людям большие возможности для планирования своей будущей жизни. Хотя технологии улучшают качество жизни человека, их чрезмерное использование может также разрушить её. В результате, правильное использование технологий может правильно направить жизнь человека и его планы на будущее.

Keywords: technology, artificial intelligence, education, healthcare, work life

Ключевые слова: технология, искусственный интеллект, образование, здравоохранение, трудовая жизнь

Technology is an integral part of people's daily lives. The rapid development of technology and the close relationship with technology have a very strong impact on the human brain. In this regard, it should be noted that technology has both positive and negative effects on human life. Continuous use of these tools can disrupt the electrical activity of the human brain and its overall working mechanism.

Modern technologies, while increasing people's learning abilities, can also lead to social isolation and internet addiction. In order to succeed in this era of brain evolution, it is necessary to move away from possible obstacles and create conditions that will allow adaptation to this evolution. In the modern era, along with technological development, the human brain is also evolving at a speed never seen before [4]. In addition, people who use the internet and play video games absorb and understand visual content and symbols faster than people who are not interested in these things. This can be considered a benefit of technology for the brain.

It is also known that the rays and radiations emitted by digital technology into the surrounding world damage brain cells. As a result, this factor causes a number of permanent diseases in humans.

Technological tools also damage human neural pathways and cause us to remember less of the information we read. It should be noted that using mobile phones and large-capacity technological tools exposes us to a greater flow of information throughout the day. This causes people to lose focus quickly. Technology also changes the physical structure of the human brain every passing year. This factor, when the time comes, causes great harm to emotions and human qualities [5].

One of the main places where the influence of technology is felt in human life is the family. The main factor that causes changes in communication and relationships within the family is modern information media. It should be noted that family relationships, which have changed over time, are increasingly under the influence of digital communication tools, social media and technological tools in modern times. Family members, and most importantly, social relations between people of different ages, are regulated in different ways today. Family members use various social networks and technical tools when communicating with each other. This speeds up and facilitates communication between family members, but weakens the living relationships that play the role

of the foundation of the family. At the same time, communication between young people and the older generation is becoming more difficult due to the technological gap [1]. In previous times, the main form of communication within the family was family conversations, advice, and spending time together with family members. In modern times, this communication is through messaging applications, social networking systems, and video connections or calls. The proper use of technology can have a positive impact on family relationships and strengthen them. Most importantly, it is easier to keep in touch with family members living or working in foreign countries with technology. However, if the role of this factor is exaggerated too much, family values may weaken.

Along with all the possibilities, technological tools also weaken the natural and emotional ties of family communication. The concentration of family members' attention on various technical devices leads to the weakening of real communication. In such cases, family relationships are formal in nature, and deep emotional ties remain in the background. One of the main issues to be noted in this regard is the aspects of technology's impact on the younger generation. While the rapid development of technology has changed the worldview and communication habits of young people, the older generation has difficulty adapting to these changes. This leads to difficulties in understanding each other between generations. The younger generation prefers instant messaging, social media, and a way of thinking expressed in digital language. However, older people prefer face-to-face conversations, physical meetings, and emotional ties and gestures. In order to properly solve this issue and eliminate the existing problem, the younger and older generations should work together. By teaching the older generation how to use technology correctly, young people can attract them to the information society and introduce them to the positive aspects of technology.

The role of technology in human life is also reflected in the education system. In the modern era, technology and innovations fundamentally change the educational process, leading to the reshaping of teaching methods, teacher-student relationships and ways of acquiring knowledge [2]. Technology is at the heart of the modern educational process, making teaching and learning easier, more efficient and accessible. Technologies such as online educational platforms, digital textbooks, virtual reality and artificial intelligence are expanding the boundaries of education.

Technology and innovation are driving forces in education, not only making existing learning more accessible, but also preparing students for the future world of work. In the future, many professions and jobs will require technological skills, language skills, and innovative thinking. Technology is also promoting international integration in education. Students can now attend classes in different countries around the world, join global education programs, and learn from different cultures. Technology and innovation are the driving forces in modern education. They connect the education system, enabling new teaching methods, personalized approaches, and global knowledge exchange. Globally integrated education with technology is of great importance in the development of society.

In modern times, artificial intelligence has become an integral part of our lives. Artificial intelligence, unlike the intelligence of humans and animals, is considered the intelligence of machines and software. The main factor that distinguishes artificial intelligence from other popular technological tools is its ability to imitate human intelligence. The impact of artificial intelligence on our lives is quite large, and this technology is already used in most areas. It should be noted that in a number of workplaces and educational institutions, even humans are replaced by robots. Unlike human intelligence, although artificial intelligence is a robot, when it feels any external influence or threat to itself, it can behave differently, deceive or confuse people with certain false information.

As a result, modern technology is of great importance in every aspect of human life. However, if a person uses technological tools properly and appropriately, he can make his life easier and gain efficient and convenient ways.

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GEOPOLITICS, ISLAM, AND GLOBALIZATION: A CRITIQUE OF RADICAL INTERPRETATIONS**Kozubaeva A.***Candidate of Philosophy, Associate Professor,
Kyrgyz National University***ГЕОПОЛИТИКА, ИСЛАМ И ГЛОБАЛИЗАЦИЯ: КРИТИКА РАДИКАЛЬНЫХ ИНТЕРПРЕТАЦИЙ****Козубаева А.О.***кандидат философских наук, доцент
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<https://doi.org/10.5281/zenodo.15879904>***Abstract**

This article explores the interconnection between Islam, globalization, and geopolitics, while offering a critical analysis of radical interpretations that erroneously associate Islam with extremism and terrorism. Historical factors—such as colonial legacies and the superpower rivalry during the Cold War—contributed to the politicization of religion and made Islamic communities vulnerable to ideological manipulation. Terrorist organizations such as al-Qaeda and ISIS use religious rhetoric to achieve political goals, which contradicts the theological and ethical foundations of Islam.

Аннотация

В статье рассматривается взаимосвязь ислама, глобализации и geopolitics, а также проводится критический анализ радикальных интерпретаций, ошибочно связывающих ислам с экстремизмом и терроризмом. Исторические факторы - такие как колониальное наследие, противостояние сверхдержав в период холодной войны способствовали политизации религии и сделали исламские сообщества уязвимыми к идеологическим манипуляциям. Террористические организации, такие как «Аль-Каида» и ИГИЛ, используют религиозную риторику для достижения политических целей, что противоречит теологическим и этическим основам ислама.

Keywords: Islam, globalization, geopolitics, extremism, terrorism, radicalization, pseudo-Islam, political Islam, jihad, al-Qaeda, ISIS, Islamophobia, Cold War.

Ключевые слова: ислам, глобализация, geopolitics, экстремизм, терроризм, радикализация, псевдоислам, политический ислам, джихад, Аль-Каида, ИГИЛ, исламофобия, холодная война

Процесс глобализации, берущий начало с эпохи Великих географических открытий, способствовали вовлечению исламского мира в глобальные политические и экономические структуры. Освободившись от колониального гнёта, мусульманские страны начали формировать самостоятельную повестку, вступая в научный, технологический и культурный диалог с Западом. Однако одновременно усилилась внутренняя напряжённость: трансформация моральных основ ислама сопровождалась всплесками деструктивных тенденций, частью которых стало формирование радикализированных идеологий.

Историческое противостояние СССР и США сыграло ключевую роль в политизации ислама, превратив его из духовной традиции в инструмент геополитической борьбы. Стремление сверхдержав к расширению влияния вынуждало их опираться на союзников в мусульманском мире. Уже с момента становления советской власти, советское руководство, начиная с середины 1920-х годов, выработало стратегию «акклиматизации» к мусульманским регионам, подчёркивая, что религия в данном случае выступает «опиумом для народа», но социально-

экономические уступки помогут получить временную лояльность. Требование руководства «учитывать специфику мусульманской бедноты» проявилось в создании национальных кадровых школ и ограниченном финансировании религиозных учреждений без тотальных репрессий против мирного духовенства. Идея мировой революции, распространённая в марксистском дискурсе, побуждала советское руководство искать поддержку среди мусульманских народов, находящихся под колониальным гнётом. Национально-освободительное движение в странах ислама воспринималось как прогрессивное и антиимпериалистическое. Однако в этом же контексте начали формироваться религиозно-политические организации, не вписывающиеся в гуманистические рамки. В то же время Запад стремился использовать исламские движения, как инструмент противостояния коммунизму, приписывая им прогрессивный, даже социалистический характер. СССР и США нередко финансировали и вооружали повстанческие движения в Африке и Азии, стремясь реализовать собственные геополитические цели. Этот прагматизм привёл к формированию радикальных групп, подкреплённых идеологией, вооружением и логистикой. Особое внимание

уделялось «Братьям-мусульманам» в Египте и Афганским моджахедам, чьи политические платформы включали элементы исламского социализма. Такое сотрудничество привело к парадоксальной ситуации, когда структуры, изначально подпитываемые западными грантами, впоследствии становились «горячими точками» терроризма.

Вторжение СССР в Афганистан (1979) стало катализатором трансформации «джихада» из религиозного понятия в инструмент внешней политики. В результате изоляции Афганистана и последующей гражданской войны страна превратилась в «тренировочный лагерь» для будущих исламистских экстремистов. После ухода советских войск (1989) последовал вакуум власти, заполнившийся радикальными ваххабитскими учениями: в Кабуле, появились мечети, где новую интерпретацию ислама преподавали арабские проповедники. Долгосрочные последствия этой кампании проявились в резком росте транснационального терроризма. Получившие опыт в войне с советской армией бойцы-моджахеда составили костяк местного движения Талибан и транснациональной террористической организации Аль-Каида. Эти ультраэкстремистские группировки подняли радикализацию политического ислама на новый уровень, резко повысив уровень одобрения войны как инструмент достижения политических целей.[1]. Итогом появления на арене неправительственных религиозно-политических организаций (НРПО), деятельность которых имеет выраженный экстремистский характер, прикрывающийся исламской риторикой, стали события 11 сентября 2001 года, когда стало известно о сотрудничестве Усамы бен Ладена с американскими спецслужбами в предыдущие десятилетия. Впрочем, признаки становления экстремистской субкультуры были заметны ещё в конце 1980-х годов - захваты заложников, теракты, идеологизация насилия под исламским флагом.

После 2001 года террористическая угроза получила новую конфигурацию в лице ИГИЛ, провозгласившего «халифат» в 2014 году. Несмотря на то, что ИГИЛ оттеснило «Аль-Каиду» с медийной повестки, последняя продолжает оставаться активной и даже расширяет своё присутствие. В дискурсе СМИ при этом закрепилось устойчивое клише, соединяющее ислам и терроризм, что в научной и общественной среде вызывает всё больше критики. Политолог О.Молдалиев справедливо указывает, что ислам не имеет никакого отношения к явлениям экстремизма и терроризма и является религией мира и прогресса[2]. Терминологическая путаница способствует искажению сущности ислама, который в своей этической и философской основе противоположен идеологии насилия.

Наша концепция основывается на принципиальной сепарации понятия «исламский терроризм», при которой религия рассматривается как реальная противоположность мировоззрению экстремизма и терроризма. Однако мы не можем игнорировать тот факт, что рассматриваемая разновидность террора

возникла в обществах исламской цивилизации. Последствия глобализации для стран Востока привели к формированию у незначительной части общественных слоев утопического сознания и экстремистского духа. Несмотря на то что эти правоверные мусульмане не участвуют непосредственно в террористической деятельности, они демонстрируют склонность к экстремистским идеям. Тем не менее морально-этические принципы ислама и дух терроризма представляют собой непримиримые противоречия. Каждый поступок мусульманина, начиная с утра и заканчивая отходом ко сну, сопровождается словами «Бисмилляхи-рахмани-рахим», что переводится как «Во имя Аллаха милостивого, милосердного». Эта важная черта ислама, отражающая его сущность, была подчеркнута А. Игнатенко. «Если вы возьмете любой исламский текст, то в нем говорится о милосердии. Каждый исламский текст начинается словами: «Во имя Аллаха милостивого и милосердного», в то время как ваххабитские тексты, заявления и лозунги начинают со слова «неверный»: «мы против неверных, мы всех неверных уничтожим». Мнение о несоответствии ислама и политического экстремизма находит отклик у многих известных общественных деятелей. Одним из наиболее авторитетных высказываний является мнение академика Е.М. Примакова, признанного эксперта в области международных отношений. Он утверждает, что «значительное количество террористических актов на международной арене сейчас осуществляется экстремистскими группами, действующими под лозунгом ислама». Автор считает попытку приравнять ислам и терроризм вредной частью политики, направленной на создание образа ислама как нового «пугала» для цивилизации Запада после краха коммунизма[3].

Историческая практика однозначно свидетельствует о том, что мусульмане, следуя духу своей религии, могут успешно и взаимовыгодно сотрудничать с представителями других конфессий на пути прогресса. Современная общественно-политическая практика демонстрирует все новые факты, подтверждающие, что ислам и терроризм — это совершенно разные явления. Под взрывами террористических бомб в арабских странах прежде всего гибнут мусульмане. Следовательно, постановка вопроса о поддержке экстремистов населением исламского Египта, в условиях, когда от терактов погибают «десятки правоверных», является абсурдной. Даже в Пакистане, который некоторыми политиками рассматривается как центр псевдоисламского экстремизма, преступники, прикрывающие свои амбиции религиозной риторикой, захватывают заложников и убивают мусульман.

Многие исследователи и журналисты усматривают истоки «исламского терроризма» в концепции шахида-человека, который, погибнув в бою против неверных, обретает место в раю. Именно принцип джихада, по их мнению, формирует террористов, готовых на самопожертвование. Однако, вместе с тем, эта точка зрения игнорирует тот факт, что и в христианстве воин, павший на поле брани, также обретает место в раю.

Существует множество единых основ и принципов, направленных на формирование человеческой морали, что подтверждается при сравнительном анализе Корана и Нового Завета, где можно выявить значительное сходство в теоретических положениях обеих религий. Предлагаемое понятие «псевдоислам», в отличие от термина «исламский терроризм», более точно и существенно характеризует исследуемое явление.

Ислам - это «система представлений, чувств и культовых действий, религиозных учреждений». Его сущностным содержанием является вера в существование Единого Бога. Это фундаментальное положение религии объясняет, что человек добровольно отказывается от роли хозяина своей судьбы, признавая, что его успех или неуспех определяются Всевышним. Важно, что достижение успеха связано с соблюдением религиозных норм и запретов, главный из которых - запрет на внеправовое убийство человека.

Экстремизм же определяется как «приверженность в политике к крайним взглядам и мерам», что является формой правового нигилизма. Теория и практика применения антигуманных методов достижения политической власти противоречит основным принципам религии, таким как любовь, милосердие, терпение и сострадание. Поэтому попытка привести экстремизм и ислам в соответствие как теоретические и духовные феномены является необоснованной. Следует отметить, что экстремизм в законодательстве характеризуется как преступное деяние, а не идеология.

Религия, как система вероучений, представляет собой сферу общественного сознания. В связи с этим, такое понятие, как религиозный экстремизм, не имеет объективных оснований в контексте религиозных учений. Экстремизм, является политическим явлением, которое, согласно законодательству, влечет за собой уголовную ответственность. Однако ответственность гражданина должна касаться конкретных противоправных деяний, а не лишь намерений. Следовательно, экстремизм представляет собой преступные действия личности или организации, направленные на насильственное захват власти. При этом характеристика данного явления как идеологической позиции конкретного индивида или социальной группы, выражающей приверженность крайним взглядам, не является проявлением экстремизма. Агрессивные настроения, если они не выражаются в противоправных действиях, не могут быть квалифицированы как экстремизм. В то же время, экстремизм как политическое учение полностью разрывает связи с религией, оказывая влияние на личность и подавляя ее внутренние сдерживающие силы, необходимые для контроля агрессивных, разрушительных наклонностей.

Основная цель лидеров экстремистских и террористических организаций заключается в достижении политической власти, прикрываясь различными идеологическими лозунгами, такими как национализм, конфессионализм и политические идеологии. К концу XX в. террористические акты,

имеющие целью регулярное, по возможности массовое уничтожение людей, превратились в распространённое средство достижения политических целей. [4]. В этом контексте терроризм является, прежде всего, инструментом этнического или этноконфессионального сепаратизма, ирредентизма и политического истеблишмента, стремящегося к мировому господству или господству в своем регионе. Террористические организации, такие как «Исламское государство» (ИГИЛ), имеют определенную народную поддержку среди иракских и сирийских суннитов. Однако это не является основанием для утверждения о жестокости ислама как такового или о поддержке суннитами радикальной интерпретации Корана. Существенная часть жертв ИГИЛ - мусульмане, в том числе и сунниты. Теория ИГИЛ, касающаяся мусульманской жизни, чужда исламской традиции. Исламский фундаментализм, как и другие формы религиозного фундаментализма, является современным явлением. Экстремистские религиозные группировки, разочарованные в современной политике, стремятся возвратиться к идеализированному исламскому прошлому, которое на самом деле никогда не существовало. Радикализм, присущий «Аль-Каиде» и ИГИЛ, возник не из исторического исламского халифата, а благодаря идеям XX века, например, пропаганде египетской ассоциации «Братья-мусульмане», возглавляемой Сейидом Кутбом.

Отметим, что сущность псевдоислама определяется в постановке конечной цели. Для всех террористических групп, прикрывающихся различными лозунгами, цель одинакова - захват и использование власти. При этом морально-этические и духовные рамки, не говоря уже о правовых, не являются сдерживающими факторами для этих групп. Католикам, таким как ирландцы, баски или кечуаны, неважно, что Папа Римский осуждает терроризм, а лжемусульманам из «ваххабитских» братств не важны нарушения установлений Корана - для них важен лишь контроль над территорией, собственными властными структурами, финансовыми потоками и легализацией преступных доходов, таких как доходы от наркоторговли.

Не может быть реальным фактором «исламского экстремизма» и принцип джихада. Знакомое только ориенталистам и студентам исторических факультетов концепция «джихада» во второй половине двадцатого века стала достоянием многомиллионной мировой мировой прессы. Отсутствие объективных и консервативных знаний о природе Ислама привело к тому, что это слово стало синонимом агрессивности, антигуманности и деструктивного характера всех мусульман [5]. Военный джихад как политический аспект ислама утратил своё значение после смерти пророка Мухаммеда. В последующие исторические эпохи, а особенно в современности, джихад используется не духовенством, а политиками, которые прикрывают свои амбиции религией, чтобы решить конкретные политические задачи. Если обратить внимание на историческую реальность распространения ислама, становится очевидным, что завоевательные походы

не преследовали цель распространения ислама. Арабы, ведущие военные действия, не ставили своей целью обращение народов в ислам. Например, на Балканах, где ислам доминировал на протяжении веков, болгары, сербы, румыны и другие народы не были обращены в ислам. Несмотря на свою абсолютную власть, мусульмане не применяли насилие для обращения местных народов в ислам. Если бы это происходило, все завоеванные территории немедленно восстали бы против мусульман. Известно, что ранние халифы, обладавшие мудростью, понимали, что законы и религия не могут быть навязаны силой. Попытки идеологов исламистских организаций оправдать свои антигуманные действия ссылкой на традиции времён Мухаммеда и утверждения, что джихад является требованием ислама, не выдерживают критики. «Джихад, священная война, не входит в пять столпов веры». Мухаммед проповедовал мирные способы разрешения конфликтов, предлагал искать мирные решения через договоры, терпимость и честность.

Завоевательные походы халифов следует рассматривать как военно-политический аспект, направленный на расширение территории и получение дополнительных выгод, а не как распространение религии. Важно помнить, что ислам, помимо призывов к джихаду, также содержит элементы терпимости к последователям других религий. Мусульмане освобождали патриархов, священников и других религиозных служителей от налогов. Например, Умар ибн аль-Хаттаб не причинил вреда христианам, когда вошёл в Иерусалим как завоеватель. Напротив, крестоносцы, входя в этот город, убивали мусульман и сжигали евреев.

Необходимо также различать терроризм и радикализм. Псевдоисламский терроризм может исходить из исламского радикализма как течения, которое выражает жесткую критику существующего социального порядка. Исламская религия и политика могут рассматриваться как социально-политический феномен, образующий исламский фактор, который включает в себя различные политические силы, включая националистические и криминальные структуры, не имеющие отношения к подлинному исламу. В этой связи необходимо отметить, что в рамках исламского фактора действуют силы, которые используют религию в целях, далеких от истинных учений ислама.

Концепция настоящего исследования основывается на утверждении, что ислам оказывает культурообразующую роль не только в исламском мире, но и на мировом уровне. Это подтверждается социально-политической практикой Саудовской Аравии и соседних стран, где правители, придерживаясь ислама, смогли добиться значительного прогресса в обществе, опираясь на научно-технологическую помощь Запада. Властям Саудовской Аравии, несмотря на приверженность фундаменталистскому исламу, не препятствует восприятие позитивных элементов западной культуры для обеспечения процветания общества.

Однако ваххабизм, играющий значительную роль в этой стране, используется как идеологическое прикрытие псевдоисламскими террористами, представляясь реакционным и антицивилизационным явлением. «Аморальный симбиоз религии и политики всё больше обостряет конфликты в межэтнических и межконфессиональных отношениях, порождая войны, которые имеют скорее не цивилизованную, а нецивилизованную форму, противоречащую духу всех традиционных религий, включая авраамические - христианство, иудаизм и ислам».

А. Игнатенко, ведущий ориенталист отмечает "разговоры об "исламе вообще" при ближайшем рассмотрении оказываются беспредметными. Ислам существует в разных, скажем так, "страновых" или "региональных" формах. Кстати сказать, пророк ислама Мухаммад предсказал эту раздробленность ислама, сказав, что после его смерти ислам расколется на семьдесят три "секты" - араб "фирка". И все они будут гореть в адском пламени, кроме одной - "спасшейся". Подразумевается, что семьдесят две "секты" из семидесяти трёх будут заблудшими, другими словами, их ислам будет "неправильным" [6]. Следует отметить, искажения в фундаментальном исламе наблюдаются в отдельных группах, таких как усамизм (последователи Усамы бен Ладена), ваххабизм, кутбизм (по имени Сейида Кутба) и халифатизм, которые выражают специфические взгляды на такие вопросы, как единобожие, такфир, джихад и другие. Искажения религиозных учений в современных условиях могут доходить до того, что возникают элементы, напоминающие первобытное язычество. Люди Писания (иудеи, христиане и мусульмане) обладают высокими нравственными критериями и следуют понятиям дозволенного и запрещенного, основанным на повелениях, содержащихся в священных писаниях. Использование ислама в агрессивных политических целях против иудеев и христиан не соответствует духу религии, поскольку мусульманам дозволено есть пищу, приготовленную людьми Писания, также как и наоборот. Именно поэтому, псевдоислам не может олицетворять исламскую религию в целом. Следует отметить, что власти ряда стран, включая Кыргызстан, официально признали недопустимость использования терминов «исламский экстремизм» и «джихад» для описания террористических групп. Согласно экспертам, правильное называть участников этих антигуманных движений «бандитами», не имеющими религиозного содержания. Их действия не могут быть оправданы религиозной принадлежностью, поскольку они представляют собой преступников, а не истинных мусульман.

