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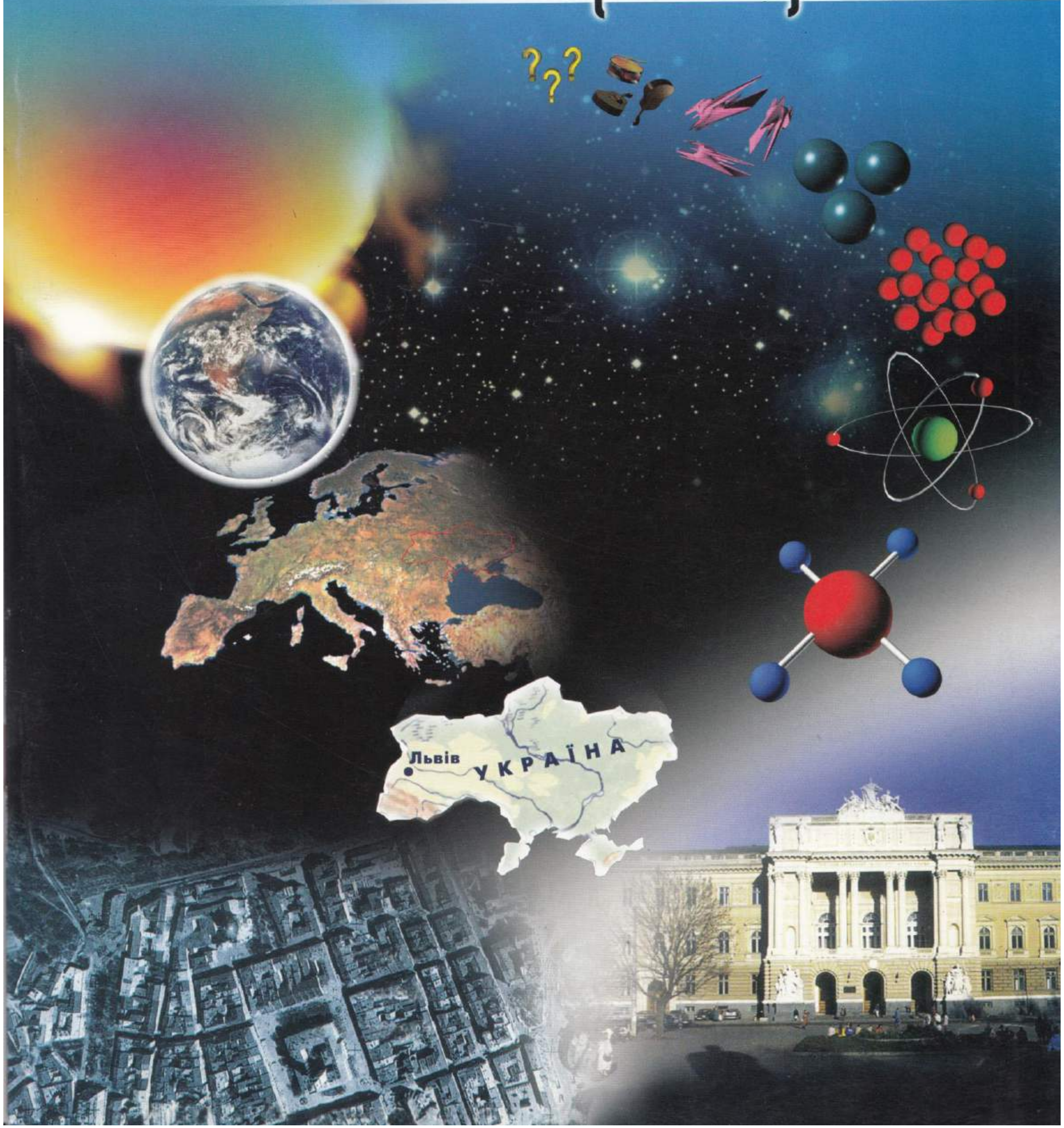
world of physics



UKRAINE

CHEERS YOUNG PHYSICISTS OF THE WORLD !

On the Organization Committee's Assembly. Odessa, the 12th of October, 2001

Taking into account conditions of the scientific progress in Ukrainian and good traditions of The Ukrainian Tournaments of Young Physicists a honourable International Committee has decided to hold The XV International Young Physicists Tournament in Odessa (Ukraine) on 23 till 30 of May 2002.

The idea of holding The International Young Physicists Tournament in Ukraine was supported by The Ministry of Science and Education of Ukraine, The State Government of Odessa, The Odessa National University by I. Mechnikov, The Richelieu Lyceum, The European Physical Society.

Many pupils from different countries are going to Ukraine. So we have a good opportunity to acquaint them with the history, culture, traditions of our country, achievements of the Ukrainian science.

During last five years the journal of „World of Physics" has already shown up and popularized Ukrainian and International tournaments of young physicists and it will be one of the primary information springs on this forum, it will inform scientific and educational community of Ukraine about the evolving of The XV IYPT.

The journal of „World of Physics" cheers the participants of The XV International Young Physicists Tournament.

A discussion of The Tournament task

I wish you as much joy from the study of our wonderful subject - physics - as I have had in my lifetime.