Таким образом, концепция, согласно которой ислам и теория и практика экстремизма и терроризма - явления несовместимые, получает все большее подтверждение.

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PHYSICAL SCIENCES

HOW THE LAWS OF PHYSICS CAN BE USED TO BRING BACK TO LIFE A PERSON WHO HAS DIED AS A RESULT OF AN ACCIDENT OR CRIME

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Abstract

In the article it is suggested that due to the fast (faster than the Earth rotates) movement on the Earth through time zones to carry out accessible to people travelling (for example, by plane) both in the past and in the future time. An example of realisation of such time travel routes is given, allowing to bring back to life people who died as a result of an accident or criminal humans activity.

Keywords: arrow of time, special theory of relativity, anti-time, internal time, external time, time zones of Earth, time travels

1. Introduction

The title of the article may be perplexing. What can physics have to do with bringing a person back to life? Especially not in science fiction, but in serious science? But, it turns out, it can, although this serious science itself does not agree with this opinion.

The fact is that it is possible to bring a person back to life by travelling through time. But the possibility of travelling in time, except for some unreal theoretical situations - in the twin paradox of the special theory of relativity (SRT), as a result of teleportation in quantum mechanics and in some other exotic theoretical situations - in practical human activity is denied by physics even in the distant future.

However, this article provides descriptions of useful new human activities that are physically already feasible on Earth now using time travel to the past and into the future.

2. Proof of the physical reality of time travel on Earth is already in the present day

Here are a couple of quotes that illustrate the current state of understanding of the problem of time. *"Time is the most frequently used word in the English language and the third most frequently used word in Russian. It is also frequently used in all other languages, too, because synchronizing actions in time is as important as coordinating them in space. Without knowing the exact time, it is impossible to organize your life and plan it in advance. If in ancient times you could rely on natural cycles and an internal sense of time, then in our days you must constantly have a watch or a phone with you. Time is the most important of the abstract concepts that we pronounce every day. Every thinking person has thought about the problem of time at least once in his life. And a huge amount of philosophical and scientific literature has been written on this topic. Nevertheless, no one can say with certainty even what time is."* [1]

And here is what Stephen William Hawking writes about this [2]: *"In ordinary life, there is a huge difference between moving forward and backward in time. Imagine that a cup of water falls from a table and breaks into pieces. If you film this fall, then when you*

watch the film, it will immediately become clear whether the film is running forward or backward. If it is running backward, then we will see how the fragments lying on the floor suddenly come together and, having formed a whole cup, jump onto the table. And you will be able to claim that the film was running backward, because in ordinary life this does not happen. Otherwise, all the faience factories would have to be closed."

This phenomenon, known as the 'arrow of time', is one of the most surprising problems in physics. The name 'arrow of time' was proposed by the British physicist Sir Arthur Stanley Eddington in the early XX century [3]. And all our life experience, as it would seem, confirms the truth of this concept.

But the corrected version of SRT [4]-[12], in which a new concept of 'anti-time' has appeared, induces this life experience to be corrected. Indeed, if we assume that soon travelling through the expanses of universes and antiverse of the hidden Multiverse will become possible for people on Earth, then time travel [13] will also become possible, both in the past and in the future.

Moreover, time travelling is now possible on Earth [14]-[28]. And since they are much easier and cheaper than in space, we will consider them. At the same time we will need two new concepts - internal (or biological) time of a human being and external time of his environment. And these two times have different properties. Human biological time cannot flow backwards. A person cannot return to his youth or childhood. But the situation in the external environment in which a human being is, as a result of human activity, can change in the most incredible way. And in this external environment it is already possible to move both to the future and to the past time. And even short-term movements in time can be very useful. For example, if you get an opportunity to look into the future time for a short time, you can make a better choice in the present. Or by travelling to the past, it is possible to correct something in the present time.

And such external time for people on Earth exists. It's known to everyone. These are 24 time zones, which

are caused by the Earth's rotation around its axis. Moving through them in space, people also move in time. And depending on the direction of movement in space - to the west or to the east - they can move both to the past and to the future time. This is well known to everyone, but it has not been used in creative human activity so far.

But this is a free resource presented to us by nature to solve the problem of time travel, which is not difficult to use if you have an aeroplane (because you need to travel faster than the Earth rotates). Indeed, to travel 24 hours into the past, for example, you only need to move westwards by 24 time zones. To move into the future, you would have to do the same thing, but only by travelling east. All this is not difficult to do. It is also necessary to take into account that the closer to the pole - it does not matter which one, northern or southern - the transport route of time travelers will run, the less biological time will be required to cross one time zone. Therefore, it is more advantageous to lay it closer to the poles (for example, at a distance of 100-1000 km from the pole around the pole). But since the internal biological time in ordinary human activity for almost all people (who do not fly) flows much faster than external

time, external time is usually not taken into account by people. Such a concept is still not even present in colloquial speech. And although millions of people are already travelling through time by flying planes, it has never occurred to anyone until now that there is any benefit to be gained from time travel. But it turns out that it is possible.

3. How the laws of physics can be used to bring a person who died as a result of a crime back to life.

Let's consider one of these situations. And from the analysis of this situation it will become clear how to act in other situations.

For example, let's assume that in one of the South American countries (this option will be convenient to explain, since this country is located near the South Pole) the president is killed. This situation is illustrated by Fig. 1, which shows the trajectories of movement in time:

- the President of this country;
- the head of the security service;
- and all the other people – both those who saw the assassination attempt on the president and those who did not.

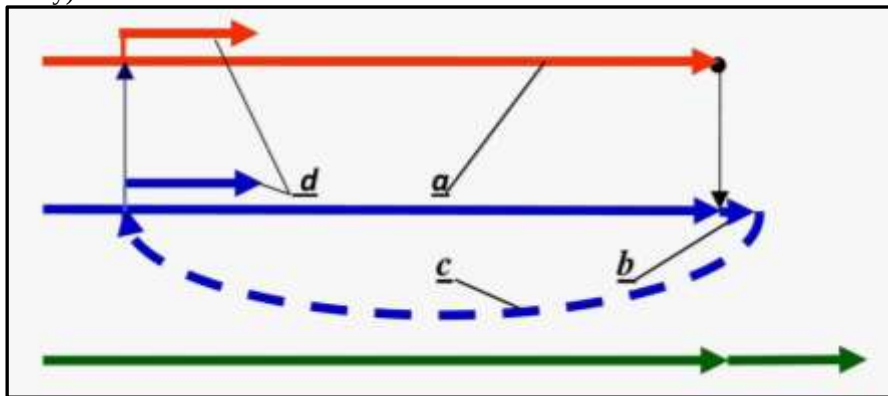


Fig. 1. Time travel routes of the President (in red) and the head of the security service (in blue), ensuring the return of the President to life after an assassination attempt on him, as well as the rest of the inhabitants of the Earth (in green). Solid lines show their movements on the surface of the Earth, and dotted lines show the movements of the head of the security service on an airplane through time zones.

Therefore, the temporal trajectory of the President's life ("a" in Fig. 1) ends with this murder (this moment is shown by a large black dot). And upon seeing this (shown by the thin black arrow), the head of the security service ("b" in Fig. 1) begins to act – he organises the President's delivery to the nearest military hospital, organises security, instructs him to report to the press that the President is alive, and instructs his staff to strictly prevent any leakage of information that the President has already died.

Then the head of the security service gets on an aeroplane ("c" in Fig. 1) and, having flown around Antarctica through 24 time zones, lands in the past time at the same aerodrome from which he took off in the present time. Outside time for him has changed into the past by 24 hours, and the internal biological time of his space-time journey, i.e. the flight time, has changed, for example, by 10 hours. Consequently, the head of the security service flew back in time 14 hours before the

assassination attempt on the President. And therefore, during the remaining time ("d" in Fig. 1) he has time to take the necessary measures to save the President and neutralise the criminal (or criminals). And so for this country, its President - a real living President at that - could be saved¹.

However, as Figure 1 shows, the situation is still unresolved. Firstly, after the assassination attempt, which was witnessed by many people, the President in this situation turns out to be not only alive but also fully healthy as a result of the activities of the head of the security service. However, even Presidents do not recover so quickly. And to explain to the people how the President was brought back to life is to be inexpedient, as it is not known how it will be perceived by them. However, this can be remedied: the President will simply have to stay out of public view for the duration of his alleged treatment. Secondly, the President with

¹ Perhaps President Kennedy could have been saved in a similar fashion

the head of the security service and the rest of the citizens have so far found themselves existing on Earth in

different times. And this circumstance is already more difficult to overcome

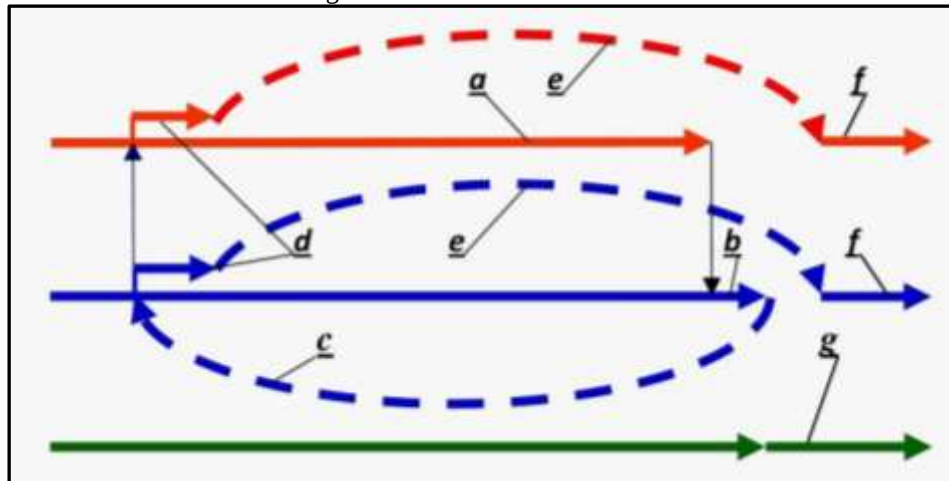


Fig.2. Time-travelling routes of the President and the head of the security service, ensuring the President's return to life after the assassination attempt, as well as the rest of the Earth's inhabitants. The solid lines represent their movements on the surface of the Earth, and the dotted lines represent the movements of the President and the head of security by aeroplane across time zones.

And there can be only one way out of this situation – the President and the head of the security service, in order to return to the same time in which the rest of the people of the Earth are, need to make a journey into the future (see Fig. 2).

Therefore let's continue. After the President and the head of the security service have solved all their issues in the past time ("d" in Fig. 2), they get on a plane and fly around Antarctica in the opposite direction ("e" in Fig. 2). And thus in 24 hours they return from the past to the present ("d+e" in Fig. 2). And while they are flying, they have time to discuss their problems of the future. And after the plane arrives in the present, the President, together with the head of the security service, secretly gets into a car and leaves for a place of stay chosen on board the plane for the duration of his alleged treatment. And after the completion of this 'healing' ("f" in Fig. 2), the President already appears in his residence. And since the conditions $a + b = g$ and $d + f = h$ were met in such a time travel (see Fig. 2) then, eventually, the President and the head of the security service returned to the same time in which all the other people of the Earth were.

This is how, presumably, the problem of bringing back to life people who have died as a result of an accident or someone else's criminal activity can be solved. But it is not excluded that during the realisation of the solution to this problem, additional circumstances may arise that will require their own solution. And which, hopefully, will turn out to be solvable.

4. Conclusion

The above are just assumptions that need to be verified experimentally. Moreover, these verification experiments are simple, easy to implement and quite convincing. But you need an airplane. And having flown around the North or South Pole through 24 time zones and having made sure that they actually got to the past or future time, the experimenters will get an answer to their question of whether they can actually travel in time. And after that, they can return to their present

time in the manner described above. And if such an experiment confirms the assumptions made in the article, then the above-described and other travel routes to the past and future can be used to solve other problems. And the knowledge gained in this way can also be used to create more comfortable time machines.

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CREATION AND M-THEORY: TOWARDS THE GOD EQUATION

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*Experimental and theoretical physicist,**Baku State University, student.**Baku, Republic of Azerbaijan.*<https://bakustate.academia.edu/VAbbasov><https://doi.org/10.5281/zenodo.15879908>**Abstract**

For centuries, the human mind has tried to understand the mysteries of creation, searching for answers about the origin and nature of the Universe. Science and philosophy constitute the two main wings of this great quest, leading us into the depths of matter, time, and space. The concept called the "God equation" in physics - that is, the ultimate expression that unites all the laws of nature in a single mathematical expression - is aimed at shedding light on this mystery. This equation is expected to solve many problems in modern physics. Humans have been striving in this direction since ancient times and have taken important steps. The 20th and 21st centuries have been the culmination of these efforts, with the successes of quantum physics and general relativity bringing us closer to a more fundamental truth—the idea that everything is inextricably linked. However, until these two great theories—quantum field theory and general relativity—can be combined, a complete and conclusive description of the Universe remains incomplete. It is at this point that superstring theory and its broader form, M-theory, emerge. M-theory is the most comprehensive and ambitious approach that attempts to unify all forces and particles into a single, unified mathematical framework. Taking into account the multidimensional nature of the Universe, it attempts to explain the essence of matter and energy not only in terms of three-dimensional space, but also in terms of higher-dimensional layers of existence. This article attempts to take one of the important steps on the scientific-philosophical path towards the "God equation". Here, both the most complex concepts of theoretical physics and the spiritual and philosophical analysis of creation are brought together. The goal is not only to create a scientific model, but also to present a broader and more meaningful perspective on the origin of the Universe. The ideas presented here interpret the multidimensional structure of M-theory in unity with the concept of creation. The string-based origin of the energy source of matter in three-dimensional space is explained and the interaction of this energy with higher-dimensional spaces is analyzed. At the same time, by considering not only the physical, but also the spiritual side of creation, it presents the beginning of the Universe not as a "mere coincidence", but as a concept expressing the entire meaning of existence. Finally, considering the limitations of our cognitive abilities, it is noted which part of the Universe is possible to fully study, and a new equation is given that may be close to the "God equation."

Keywords: God equation, creation, supersim and M theory, early quantum effects, quantum field theory, quantum gravity, living space of being.

Introduction. One of the most fundamental questions that humanity has faced since time immemorial has been: Why does the universe exist and what power governs it? Over time, this question has become a common interest not only in the religious and metaphysical spheres, but also in mathematics, physics, and philosophy.[1] The qualitative and quantitative explanation of events by laws has changed people's perspective on the universe. The existence of these constants in the universe has made scientists ponder the origin and structure of the universe for centuries. As science has developed, scientists' views on this subject have emerged. To

this day, many scientists have expressed their views on the creation and dynamics of the Universe. Some scientists believe that every event in the Universe is subject to certain laws and therefore all theories can be unified around a single goal[2]. Scientists with this type of thinking believe that there is a creative force behind the Universe and that the Universe was created. Another group of scientists believe that the Universe was created by chance or did not exist at all. Scientists with this type of thinking support the idea that there is chaos in the Universe and that there is no need for a creative force[3].



Figure 1. Human intelligence and the Universe.

The first group of scientists, based on the idea of a creative force, are convinced that there is a final expression, such as the "Equation of Everything", that can explain every phenomenon in the Universe. This final equation is called the "God equation". The "God equation" refers to the final equation that unifies all the laws of physics[4]. This equation is expected to eliminate many problems in modern physics. Because approaching the contradictory branches of physics with the same mathematical equation can unite these branches around a common goal. In this regard, the concept of the "God equation" is a very important direction in physics[5]. In order to approach this equation, we must first deeply examine the reasons for the emergence of this idea, where the need for this theory comes from, and the thoughts of historical figures on this subject. The idea of the "God equation" - that is, the expression of all the laws governing the Universe in the form of a unified and all-explaining formula - has been at the center of thoughts about the divine origin of the physical order throughout history[6]. The roots of this idea go back to Ancient Greek philosophy. The Ancient Greek philosopher Plato, claiming that the Universe is based on perfect forms in the world of ideas, noted that there is a rational and unchanging principle behind the order in the physical world[7]. Plato's student, the philosopher Aristotle, accepted the existence of a beginning - the "First Cause" - that would stand in the chain of movement and causality.[8] This "first cause" was the philosophical form of the concept of the "Equation of God" in the modern sense. According to Aristotle, the Universe was set in motion not by chance, but by a first mover. This being does not move itself, because it is motionless. It moves other things through perfection and purpose.[9] Aristotle notes that forms and causes manifest themselves in mathematical structures. Mathematics is the language of being, but it must be explained not only by physical, but also by philosophical reasons.[10] The concept of the "unmoved mover" presented by Aristotle in his work "Metaphysics" forms the philosophical basis of the model explaining creation - the "Equation of God". If the universe is a collection of resonances, and these resonances produce certain forms, then there must be a causal equation behind these forms that can be expressed mathematically. In the Middle Ages, Islamic and Christian philosophers developed these ideas further. Ibn Sina and Thomas Aquinas emphasized that God is the creator not only of existence but also of its lawful structures.[11] Thus, the concept of "law" began to be seen not only as a physical order, but also as a product of reason. In the scientific views of this period, God was both the author of laws and their permanent preserver in time and space.[12]

According to the English philosopher David Hume, the Universe must have a cause, and that is God. We have not observed how the Universe was created, and therefore it is impossible to draw causal conclusions about it[13]. D. Hume denies that God can be proven by rational arguments. The German philosopher Immanuel Kant believed that the main purpose of creation was to determine the possibilities of people to acquire knowledge. According to I. Kant, complete knowledge is impossible[14]. This creates a deep harmony from both philosophical and scientific points of view. During the rise of classical physics, especially in the works of Isaac Newton, this concept took on a more scientific form. Newton's law of gravity described not only an observed phenomenon, but also a universal rule that God applied to created nature.[15] Newton himself described God as "an intelligent and living being who rules over the whole Universe".[16] He believed that these laws were a manifestation of God's will and mind. In Newton's own words, if we put all other facts aside, even five fingers are enough for us to believe in God.[17] Some mathematicians who supported Newton's ideas during this period also expressed their own opinions on this subject. The French mathematician René Descartes believed that the existence of God is more real than geometric expressions expressing a truth,[18] and the German mathematician Wilhelm Leibniz proposed the idea that everything that exists is a reflection of God's infinite knowledge.[19] The late 19th century was a period of great scientific achievement, but also of profound theoretical crisis. The laws of Isaac Newton's mechanics, Maxwell's electromagnetism, and thermodynamics were long accepted as the absolute truths that explained the nature of the universe. However, despite the consistent success of this classical model, as the 20th century approached, some experimental observations revealed serious inconsistencies that the classical theory could not explain.[20] This fact indicated the need for fundamental changes in the foundations of physics. One of the most important problems was absolute blackbody radiation. The application of classical physics here led to infinite energy - the "ultra-violet catastrophe".[21] In addition, the application of the laws of classical physics to other micro-events also yielded disappointing results. To resolve this paradox, the German physicist Max Planck proposed in 1900 that energy is not transported continuously, but in discrete packets - "quanta" [22]. This approach was the first theoretical attempt to break the boundaries of classical determinism. All these facts indicated the need for the emergence of a new physics - quantum physics, which qualitatively explains micro-events.

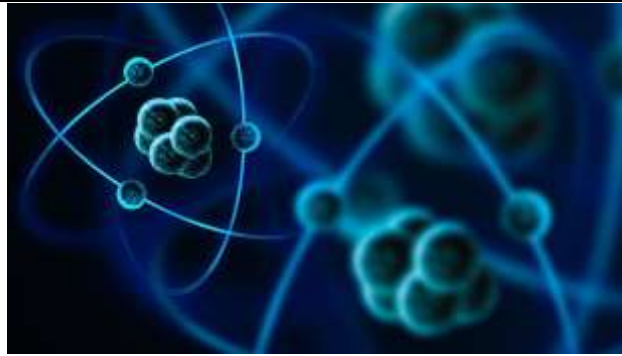


Figure 2. The quantum world.

It is clear that the laws of motion of micro-objects are completely different from those of macro-objects[23]. The characteristics of quantum physics have led scientists to disagree on the subject of creation and the existence of God[24]. Max Planck, considered the founder of quantum physics, put forward the idea that "every serious scientist encounters God when he opens the door to science." [25] The German physicist A. Einstein associated the immutability and mathematical beauty of physical laws with the "intelligence" of God. His famous statement "God does not play dice" was a manifestation of an idea that strongly defended the divine origin of order and determinism in the Universe.[26] The laws of the universe are so precisely tuned for life that it seems to have been created by a mind. According to A. Einstein, the universe emerged "from nothing," and the harmony of its laws and the existence of God can be explained simultaneously by the "God equation"[27]. Werner Heisenberg, the founder of the uncertainty principle, the most problematic topic

of quantum mechanics, said this about it: "The first sip you take from the glass of natural science will make you an atheist, but at the bottom of the glass the creator is waiting for you." [28] Quantum mechanics shows that reality is often shaped by the participation of subjective consciousness. [29] Reality is shaped by observation, but observation itself is a physical phenomenon—which increases the role of "consciousness." It should be noted that the implications of quantum physics cannot be fully understood without philosophy.[30] We see that some people think that the existence of quantum mechanics does not pose a problem for the existence of God. As many new concepts emerged in quantum mechanics and theoretical physics during this period, some scientists have tended to exclude the concept of God from scientific explanations. The English astrophysicist Steven Hawking argues that the Universe originated from a finite but infinite beginning—the "Big Bang."

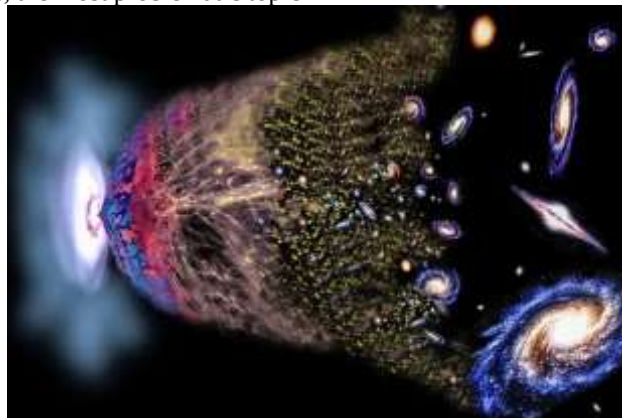


Figure 3. Illustration of the Big Bang.

This is a topic that is not classical physics, but rather a field where quantum gravity theory comes into play[31]. According to Hawking, the Universe spontaneously emerged from nothingness, from a pure quantum state. In the beginning, time did not exist in the classical sense, only quantum fluctuations existed. The very nature of the laws of physics allows for the spontaneous emergence of the Universe[32]. The Universe can and should be created from nothing. No "hand of God" or external cause is needed. This fact comes from within the laws of physics[32]. That is, creation can arise from within the laws of physics without a divine external force. However, Hawking also emphasized the fact that the cosmological constants seem to be finely

tuned for the development of life[33]. Hawking based his argument on this fact and proposed the possibility of a unified theory. S. Hawking explains that this theory must be compatible with both general relativity and quantum mechanics, and must explain every aspect of the Universe. However, the existing equations do not fit together. If such a theory is found, it will be like "reading the mind of God"[34]. In the event of a unified theory being found, it will explain everything from the beginning to the end of the Universe. What we know about reality is only possible through observation and theoretical models. S. Hawking emphasized the importance of string theory in this direction[32]. Austrian-American physicist Frotjof Capra wants to show that

the structure discovered by physics and the description of the Universe understood by Eastern philosophy through mystical experience have the same roots - which shows that the "God equation" must be both mathematical and consciousness-oriented[35]. In mystical approaches, a new convergence point of science emerges - consciousness, mathematics and the structure of the Universe are not separate from each other. Everything is interconnected[36]. If mathematics is so powerful, perhaps the Universe itself is a mathematical object[37]. According to F. Capra, understanding the Universe is possible not only through technical mathematics, but also through deep experience of consciousness[38]. This approach shows the importance of building the "God equation" on both scientific and philosophical-mystical foundations. As a result, F. Capra's approach shows that the "God equation" is not just a mathematical formula, but also a unified view of the meaning of existence. The "God equation" is not just a mathematical combination of all forces, but also a deep and holistic understanding of the essence of existence and the Universe[39]. American theoretical physicist Brian Greene explains that the two pillars of current physics - general relativity and quantum mechanics - one explains gravity, the other the microworld, but these theories contradict each other[40]. B. Greene shows that the strongest candidate for solving this problem is superstring theory. The "Big Bang" is not just the starting point, but may have been created by the transition of vacuums in string theory. Creation occurs by vacuum transition in a multidimensional space[41]. B. Greene states that strings can operate not only in 3+1-dimensional space, but also in 10 and 11 dimensions. These spaces are very twisted and therefore cannot be observed[42]. If each particle is not a point, but in the form of a small vibrating string, then both quantum theory and gravity can be explained by the same mechanism. According to B. Greene, superstring theory provides a unified framework that can unify all the forces of the Universe[41]. All the diversity of the Universe may be hidden in a single symbolism[43]. Based on this approach, this equation, which could be called the "God equation," can be used to explain both microscopic quantum phenomena and macroscopic gravitational laws. The main idea of the American physicist Edward Witten, one of the founders of string theory, is that fundamental particles are not point-like objects, but very small one-dimensional 'strings'. When these strings vibrate in different modes, the particles we are familiar with appear[44]. E. Witten also notes that string theory has the ability to unify many different physical phenomena into a single framework. This makes it possible to think of it as a "theory of everything".[45] In 1995, E. Witten proposed the idea that "the five different superstring theories that actually exist are five different limit states of 'M-theory'". M-theory is formulated within an 11-dimensional space-time[46]. E. Witten finally says that M-theory may be a more fundamental structure that complements string theory[46]. The gravitational field appears naturally in string theory. This is its advantage over other models[47]. In this respect, the strongest aspect of string theory is that it automatically

includes "quantum gravity" - that is, the graviton naturally appears within this theory[45]. Quantum gravity is a field that seeks an answer to one of the biggest problems in physics - the problem of unifying gravity and quantum mechanics. The goal of this field is to unify classical gravity, described by A. Einstein's general theory of relativity, and the microworld governed by quantum field theory under a single theory[48]. These two theories cannot be combined. Quantum gravity has set itself the most difficult and highest goal of science, to unify all the laws of nature in a single framework. One of these approaches, string theory, quantizes not only matter but also gravity and claims that all existence is expressed through mathematical strings[44]. Such an approach is seen as the closest scientific model to the idea of the "God equation". Because here the laws are not just physical descriptions, but also emerge as a deep, harmonious and purposeful structure. On the other hand, scientists suggest that quantum field theory also has the potential to become a "theory of everything"[49]. Quantum field theory is an important framework that plays a fundamental role in modern theoretical physics, unifying quantum mechanics and special relativity. The emergence of this theory arose from the insurmountable necessity of the limitations that classical field theories and quantum mechanics separately faced[50]. Quantum field theory is one of the cornerstones of modern physics, and its complete understanding and completion, in terms of its importance, could pave the way for a major scientific breakthrough, both theoretically and practically[51]. In the 1970s, all of these field theories were unified to form the modern "Standard Model." This model is the result of the quantum field revolution that began in the mid-20th century and is still the most accurate theory of nature.[52] The Standard Model is based on the 12 particle fields that exist in nature, called fermion fields. Fermions represent the fundamental matter components of nature, and in quantum field theory, each is described as a field that waves in a different way.[53].

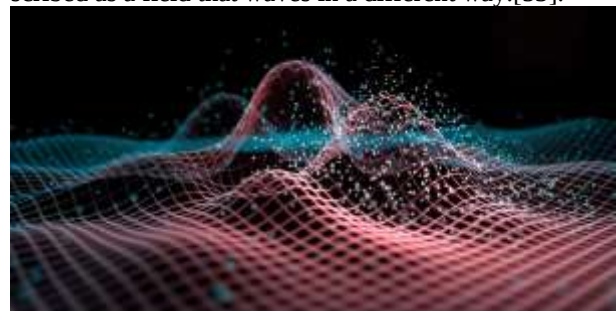


Figure 4. Fluctuation of quantum fields.

For example, the electron particle is created as a result of the quantization of the electron field, and quarks are created as a result of the quantization of quark fields. In addition to the 12 fermion fields, there are also 12 force-carrying particle fields (if gravity is not taken into account)[54]. Over time, this theory has ceased to be just a theoretical model and has become the central pillar of modern physics[55]. As can be seen, at this time, scientists tried to understand physical phenomena only with the help of laws. Nevertheless, Paul Davies, Leonard Sussking, Roger Penrose and

other prominent physicists did not hesitate to think that the mathematical harmony and laws in the Universe had a "goal at its center".[56] In their opinion, such a deep order and consistency cannot be explained only by "physical coincidence". On the contrary, this order bears the imprint of an intelligent creator, that is, God.[57] In order to determine the reasons behind this idea, the essence of these reasons must first be examined in detail. Here, two different perspectives will become clear. The English-born American theoretical physicist Freeman Dyson notes that I feel that God is present somewhere in the Universe, as if God did not just create it and withdraw, but rather works within the Universe and us[58]. In this idea, F. Dyson imagines God not as a force that intervenes from time to time, but as an intelligence that lives in the structure of the Universe. F. Dyson is one of the first scientists to put forward the idea that the Universe is regulated in accordance with the emergence of life and the development of consciousness. According to F. Dyson, the Universe seems to be waiting for our future[59]. However, F. Dyson had a different opinion about the "God equation". F. Dyson believed that physics and mathematics had not yet fully explained the fundamental principle of the Universe. F. Dyson wrote while thinking about the "Final Theory": "Physics has not reached its limits. We have not yet understood much. The Universe does not yet allow us to fully understand it"[58]. It should be noted that human intelligence ultimately owes its existence either to mindless matter or to a creator. It is really ridiculous that some people attribute their choice of the first option to their intelligence instead of the second option[60]. According to American theoretical physicist Sean Carroll, God is not a scientific theory, but a model that can be tested experimentally or expressed mathematically.[61] S. Carroll therefore does not accept the idea of a "God equation". S. Carroll notes: "I believe that a theory that explains all physical phenomena is possible, but this theory would not need God"[61]. One of the supporters of another type of view is the English physicist Paul Davies. P. Davies states that the problem of God is not just a theological one, but also a physical and philosophical problem.[62] Davies also emphasizes that scientific laws can explain how the Universe works, but the question of why the Universe exists cannot be answered by science alone.[63] Science encourages us to think objectively, moving us away from emotional, attractive, but unproven ideas.[64] Davies's own opinion is in the form of "For me, there is strong evidence to believe that there is something behind this. It seems that someone has tuned the cosmic constants in a sensitive way to create the Universe. The evidence for the traces of creation is very strong." [65] Davies is talking about sensitive tuning here, that is, the parameters of the Universe are at values such that the Universe exists. P. Davies, who thinks that there is such precision, states in his opinion about the final theory: there may be an equation, a source, that unifies all the laws of physics.[65] This point symbolizes the approach to the "God equation".

If the "God equation" exists, this equation should not only explain the material world, but also justify where the laws come from, their values and symmetries[66]. P. Davies notes here that the "God equation" is related not only to mathematics, but also to philosophy. If there is a final equation, it can be a consequence not only of nature, but also of consciousness and purpose. P. Davies says that consciousness is not just a product of matter, but perhaps the initial structure of the Universe itself[67]. This idea is very important: if the mind comes before matter, then the "God equation" can be both a mathematical and a mental structure. The goal of the Japanese-American physicist Michio Kaku is precisely to unite all fundamental forces in one equation. Such an equation (God equation) can explain both the beginning of creation and the nature of the entire Universe[68]. M. Kaku believes that this equation is inherent in M-theory and that we are very close to it.[69] M. Kaku notes that if the "God equation" is found, this equation can also model the state before the "Big Bang".[68] M. Kaku says that M-theory may be the only theory that attempts to explain the physical cause of the Big Bang.[69] M. Kaku agrees with Edward Witten that the five versions of string theory are actually different perspectives of M-theory.[69] The final equation can explain the origin, evolution, and end of the Universe. The "unified equation" should describe the laws of vibration underlying the Universe. Since superstrings are a vibrational model, it can be written:

God equation = vibrational code of the Universe (1)

The "God equation" is a mathematical model of vibrations.[70] This expression is similar to the mathematical formulation of the Serbian scientist Nikola Tesla's statement, "If you want to know the secret of the universe, look at the relationship between energy and frequency." [71] This equation, which contains the unified code of time, space and matter, may constitute the scientific basis of creation. The English physicist Roger Penrose is one of the scientists who has approached the concept of the "God equation" very cautiously and critically. Although R. Penrose admits that this concept is very attractive from a scientific point of view, he opposes its naive presentation.[72] R. Penrose notes that many believe that a "Unified Theory" will be found that unifies all the laws of the Universe. However, this can often turn into an overly simplified and even metaphysical belief. [73] There are serious inconsistencies between the physics we have today, especially quantum mechanics, and the theory of general relativity, and their unification is not so simple. [74] It is clear that R. Penrose believes that a deeper and broader approach is needed that explains the Universe, consciousness, and the interrelationships of the Universe. In his opinion, we are not yet close to this equation, because the Universe has a more complex and surprising structure than we think.[73] R. Penrose believes that the creation of the Universe is not random, but follows a deeply planned order. The very precise arrangement of the Universe at the beginning was carried out with the following numerical precision:



This number is the probability of the entropy at the beginning of the Big Bang, according to R. Penrose's calculations. That is, the Universe had to be so finely tuned for it to start in such a low entropy state[75]. Entropy itself is the parameter that determines the fate of the Universe[76]. This fact is a purely super-random situation. This number strongly supports the phenomenon of "fine tuning". That is, the laws of nature, constants and initial conditions are so finely tuned that if these values were to change even slightly: no matter would be created, no galaxies would form, and no life would exist.[75]. This approach is considered by many test scientists and philosophers to be a sign of God's creative intervention. It is practically impossible for such precise initial conditions to arise by pure chance or statistical probability.[77] As R. Penrose has said, it seems that the creator has determined how precisely his goal is.[78] American theoretical physicist Leonard Sussking notes that the cosmological constant $1/10^{120}$ It is perfectly arranged, like this. Put 120 times 10 side by side and multiply them together. No one can claim that this is a coincidence.[79] To confirm the truth of all these ideas, it is necessary to touch on the nature of the problematic phenomena. If there is a design, we must look for traces of this design in the laws of physics.[80] Even the language of physics itself leads us to question the existence of God.[81] Since the most naturally observed objects are macroobjects, let us first examine the problematic points between macroevents. It should be noted first that

$$3\text{-dimensional space} \neq \text{Universe} \quad (3)$$

3-dimensional space is the field in which material structures are located. The Universe is a dynamic system expanding within this space. 3-dimensional space is more fundamental, stable and universal in nature, while the Universe is a local field within it[82]. All these living conditions show that these concepts are interconnected, that is, spaces and the Universe can be manifestations of the same basic form of energy in different directions. This energy is called "Basic energy" or "Unit energy". "Unit energy" is a single, indivisible and all-causing energy that underlies the creation of the Universe, the formation of structures (spaces) and the influence exerted by higher-dimensional spaces on lower-dimensional entities[83]. This energy:

- Creates spaces (forms structure);
- Formulates laws;
- Creates matter and fields;
- And ultimately, it creates us, the observable and the unknowable reality.

Since the distribution of a unit energy is different according to the dimensions of the spaces, each space has its own properties and, as a result, its own quantities that characterize them[84]. For example, in 2-dimensional space, each object has an area and a velocity. In 3-dimensional space, the object has the property of mass and the associated density and volume[85]. Therefore, if an object moves from 2-dimensional space to 3-dimensional space, the object will acquire new properties such as mass, density, and volume. However, human perception can only perceive 2- and 3-dimensional spaces. Continuing with the logic shown, we can conclude that if an object moves from 3-dimensional space to 4-dimensional space, it will acquire an additional property and two more properties associated with it, that is, it will be characterized by 3 new parameters (α, β, γ).

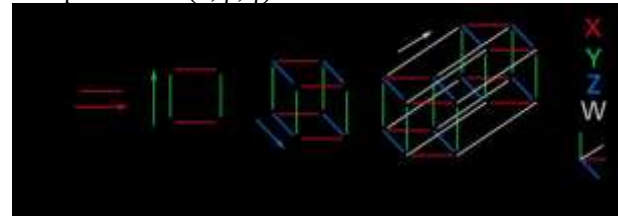


Figure 5. Formation of spatial dimensions.

Similarly, if an object moves from 4-dimensional space to 5-dimensional space, it will gain three new properties (ϕ, ξ, ψ). It is clear that if an object moves directly from 3-dimensional space to 5-dimensional space, it will gain 6 new properties ($\alpha, \beta, \gamma, \phi, \xi, \psi$). Each of the spaces is formed by an infinite number of orderings of the previous spaces in a new direction[86]. It is clear that 3-dimensional space is formed by ordering 2-dimensional spaces in new directions, and 4-dimensional space in turn is formed by ordering 3-dimensional spaces in new directions. However, since we cannot imagine this new direction, we cannot fully comprehend 4-dimensional space. Our space is just one of the spaces located within 4-dimensional space, just like one of the galaxies located in the Universe. Here another issue arises. If the dimensions and properties of the spaces differ from each other, then we can come to the idea that the spaces could have been formed at different times. That is, higher-dimensional spaces could have been formed before our space. In fact, based on the above inequality, it can be said that 3-dimensional space was formed before the Universe we live in. The problem of how many Universes can be located within 3-dimensional space leads scientists to the idea of "Parallel Universes Theory". The theory of parallel universes was proposed by American physicist Hugh Everett in 1957.[87] The theory of parallel universes proposes that the universe is not a single system, but rather that many different, independent, and sometimes different universes with different physical laws may exist.[88]

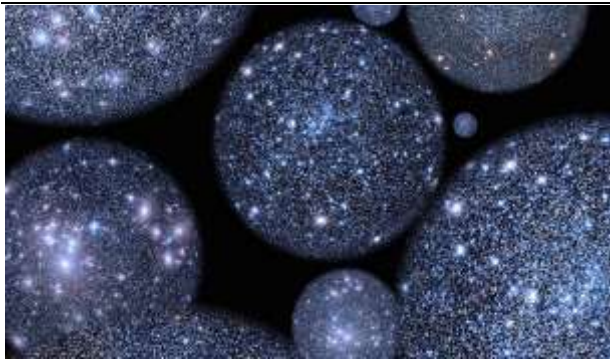


Figure 6. Illustration of Parallel Universes.

This theory has emerged in different fields with different motivations. M-theory proposes that our Universe may be one of many Universes. Each Universe may have its own laws and constants[69]. The theory of parallel Universes was originally proposed to explain the uncertainties in quantum measurements and the paradox of the "wave function collapse".[87] Now, let's look at the dynamic part. Today, the idea that the Universe was formed as a result of the "Big Bang" is based on a huge amount of experimental evidence and there is no new evidence that this idea is wrong[89]. The Universe we live in emerged from a single point as a result of the Big Bang. The Big Bang is not only the beginning, but also the point of origin of the energy and matter of the Universe[90]. For many years, scientists assumed that the Universe was static. However, as technology developed, this idea was proven wrong. In 1929, the American astronomer Edwin Hubble, through observations at the Mount Wilson Observatory in California, determined that distant galaxies in the sky showed a redshift[91]. This indicates that galaxies that do not redshift have their light pulled to longer wavelengths, as if they were moving away from us. This phenomenon is explained by the Doppler effect. As a result, E. Hubble showed that the farther away galaxies are from us, the faster they are moving away[92]. This meant that the Universe is expanding. E. Hubble was able to prove Lemaitre and Einstein, who had theoretically proposed the idea of the expansion of the Universe, right[93]. For the universe to expand, energy must be given to it. A portion of the same energy was given to our universe, causing it to expand. If we consider that the universe expanded from a single point, then it can be said that matter and the physical field, which are manifestations of matter, must have the same source at the smallest level. Whatever creates matter is not matter[94]. The source in question must be the smallest unit in the universe. The concept of the smallest unit is variable[95]. As the universe expanded and increased its volume, different forms of matter and the physical field emerged. It is clear that the fact that the Unified Energy creates so much diversity in the Universe leads to the interaction of different particles and fields with each other. Quantum field theory, by unifying this diversity, says that in fact there is no such thing as a particle in the Universe[96]. For centuries, scientists have wanted to build a theory that explains the behavior of all these particles and fields. The behavior of particles is determined by their internal structure and the field in which they carry their energy[97]. In the

above topics, we have seen that there are many models that come close to this theory. However, the gravitational field cannot be fully explained by these models[98]. Gravity is explained by the general theory of relativity, and this theory is based on curvatures in space and time[99]. That is, gravity is the result of the influence of matter and energy on space. Gravitational attraction is not just a force, but a fundamental mechanism that determines the very structure of time and space itself[100]. This fact makes it difficult to quantify the classical and gravitational fields. Quantum field theory operates in a fixed space and treats all particles as field quanta. But in gravity, space itself is variable—a very big difference[101]. On the other hand, a spin-2 particle called the "graviton" has been theoretically proposed as the quantum equivalent of the gravitational field, but quantum field theory of gravity based on this particle cannot renormalize it[102]. This means that mathematical infinities cannot be eliminated, that is, the results become physically meaningless. If we look at A. Einstein's idea of gravity, we see that in fact the space-time fragment exists in a higher-dimensional space. That is, the larger the mass of an object, the larger the area it bends in the space-time fragment. Objects with a smaller mass revolve around this object[103]. Therefore, all objects and collections of objects with mass give rise to a bend in space. In this case, the number of bends becomes infinite, and an unimaginable picture emerges.

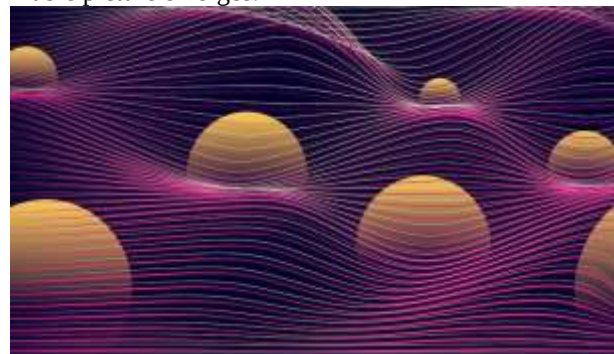


Figure 7. Objects bending the fabric of space-time.

If there are extra dimensions, their influence may be hidden in the weakness of gravity.[104] All these facts, and the close observation of the influence of the gravitational field, allow us to accept gravity as existing in the 4-dimensional space, which is the closest to us of the higher-dimensional spaces. However, the situation is quite the opposite in the equilibrium of galaxies. Studies have shown that for a galaxy to actually move, it must have a mass greater than the sum of the masses of the stars and other celestial bodies within the galaxy.[105] This is an unusual phenomenon. Since this matter cannot be observed and cannot be observed with modern technology, it is called "dark matter".[105] It is estimated that the baryonic matter (stars, gas, planets, etc.) within galaxies is about 10–20%, and the amount of dark matter is about 80–90%.[106] Therefore, in order for a galaxy to maintain its gravitational equilibrium, most of its mass is dark matter.

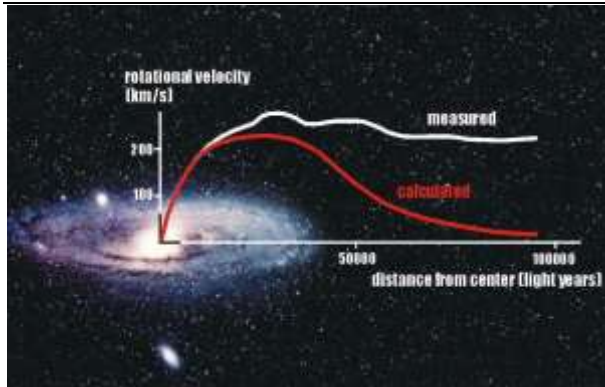


Figure 8. The effect of dark matter on the galaxy.

This fact has led scientists to conclude that only 5 percent of the universe is the part we understand. Dark energy, which forms dark matter, acts as a background energy that accelerates the expansion of galaxies, not galaxies.[107] Recently, some theoretical models have associated holoregions around black holes with high concentrations of dark matter. Gravitational waves in these regions are cited as indirect evidence for the existence of dark matter.[108] The most obvious place to observe the influence of dark matter is in the black holes at the centers of galaxies. The gravitational process for black holes is a problematic issue. At the same time, the first gravitational waves to be detected were also produced by the collision of black holes[109]. It is clear how much energy black holes carry. The sharp change in gravitational energy can be explained by a defect in the fabric of space-time. Dark matter is the main source of mass in galaxies and is directly related to black holes[103]. Therefore, black holes are not actually the remains of stars, but the skeleton of the Universe, its structural coding pillars.



Figure 9. Black hole.

Black hole systems can be scientifically called dark matter networks. Black holes are interconnected, and through this connection, objects with enormous masses in space remain in equilibrium, preventing the collapse of the Universe.