John Stachel

John Statchel,
the professor of Boston University, the director of The Einstein Developments Center

WE REFER TO THE SPONSORS WITH THE ASK TO SUPPORT THE YOUNG PHYSICISTS TOURNAMENTS

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World of physics

- it is an all-Ukrainian popular science;
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- it reports on olympiads, tournaments, other creative competitions for students;
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- it helps pupils and teachers to develop insights into problems of physics;
- it promotes modern Ukrainian scientific and technical terminology;
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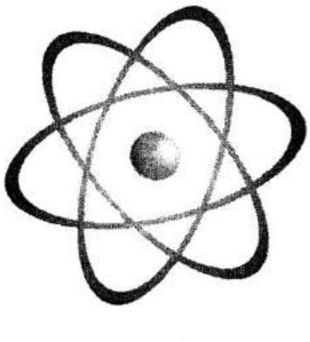
- it develops aesthetical sensitivity.

Scholars, teachers, students, pupils in Ukraine and abroad read this journal.



Subscription index
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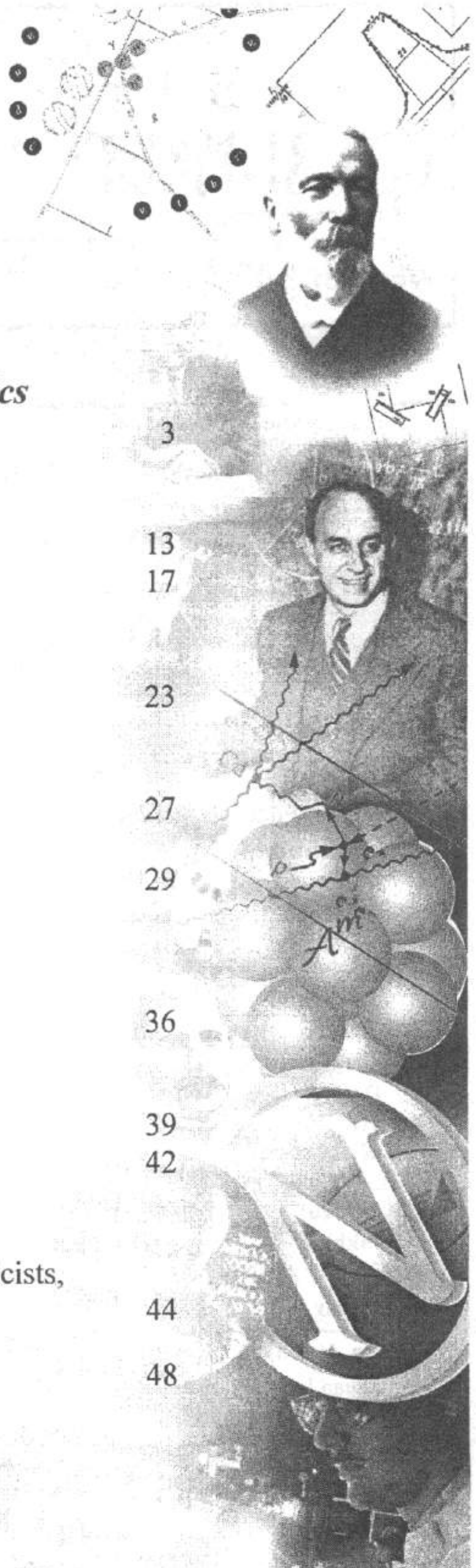
CONTENTS



Hide-and-Seek Particles

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Introduction

Magnetic monopoles, gravitons, tachyons, Higgs bosons, *s*-particles, and a whole collection of exotic entities[1] – these are examples of particles envisioned in theoretical physics, but which, so far, experimental physicists have not definitively substantiated.

In the past, searches for predicted particles were often successful, even though the path to discovery generally was involved and laborious. In the first part of this article, we shall consider five examples form the past which show the kind of adversities the researchers encountered in their quests. The choice of cases is rather arbitrary – particles discussed are the neutron, positron, neutrino, Ω^- (omega minus), and the top-quark. Any one of the other discoveries has its own specifics and could serve as an example. Nonetheless, the five selected cases encompass the most typical of the encountered difficulties.

In the second part, five examples of current intensive searches for particles that have been credibly predicted, but which remain unobserved, will be highlighted. The five chosen are magnetic monopoles, gravitons, tachyons, Higgs bosons, and *s*-particles.

Examples of successful searches

The Neutron

As a result of his investigations of the atom of Helium, the physicist Ernest Rutherford, a native of New Zealand (Baron Ernest Rutherford of Nelson, 1871–1937), concluded in 1920 that along with the proton there must exist another particle, similar to the proton, except for being neutral. He foresaw that that this particle will pass freely through matter, that it will be difficult to detect, and that it will be "impossible to restrain this particle in a sealed container". Ten years later, in 1930, two German physicists, Walter W.G. Bothe (1891–1957) and Herbert Becker (1911–1942), announced the discovery of "mysterious, very penetrating rays", but they failed to associate their discovery with Rutherford's hypothesis. The French husband-and-wife team Frederic (1900–1958) and Irene (1897–1956) Joliot-Curie similarly missed the boat. They too detected "very penetrating rays" but concluded that these are highly energetic gamma-rays. Soon thereafter, the English physicist James Chadwick (1981–1974), who was thoroughly familiar with Rutherford's prediction, correctly interpreted the German and French results, confirmed them with his own experiments, and unequivocally established that the "very penetrating rays" are Rutherford's neutrons. This work earned him the Nobel Prize in 1935.