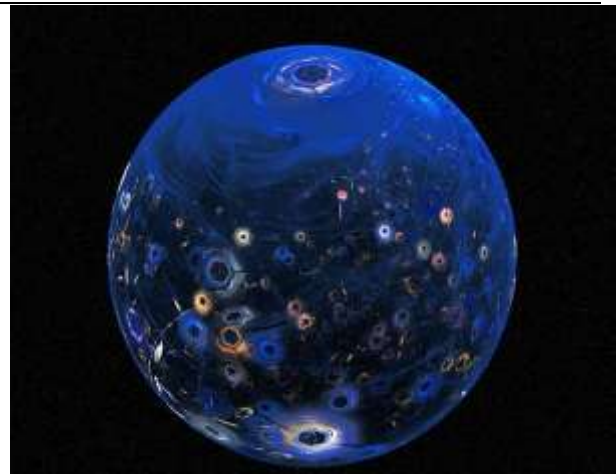


Figure 10. System of spatial defects in the universe.

Many theories have been put forward about how long the universe will continue to expand. The universe cannot be infinite. It is mathematically contradictory for an infinite object to not expand.[110] Of course, this finite system cannot always remain in equilibrium, and the end of the universe could occur. Many scientists believe that the end of the universe will be a final destruction, such as a big rift, freezing, or collapse.[111]



Figure 11. Large tear.

However, according to the theory of "Conformal cyclic cosmology" of R. Penrose, which we have already discussed, the end of the Universe will not be a big rift. As the Universe continues to expand, all matter will be destroyed by turning into photons[112]. It was unclear whether there was any order in the expansion of the Universe. In 2025, Willi Sun, a scientist at Harvard University, stated in an interview with "Tucker Carlson Network" that the expansion of the Universe continues in a stable mode. Sun says that this behavior of the Universe is not random. This fact suggests a pre-determined "architecture" - a unique focus on creating conditions favorable for life.[113] These findings support the idea that the emergence of intelligent life is not a mere coincidence, but a consequence of the physical laws and initial conditions of the Universe. When we examine all these facts, we can say how the Universe was created and governed by complex laws. It is possible to believe that if a "theory of everything" that explains the mentioned facts and the "God equation" that forms its basis are formed, all problems will disappear. Currently, the closest theories to a "theory of everything" are M-theory, superstring theory, and the quantum gravity model.[114] It should be noted that when the Universe and all the structures behind it are considered, M-theory is considered the closest theory to the

goal. We noted above that the primordial particle is the source of both the physical field and matter. The particles that meet these conditions are strings. However, there are various models of string theory[69]. It is a problematic question which of these models is correct. As we examine the properties of these models, we see that the properties of strings do not coincide with the properties of space. The current form of string theory is not specific enough. There are no testable results for reality yet[115]. Many models emphasize that strings are one-dimensional and massless. The point is that the idea that one-dimensional and massless one-dimensional particles create objects with mass and shape in the Universe located in 3-dimensional space, as well as a one-dimensional form of vibration, is an approach that has no mathematical basis and is not logically acceptable.



Figure 12.

Model of strings vibrating at different frequencies.

If an object exists in any space, it and its constituent particles must correspond to the properties of that space[116]. Unless these conditions are met, we accept that the object does not correspond to this space. On the other hand, most sources state that the ratio of the size of a string to an atom is similar to the ratio of an atom to the entire solar system[117]. This ratio is usually in the sense of size. This ratio can be indirectly related to mass and a suitable result is obtained. Some researchers consider it essential that one-dimensional strings be massless and consider this model contradictory. However, the presented 3-dimensional string model resolves these contradictions with a real space structure. Finally, the description of a particle by a string is a contradictory issue in terms of both energy exchange and particle-field relations[118]. As it turns out, a new model of string theory must be created that eliminates all these contradictions. That is, in this model, M-theory must be fully formed by imposing realistic conditions on the strings.

Structure of the problem It is clear that a model that can be a "theory of everything" must be able to gather all fields of physics around a single source. When trying to bring together the above-mentioned facts, a number of problematic issues arise. These problems occur when examining the characteristics of all

phenomena. The following questions should be clarified with the new model we have given: are all high-dimensional spaces part of our Universe or did our Universe arise after structures? Are there parallel Universes and how are they located in the spatial structure? What is the relationship between the unified energy and the spatial structures and the Universe? Is there a connection between the gravitational field and dark matter and what is its essence composed of in reality? If the Universe expands, does its total energy increase? What properties should strings, the smallest particles in the Universe, have? Which of the string theory models of the formation of M theory should be accepted as correct? What does the "God equation" actually express and what parameters should be included in it? Finally, in what form will the end of the Universe occur? etc., important questions need to be answered.

Solution to the problem: To overcome all the problems that arise, it is necessary to explain the intricacies of the given model. Brain cosmology shows that our Universe is part of a multidimensional structure[119]. All the spaces, the exact number of which we do not know, were formed by the "Unit Energy". We simply continue our lives in the 3-dimensional space. This Universe we live in was created by the "Big Bang" and continues to expand in the 3-dimensional space. As a result, most galaxies are moving away from each other[92]. Since the objects we see exist in 3-dimensional space, they have the properties of 3-dimensional space. Every object that exists in 3-dimensional space has a shape, size and other properties. The reason for the expansion of space is the supply of energy to the Universe in a certain stable mode. This model can be likened to a balloon with dots on it and a certain amount of air inside it in a square room. As the balloon is blown with air (given energy), it begins to inflate and its volume expands within the room (the Universe expands). As the balloon grows, the dots on it move apart (galaxies move away from each other). After a certain value, the balloon either bursts (a big rupture), or the balloon empties itself (collapses) as the air flow stops. Although this is a very simplified model, it is very similar to the dynamics of our Universe. As it can be seen, high-dimensional spaces should actually be considered extremely large, not very small. For the process in the example to occur, the room must have existed before the balloon. That is, structures that existed before the Universe we live in may have existed. Other parallel Universes could be like balloons expanding independently of each other inside this room. The reason the balloon inflated was because air (energy) was given to it. As our Universe expanded, the energy of the void increased, and since the void actually consists of energy, the energy of our Universe increased. Since 3-dimensional space is inside 4-dimensional space, this space has a specific energy value that affects our Universe. When we look at the properties of dark matter, we see that it does not meet the conditions of 3-dimensional space. This matter could be an object that exists in a higher space and exerts its influence on our Universe. Since matter is a form of matter that exists only in 3-dimensional space, we can say that dark matter is not actually matter at all, but a more complex structure.

The structure in question could be the material of a piece of space-time. This material could be the layer of influence that surrounds the ball in the example room on all sides. The initial particle of our universe must obey the properties of 3-dimensional space and form both matter and the physical field. The most suitable particles that meet these conditions are strings - vibrating energy threads. The vibration of strings in different patterns creates the variety in the Universe. [120] This vibration causes displacement in space. Since it has no movement, it must be constantly given energy (actuated). [121] This energy is both the energy that expands the Universe and the energy of the action of 4-dimensional space. As we move towards higher-dimensional spaces, our 3-dimensional space shrinks to an inconsiderable size. In this respect, the influence of high-dimensional spaces is extremely small. The strings described in this model are not one-dimensional, contrary to what is said, but rather a 3-dimensional energy wire with shape, mass, and frequency. This result gives the properties of 3-dimensional space and its mathematical description. Since the strings are elementary particles, their dimensions should be almost the same, and since the described shape of the string is taken into account, its mass is approximately $1,42 \times 10^{-84}$ kg should be [122]. The model, built on the basis of this given mass value, allows us to determine not only the structure of the particles, but also the distribution of energy throughout space. When the masses of particles and strings are taken into account, for example, the electron has approximately $6,4 \times 10^{53}$. It is clear that there are a number of strings [122]. If we look at the system containing particles in this arrangement from a higher-dimensional space, the system will be simplified. The strings are distributed in different numbers in different parts of space under the influence of high-energy spaces, and then a difference in distance between them appears. As a result, particles with more strings in one part of space are formed, and a field with more strings in another part is formed [123]. Strings with similar vibrational patterns are collected and create the appropriate particle. Since all of these particles are related to each other, it is as if there are quantum fields corresponding to the particles in space, and these particles are also related to each other through strings [123]. Every point in the universe carries all the information of the whole [124]. This picture also creates what we call a space lattice. Thus, we see that in reality, the void is composed of strings, and the energy of the void is not zero [123]. Since the string has mass, we understand that in reality everything has mass. The proof that the strings are characterized by specific parameters is related to the existence of constants in the Universe. At this point, we see that A. Einstein's $E=mc^2$ expression is satisfied. A. Einstein's $E=mc^2$ equation showed that matter and energy are different manifestations of the same essence, that is, everything that has energy also has mass [125]. We feel the effect of the gravitational field, which affects the strings and everything in general, only at a certain energy level, and this effect increases as the mass of the object increases. Since the gravitational effect is constant, the effect on the movement of micro and macro objects is different due to the

difference in mass. Since the interaction energy between micro particles corresponds to the gravitational energy, the power of gravity over the particle does not play a dominant role, and many strange phenomena and uncertainties arise in the microworld. Defects in the space of strings cause this effect energy to be felt more sharply. These defects exhibit a number of behaviors that differ from the laws of 3-dimensional space. Since the processing of a material is mainly by external influence, for there to be so many differences in a Universe consisting of just strings, this influence needs to be done from different directions, and these defects are actually important. When we look at space, we observe a number of different properties in black holes that we are not used to. From this point of view, we can conclude that black holes are spatial defects and play the role of the skeleton of the Universe. The energy given to our Universe causes the strings to vibrate. This amount of flowing energy, in turn, shapes time. The structure of time can be twisted, and time loops are possible in real physics. [126] Since the smallest movement expresses the smallest time, we come to the issue of quantization of time. This form of quantization of time forms the concepts called quantum time, and the quantization of gravity forms the concepts called quantum gravity. As the universe continues to expand, the number of defects within it will begin to increase, and after a certain critical point, this external impact energy will overcome our space energy and destroy it. Every idea regarding the disappearance of the universe can be explained in this model. It should be noted that in high-dimensional spaces, new physical parameters and phenomena expressed by them occur that we could never even imagine. Since human perception is limited to only 3-dimensional space, we get correct results for this space with our mathematical calculations. Since new directions appear in higher spaces, our mathematics will be insufficient to explain these 4-dimensional figures, phenomena and living beings. Although many of us mathematicians try to explain high-dimensional spaces mathematically, it cannot be said that these calculations are completely correct. Because, high-dimensional spaces are trying to explain with 3-dimensional mathematics. M-theory suggests that the Universe is 11-dimensional, but it is very difficult to prove this accurately. We said above that each space has its own additional 3 new parameters by logical calculation. From this point of view, each object in the 11-dimensional phase will have 24 new properties. Therefore, it is necessary to complete the "theory of everything" that we want to be sure of. It is enough to build a theory that includes the entire 3-dimensional space and the constant energy of the 4th space from the 11-dimensional spaces of M-theory. One of the measured things here is not time. When we look at the properties of spatial dimensions, we can say that time does not belong to them. Time is the observed sequence of changes and sequences that occur as a result of the transfer of a single energy to 3-dimensional space [127]. Since any event in our universe is described, these events need to be explained qualitatively and quantitatively. The "God equation" should not include all quantities, but only relate the most important factors for the existence of these

quantities, constants, and phenomena. The concept of the "God equation" here acts as a symbol of infinite harmony and conscious design, which are the basis of both material and spiritual existence[68]. It becomes clear that the basic energies that we can understand in these two spaces are the current energy of our Universe, the energy that expands the Universe, and the energy of gravitational influence. The "God equation" should be an equation consisting of these energies, and the nature of other phenomena should be investigated on its basis. It is also necessary to touch upon the essence of some important quantities (entropy, temperature, etc.) with the given model.

Result: The model given for the "Theory of Everything", whose truth we can be sure of, has provided answers to many problematic issues. If we accept the Universe as a structure that contains all spaces, we understand only a very small part of this Universe. What is important for us is the Universe we live in. This Universe is a structure that was created by the big bang and is expanding within 3-dimensional space. We can say that it is possible to describe and qualitatively explain all phenomena by taking into account the unique characteristics of 3-dimensional space. The initial particle that is created has specific characteristics. Given the limited mathematical understanding, it is necessary to work considering 3-dimensional space and the effect of 4-dimensional space on energy. The science related to the explanation of micro-events is at a very low level. Based on the model given above to solve the problem, the equation close to the "God equation" is as follows:

$$E = E_{3d} + E_{4dT} + E_{5dT} + \dots \quad (4)$$

here, all the energy of our E-Universe, E_{3d} - The energy in which the 3-dimensional part of the universe exists, E_{4dT} - The impact energy of 4-dimensional space on the universe, E_{5dT} -The universe is influenced by the energy of 5-dimensional space.

We can ignore the effects of 5-dimensional spaces and higher, then

$$E = E_{3d} + E_{4dT} \quad (5)$$

Since 3-dimensional space consists entirely of strings, expression (5) will be as follows:

$$E = N \times E_{sim} + N \times E_{sim,t} = N(E_{sim} + E_{sim,t}) = 7 \times 10^{136} (E_{sim} + E_{sim,t}) \quad (6)$$

where N is the number of strings in the universe ($N = 7 \times 10^{136}$; [122]), E_{sim} is the energy of a string, and $E_{sim,t}$ is the gravitational energy acting on a string.

The expressions in brackets must be discovered in later stages and the discrete increase of N must be taken into account. When we insert the values of the given quantities into this expression, which at first glance seems very simple, and we derive all the expressions from it. It will become clear how all the diversity of the Universe arises from such simplicity. In fact, we see that the gravitational field is not a fundamental interaction at all. In order to prove that the model we have given is correct, all phenomena in the Universe must be perfectly explained by this model, that is, by placing conditions on the strings. All objects, from elementary particles to macroobjects, must be described correctly[128]. A new string model that satisfies the given conditions must be created. All mathematical expressions and physical constants must be taken from the

"God equation". In this form, the model given can be proven to be correct. It should be noted that it is logically impossible to say with such great precision that the great grandeur of the Universe and its diversity arose by chance, simply in unconscious energy threads. It would be illogical to say that creation in this form was accidental. It seems that someone behind the Universe and superior to itself built the Universe in a way that is suitable for life. The universe is created in a way that is precise and perfect to the point of being expressed in a theory, but complex to the point that we cannot understand it. The creation of the universe to such a perfect degree means that it actually has an important essence. We accept that everything was created starting from a point, then we must accept that all sciences study the properties of this Universe. We explain how the Universe works with the laws of physics, but physics does not answer the question of why it was created. In this case, it is necessary to turn to another science (religion). God, who created the universe to such a perfect degree, has definitely stated why He created it and what our duty is, and learning this information from God is the most correct approach.

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INTERCALATION OF GRAPHITE WITH MICROCLUSTER WATER IN ULTRASONIC AND MAGNETIC FIELD

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Abstract

The article presents an experimental and theoretical study of natural graphite exfoliation by microcluster water in the presence of ultrasound and a stationary magnetic field. Theoretically, ultrasonic exfoliation of graphite is considered as a Stefan problem for a finite cylinder. It is shown that graphite intercalation will increase in the system "liquid-graphite" with an increase in the ultrasound power and surface tension of the liquid. It is shown that water has the highest surface tension (except mercury) and surpasses all liquids in ultrasonic splitting of graphite in order to obtain graphene plates from it. The effect of ultrasound on graphite splitting is far from complete. Particular attention should be paid to the theory of cavitation and its nonlinearity. It is shown that any effect on water (chemical impurities, ultrasound, magnetic field, etc.) leading to an increase in the surface tension of water will contribute to the exfoliation of graphite. It is shown that the energy of graphite deformation under external influence (ultrasound, friction, magnetic field, etc.) is spent on heat, acoustic emission, autoelectronic emission and fractoluminescence. Due to the law of conservation of energy, the energy of deformation should be comparable with the energy of ultrasound, leading to the stratification of graphite with the formation of grapheme.

Keywords: graphite, graphene, intercalation, ultrasound, magnetic field, delamination, deformation, surface layer

Introduction

Layered graphite crystals were exfoliated mechanically using adhesive tape in 2004 [1]. A single-layer graphite sheet was called graphene. However, it is impossible to use mechanically obtained graphene on an industrial scale. Therefore, various methods for obtaining graphene have appeared, an overview of which is given in [2-5].

The purpose of this article is to study the production of graphene by intercalation of graphite with microcluster water in ultrasound and in a magnetic field using the RIMS complex.

Graphite intercalation in ultrasound (brief overview)

Let us turn to the latest works. Thus, in [6], to prepare the initial mixture, precise weighed components were used: 1 mg of thermally expanded graphite (TEG), 14 mg of a 2% Nafion solution, 4 ml of a mixture of isopropanol + water (1:1) were added. The mixture was

subjected to ultrasonic treatment in a Branson 3510 ultrasonic bath at a power of ~ 180 W for ~ 180 min. After that, 2 drops (0.04 ml) were collected from the resulting suspension, 4 ml of an isopropanol + water mixture (1:1) were added, and ultrasonic dispersion was carried out for different durations. The results are shown in Fig. 1.

Fig. 1b shows the Raman spectrum of a dispersed material film obtained by spraying the dispersion with an airbrush onto a silicon wafer. Three most significant clear lines are visible in the Raman spectrum: D, G and 2D, as well as the D' line. The presence of an intense D line, as well as a D' line in the Raman spectrum, indicates a fairly high degree of defectiveness of the material. Data on the ratio of the integrated intensities of the D and G lines ($AD/AG = 2.1$) and the full width at half height of the G line ($FWHM(G) = 40 \text{ cm}^{-1}$) make it possible to estimate the concentration of one-dimensional (crystallite boundaries) and 0-dimensional (point) defects in graphene.

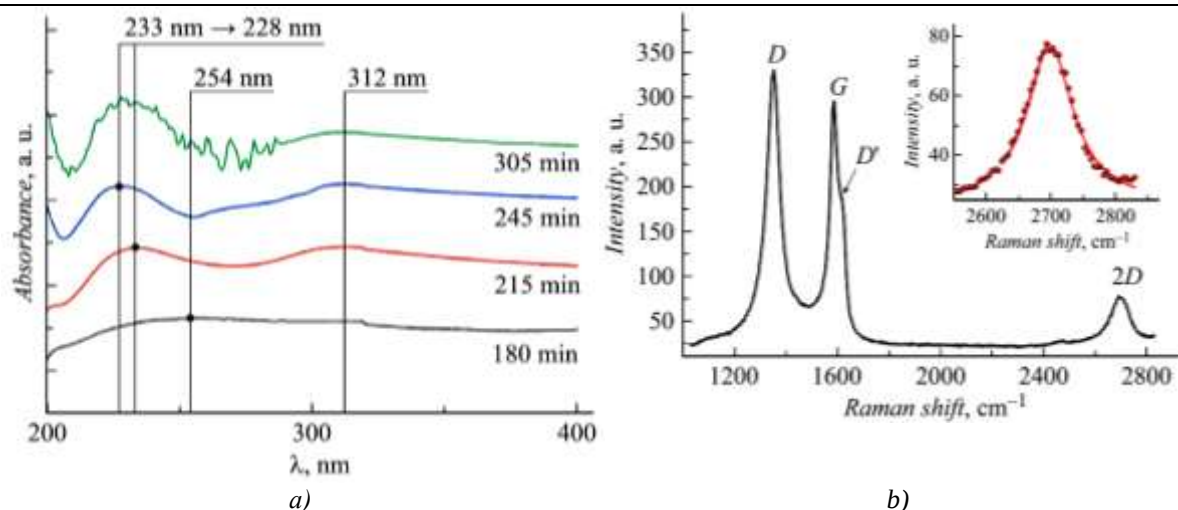


Figure 1. - UV spectra of the dispersion of TEG-Nafion in a mixture of isopropanol with water (1:1) during dispersion (a); Raman spectrum of the obtained graphene layer (b) [6].

The 2D line is well approximated by a single Lorentz function (insert in Fig. 1b), which is typical for graphene. At the same time, due to the presence of defects in its crystal lattice, the 2D line has a fairly large width (FWHM $\sim 90 \text{ cm}^{-1}$), which is typical for graphene with a thickness of about 2-3 monolayers.

In [7], mechanical stirring and ultrasonic (US) treatment are used to separate graphite electrode materials from copper foil during the recycling of spent lithium-ion batteries (LIB). Firstly, the effects of ultrasonic power (60~180W), ultrasonic time (1~8 min), stirring speed (420~2000 rpm) and stirring time (1~8 min) on the separation rate of the active material from the copper foil were studied. It was found that the separation rate of the electrode material in the ultrasonic treatment was 91.34% compared with that in the stirring treatment (84.22%). The removal of the electrode material from the copper foil during stirring was mainly realized by mechanical cleaning. In comparison, the generation of micro jets caused by ultrasound, local high-temperature and high-pressure environment, and free radicals during ultrasonic treatment are the key factors to further improve the removal efficiency of the electrode mate-

rial. The integrated ultrasonic mechanical stirrer technology can achieve highly efficient separation performance (approximately 100% peeling rate) of the anode electrode materials from the copper foil. The effects of mechanical stirring speed, temperature and treatment time on the peeling coefficients of the ultrasonic mechanical stirrer system were investigated. Finally, the results of XRF (X-ray fluorescence spectrometer), XRD (X-ray diffraction) and SEM-EDS (scanning electron microscopy coupled with energy dispersive X-ray spectroscopy) showed that the graphite electrode material after peeling was of high purity and contained almost no copper foil impurity. The numerical simulation analysis briefly showed that the difference between the pressure and ultrasonic temperature changes at the interface between different anode layers (graphite on copper foil in aqueous solution) was the main effective factor in significantly peeling off graphite from copper anode foil in ultrasonic peeling. The main effect of ultrasonic action on water is cavitation. Acoustic cavitation can cause both isotropic and anisotropic collapse of bubbles in water, resulting in shock waves and microjets (Fig. 2) [7].

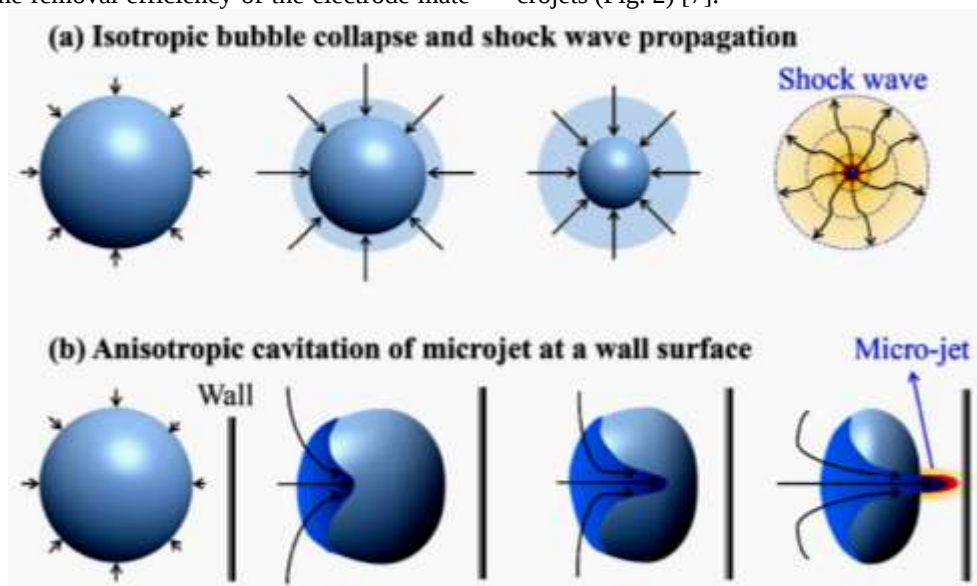


Figure 2.

Schematic diagram of a shock wave (a) and a microjet (b) formed during the collapse of a cavitation bubble [7].

Samples and research methods, RIMS complex

We used natural graphite of the GL-1 brand. Ultrasonic (US) dispersion of natural graphite in the liquid-graphite system was carried out in the Sapphire UZV-5.7 ultrasonic bath (Fig. 3).

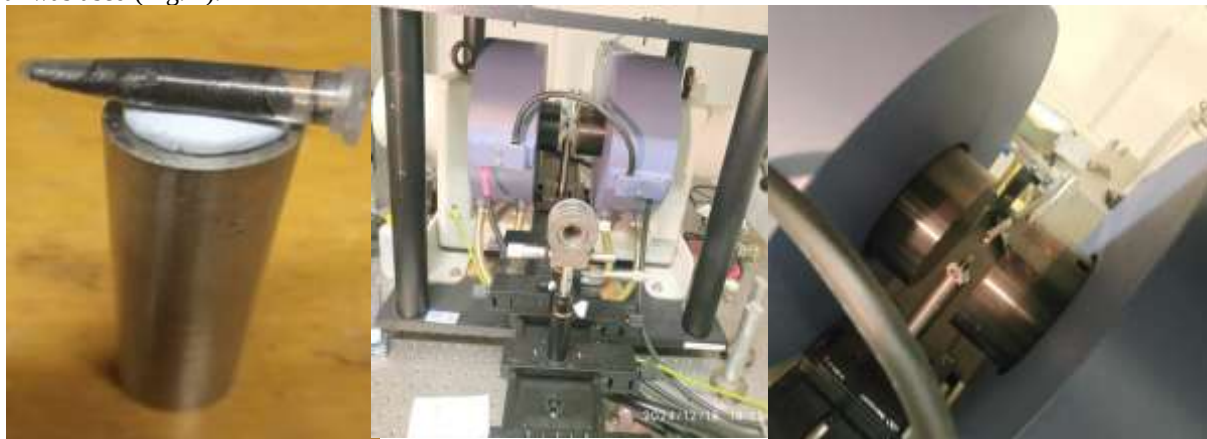


Technical characteristics of the ultrasonic bath Sapphire UZV-5.7

Volume	5.7 l
Operating frequency	35 kHz
Timer digital	1-99±1 min
Power consumption	280 W
Thermostat digital	15-65±1 °C
Heater power	130 W
Generator power	150 W
Supply voltage	220 V 50-60 Hz

Figure 3. – Ultrasonic bath “Sapphire UZV-5.7”

To conduct research in a magnetic field, a suspension obtained after ultrasonic dispersion in an ultrasonic bath was used (Fig. 4).



a) Figure 4. – Vessel with graphite suspension after MCW (a) magnet (b).

The morphology of the samples was studied by SEM on a JEOL. The accelerating voltage varied from 2 to 20 kV. The method allows one to study the morphology of films, particle sizes and film thickness. X-ray diffraction spectra (FTIR) were obtained on a Brucker D8 Discover (Fig. 5).



a) Figure 5. - Diffractometer (a); its working chamber (b)

Spectroscopic workstation with Raman spectroscopy, basic fluorescence spectroscopy, UV/VIS includes:

- TEC spectrometer cooled to $-40\text{ }^{\circ}\text{C}$: focal length 200-4000 cm $^{-1}$; focal length 250 mm, resolution from 1 to 3 cm $^{-1}$. Detector Raman channel (pre-equipped with 2D-detector)
- TEC spectrometer cooled to $-35\text{ }^{\circ}\text{C}$: focal length 200-1100 nm (focal length 120 mm), channel 2 for the RIUS part Detector: Linear CCD array, 3648 pixels Slit: Continuous variable.

Photo of the device is shown in Fig. 6.

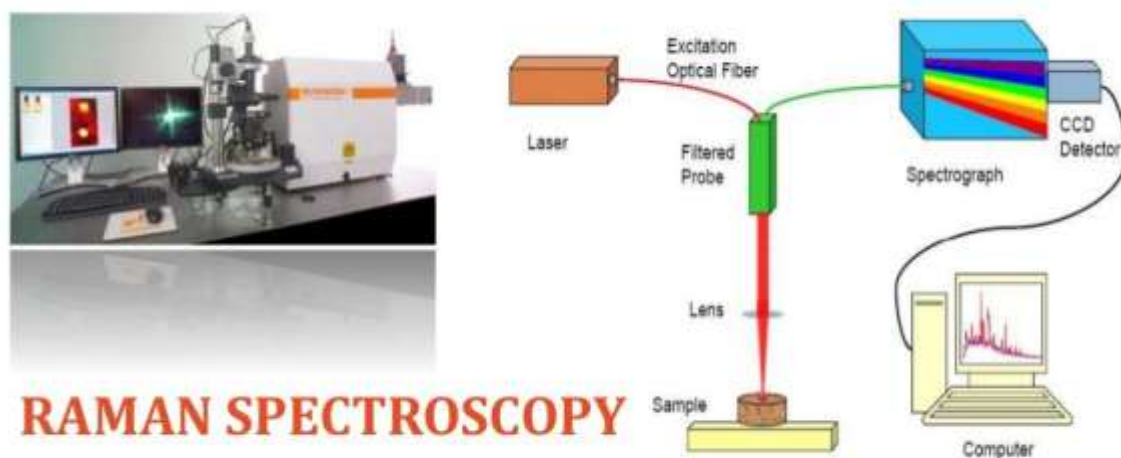


Figure 6. - Spectroscopic workstation

Results of the study

The stratification of MCW graphite during ultrasonic dispersion in an ultrasonic bath is shown in Fig. 7.

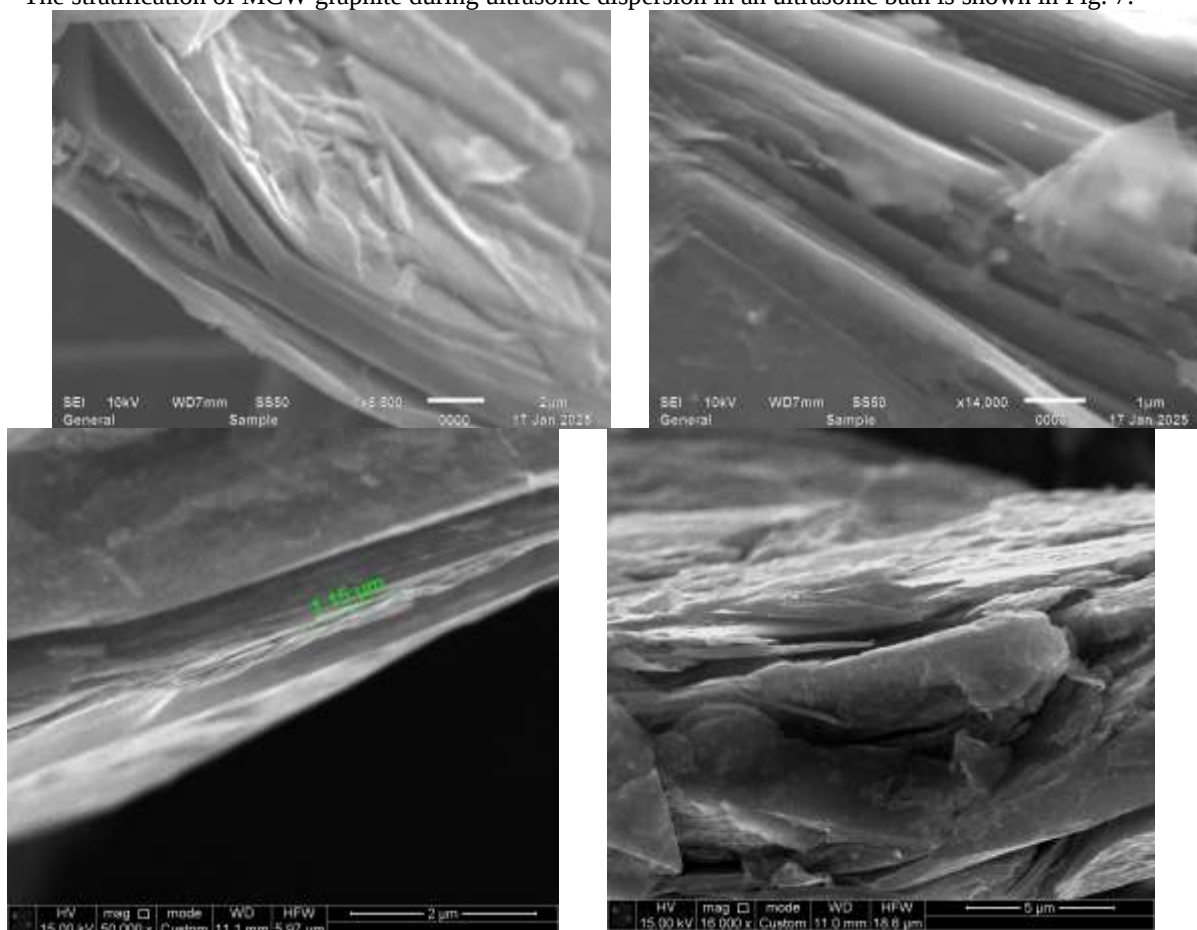
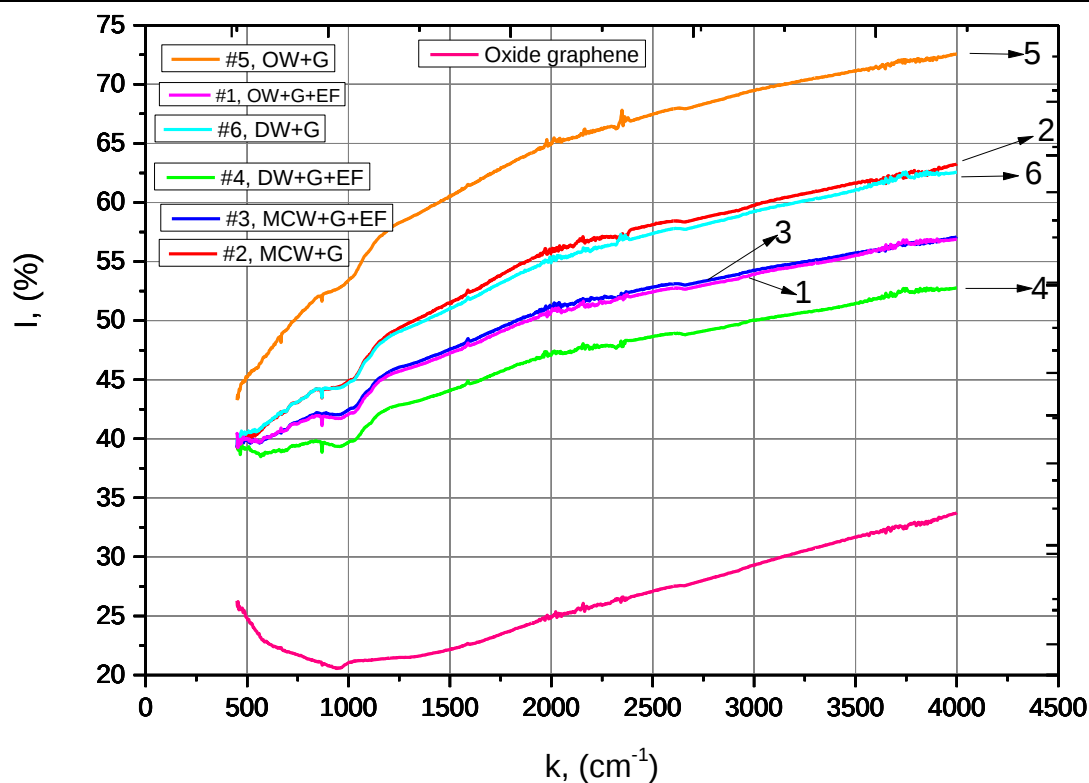


Figure 7. – Exfoliated natural graphite

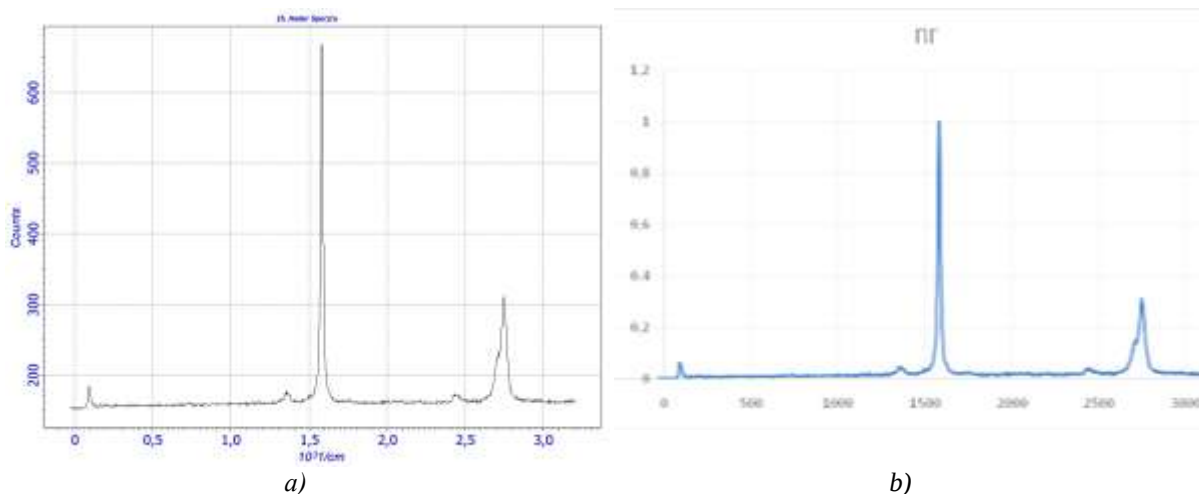
Comparison of FTIR and XRD spectra for dried graphite solutions in normal/microcluster/distilled water with and without an applied external magnetic field shows that there is a certain correlation between them (Fig. 8) and Table 1.

Table 1.

Values of intensity drop of absorption spectra			
	Without magnetic field	With magnetic field	Decrease, in %
MCW	63,24	57,1	10,9
Distilled water	62,45	52,77	18,3
Regular water	72,55	56,98	27,3

Figure 8. - Absorption spectra at 4000 cm^{-1}

Raman spectra of graphene were measured on the RIMS complex and are shown in Fig. 9. Raman spectroscopy or Raman spectroscopy allows obtaining information on the number of graphene layers by analyzing the "shear" and "breathing" modes that arise due to interlayer interactions in graphite.



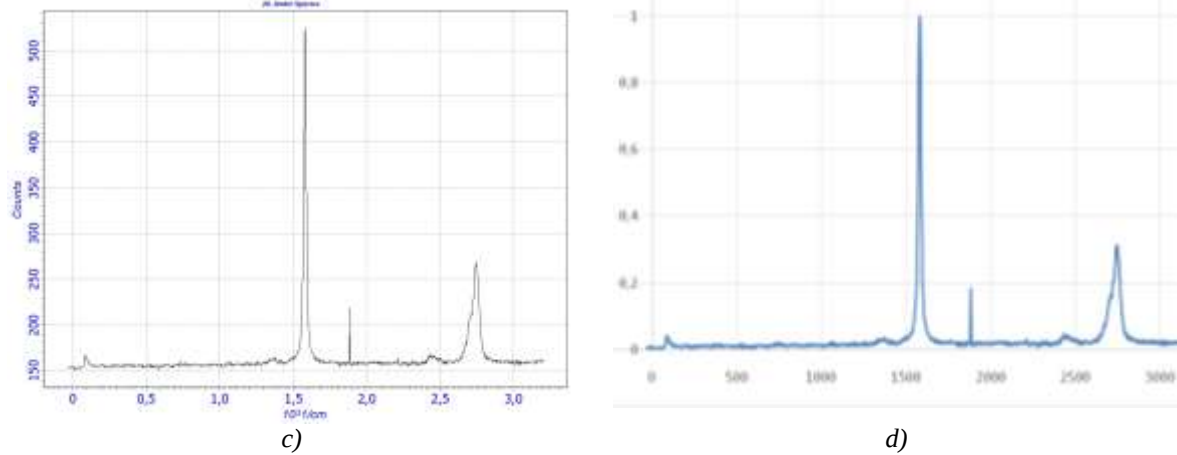


Figure 9. - Raman spectrum of the original graphite (a); normalized Raman spectrum of the original graphite (b); spectrum of graphite intercalated with MCW in ultrasound (c); normalized spectrum of graphite intercalated with MCW in ultrasound (d).

Discussion of the research results

Graphite is a thermodynamically stable allotropic modification of carbon - an element of the 4th group of the main subgroup of the 2nd period of the periodic table, atomic number 6, the atomic mass of the natural mixture of isotopes is 12.0107 g/mol. The theoretical density of 2.26 g/cm³ is achieved only in natural graphite. The density of artificial graphite is in the range of 1.65-1.75 g/cm³. Such a low density of artificial graphite is explained by its porosity [8].

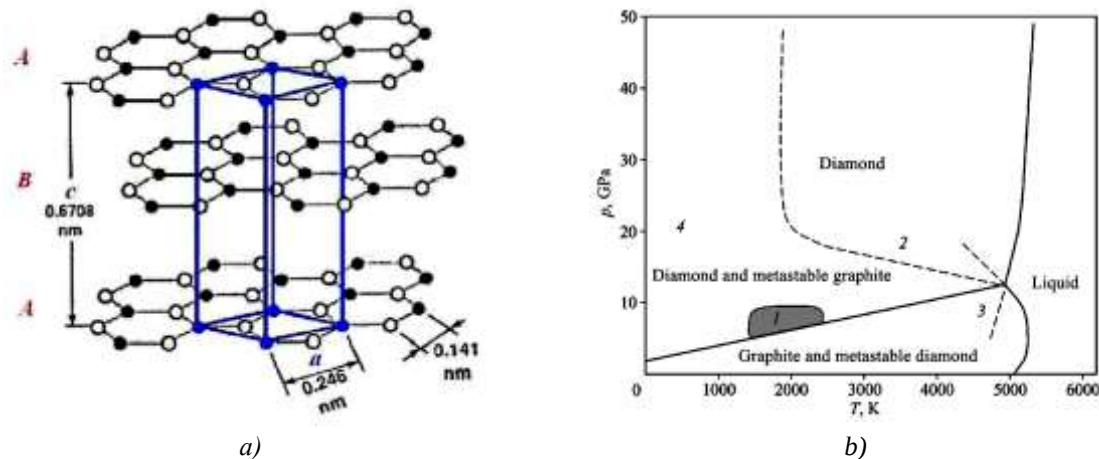


Figure 10. - Graphite structure (a) [8] and carbon diagram (b) [9].

The crystalline structure of graphite has hexagonal symmetry and consists of flat layers of carbon atoms located parallel to each other (Fig. 10a). The phase diagram of carbon according to Bundy [9] is shown in Fig. 10b.

The thickness of the surface layer $R(I)$ is given by the formula [10]:

$$R(I) = L_{nm} = 0,17 \cdot 10^{-9} \cdot \alpha \cdot \nu \text{ [m]}. \quad (1)$$

In equation (1) one parameter must be known – the molar volume of the element, which is equal to $\nu = M/\rho$ (M is the molar mass, ρ is its density), $\alpha = 1 \text{ mol m}^{-2}$ is a constant to maintain the dimensionality ($R(I) = [\text{m}]$). The diagram of the surface layer is shown in Fig. 11.

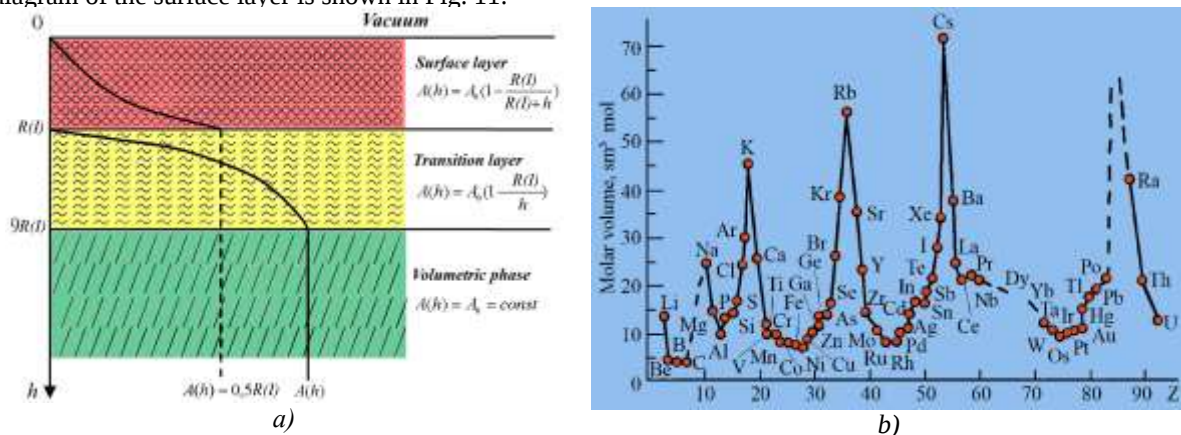


Figure 11.

Schematic representation of the surface layer (a), periodic change in the atomic volume of elements (b) [10].

Using formula (1), we calculate $R(I)$ (Table 2) for graphite parallel to the plane $x = a = b$ and perpendicular to this plane $x = c$.

Table 2.

Parameters $R(I)$ of graphite.					
Graphite	Structure	M, g/mol	ρ , g/cm ³	$R(I)_a$, nm	$R(I)_c$, nm
C	C6/mmc-D _{6h} ⁴	12,0107	2,26	0.90 (3)	2.46 (3)
			1,75	1.17 (4)	3.19 (4)
			1,65	1.24 (5)	3.39 (5)

From Table 2 it is evident that natural graphite has three (3) graphene monolayers (Fig. 12), which are detected by the Raman method (Fig. 9).