Examples of the German and French fumbles constitute a persuasive proof that physics researchers need to be well acquainted with the broad aspects of physics, and not be merely specialists, even preeminent, in their narrow field.

Positron and antipartlcles

An illustration of how a perceived weirdness of a theory discourages researchers to take its predictions seriously is the story of the discovery of the positron, the antiparticle of the electron.

In 1928, the English physicist Paul Adrien Maurice Dirac (1892–1984) has published an extension of the quantum theory into the relativistic realm. His equation for the electron rendered with extraordinary accuracy the finest details of atomic structure. Puzzling, however, was the fact that this equation yielded two-fold solutions. One solution was the one that so well described the electron, but the other perplexed even Dirac, because it did not correspond to any known particle. It described a particle which appeared to be something like a mirror image of the electron, except that it was positive.

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[1] Here are some of the "exotic" entities currently contemplated in physics. A description of most of them may be found on the internet: arions, axions, baryobosons, chargions, dilatons, dyons, electrinos, ether (!), familons, gauginos, glueballs, Goldstone bosons, hybrid mesons, instantons, lepfco-gluons, majorons, mirror matter, neufcralinos, pomerons, quintessence, quantum foam, strangelefcts, wimps, wimpzillas.

Such a particle was discovered, quite accidentally, without knowing of Dirac's work, by the American investigator of cosmic rays, Carl David Anderson (1905–1991). He coined for it the name of positron. Not long thereafter, Dirac ascertained that the properties of this positron correspond perfectly to those predicted by his "extraneous" solutions. In the course of time, further experiments have shown that each particle possesses a "twin" – its antiparticle.

In his memoires, Anderson stresses the importance for physicists not only to be acquainted with the broad picture of physics, but also not to permit their personal preconceptions to ignore "weird" theoretical predictions. Because Dirac's theory encompassed such "unphysical" concepts as negative mass, negative energy, passage of a particle from future into the past, the majority of "serious" physicists considered his theory excessively esoteric to be useful. Anderson remarks that an experimentalist, who would have accepted Dirac's theory without prejudgment, could have discovered the positron "in one afternoon", because Dirac had provided a clear indication that electron-positron pairs should be obtainable by means of gamma rays.

In the same way as in the case of the neutron, the positron slipped, without having been recognized, though the fingers of such excellent investigators as Patrick M.S. Blacket (1897–1974), Dimitri Skobeltsyn (1892–19??), and the Joliot-Curie team. The reason for this was again the insufficient awareness of the broad horizons of physics, probably enhanced by distaste for outlandish predictions.

The Neutrino

One of the most untouchable precepts of physics is the principle of conservation of energy. Yet in the years 1920–1930 even this law became a subject of doubt. In measurements of the energy of particles resulting from the decay of a nucleus "A" into "B" + β (e. g. $^{32}P \to {}^{32}S + \beta$), the expectation was for all the beta particles to emerge with a well defined energies, determined by the mass difference of "A" and ("B" + β). Yet as early as 1914, James Chadwick, and other investigators after him, arrived at the conclusion that in beta decay the energy appears not to be conserved. An egress from this perplexity was proposed in 1930 by the Austrian physicist Wolfgang Pauli (1900–1958). In a letter addressed to his "radioactive friends" he put forth the hypothesis that beta decay is accompanied by a so far undiscovered neutral particle having a spin of 1/2. He showed that such a particle would not only preserve the principle of conservation of energy, but also those of the linear and angular momenta. Unaware that this name was already preempted, Pauli called this particle neutron. When in 1933 a student asked Enrico Fermi (1901–1954) if the "neutron of Chadwick" and the "neutron of Pauli" were one and the same, Fermi explained: "No, il neutrone di Pauli è molto piu piccolo. Cio è un neutrino." ("No, the neutron of Pauli is much smaller. It's a tiny neutron.") From that time on the «neutron of Pauli» became known as neutrino, the Italian diminutive form for the neutron.

Be it as it may, many physicists were skeptical of Pauli's hypothesis. One of the experimentalists who obtained new convincing data supporting the existence of the hypothetical neutrino, was the Ukrainian physicist from Kharkiv, Oleksander Leipunskyj (1903–1972). In 1935, when invited by Ernest Rutherford to conduct experiments in England, Leipunskyj measured, with high precision, the energy of recoiling nuclei in beta decay. As a result, he showed that the kinetic energy of the recoiling ^{32}S nucleus, following the decay $^{32}P \to {}^{32}S + \beta$, is considerably higher than the energy corresponding to the recoil from the electron (the β-particle) alone. This finding suggested that the nucleus ^{32}S is recoiling not just from the electron but also from the, so far hypothetical, neutrino.

A direct proof of the existence of the neutrino was not realized until 1953, when Clyde Lorrain Cowan and Frederic Reines carried out the nuclear reaction in which a neutrino (in that case actually an antineutrino) transformed a proton into a neutron plus a positron: $p + \bar{\nu} \to n + e^{+}$. A nuclear reactor served as the source of the antineutrinos.

This definitive proof of the existence of the neutrino completed a long process of hints, inferences, and querying. But already for quite a few years before the conclusive validation of the neutrino – the conformity and mutual reinforcement of earlier experiments have convinced most physicists that the neutrino does exist and that it will be discovered sooner or later.

Ω^- (Omega minus)

When towards the end of the 1950's the number of elementary particles observed in cosmic rays and in accelerators increased considerably (58 baryons, 72 mesons – with their antiparticles the number was 260!), physicists began to wonder if these particles were indeed fundamental, or if perchance they were composed from a smaller number of truly fundamental particles. At the beginning of the decade of 1960 it became patent that the mathematical symmetry group SU-3 reflects admirably the observed regularities within the aggregates of baryons and mesons. Moreover, similarly as in the case of the periodic table of chemical elements of Dimirtij Ivanovich Mendeleev (1834–1907), the SU-3 approach revealed that some particles remain undiscovered and predicted their properties. This new group classification was proposed independently by Murry Gel-Mann (1929-) and George Zweig (1937) from the California Institute of Technology, and by Yuval Ne'eman (1925-) from the Imperial College of London. On the basis of this classification, Gel-Mann predicted, in 1962, the existence of the baryon Ω^-, having a mass of 1680 MeV, spin 1/2, electrical charge –1, positive parity, baryon number +1, and strangeness –3. The discovery of such a baryon became crucial as a proof that the SU-3 group indeed classifies all baryons and mesons fully and without exceptions.

In 1964, physicists from the Universities of Rochester and Syracuse, and from the Brookhaven National Laboratory (all three in the State of New York), under the direction of Nicholas Peter Samios (1932), discovered, in a 2-meter bubble chamber of Brookhaven, the particle predicted by Gel-Mann, with all the anticipated properties. This discovery became the signal event which provided the unequivocal rationale for accepting the quarks as the truly fundamental entities from which all hadrons (protons, neutrons, and their short-lived relatives – hyperons), and all mesons, are made up.

But time marches on and on the horizon loom new, even smaller, pretenders – called strings and branes – for the role of ultimate building blocks of matter (see section on *s*-particles in the second part of this article).

Top-Quark

Even though quarks have acquired full citizenship as essential constituents of hadrons and mesons, they remain undetectable in the hide-and-seek game experimentalists play with particles. No quark has ever been detected in isolation and according to current theory – never will. For any attempt to separate a quark from its two partners in a barion (e. g. proton), or from its antipartner in a meson, the amount of energy needed is such that one gets a new quark-antiquark pair, rather than a single free quark.

Notwithstanding, physicists have incontestably established the peculiar properties of quarks. Their electrical charge is fractional: +3/2 or –1/3. In addition to the electric charge, quarks possess three types of the so-called "color charge" – "red", "green", and "blue" [2]. When three quarks make up a baryon (e. g. a proton), each of them has a different color and as a result all baryons are "colorless". Also "colorless" are all mesons, which consist of a quark and an antiquark, with the antiquark having the anticolor of its partner.

Quarks are further classified into tree generations, each having two flavors [3]. Thus the first generation consists of flavors called up and down, the second – of charmed, and strange, and the third of top and bottom [4].

By 1977, five of the envisaged six flavors have been identified. Remaining to be ascertained was the sixth – top – quark. To establish its existence became the paramount task of experimental particle physics. Without the top-quark the whole Standard Theory, on which the entire understanding of the structure of matter is based, would collapse like a house of cards from the base of which one card was removed.

The searches for the top-quark were undertaken at the Stanford linear accelerator in California, at the German accelerator center near Hamburg, and in 1980 at the new high-energy accelerator at the European Center of Nuclear Research (Centre Europeén de Recherche Nucléaire – CERN) near Geneva. Even though at CERN the collisions between protons and antiprotons took place at an energy of 300 GeV, no evidence for the top-quark was found. Taking into consideration the fact that collisions do not actually occur between proton and antiproton, but between

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[2] The name "color charge" has nothing in common with the customary meaning of color. The three kinds of charge of the strong interaction were at first labeled by American physicists as "red", "white", and "blue". They may have gotten self-conscious about this, so they changed the names to "red", "green", and "blue".

[3] The term "flavor" also has here an exclusively physical significance, unrelated to the everyday meaning of the word.

[4] Following the poetic terms "charmed" and "strange", imaginative physicists tried to replace the prosaic terms "top" and "bottom" with the more appealing "truth" and "beauty". Unfortunately, the stodgy physicists won out...

the three quarks of the proton and the three antiquarks of the antiproton, only 1/3 of the collision energy is available for the creation of the top-antitop quark pair. After 8 years of experimentation the researchers at CERN concluded that if the top-quark exists, its mass has to be at least an order of magnitude higher that the heaviest of the known quarks, the bottom-quark, whose mass is 4,5 GeV.

In 1985 the search for the top-quark was joined by the National Fermi Laboratory ("Fermi Lab") near Chicago, where the most powerful accelerator on earth, the TEVATRON, just became operational. At the TEVATRON collisions between protons and antiprotons were taking place at an energy of 1 Teravolt (1 TeV = 1000 GeV = 10^{12} eV). At such a high energy, the experimenters expected a speedy success. Yet success came only after 10 years of hard work of over 400 physicists, and even more engineers and technicians, form over 40 universities and laboratories from around the world. The total cost of the enterprise ran into 500 million US dollars.