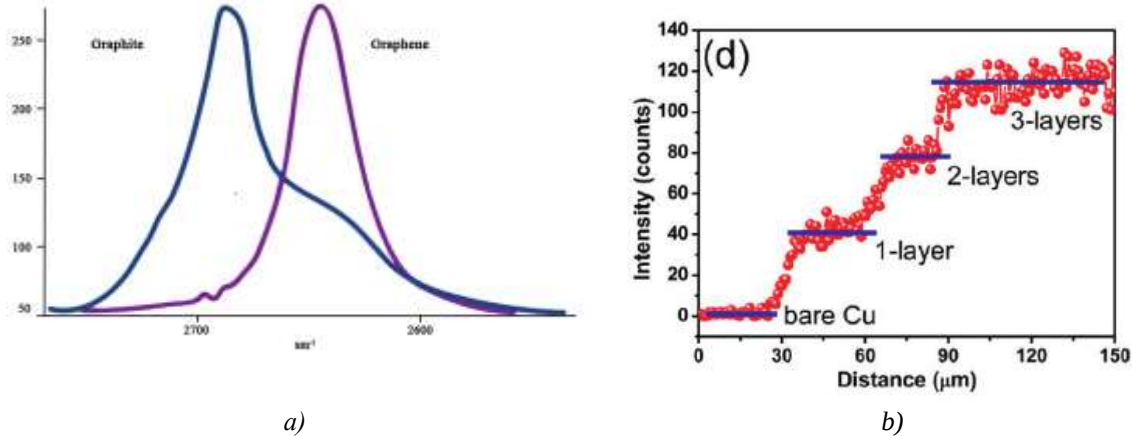


Figure 12. - 2D Raman band of graphite and graphene (a); number of graphite monolayers (b).

The first monolayer of graphite is graphene, it is determined by the unique physicochemical properties of graphene, such as a large specific surface area ($\sim 2600 \text{ m}^2/\text{g}$), high mobility of charge carriers ($\sim 200,000 \text{ cm}^2/\text{V}\cdot\text{s}$), high Young's modulus ($\sim 1000 \text{ GPa}$), thermal conductivity ($\sim 5000 \text{ W/m K}$), optical transparency ($\sim 97.7\%$), mechanical strength, etc. [11].

Bilayer graphene differs from single-layer graphene and graphite. It is actively studied [12] due to the controllable width of the band gap. An analogue of bilayer graphene is SW graphene, which is more stable than graphene [13].

Three-layer graphene differs from the latter two in mobility and conductivity [14]. A special feature of three-layer graphene is that after its twisting at a magic angle, it develops superconductivity, which can withstand magnetic fields 2-3 times greater than the Pauli limit for spin-singlet pairing [15]. Let us consider the issue of ultrasonic dispersion theoretically as a Stefan problem, using an analytical solution to the non-stationary problem. The non-stationary diffusion equation in a moving cylindrical coordinate system moving according to the law $\beta(t)$ has the form:

$$\frac{\partial U}{\partial t} = D \left[\frac{\partial^2 U}{\partial z^2} + \frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial U}{\partial r} \right) \right], \quad (2)$$

where D is the diffusion coefficient.

We will choose the initial and boundary conditions in a general form:

$$U(r, z, t)|_{t=0} = \varphi(r, z), \quad (3)$$

$$U(r, z, t)|_{r=R} = \gamma(z, t), \quad (4)$$

$$U(r, z, t)|_{z=0} = \gamma_1(r, t), \quad (5)$$

$$U(r, z, t)|_{z=\beta(t)} = \gamma_2(r, t). \quad (6)$$

We will consider the functions $\beta(t)$, $\varphi(r, z)$, $\gamma(z, t)$, $\gamma_1(r, t)$ and $\gamma_2(r, t)$ to be continuous. We seek the solution to the problem in the form:

$$U(r, z, t) = \sum_{k=0}^{\infty} \bar{U}_k(z, t) I_0(\lambda_{0k} r), \quad (7)$$

where λ_{0k} are the roots of the equation

$$I_0(\lambda_{0k} R) = 0 \quad (8)$$

and $I_0(\lambda_{0k} R)$ is the zero-order Bessel function satisfying the equation:

$$\frac{1}{r} \frac{d}{dr} \left[r \frac{dI(\lambda_{0k} r)}{dr} \right] + I_0(\lambda_{0k} r) = 0, \quad (9)$$

$$\bar{U}_k(z, t) = \int_0^R U_k(r, z, t) I_0(\lambda_0 r) r dr. \quad (10)$$

Applying the integral transformation (10) and taking into account (7) and (8), we reduce equation (2) to the form:

$$\frac{1}{\mathcal{A}} \frac{\partial \bar{U}_k}{\partial t} = \frac{\partial^2 \bar{U}_k}{\partial z^2} + \bar{\Phi}_k(z, t) - \bar{U}_k(z, t), \quad (11)$$

Using the substitution $\bar{U}_k = \tilde{U}_k e^{-\tilde{A}t}$ and transforming the boundary conditions in a similar way, we obtain the following problem:

$$\frac{1}{\mathcal{A}} \frac{\partial \tilde{U}_k}{\partial t} = \frac{\partial^2 \tilde{U}_k}{\partial z^2} + \tilde{\Phi}_k(z, t), \quad (12)$$

$$\tilde{U}_k(z, t)|_{t=0} = \tilde{\varphi}(z), \quad (13)$$

$$\tilde{U}_k(z, t)|_{z=0} = \tilde{\gamma}_1(t), \quad (14)$$

$$\tilde{U}_k(z, t)|_{z=\beta(t)} = \tilde{\gamma}_2(t), \quad (15)$$

in the area $\mathcal{A} : (t > 0, 0 < z < \beta(t))$.

We seek the solution to problem (12)-(15) in the form of the sum of potentials of the first and second kind, as well as two double layer potentials:

$$\begin{aligned} \tilde{U}_k(z, t) = & \frac{1}{2\sqrt{\mathcal{A}}} \int_0^\ell \frac{\tilde{\varphi}(\xi)}{\sqrt{\pi t}} e^{-\frac{(z-\xi)^2}{4\mathcal{A}t}} d\xi + \int_0^t d\tau \int_0^\ell \frac{\tilde{\Phi}_k(\xi, \tau)}{2\sqrt{\pi\mathcal{A}(t-\tau)}} e^{-\frac{(z-\xi)^2}{4\mathcal{A}(t-\tau)}} d\xi + \\ & + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{z}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{z^2}{4\mathcal{A}(t-\tau)}} K_1(\tau) d\tau + \\ & + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{z - \beta(\tau)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{[z-\beta(\tau)]^2}{4\mathcal{A}(t-\tau)}} K_2(\tau) d\tau. \end{aligned} \quad (16)$$

Using conditions (14), (15), we obtain a system of integral equations:

$$\begin{aligned} \tilde{\gamma}'_1(t) = & \frac{K_1(t)}{2\mathcal{A}} - \frac{1}{4\sqrt{\pi}} \int_0^t \frac{\beta(\tau)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{\beta^2(\tau)}{4\mathcal{A}(t-\tau)}} K_2(\tau) d\tau, \\ \tilde{\gamma}'_2(t) = & \frac{K_2(t)}{2\mathcal{A}} + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{\beta(t) - \beta(\tau)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{[\beta(t)-\beta(\tau)]^2}{4\mathcal{A}(t-\tau)}} K_2(\tau) d\tau + \\ & + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{\beta(t)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{\beta^2(t)}{4\mathcal{A}(t-\tau)}} K_1(\tau) d\tau \end{aligned} \quad (17)$$

$$\text{where } \tilde{\gamma}'_1(t) = \tilde{\gamma}_1(t) - \frac{1}{2} \int_0^\ell \frac{\tilde{\varphi}(\xi)}{\sqrt{\pi\mathcal{A}t}} e^{-\frac{\xi^2}{4\mathcal{A}t}} d\xi - \int_0^t d\tau \int_0^\ell \frac{\tilde{\Phi}_k(\xi, \tau)}{2\sqrt{\pi\mathcal{A}(t-\tau)}} \cdot e^{-\frac{\xi^2}{4\mathcal{A}(t-\tau)}} d\xi;$$

$$\tilde{\gamma}'_2(t) = \tilde{\gamma}_2(t) - \frac{1}{2} \int_0^\ell \frac{\tilde{\varphi}(\xi)}{\sqrt{\pi\mathcal{A}t}} e^{-\frac{[\beta(t)-\xi]^2}{4\mathcal{A}t}} d\xi - \int_0^t d\tau \int_0^\ell \frac{\tilde{\Phi}_k(\xi, \tau)}{2\sqrt{\pi\mathcal{A}(t-\tau)}} \cdot e^{-\frac{[\beta(t)-\xi]^2}{4\mathcal{A}(t-\tau)}} d\xi.$$

Eliminating from the first equation of system (17) and substituting into the next equation $K_1(t)$, we have:

$$\begin{aligned}
\tilde{\gamma}'_2(t) &= \frac{K_2(t)}{2\mathcal{A}} + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{\beta(t) - \beta(\tau)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{[\beta(t)-\beta(\tau)]^2}{4\mathcal{A}(t-\tau)}} K_2(\tau) d\tau + \\
&+ \frac{2\mathcal{A}}{\sqrt{\pi}} \int_0^t \frac{\beta(t)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{\beta^2(t)}{4\mathcal{A}(t-\tau)}} \tilde{\gamma}'_1(\tau) d\tau + \\
&+ \frac{\mathcal{A}}{8\pi} \int_0^t \frac{\beta(t)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{\beta^2(t)}{4\mathcal{A}(t-\tau)}} \left(\int_0^\tau \frac{\beta(\tau_1)}{[\mathcal{A}(t-\tau_1)]^{3/2}} e^{-\frac{\beta^2(\tau_1)}{4\mathcal{A}(t-\tau_1)}} K_2(\tau_1) d\tau_1 \right) d\tau.
\end{aligned} \tag{18}$$

Introducing the notation

$$q(t) = \tilde{\gamma}_2(t) - \frac{\mathcal{A}}{2\sqrt{\pi}} \int_0^t \frac{\beta(t)}{[\mathcal{A}(t-\tau)]^{3/2}} \tilde{\gamma}'_1(\tau) e^{-\frac{\beta^2(t)}{4\mathcal{A}(t-\tau)}} d\tau, \tag{19}$$

and calculating the integral in (18), we obtain

$$\begin{aligned}
& - \frac{K_2(t)}{2\mathcal{A}} + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{\beta(t) - \beta(\tau)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{[\beta(t)-\beta(\tau)]^2}{4\mathcal{A}(t-\tau)}} K_2(\tau) d\tau + \\
& + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{\beta(t)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{\beta^2(t)}{4\mathcal{A}(t-\tau)}} K_2(\tau) d\tau = q(t).
\end{aligned} \tag{20}$$

Designating,

$$\begin{aligned}
\lambda &= \frac{1}{2\sqrt{\mathcal{A}}}, \quad f(t) = 2\mathcal{A}q(t), \quad K(t, \tau) = \frac{\lambda}{\sqrt{\pi}} \frac{\beta(t) - \beta(\tau)}{(t-\tau)^{3/2}} \times \\
& \times e^{-\frac{\lambda^2 [\beta(t)-\beta(\tau)]^2}{(t-\tau)}} + \frac{\lambda}{\sqrt{\pi}} \frac{\beta(t)}{(t-\tau)^{3/2}} e^{-\frac{\lambda^2 \beta(t)^2}{(t-\tau)}},
\end{aligned} \tag{21}$$

we obtain the integral equation

$$K_2(t) - \int_0^t K(t, \tau) K_2(t, \tau) d\tau = f(t). \tag{22}$$

The integral equation (22) is Volterra in $C(0,1)$ if and only if:

$$\lim_{t \rightarrow 0} \int_0^t K(t, \tau) d\tau = 0.$$

Indeed, given that $e^{-z} < 1$ for $z > 0$, it is easy to show that the above equality holds. Then for equation (22) there is a unique solution, which has the form:

$$\begin{aligned}
K_2(t) &= \sum_{n=0}^{\infty} K_{2,n}(t), \\
K_{2,0}(t) &= f(t), \\
K_{2,1}(t) &= \int_0^t K(t, \tau) K_{2,0}(\tau) d\tau, \\
K_{2,2}(t) &= \int_0^t K(t, \tau) K_{2,1}(\tau) d\tau, \\
&\dots\dots\dots \\
K_{2,n}(t) &= \int_0^t K(t, \tau) K_{2,n-1}(\tau) d\tau \\
&\dots\dots\dots
\end{aligned} \tag{23}$$

and (23) converges absolutely and uniformly in the topology $C(0,1)$.

Then

$$K_1(t) = 2\mathcal{A}\tilde{\gamma}_1(t) + \frac{\mathcal{A}}{2\sqrt{\pi}} \int_0^t \frac{\beta(t)}{[\mathcal{A}(t-\tau)]^{3/2}} e^{-\frac{\beta^2(t)}{4\mathcal{A}(t-\tau)}} \sum_{n=0}^{\infty} K_{2,n}(\tau) d\tau. \tag{24}$$

Performing the inverse transformation, we finally have:

$$\begin{aligned}
 U(r, z, t) = & \sum_{\kappa=0}^{\infty} J_0(\lambda_{\kappa} r) \left\{ e^{-\lambda t} \left[\frac{1}{2\sqrt{\pi}} \int_0^t e^{-\frac{(z-\xi)^2}{4\lambda t}} dt \right. \right. \\
 & \times \left(\int_0^{\ell} \varphi(r, \xi) I_0(\lambda_{\kappa} r) r dr \right) d\xi + \frac{R I_1(\lambda_{\kappa} R)}{2\sqrt{\pi} \lambda} \int_0^t d\tau \int_0^{\ell} \frac{\gamma(\xi, \tau)}{\sqrt{t-\tau}} e^{-\lambda t} e^{-\frac{(z-\xi)^2}{4\lambda(t-\tau)}} d\xi + \\
 & \left. \left. + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{z}{[\lambda(t-\tau)]^{3/2}} e^{-\frac{z^2}{4\lambda(t-\tau)}} K_1(\tau) d\tau + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{z-\beta(\tau)}{[\lambda(t-\tau)]^{3/2}} e^{-\frac{[z-\beta(\tau)]^2}{4\lambda(t-\tau)}} K_2(\tau) d\tau \right] \right\}. \quad (25)
 \end{aligned}$$

Thus, an analytical solution to the problem of crystallization of a cylinder of finite dimensions is obtained.

Let us choose the boundary conditions in the simplest periodic form. The diffusion problem in this case has the boundary conditions:

$$\begin{aligned}
 \frac{\partial C}{\partial t} &= \lambda \left[\frac{\partial^2 C}{\partial z^2} + \frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial C}{\partial r} \right) \right] \\
 C(r, z, t) \Big|_{t=0} &= \varphi(r, z) \\
 C(r, z, t) \Big|_{t=R} &= \gamma(z, t) = C_0 \sin \omega t \sin \mathbf{k} \mathbf{r}, \\
 C(r, z, t) \Big|_{z=0} &= \gamma_1(r, t) = C_1 \sin \omega t \sin \mathbf{k} \mathbf{r}, \\
 C(r, z, t) \Big|_{z=\beta(t)} &= \gamma_2(r, t) = C_2 \sin \omega t \sin \mathbf{k} \mathbf{r}. \quad (26)
 \end{aligned}$$

where C_0, C_1, C_2 are the concentration of the substance on the side walls of the crystallizer and on the moving phase boundary, respectively; $\omega, \mathbf{k}$ are the cyclic frequency of the disturbing field and the wave vector.

The general solution to such a problem is given above:

$$\begin{aligned}
 C(r, z, t) = & \sum_{\kappa=0}^{\infty} J_0(\lambda_{\kappa} r) \left\{ e^{-\lambda t} \left[\frac{1}{2\sqrt{\pi}} \int_0^t e^{-\frac{(z-\xi)^2}{4\lambda t}} dt \right. \right. \\
 & \times \left(\int_0^{\ell} \varphi(r, \xi) I_0(\lambda_{\kappa} r) r dr \right) d\xi + \frac{R I_1(\lambda_{\kappa} R)}{2\sqrt{\pi} \lambda} \int_0^t d\tau \int_0^{\ell} \frac{\gamma(\xi, \tau)}{\sqrt{t-\tau}} e^{-\lambda t} e^{-\frac{(z-\xi)^2}{4\lambda(t-\tau)}} d\xi + \\
 & \left. \left. + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{z}{[\lambda(t-\tau)]^{3/2}} e^{-\frac{z^2}{4\lambda(t-\tau)}} K_1(\tau) d\tau + \frac{1}{4\sqrt{\pi}} \int_0^t \frac{z-\beta(\tau)}{[\lambda(t-\tau)]^{3/2}} e^{-\frac{[z-\beta(\tau)]^2}{4\lambda(t-\tau)}} K_2(\tau) d\tau \right] \right\}. \quad (27)
 \end{aligned}$$

On the z -axis and at $r=0$, we have

$$C(z, t) = \frac{1}{4\sqrt{\pi}} \left(\int_0^t \frac{z}{[\lambda(t-\tau)]^{3/2}} e^{-\frac{z^2}{4\lambda(t-\tau)}} K_1(\tau) d\tau + \int_0^t \frac{z-\beta(\tau)}{[\lambda(t-\tau)]^{3/2}} e^{-\frac{[z-\beta(\tau)]^2}{4\lambda(t-\tau)}} K_2(\tau) d\tau \right). \quad (28)$$

Taking $\beta(\tau) = H$ (i.e. for a finite cylinder of depth H and radius R), calculating $K_1(\tau)$ and $K_2(\tau)$, for the axial concentration gradient we have:

$$\frac{\partial C}{\partial z} = \frac{8\pi v}{\lambda} \cdot \sqrt{\frac{\pi}{\lambda}} e^{-\frac{(z-h)^2}{4\lambda} t} (C_1 + C_2). \quad (29)$$

where v, λ are the speed and wavelength of the alternating field; h is the distance to the horizontal plane coinciding with the cross-section of the source of the excited field.

Let us designate:

$$W = \frac{8\pi v}{\lambda} \cdot \sqrt{\frac{\pi}{\lambda}} (C_1 + C_2). \quad (30)$$

Finally, we can write down:

$$\frac{\partial C}{\partial z} = W \cdot e^{-\frac{(z-h)^2}{4\lambda} t}. \quad (31)$$

From formula (31) it follows that the presence of periodic boundary conditions simulating periodic ultrasonic action on the “water-graphite” system leads to an exponential law of change in the vertical component of concentration, where:

$$\nu = \frac{\omega\lambda}{2\pi} \quad (32)$$

In other words, graphite intercalation will increase in the system + liquid-graphite” with an increase in the ultrasound power $\sim \nu$ and the surface tension of the liquid $\sim \gamma$. According to the classical theory, $D = \nu$, where ν is the kinematic coefficient of viscosity. We have shown that $\nu \sim 1/\gamma$ and therefore $W \sim \gamma^{1/2}$.

Let us present some values of γ for some liquids.

Table 3.

Surface tension of liquids at 20 °C [16]					
Liquid	$\gamma, 10^{-3} \text{ N/m}$	Liquid	$\gamma, 10^{-3} \text{ N/m}$	Liquid	$\gamma, 10^{-3} \text{ N/m}$
water	72,75	glycerol	63,40	chloroform	27,14
acetonitrile	26,64	phenol	40,90	benzene	28,88
toluene	28,40	acetone	23,70	ethyl acetate	23,60
orthoxylylene	30,10	ethanol	22,80	mercury	465,0

It follows from Table 3 that water has the highest γ value (except mercury) and surpasses all liquids in the ultrasonic splitting of graphite to obtain graphene plates from it. The effect of ultrasound on the splitting of graphite is far from complete. Particular attention should be paid to the theory of cavitation and its nonlinearity. The splitting of graphite is the destruction of solids, where it is necessary to apply the theory of catastrophes. When graphite is split, many new planes arise that differ significantly from the properties of bulk graphite. This list can be continued, but the main thing is to obtain graphene plates or flakes suitable for their practical application.

Intercalation of water into graphite and its subsequent stratification is possible when the following relationships are met:

$$\begin{aligned} W(C) - W(H_2O) &\rightarrow \min, \\ \gamma(C) - \gamma(H_2O) &\rightarrow \min, \end{aligned} \quad (33)$$

where $\gamma(C) = 0.798 \text{ J/m}^2$ is the surface energy of graphite in the c plane; $\gamma(H_2O) = 0.0728 \text{ J/m}^2$ is the surface energy (surface tension) of water.

Equation (33) shows that any impact on water (chemical impurities, vibration, ultrasound, electric and magnetic fields, increased temperature, etc.) leading to an increase in $\gamma(H_2O)$ will contribute to the stratification of graphite.

In the work [15] a system of permanent magnets mounted on a piezoelectric plate was used to activate water to modulate the magnetic field. The conductivity and permittivity of water activated by this source were experimentally studied. The effect of a magnetic field on bidistilled water ($0.84 \cdot 10^{-4} \text{ Ohm}^{-1}\text{m}^{-1}$) leads to an increase in surface tension with an increase in the magnitude of the field (Table 4).

Table 4.

Parameters of bidistillate in a magnetic field [17]						
Magnetic field, T	pH		Surface tension		Dielectric constant	
	fractions of a unit	%	10^{-3} N/m	%	F/m	%
0.19	0.35	5.1	1.6	2.2	1.5	1.8
0.35	0.44	6.4	3.7	5.1	1.4	1.7
0.48	0.62	9.1	4.7	6.4	1.4	1.7
0.57	0.62	9.1	5.3	7.3	1.4	1.7

From Table 4 it is evident that $\gamma(H_2O)$ increases with a threefold change in the magnetic field strength, i.e. linearly: $\gamma(H_2O) = \alpha H$, where α is the proportionality coefficient, H is the magnetic field strength. Since in our case $\alpha = 3$, equation (33) yields: $\gamma(C) - 3H = 0$ and $H \approx 0.3 \text{ T}$. With such a magnetic field strength, graphite can be exfoliated with water. Graphene, created 21 years ago, is a unique material destined to become the substance of the 21st century. Graphene has a wide range of applications. The global graphene market began to grow only five years ago, which was due to the high cost of graphene. Our proposed method for obtaining graphene from graphite with microcluster water using ultrasound and a magnetic field deserves further study, since it can provide an environmentally friendly and reliable method for obtaining a high-volume initial product.

Thus, using equations (1) - (33) it is possible to obtain exfoliation of graphite with water in a magnetic field and obtain graphene in an environmentally friendly way.

Ultrasonic dispersion

Let us propose another model of ultrasonic dispersion. The nanolayer $R(I)$ of graphite from equation (1) is subject to reconstruction of its surface [18]. In this regard, internal stresses σ_{is} arise at the interphase boundary:

$$\sigma_{is} = \sqrt{W_a \cdot E / R(I)}, \quad (34)$$

where E is Young's modulus.

These stresses lead to deformation, the "latent" energy of which is equal to E_d :

$$E_d = W_a \cdot a^2, \quad (35)$$

where a is the lattice constant.

Above we used the term - "latent" deformation energy, equal to $E_d = W_a a^2$. We took this term from the article [19], where it is shown that the "latent" deformation energy can be represented as a logistic function, characteristic of the theory of catastrophes. The elastic constants are shown in Table 5.

Table 5.

Elastic constants along various planes ($a=b, z=c$)						
Mineral	$W_{aa}, J/m^2$	$W_{ac}, J/m^2$	σ_{isa}, GPa	σ_{isc}, GPa	E_{da}, eV	E_{dc}, eV
Graphite	2,85	1,69	4,9	1,4	1,08	4,75
Graphene	3,45	-	118,4	-	1,30	-

In [20], we showed that the energy of deformation under external influence (ultrasound, friction, magnetic field, etc.) is spent on heat, acoustic emission, field emission, and fractoluminescence.

First, let us consider the transformation of deformation energy into acoustic emission. Today, several sources of acoustic emission of metals and semiconductors are known: movement of dislocations; initiation and growth of cracks; twinning process [21]. The authors of this article add to this list – the transformation of deformation energy into acoustic emission.

The essence of acoustic emission (AE) consists in the analysis of the parameters of extremely weak ultrasonic radiation accompanying any change in the structure of a solid body, especially during its deformation (Fig. 13).

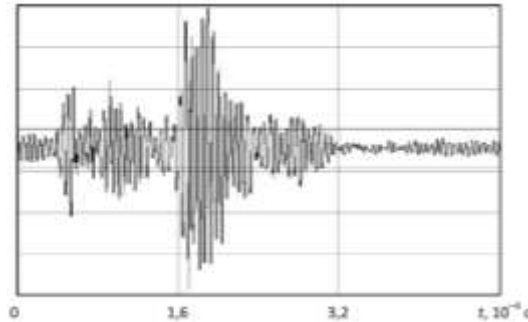


Figure 13. - Typical picture of the fine structure (oscillations) of acoustic emission signals recorded by a sensor on the body surface [22].

The total energy of AE EAE is equal to [23]:

$$E_{AE} = \frac{\sigma_0^2 \cdot \lambda \cdot [R(I)]^2}{8\rho \cdot v^2}, \quad (36)$$

where σ_0 is (in our case $\sigma_0 \approx \sigma_{is}$) the maximum amplitude of elastic vibration stress; λ is the vibration wavelength (in our case $\lambda = R(I)$; ρ is the density of the body; v is the speed of sound.

The maximum value of the wavelength λ propagating in a discrete chain of the z axis is equal to $R(I)$. The speed of sound in the surface layer of graphite is equal to $v = R(I)/\tau$, where τ is the relaxation time, which we estimated using the formula from [24]. For longitudinal modes, the time $\tau_L = 0.2 \cdot 10^{-12}$ s, for transverse modes - $\tau_L = 2 \cdot 10^{-12}$ s. For graphite, the speed of sound is shown in Table 6.

Table 6.

Speed of sound modes in graphite and graphene		
Graphite	$v_L, m/s$	$v_T, m/s$
$\rho = 2260, kg/m^3$	4500	2380
$\rho = 1986, kg/m^3 [AE]$	3505	1854
$\rho = 1753, kg/m^3 [AE]$	2631	1591
Graphene	$v_L, m/s$	$v_T, m/s$
$\rho = 0,77, mg/m^2 [AE]$	19700	10700

From Table 6 it is evident that graphene has a lower density of matter than graphite, but the speed of sound in it is almost 5 times greater than that of graphite.

Transforming formula (36), we obtain as a result:

$$E_{AE} = \beta \cdot \frac{T_m \cdot E \cdot R(I)}{M} \quad (eV), \quad (37)$$

where $\beta = 2 \text{ eV kg/K Pa m} = \text{const}$; T_m is the melting point of the solid (K); E is Young's modulus (GPa); M is the mass of the crystal (kg).

Let us estimate E_{AE} for graphite: $T_m = 3890$ K, $E = 3.48 \cdot 10^9$ Pa, $R(I) = 2.46 \cdot 10^{-9}$ m, $M = 12000$ kg; then $E_{AE} = 4.6$ eV. Comparing this value with Table 5, we obtain that $E_{AE} \approx E_{dc} = (4.6-4.7)$ eV and the deformation energy E_d of graphite, arising due to the reconstruction of their surface, coincides within the experimental error with the acoustic emission energy E_{AE} , i.e. $E_d \approx E_{AE}$.

Thus, it can be considered proven that in natural graphite (as in all solids) acoustic emission occurs due to the reconstruction of its surface, leading to the formation of a surface layer $R(I)$ and energy E_d .

Due to the law of conservation of energy, the energy of deformation E_d should be comparable with the energy of ultrasound, leading to the exfoliation of graphite with the formation of graphene.

Conclusion

As a result of experimental and theoretical studies, the following patterns were revealed:

1) Exfoliation of layered graphite crystals was carried out by microcluster water using ultrasound in a magnetic field;

2) It was theoretically shown that any impact on water (chemical impurities, vibration, ultrasound, electric and magnetic fields, increased temperature, etc.) leading to an increase in γ (H_2O) will contribute to the exfoliation of graphite;

3) It was shown that it is possible to obtain exfoliation of graphite with water in a magnetic field and obtain graphene in an environmentally friendly way;

4) A model was proposed: the energy of deformation E_d should be comparable with the energy of ultrasound, leading to the exfoliation of graphite with the formation of graphene.

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SOCIAL SCIENCES

INSTAGRAM AS A TOOL OF CIVIC JOURNALISM: ANALYSIS OF YOUTH MEDIA INITIATIVES IN KYRGYZSTAN

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INSTAGRAM КАК ИНСТРУМЕНТ ГРАЖДАНСКОЙ ЖУРНАЛИСТИКИ: АНАЛИЗ МОЛОДЕЖНЫХ МЕДИА-ИНИЦИАТИВ В КЫРГЫЗСТАНЕ

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Abstract

In the context of the development of digital technologies and the growing role of social networks in information dissemination, Instagram is becoming an important platform for expressing civic positions, highlighting social issues, and implementing youth media initiatives. This article examines the potential of Instagram as a tool of civic journalism in Kyrgyzstan. Based on the analysis of four popular youth-oriented pages (limon_kg, checkit_media, idea_ca, we_project), the article identifies key features and common formats of information delivery. The study shows that the platform enables young creators to respond promptly to socially significant events and influence the public agenda. The article offers recommendations for strengthening Instagram's role in the development of civic journalism.

Аннотация

В условиях развития цифровых технологий и усиления роли социальных сетей в распространении информации, Instagram становится важной платформой для выражения гражданской позиции, освещения социальных проблем и реализации молодежных медиа-инициатив. В статье рассматривается потенциал Instagram как инструмента гражданской журналистики в Кыргызстане. На основе анализа четырех популярных молодежных страниц (limon_kg, checkit_media, idea_ca, we_project) выявлены особенности и типичные форматы подачи информации. Исследование показывает, что социальная сеть предоставляет молодым авторам возможность оперативно реагировать на общественно значимые события и влиять на повестку дня. В статье предложены рекомендации по усилению роли Instagram в развитии гражданской журналистики.

Keywords: civic journalism, Instagram, youth media, digital initiatives, Kyrgyzstan.

Ключевые слова: гражданская журналистика, Instagram, молодежные медиа, цифровые инициативы, Кыргызстан.

Введение

Развитие цифровых технологий трансформирует традиционные формы коммуникации и журналистики, создавая новые условия для взаимодействия между обществом и информацией [2]. Одним

из проявлений этой трансформации стала гражданская журналистика — форма непрофессиональной медиаактивности, при которой обычные пользователи, не являясь профессиональными журналистами, освещают события, выражают мнение и участвуют в общественном дискурсе [5].

Instagram, как одна из наиболее популярных платформ среди молодежи Кыргызстана, превратился в пространство для реализации медиа-инициатив, направленных на освещение актуальных проблем — от экологии и образования до гендерных вопросов и политического участия [4]. Такие аккаунты, как @limon_kg, @checkit_media, @idea_ca и @we_project демонстрируют рост участия молодежи в информационном поле страны.

Теоретическая основа

Термин гражданская журналистика впервые вошел в научный обиход в 1990-х годах. Один из её основоположников, Дэн Гилмор, в своей книге *We the Media* утверждает: «Журналистика — это то, что делают граждане, когда они сообщают друг другу новости» [5].

Согласно исследованию Мануэля Кастельса, гражданская активность в цифровой среде усиливается за счёт децентрализации информации, доступности платформ и анонимности [2]. Также Генри Дженкинс отмечает развитие культуры участия, где границы между потребителями и производителями информации стираются [7].

Кроме того, Клэй Ширки [10] и Говард Рейнгольд [9] подчеркивают роль социальных медиа как инструмента координации коллективных действий.

Цель данной статьи — изучить Instagram как инструмент гражданской журналистики на основе анализа молодежных медиа-инициатив в Кыргызстане.

Задачи исследования:

1. Определить теоретические основы понятия гражданской журналистики и ее проявлений в цифровом пространстве;
2. Провести контент-анализ молодежных Instagram-страниц;
3. Выявить ключевые функции и формы выражения гражданской позиции в рамках платформы;
4. Предложить рекомендации по использованию Instagram для развития гражданской активности.
5. Теоретическая основа.

Понятие гражданской журналистики возникло в ответ на изменение ролей в информационном обществе. С развитием интернета и социальных сетей каждый пользователь получил возможность не только потреблять, но и производить и распространять информацию, что привело к размыванию границ между профессиональными журналистами и обычными гражданами.

Гражданская журналистика как феномен

Дэн Гилмор (Dan Gillmor) — один из первых исследователей гражданской журналистики — определяет её как «журналистику, совершаемую гражданами, для граждан и с помощью граждан» [Gillmor, 2006]. Это форма общественного участия, при которой пользователи становятся свидетелями событий и делятся информацией с общественностью, используя цифровые каналы.

Генри Дженкинс (Henry Jenkins) вводит понятие «культуры участия» (participatory culture), при

которой граница между потребителем и производителем контента размывается. Молодёжь не просто читает новости — она их создаёт, комментирует, распространяет [Jenkins, 2009].

Мануэль Кастельс (Manuel Castells) в теории сетевого общества подчеркивает важность цифровых коммуникаций как новых форм социальной силы. Он утверждает, что социальные сети стали ареной для формирования гражданской идентичности и организации коллективных действий [Castells, 2012].

Instagram как цифровая платформа

Instagram, как визуально-ориентированная платформа, предлагает уникальные возможности для гражданской журналистики:

- мгновенная публикация новостей;
- сторителлинг через фото и видео;
- вовлечение аудитории через интерактивные элементы (опросы, прямые эфиры, комментарии);
- быстрое распространение информации за счёт алгоритмов и репостов.

По данным Statista (2024), более 65% молодежи в Кыргызстане используют Instagram ежедневно, а 30% из них подписаны на страницы, связанные с общественными темами (экология, права человека, образование и т.д.).

Instagram отличается от других платформ (Facebook, YouTube, Telegram) именно своей визуальной подачей, что делает его более эффективным в привлечении внимания и эмоциональном воздействии. Исследование DW Akademie (2023) подчеркивает: «визуальные платформы формируют гражданскую позицию через эмпатию и сопричастность».

Связь с молодежными инициативами

Для молодежи Кыргызстана Instagram стал не только средством самовыражения, но и способом участвовать в жизни общества:

- поднимать социальные и политические темы;
- привлекать внимание к локальным проблемам;
- организовывать информационные кампании (например, экологические челленджи, противодействие насилию и т.д.).

Методология исследования

Методологической основой исследования стал качественный контент-анализ. В качестве объектов анализа выбраны 4 Instagram-аккаунты:

1. @limon_kg — развлекательно-информационный youth-журнал [8];
2. @checkit_media — активистская платформа, освещающая темы прав женщин и молодежных инициатив [3];
3. @idea_ca — аккаунт, направленный на развитие критического мышления и самореализации [6];
4. @we_project — медиа-платформа для региональной молодежи Центральной Азии [12].

Данное исследование основано на качественном контент-анализе Instagram-страниц, реализующих молодежные медиа-инициативы в Кыргызской

Республике. Методы, использованные в исследовании, включают:

01. Объект и предмет исследования

Объект исследования: молодежные медиа-инициативы в Instagram.

Предмет исследования: формы и функции гражданской журналистики Instagram через призму активности молодежных страниц.

02. Методы исследования

Исследование включает следующие методы:

1. Контент-анализ — для изучения структуры, тематики и форм контента в аккаунтах: [@limon_kg](#), [@chekit_media](#), [@we_project](#) (в сравнительном аспекте)

Было проанализировано по 15 публикаций (период: март–июнь 2025 года), посвящённых социально значимым темам. Анализ охватывает посты и

риелсы за март–июнь 2025 года (около 120 публикаций). Учитывались тематика, визуальные коды, форма подачи, реакция аудитории (комментарии, лайки) [11].

2. Сравнительный анализ — чтобы определить различия между локальными и региональными инициативами.

3. (Дополнительно, при необходимости) Опрос среди студентов и молодых активистов — с целью выявить восприятие Instagram как платформы гражданской журналистики.

03. Критерии анализа контента

Анализ публикаций проводится по следующим критериям:

Таблица 1

Таблица критерии анализа контента

Критерий	Описание
Тематика	Общественные, экологические, гендерные, образовательные, правозащитные темы
Форма подачи	Видео, рилс, сториз, карточки, текстовые посты
Интерактивность	Наличие опросов, обсуждений, активных комментариев
Обратная связь	Вовлеченность подписчиков (лайки, шеры, комментарии)
Автономность	Независимость от традиционных медиа и политических структур
Гражданская направленность	Признаки инициативности, позиции, участия в социальных процессах

Период и объем анализа:

- Период: март – июнь 2025 года
- Объем: 60 постов (по 15 с каждой страницы)

Контент-анализ молодежных медиа-инициатив в Instagram

Для выявления форм и содержания гражданской журналистики в Instagram было проведено контентное исследование четырёх страниц, активно работающих в медиапространстве Кыргызстана:

01. @limon_kg – Информационно-развлекательный паблик с гражданской позицией [8]

Тематика постов:

Анализ 15 публикаций (март–июнь 2025) показал, что около 40% контента связано с социально значимыми темами:

- проблемы образования,
- освещение инцидентов с полицией,
- инициативы волонтеров,
- история кыргызских активистов.

Форма подачи:

- Короткие видео-истории (reels),
- карточки с тезисами,
- сатирические образы для критики госструктур.

Элементы гражданской журналистики:

- использование личных историй очевидцев,
- подача альтернативных точек зрения,
- призывы к участию.

Комментарий:

Хотя аккаунт имеет развлекательный характер, его редакционная политика даёт молодёжи площадку для выражения мнения.

02. @checkit_media – Платформа для голосов молчаливых [3]

Тематика:

Чёткая гражданская направленность:

- права женщин,
- экологические протесты,
- коррупция и выборы.

Форматы:

- Видео-интервью,
- сторителлинг на основе реальных историй,
- рубрики “чекит ойлор” с цитатами и вызовами.

Элементы гражданской журналистики:

- представление проблем изнутри,
- фокус на “незаметные группы”,
- критика властей на основе фактов.

Комментарий:

Это наиболее последовательный гражданский медиапроект, активно использующий Instagram как канал прямой демократии.

03. @idea_ca – Молодёжная медиа-лаборатория [6]

Тематика:

- психологическое здоровье,
- самореализация,
- цифровое образование,
- гендерное равенство.

Форма подачи:

- сериалы-сторис,
- карточки с фактами,
- видео с активистами.

Отличие:

Они делают упор на просветительские кампании, применяя медиа для “тихой” гражданской журналистики.

Комментарий:

Контент развивает критическое мышление и формирует ответственную гражданскую позицию у молодежи.

04. @we_project – Региональный пример [12]

Сравнительно (по 10 постам):

- охватывает темы прав человека, идентичности, культурной памяти в Казахстане, Кыргызстане, Узбекистане;

- использует сторителлинг с визуальным минимализмом.

Комментарий:

Является примером того, как Instagram позволяет создавать транснациональные гражданские проекты, ориентированные на локальные сообщества.

Таблица 2

Общие наблюдения:

Аккаунт	Признаки гражданской журналистики	Уровень вовлечения
@limon_kg	Освещение актуальных проблем, участие читателей	Средний
@checkit_media	Глубокий сторителлинг, активная гражданская позиция	Высокий
@idea_ca	Просвещение, поддержка критического мышления	Средний
@we_project	Локальные истории с региональным охватом	Высокий

Сравнительный анализ: локальные и транснациональные медиа-инициативы

@we_project как региональный кейс гражданской журналистики

Платформа @we_project базируется в Казахстане, но охватывает Центральную Азию, включая Кыргызстан. Её материалы посвящены:

- личным историям борьбы (инвалидность, миграция, дискриминация),
 - культурной памяти,
 - правам человека и свободе самовыражения.
- Отличительная особенность — универсальность тем при сохранении локального акцента.

Таблица 3

Сравнение с кыргызскими инициативами

Параметр	Кыргызские аккаунты (@checkit_media, @limon_kg, @idea_ca)	@we_project
География	Кыргызстан	Центральная Азия
Тематика	Локальные проблемы (экология, насилие, права женщин)	Личные истории, идентичность
Формат подачи	Reels, сторис, карточки	Мини-интервью, лонгриды, stories
Визуальный стиль	Яркий, молодежный, эмоциональный	Минимализм, сдержанность
Тональность	Часто критическая, активистская	Спокойная, документальная
Интернационализация	Практически отсутствует	Явно выражена
Гражданская направленность	Явная, в форме призывов и освещения	Через личные истории и эмпатию

Вывод из сравнения

Кыргызстанские молодежные страницы фокусируются на мгновенной реакции и мобилизации аудитории через визуальный сторителлинг и эмоциональные месседжи. Это делает их мощным инструментом локальной гражданской журналистики.

В свою очередь, @we_project использует документальный стиль и транскультурный подход, подчеркивая, что гражданская журналистика может быть мягкой, но глубокой.

Заключение и рекомендации

В ходе исследования было выявлено, что Instagram в Кыргызстане играет значительную роль как инструмент гражданской журналистики среди молодежи. Анализ популярных медиа-инициатив (@limon_kg, @checkit_media, @idea_ca) показал, что:

• Платформа обеспечивает возможность для оперативного освещения социальных и политических проблем, часто игнорируемых традиционными СМИ.

• Молодежные аккаунты активно используют визуальные форматы (reels, сториз), что способствует быстрому вовлечению аудитории.

• Формы гражданской журналистики варьируются от сатирического освещения до глубокого сторителлинга, что делает платформу многообразной и адаптивной.

• Instagram становится площадкой не только для информирования, но и для мобилизации, повышения гражданской активности и формирования критического мышления. Проведённое исследование показало, что Instagram — это не просто социальная сеть для фото и развлечений, а мощный инструмент гражданской журналистики. Особенно в условиях Кыргызстана, где традиционные СМИ не всегда охватывают молодежные темы, Instagram позволяет молодёжи высказывать свою позицию,

распространять достоверную информацию и участвовать в социальных изменениях [2], [5].

Медиа-инициативы @checkit_media, @limon_kg, @idea_ca и @we_project играют значимую роль в формировании гражданского сознания, развитии критического мышления и стимулировании диалога в обществе.

Instagram доказал свою эффективность в повышении гражданской активности среди кыргызской молодежи [4], [9].

Основные выводы:

1. Рост гражданской журналистики в Instagram связан с увеличением цифровой грамотности молодежи и доступом к мобильным технологиям.
2. Визуальная природа платформы способствует эмоциональному вовлечению и распространению информации.
3. Молодежные медиа-инициативы в Кыргызстане отличаются высокой активностью и разнообразием тематик, отражая современные вызовы общества.
4. Платформа служит эффективным каналом для распространения альтернативных и маргинализированных точек зрения.

Рекомендации:

- Усилить взаимодействие между молодежными медиа и образовательными учреждениями для повышения медиаграмотности и развития гражданской журналистики.
- Разрабатывать методические материалы и тренинги для активистов по эффективному использованию Instagram как инструмента социальных изменений.

- Создавать межрегиональные проекты, объединяющие молодежь из разных стран Центральной Азии для обмена опытом и совместных инициатив.

- Активнее использовать возможности платформы для вовлечения широкой аудитории через интерактивные форматы и сотрудничество с лидерами мнений.

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TECHNICAL SCIENCES

ON IMPACT THEORY IN TRAFFIC ACCIDENT ANALYSIS

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Abstract

Impact theory through the use of coefficient of restitution is a frequently used methodology in traffic accident analysis. In expert practice, it has been established as quite reliable for investigating head-on and rear-end collisions between vehicles with small angles between their longitudinal axes, when the "Momentum 360" method has large physical error and is practically inapplicable. This methodology is also used for impacts between vehicles that have large mass differences. Impact theory is quite effective in calculating the velocities of motor vehicles before the impact when one is known - for example, from a tachograph of a commercial vehicle or from another data storage device. In the classical application of this methodology in the general case, it is assumed that the velocities of the contact points are equal to the velocities of the centers of mass of the motor vehicles before and after the impact. This article proposes a more precise methodology for calculating impacts between vehicles, which has proven its effectiveness and good physical accuracy in practice.

Keywords: impact theory, restitution coefficient, traffic accident analysis, vehicle dynamics

1. Classical formulation

From the law of conservation of momentum of the mechanical system of the two motor vehicles for the time interval of the impact (fundamental equation of impact dynamics), we have

$$\vec{Q} = m_1 \cdot \vec{V}_1 + m_2 \cdot \vec{V}_2 = m_1 \cdot \vec{u}_1 + m_2 \cdot \vec{u}_2 \quad (1)$$

$$\cos\alpha_1 \cdot m_1 \cdot V_1 + \cos\alpha_2 \cdot m_2 \cdot V_2 = \cos\beta_1 \cdot m_1 \cdot u_1 + \cos\beta_2 \cdot m_2 \cdot u_2 \quad (2)$$

where α_j , $j=1,2$ is the angle measured from the x-axis to the velocity of the center of mass of the corresponding motor vehicle before the impact; β_j , $j=1,2$ is the analogous angle after the impact.