The energy released at each collision gave rise to a myriad of particles. The problem was to glean from the midst of billions of traces those that would bear incontrovertible evidence of the decay of top-antitop pairs. Huge and complicated detectors were designed and built. Sophisticated programs were devised for powerful supercomputers to analyze the deluge of data. Investigations were carried out in parallel by two independent groups. Both groups were prepared to deal with the horrendous problems imposed by the inescapable glut of background particles. But they were not prepared for the top-quark to have a mass of 175,6 GeV. After all, this corresponds to the mass of an entire atom of gold!

The reports on the identification of the top-quark appeared in the journal PHYSICAL REVIEW LETTERS [1], [2]. The number of authors on both publications is close to 1000.

The top-quark has been found. The next task is to unravel the enigma of mass (see section on Higgs bosons in the second part of this article).

Examples of current searches

Magnetic Monopole

The absence of a magnetic charge, analogous to the electric charge, spoils the symmetry of the equations of James Clark Maxwell (1831–1879) which otherwise would be perfect for electricity and magnetism. The nonappearance of the magnetic charge has troubled physicists from early on and many of them were, and still are, convinced that magnetic charges exist and will indubitably be discovered. As early as 1896, soon after the discovery of the electron by Joseph John ("J. J.") Thomson (1856–1940) in 1895, the renowned French physicist Henri Jules Poincaré undertook the calculation of the motion of an electron in the field of a magnetic charge [3].

The classical theory of elecfcromagnetism does not contain any limitations which would contravene the existence of a magnetic monopole (magnetic charge). When at the beginning of the 1930's Paul Dirac took up this problem, he did not find any quantum-electrodynamic restrictions in this regard either [4]. Quite the contrary, he proved that the existence of the elementary electric charge, e_0, implies the existence of an elementary magnetic charge, m_0. Dirac's computations showed that the interaction between two elementary magnetic charges would be stronger by a factor of 4692 than that between two electrons separated by the same distance. Which means that a magnetic charge would ionize atoms and scatter photons much more effectively than an electric charge. This prediction is one of the main clues that guides the searches for the magnetic monopole.

Some cosmological theories allow for a copious presence of magnetic monopoles in the early stages of cosmic development, but few monopoles, if any, would have survived to the present day. Considering that they interact with magnetic fields, the best refuge for those that survived would be natural sources of magnetic fields, such as iron ores.

Primarily due to the persuasive arguments of Dirac, efforts to find magnetic monopoles continue unabated, albeit unsuccessfully so far. Every time that a new avenue opens towards a potential source of monopoles, the searches resume. For example, the rocks which American astronauts brought back from the moon in 1969 were subjected to an exhaustive study in this regard.

Dirac also concluded that monopoles will be very massive, which should make a search for them at current accelerator energies pretty futile. Notwithstanding, among the first experiments carried out at new, more powerful, accelerators are searches for highly ionizing monopole-antimonopole pairs.

Most promising for physicists appears to be the possibility that monopoles are present in cosmic rays, or that monopole-antimonopole pairs are occasionally created by those cosmic protons whose energy exceeds by orders of magnitude anything obtainable in accelerators. Deep under the Gran Sasso mountain in the Apennines, in the Italian National Laboratory, an array of detectors containing 550 tons of liquid scintillator for years now eagerly awaits the detection of its first magnetic charge.

And yet the lack of success does not discourage the investigators. They continue to believe firmly that monopoles exist, and ascribe the lack of the results to the scarcity of monopoles and to their excessive mass. The latest estimates of that mass, based on studies of proton-antiproton collisions at the TEVATRON in Fermi Lab, range upward form 1600 GeV.

Thus it would appear, that there is no sense to look for monopoles in accelerators. Nevertheless such searches were recently undertaken, after a physicist from Novosibirsk, Illya F. Ginzburg [5], described a possible quantum process in which virtual[5] monopoles, give rise to a pair of gamma rays which would attest unmistakably to the existence of monopoles, no matter how ephemeral. First such searches actually have already been carried out by Ginzburg, in the mid 1990's, jointly with his American colleagues at the TEVATRON, and with European physicists at the LEP (Large Electron-Positron Collider) at CERN near Geneva. No doubt, new searches along these lines will be taken up again when in 2006 the new super-powerful Large Hadron Collider (LHC) will come on line at CERN.

But even when the monopoles will refrain from showing themselves at LHC, searches for them will not cease. Such searches will be discontinued only after monopoles are found, or after theorists discover, in the whole of physical laws, a reason why monopoles cannot exist. According to the facetious "Totalitarian Principle" of Gel-Mann "In physics unexcused absences are not tolerated."

[5]According to Heisenberg's indeterminacy relation, $\Delta E \Delta t \leq \hbar$, particles inhabiting the negative-energy "vacuum", may, for a duration Δt acquire spontaneously sufficient energy ΔE to appear in our world as real positive-energy particles, without violating the principle of conservation of energy. Such appearance is referred to as *virtual.*

Gravitons

Einstein's equations for the gravitational field, when written in the so-called approximation of weak fields, are quite similar to Maxwell's equations for the electromagnetic field. These equations foresee the existence of gravitational waves, in analogy to the electromagnetic waves. Just as the photons, gravitons, the quanta of the gravitational fields, have zero rest mass, and thus move at the speed of light. However, gravitons result from quadrupole energy transitions, which indicates that their spin should be 2, rather than 1 that holds for photons.

Because so far all predictions of Einstein's relativity theory have faithfully come true, physicists are confident that gravitons exist and that they unquestionably will be discovered. Preliminary experimental indications that gravitons exist are already at hand. Observations, carried out over the last 15 years of the pulsar PSR1913+16 and of its companion star, have established that the rotational energy of this system decreases with time. Computations performed under the assumption that this decrease results from radiation of gravitons are in full agreement with observations. But even though in 1993 two American astrophysicists (Joseph Taylor and Russel Hulse) have been awarded the Nobel Prize for this work, the search for gravitons goes on. The aim is to detect the actual gravitons directly. Over the last decades ever more refined and extensive instruments have been devised and built. The task is not easy considering that the gravitational interaction is incomparably weaker then the electromagnetic interaction – weaker by 38 orders of magnitude! What has to be carried out is the measurement of the distortion of space due to the passage of a gravitational wave. The first attempts involved the measurement of the length of a "gravitational antenna". Upon passage of a gravitational wave, such an antenna, say a solid metal cylinder 10 meters long, should undergo a transient longitudinal vibration with a maximum amplitude of some 10^{-15} meters – about one tenth of the diameter of an atom! Even though experiments of this kind have been underway for over 40 years, this approach has not been successful. (In 1976 such an experiment was carried out in the basement of the Institute of Theoretical Physics in the Theophania suburb of Kyiv in Ukraine.)

A more promising phase of graviton searches began in 1978 in California where a graviton detector was devised using the interference of two laser beams as the indicator of space distortion. By 1985, the prototype of such an interferometer, spanning a distance of 40 meters, was already capable of measuring the change by a factor of 10^{-18} of the observed length. Similar interferometers have been constructed in Italy, Japan, Germany, France and England. The most sensitive system of such interferometers, called LIGO (Laser Interferometer Gravitational Observatory) is in the final stages of calibration and should start operating in the USA before the end of 2002. This system consists of two units – one in the state of Washington and the other in Louisiana. The design sensitivity of this system is one part in 10^{22}.

In different stages of construction are similar systems in Germany (Project GEO), in Japan (Project TAMA), and the French-Italian Project VIRGO. Several other systems are in different stages of design. The most recent approach to the direct detection of gravitons relies on the measurement of the Doppler shift in microwaves from cosmic probes induced by passage of gravitational waves. Calculations permit to anticipate that this method will permit to register a change of the Earth-Mars distance of 8 microns (8×10^{-6} meters). There are reasons to expect that by the time this article appears in print the first results of detection of gravitons will be at hand. At least that is what many astrophysicists are hoping for.

Tachyons

Until the early 1960's, in physics prevailed the unjustified belief that Einstein's special theory of relativity excludes the possibility of existence of particles with velocities greater than *c*, the velocity of light in vacuum. It turned out, however, that such a restriction applies only to particles which possess a real, non-zero proper mass (rest mass). These particles can never quite reach light speed, no matter how much energy is imparted to them. Particles (quanta) that do travel at the velocity of light are photons, which have **zero** proper mass. Similarly, Einstein's theory does not preclude the possibility of existence of particles whose velocities would **always** be greater than *c*, spanning the range from *c* to an infinite velocity. Into the bargain, it was the very theory of Einstein which permitted to surmise some of the properties of these hypothetical superluminal particles, which became known as **tachyons.** A detailed discussion of these properties may be found in references [6–9].

The hypothesis of the possibility of existence of tachyons [6] was sufficiently convincing for experimental searches for them to begin soon after its publication. Such searches were carried out at the Nobel Institute in Stockholm, Sweden, Princeton University, Columbia University, University if Colorado, Brookhaven National Laboratory, USA, Tata Institute, India, in arrays of cosmic ray detectors in Australia and Japan, and in several other research centers. Experimenters were looking for telltale Cherenkov radiation that would accompany superluminal charges. Nuclear reactions in accelerators were analyzed for evidence of particles in angular regions kinematically accessible only with presence fcachyons. Cosmic ray detectors were set up to detect possible tachyonic "precursors". Following the hypothesis of Leonard Parker [10], searches for magnetic monopoles took into account the possibility that monoploes are tachyonic. Descriptions of these, and of other early tachyonic searches, may be found in references [11–13]. With all the above searches ending up negative, the interest in tachyons waned. That interest, however, became reinvigorated in 1985 when Alan Chodos and Avi I. Hauser (Yale University), and Alan Kostelecky (Los Alamos Natonal Laboratory) jointly published, in the journal PHYSICS LETTERS, a paper entitled "The Neutrino as a Tachyon" [14]. In that paper the authors argue that at present neither theory, nor experiment, negate the possibility that the electron neutrino is actually a tachyon. The primary rationale for their hypothesis comes from experimental indications that the square of the neutrino mass m_υ^2 may be negative. This would mean that the mass of the neutrino is imaginary, which, in turn, would place it into the category of tachyons. (In our laboratories a tachyon does not possess a rest frame, hence its mass is not subject to observation and may be imaginary. At the same time, the energy and the momentum of a tachyon remain real and in principle observable [6], [7]. Similar arguments apply to photons whose, rest mass is zero.)