According to impact theory, the coefficient of restitution is determined by the expression

$$k = \frac{|\Delta u_n|}{|\Delta V_n|} \quad (3)$$

where Δu_n is the projection of the relative velocity between the centers of mass of the vehicles after the

$$\begin{aligned} & (\cos\alpha_1 \cdot e_x + \sin\alpha_1 \cdot e_y) \cdot V_1 - (\cos\alpha_2 \cdot e_x + \sin\alpha_2 \cdot e_y) \cdot V_2 = \\ & = \frac{1}{(\pm k)} [(\cos\beta_2 \cdot e_x + \sin\beta_2 \cdot e_y) \cdot u_2 - (\cos\beta_1 \cdot e_x + \sin\beta_1 \cdot e_y) \cdot u_1] \end{aligned} \quad (5)$$

The velocity of the center of mass of each motor vehicle is calculated by the formula velocity of the motor vehicle after the impact is calculated by the formula

$$u_j = \sqrt{2 \cdot g \cdot \sum(\mu_j \cdot s_j)}, \quad (6)$$

where μ_j , $j=1,2 \dots n$ is the average resistance during the movement of the vehicles after the impact on the corresponding section, $g = 9,81 \text{ m/s}^2$ is gravitational acceleration; s_j , $j=1,2 \dots n$ is the distance traveled by the center of mass of the corresponding vehicle after the impact on the corresponding section.

Here e_x и e_y are projections of the unit vector of the impact impulse, assumed for the first vehicle. They have the form

where m_j , $j=1,2$ re the total masses of the vehicles, $\vec{V}_j$, $j=1,2$ и $\vec{u}_j$, $j=1,2$ are the velocities before and after the impact. After projecting the vector equality onto the coordinate axis x – the longitudinal axis of the road, the expression is obtained

impact onto the direction of the impact impulse, and ΔV_n - the projection of the relative velocity between the centers of mass before the impact. We obtain the relationship

$$\frac{(\vec{u}_2 - \vec{u}_1) \cdot \vec{e}}{(\vec{V}_1 - \vec{V}_2) \cdot \vec{e}} = k \quad (4)$$

where $\vec{e}$ is the unit vector of the impact impulse vector for the first vehicle.

Expression (4) in the present case is written in the form

$$e_x = \cos(\alpha_s); e_y = \sin(\alpha_s) \quad (7)$$

where α_s is the angle of the resultant of the impact impulse. It is assumed for the first vehicle.

Using the software product Matlab, through successive iterations with sufficient physical accuracy, correspondence is achieved between the previously assumed direction of the impact impulse and the obtained one, as well as parallelism between the vectors of velocity changes of the centers of mass of the vehicles. Variables within the bounds of reliability are the coefficient of restitution, the angles of the velocities of the vehicles before the impact, and the angle of the direction of the impact impulse. The changes in the specified quantities must satisfy the known limits of admissibility according to the deformations of the motor vehicles

and the fundamental theorems of mechanics - the theorem of change of momentum and the theorem of change of angular momentum with respect to the center of mass.

2. More accurate solution with coefficient of restitution referred to the contact points.

According to impact theory, the coefficient of restitution has the form

$$k = \frac{|\Delta u_{ps}|}{|\Delta V_{ps}|} \quad (8)$$

where Δu_{ps} is the projection of the relative velocity between the contact points of the vehicles P_1 and P_2 after the impact onto the direction of the impact impulse, and ΔV_{ps} - the projection of the relative velocity between the contact points of the vehicles before the impact. We obtain the relationship

$$k = \pm \frac{(\vec{u}_{P_2} - \vec{u}_{P_1}) \cdot \vec{e}}{(\vec{V}_{P_1} - \vec{V}_{P_2}) \cdot \vec{e}} \quad (9)$$

where ω_j ($j = 1, 2$) are the magnitudes of the angular velocities of the motor vehicles after the impact

$$\begin{aligned} (\vec{\omega}_1 \times \vec{\rho}_{P_1}) \cdot \vec{e} &= \vec{\omega}_1 \cdot (\vec{\rho}_{P_1} \times \vec{e}) = \omega_1 \cdot h_1; \\ (\vec{\omega}_2 \times \vec{\rho}_{P_2}) \cdot \vec{e} &= \vec{\omega}_2 \cdot (\vec{\rho}_{P_2} \times \vec{e}) = -\omega_2 \cdot h_2 \end{aligned} \quad (11)$$

where P_1 and P_2 are the contact points of the two vehicles at the moment of impact; $\vec{u}_{P_j}$ ($j = 1, 2$) - velocities of the contact points after the impact; $\vec{V}_{P_j}$ - velocities of the contact points before the impact; $\vec{e}$ - unit vector of the impact impulse vector, assumed for the first vehicle.

The velocity of each contact point after the impact, according to the law of velocity distribution, is determined by the expression

$$\vec{u}_{P_j} = \vec{u}_j + \vec{\omega}_j \times \vec{\rho}_{P_j} \quad (10)$$

where $\vec{u}_j$ ($j = 1, 2$) are the velocities of the centers of mass of the motor vehicles after the impact; $\vec{\omega}_j$ - angular velocities of the motor vehicles after the impact; $\vec{\rho}_{P_j}$ - radius vectors of the corresponding contact points with respect to the corresponding centers of mass.

The following relationships are valid

(positive), and h_j are the lever arms of the impact impulse vector with respect to the corresponding centers of mass of the motor vehicles.

Similarly, the following equalities are valid

$$\begin{aligned} \vec{V}_{P_j} &= \vec{V}_j + \vec{\omega}_{j0} \times \vec{\rho}_{P_j} \\ (\vec{\omega}_{10} \times \vec{\rho}_{P_1}) \cdot \vec{e} &= \vec{\omega}_{10} \cdot (\vec{\rho}_{P_1} \times \vec{e}) = \omega_{10} \cdot h_1; \\ (\vec{\omega}_{20} \times \vec{\rho}_{P_2}) \cdot \vec{e} &= \vec{\omega}_{20} \cdot (\vec{\rho}_{P_2} \times \vec{e}) = -\omega_{20} \cdot h_2 \end{aligned} \quad (12)$$

where $\vec{V}_j$ ($j = 1, 2$) are the velocities of the centers of mass of the motor vehicles before the impact; $\vec{\omega}_{j0}$ - angular velocities of the motor vehicles before the impact; $\vec{\rho}_{P_j}$ - radius vectors of the corresponding contact points with respect to the corresponding centers of mass; ω_{j0} - projections of the angular velocity vectors of the motor vehicles before the impact onto the corresponding angular velocity vectors after the impact (with positive or negative sign).

In practice, most often $\omega_{j0} = 0$ ($j = 1, 2$) and the velocities before the impact involved in the expression $\vec{V}_{P_j}$ are equal to the velocities of the centers of mass of the motor vehicles.

The angular velocity of each motor vehicle after the impact on a homogeneous section can be determined by the formula

$$\omega_j = 2 \cdot \omega_{cpj} = 2 \cdot \frac{\varphi_j}{t_j} = 2 \cdot \frac{\varphi_j}{u_j} \cdot j_j \quad (13)$$

where φ_j ($j = 1, 2$) is the angle of rotation of the corresponding vehicle after the impact; t_j - the time of movement after the impact; j_j - the average braking deceleration after the impact.

For a non-homogeneous section, the procedure is analogous for each section from the final to the first until obtaining the angular velocity immediately after the impact.

The coefficient of restitution takes the form

$$\begin{aligned} &(\cos \alpha_1 \cdot e_x + \sin \alpha_1 \cdot e_y) \cdot V_1 - (\cos \alpha_2 \cdot e_x + \sin \alpha_2 \cdot e_y) \cdot V_2 = \\ &= \frac{1}{(\pm k)} \left[(\cos \beta_2 \cdot e_x + \sin \beta_2 \cdot e_y) \cdot u_2 - \omega_2 \cdot h_2 - \right. \\ &\quad \left. - (\cos \beta_1 \cdot e_x + \sin \beta_1 \cdot e_y) \cdot u_1 - \omega_1 \cdot h_1 \right] - \omega_{10} \cdot h_1 - \omega_{20} \cdot h_2 \end{aligned} \quad (14)$$

3. Example

For comparative analysis, a crash test conducted on a specially adapted testing facility is used. The described methodologies are applied, and the results are compared with the previously known velocities of the

vehicles at the moment of impact. They are respectively as follows: for the **Ford Focus Turnier** – 55.9 km/h = 15.53 m/s; for the Peugeot 107 – 61.1 km/h = 16.97 m/s. The main technical data of the vehicles are also known in advance, presented in Table 1.

Table 1

Vehicle	Ford Focus Turnier	Peugeot 107
Manufacturer	Ford	Peugeot
Model	Focus Focus Turnier	107 (P) 1.0 50KW - 3d
Total Weight [kg]	1340	889
Length [m]	4.47	3.43
Width [m]	1.84	1.66
Height [m]	1.503	1.47
Wheelbase [m]	2.64	2.34
Overhang [m]	0.87	0.64
Track Axle 1 [m]	1.54	1.42
Track Axle 2 [m]	1.54	1.42
Tyre Radius [m]	0.317	0.279
Tyre Width [m]	0.195	0.155
C.G. height [m]	0.75	0.53
C.G. X-position [m]	-1.32	-0.91
Yaw Inertia [kg.m ²]	2007	905
Roll Inertia [kg.m ²]	669	302
Pitch Inertia [kg.m ²]	2007	905
Turning Circle [m]	10.9	9.46
Steering Ratio	1:16	1:16
Engine Power [kW]	59	50
Motor Braking Factor	0.05	0.05
Drive train	Front	Front
Brake Distribution (Front/Rear)	0.14 / 0.36	0.14 / 0.36
Stiffness [N/m]	21909	17740
Damping [Ns/m]	2465	11330
Max Spring Deflection [m]	0.12	0.12
Stabilizer Factor	2.0	2.0
Load Capacity per axle [N]	5250	3540
Skew Angle [°]	12	12
cw Value	0.3	0.3
Rolling Res.Coeff.	0.005	0.005

The figures below show characteristic views of the motor vehicle positions before the impact, during the impact, and after it.



Figure 1 – Vehicles shortly before the traffic accident



Figure 2 – Initial contact



Figure 3 – Maximum penetration



Figure 4 – Maximum penetration and impact impulse (side view)



Figure 5 - Maximum penetration and impact impulse (rear view)



Figure 6 – Maximum penetration and impact impulse (rear view)



Figure 7 – Final positions



Figure 8 – Final positions

4. Calculations and Results

Table 2

Theory applied to center of the mass		
Param.	Ford Focus Turnier	Peugeot 107
total mass, kg	1340	889
α , deg	0	188
β , deg	322	12
α_s , deg	188,4	
j , m/s ²	5	0,98
s , m	1,04	3,1
g , m/s ²	9,81	
u , m/s	3,22	2,47
u , km/h	11,6	8,9
k	0,007	
S , N.s	18 248	18 253
ΔV , m/s	13,6	20,5
ΔV , km/h	49,0	73,9
VB1,2 m/s	16,0	18,1
VB1,2 km/h	57,7	65,1

Table 3

Theory applied to contact point		
Param.	Ford Focus Turnier	Peugeot 107
total mass, kg	1340	889
α , deg	0	188
β , deg	322	12
αs , deg	188,9	
j , m/s ²	5	0,98
s , m	1,04	3,1
g , m/s ²	9,81	
u , m/s	3,22	2,47
u , km/h	11,6	8,9
φ , deg	10	43
$\omega_{1,2}$, rad	0,54	0,6
h_1 , m	0,05	0,22
$\omega_{10,20}$, rad	0	0
k	0,013	
S , N.s	17 258	17 242
ΔV , m/s	12,9	19,4
ΔV , km/h	46,4	69,8
$VB_{1,2}$ m/s	15,3	16,9
$VB_{1,2}$ km/h	55,1	61,2

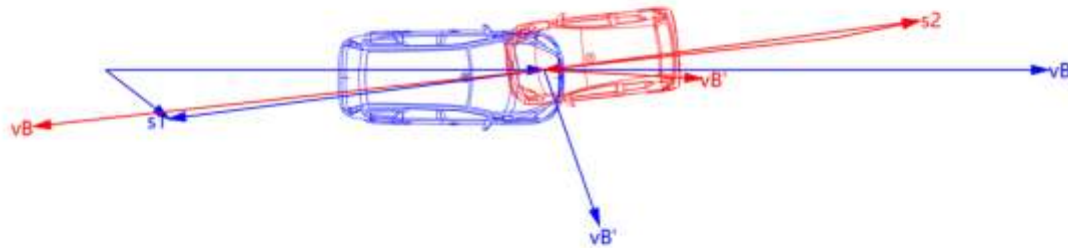


Figure 9 – Vehicles at the moment of impact and velocity diagram

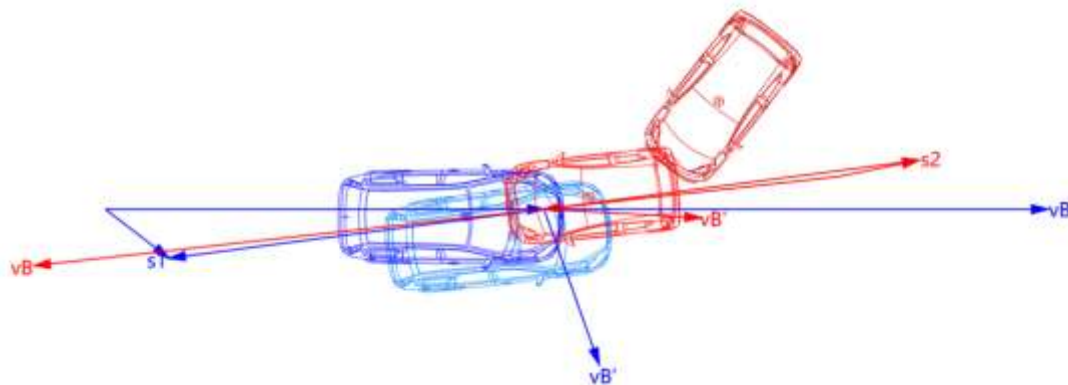


Figure 10 – Vehicles at the moment of impact, velocity diagram and final positions

Table 4

Vehicle	Method	Speed (m/s)	Speed (km/h)	Δ from crash (m/s)	Δ from crash (km/h)
Ford Focus Turnier	Crash test	15.53	55.9	—	—
	Center of mass	16.01	57.7	+0.48	+1.8
	Contact point	15.3	55.1	-0.23	-0.8
Peugeot 107	Crash test	16.97	61.1	—	—
	Center of mass	18.07	65.1	+1.10	+4.0
	Contact point	16.9	61.2	-0.07	-0.3

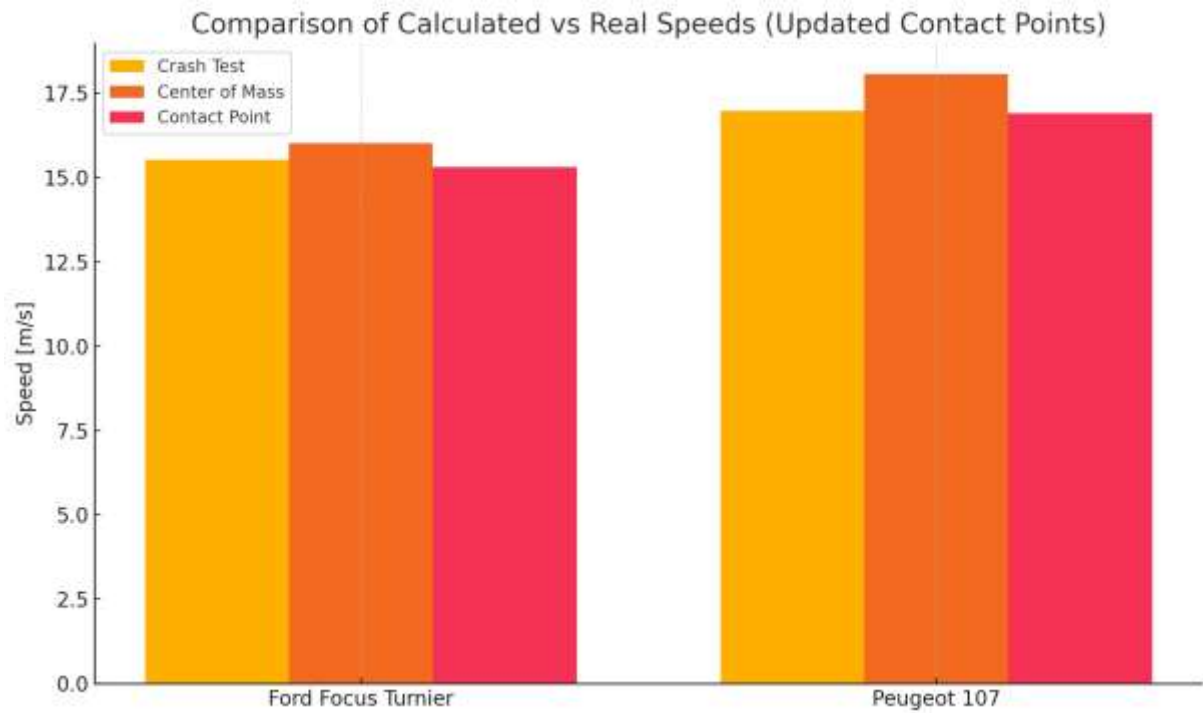


Figure 11 – Comparison of calculated and real speed

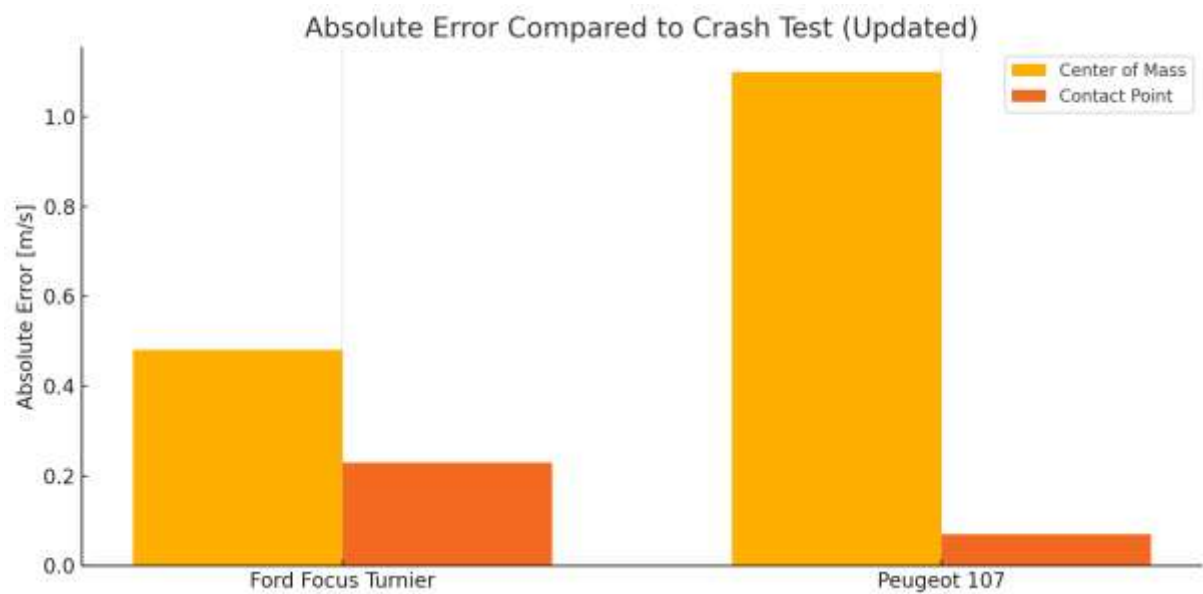


Figure12 – Absolute error

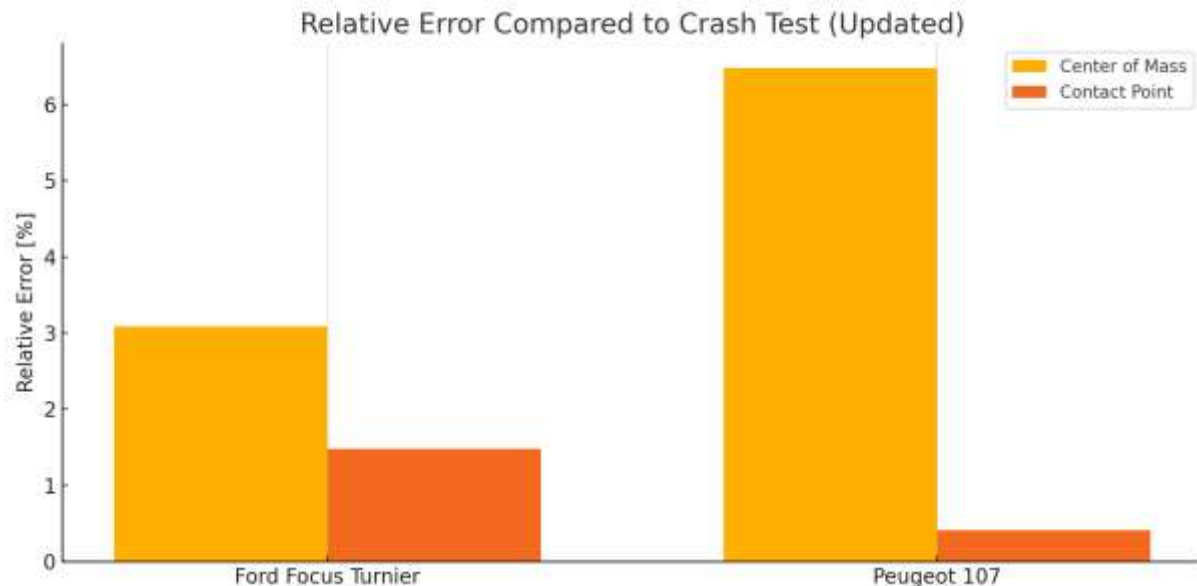


Figure 13 – Relative error

5. Analysis

5.1. Ford Focus Turnier

- The center of mass method differs in velocity by **+0.48 m/s (1.8 km/h)**.
- The contact points method is much closer to reality – the deviation is only **–0.23 m/s (–0.8 km/h)**.

5.2. Peugeot 107

- The center of mass method significantly overestimates the velocity – by **+1.10 m/s (4.0 km/h)**.
- The contact points method almost completely matches the actual velocity – the deviation is **–0.07 m/s (–0.3 km/h)**.

6. Conclusions

Overall, the results obtained by the classical methodology and the proposed more accurate one has sufficient physical accuracy. For both vehicles, **the more accurate "Theory applied to contact point" method gives more precise results**, with minimal deviations from the actual velocities of the crash test. The **"Theory applied to center of the mass" methodology, as a whole, has acceptable results**, with a larger error observed for the vehicle with smaller mass - the Peugeot 107.

The proposed update to impact theory, intended for accident analysis between vehicle collisions, has been repeatedly applied by the authors in forensic investigation in combination with other methods. Very good accuracy is achieved when using multi-mass spatial (three-dimensional) mechanomathematical modeling of motor vehicle movement after impact, from which the velocities of their centers of mass and their angular velocities after impact are accurately obtained.

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