For considerable time the notion prevailed that the proper mass of the neutrino is zero, just as for the photon. This conviction was based on the measurements of the end point of beta spectra in beta decay. Such measurements permit to determine the value of m_υ^2 of the accompanying neutrino. The results appeared scattered around $m_\upsilon^2 = 0$. As with time measurements became more exact, negative values of m_υ^2 began to predominate [15, 16]. Since then, dozens of theoretical and experimental papers appeared on the possible tachyonic nature of the neutrino (see internet for tachyon neutrino references). Some of these references discuss the possibility that the negative m_υ^2 results may be due to difficulties associated with measurements of extremely small electron energies. Clearly this question remains to be settled.

Another hint concerning the possible existence of neutrinos came when astrophysicists noticed a peculiar event in connection with the explosion, in 1987, of the supernova SN1987A. The neutrino flux from that explosion arrived one day ahead of the corresponding gamma flux. Because so far this is the only observation of this kind, which may be subject to different interpretations, it cannot be regarded as a convincing proof of existence of tachyons.

More promising in this regard are investigations of the so-called "knee" in the spectra of cosmic protons. According to theory, at ultra-high proton energies the following reaction becomes possible: $p+\bar{\nu} \rightarrow n+e^{+}$ [17], where a proton absorbs a tachyonic antineutrino. In 1993 Alan Kostelecky suggested that the observed "knee" in the spectrum of cosmic protons could be explained as the decay of a proton into a neutron, positron and a tachyonic neutrino. (In our reference frame this amounts to absorption of the antineutrino by the proton.) Based on this hypothesis, Robert Ehrlich predicted in 1999 that at proton energies corresponding to the "knee" there should exist an amassment of neutrons. Ehrlich found an indication of such an amassment in the 1983 data form the source "Cygnus X-3". Again, considering that this is an isolated observation, it cannot be considered evidential.

The hypothesis of the tachyonic nature of neutrinos has again hightened the interest in tachyons. This hypothesis has provided new, concrete, pointers for tachyonic searches. First of all, measurements of beta spectra endpoins need to be refined, sources of errors analyzed, and unambiguous results on the sign of m_υ^2 must be obtained. Secondly, the measurements of the "knee" in the cosmic proton spectrum ought to be perfected and an effort made to ascertain if this "knee" indeed coexists with an amassment of neutrons. This will not be easy, considering that neutrons are short lived. And thirdly, it may soon be possible to carry out a direct time-of-flight measurement between the production of a neutrino pulse and its arrival at a detector. With current technology these tasks are difficult in the extreme, but in principle realizable.

There is one more argument which suggests a possible action of tachyons. It has to do with the so-called "quantum entanglement". Both theory and experiment indicate that a system of two electrons, or two photons, remains linked even when greatly separated one from the other. Even though physicists have been aware of this linkage since the 1950's, it is still referred to as "spooky", because so far there is no theory to explain its mechanism. It is in this connection, that transcendental tachyons (tachyons with infinite velocity) come to mind. This thought awaits a theorist who would embody it within the framework of a new physics.

Even if the hypothesis of tachyonic neutrinos should prove incorrect, searches for tachyons will resume each time a new path appears. As in the case of the magnetic monopoles, these particles have to be found, or "an excuse for their absence" has to be obtained.

Higgs bosons

For its culmination, the highly successful *Standard Theory* of elementary particles requires that experimental physicists find one more particle. This particle is called *Higgs boson,* or simply *higgs.*

Higgs is the quantum of a field that spans all of the universe. The author of the idea of such a field is professor Peter Higgs from the University of Edinburgh, Scotland. Higgs particles have assumed the role of touchstone of the Standard Theory, because on them hangs the resolution of the problem of mass of elementary particles. This problem is the "Achilles heel" of the Standard Theory. That is why physicists look for the higgs "with searchlights in daylight".

According to theory, Higgs particles are expected to be very massive. Searches for them began only after new powerful accelerators became operational – TEVATRON in the USA and LEP at CERN in Switzerland. First indications of a possible existence of the higgs were obtained in October 2000 at the LEP collider when its energy was raised to 209 GeV. Corresponding events, eight in all, were considered by a group of physicists under the direction of Chris Tully from Princeton University. They concluded tentatively that the mass of the higgs appears to be 114,9 GeV.

These observations were carried out just before LEP was scheduled to be shut down, to make room for the more potent Large Hadron Collider (LHC). Because the statistics on the higgs measurements were insufficient to say with certainty that the higgs was found, professor Tully and his group made all that was possible to postpone the closing down of LEP, so that they could complete their work. In vain – the work on the LHC began on time.

The energy which the LHC will provide for creation of particles will be on the order of 14000 GeV (14 TeV). The LHC is scheduled to become operational in 2006. The very first task for it will be the detection of the higgs. To this end, a giant detector, called ATLAS, is already being designed and constructed.

Notwithstanding, the physicists at Fermi Lab cherish the hope that the observation of the higgs at the LHC will only be the confirmation of their prior detection of the higgs. After four years of upgrading, the TEVATRON energy has been boosted to the point that there is a fair chance for the higgs to be seen there before the LHC comes on line.

In the end, much more rides on the existence of the higgs than the validation of the Standard Theory. The next daunting task of theoretical physics is the so-called *Grand Unification* of all forces in an all-encompassing *Theory-of-Everything* ("ToE"). Since it was proposed some 30 years ago by Sheldon Glashow and Howard Georgi, this endeavor has made grand strides via "strings", "branes", "super symmetry" to its current version known as M-theory. Yet this elaborate creation is in danger of downfall should the higgs refuse to show itself.

The majority of physicists, including such gurus of theoretical physics as Edward Witten (Institute for Advanced Studies, Princeton, NJ) and Gordon Kane (University of Michigan, Ann Arbor, MI) are confident that the TEVATRON and/or the LHC will in due time be celebrating the detection of the Higgs particle. But there are also those who bide their time on the sidelines, ready to enter the stage should the higgs refuse to appear. Among them are Bernard Haisch (California Institute of Technology), Alfonso Rueda (California State University), and Harold Puthoff (Institute for Advanced Studies, Austin, TX), who proposed, in 1994, a drastically different and original solution to the problem of mass of elementary particles.

S-particles

By far the most pressing problem of contemporary physics is reconciliation of the *General Theory of Relativity* with *Quantum Theory*. Strange as it may seem, these two cornerstones of all physics are mutually incompatible. On the distant horizon looms a new theory whose aim is to reunite gravitation and quantum formalisms into one self-consistent whole. One of the aspects this new theory is *Supersymmetry*.

The principal prediction of this theory is the existence of a whole new realm of particles corresponding to our *fermions* (components of our material world – quarks, electrons), and to our *bosons (carriers* of interactions between fermions – gluons, W, Z, photons, gravitons). In this hypothetical new realm, the so-called *sfermions (squarks, selectrons) are* counterparts of our fermions. While our fermions possess a spin (internal angular momentum) of 1/2, all the sfermions are predicted to have a spin of 1, just as our bosons. Conversely, the counterparts to our bosons, called *bosinos* (*gluinos, winos, zinos, photinos, gravitinos*) have a spin of 1/2, like our fermions. According to theory, this new world of *s*-particles (sparticles) interacts with our known particles only gravitationally.

It is expected that the lightest of the supersymmetric particles should be stable and hence observable in principle. The discovery of such a particle would not only confirm the validity of supersymmetry and bring physics one step closer to the grand unification, but would also solve the problem of the *dark mass* of the universe [20]. The observed rotational movement of galaxies incontrovertibly shows that an invisible dark mass does exist and, in fact, makes up the better part of the mass of the universe. What this dark mass actually is remains the biggest puzzle of astrophysics. If the cosmic dark mass consists of *s*-particles they should also be a component of cosmic rays. Experimenters at such subterraneous cosmic ray observatories as that at Gran Sasso (Italy), Boulvey (England), and Soudan (Minnesota) are groping for ways to look for them.

As is often the case, the first hint of the possible existence of *s*-particles came from unexpected quarters – from the precision measurement, at Brookhaven, of the magnetic dipole of the muon (heavy, short-lived electron). Only by taking into account the virtual presence of *s*-particles are theorists able to reconcile the experimental result with their calculations. So far the statistics of the data are unsatisfactory and measurements continue. But if sufficient accumulation of data should confirm their preliminary finding, the Brookhaven physicists will be ready not only to proclaim that *s*-particles exist, but even to offer an upper limit of 400 GeV for their mass. Such a result would be most welcome for two reasons. Firstly, if the mass were much larger than 400 GeV the unification of the gravitational force with the strong, electromagnetic, and weak forces would find itself in difficulties. Yet such a unification coincides with the main aim of the supersymmetry theory. Secondly, one would hope that such "light" *s*-particles could be created in new accelerators. Searches for *s*-particles have already begun at the TEVATRON at Fermi Lab, even though its energy may still be insufficient even after the upgrades. At any rate, the discovery of *s*-particles could become the great crowning achievement of the Large Hadron Collider (LHC) at CERN in Switzerland, after it becomes operational in 2006.

References

[1] Abe F. *et al.* Phys.Rev.Lett. **74,** 1626–2631, 1995.

[2] Abachi S. *et al.* Phys.Rev.Letfc. **74,** 1626–2631, 1995.

[3] Poincare H, Comp.Rend. **122,** 530, 1896.

[4] Dirac P.A.M., Proc.Roy.Sov.London, **A133,** 60, 1931.

[5] Ginzburg I.F. and Panfil S.L., Sov.J.Nucl.Phys. **36**, 850, 1982.

[6] Bilaniuk O.M.P., Deshpande V.K., Sudarshan E.C.G., Am.J.Phys. **30**, 718–723,1962.

[7] Bilaniuk O.M. and Sudarshan E.C.G., Physics Today 5, 43–51, May 1969.

[8] Recami E et al. *Tachyons, Monopols...,* North Holland, 1978.

[9] Bilaniuk O. Svit Fizyky (The World of Physics), **2(2),** 3–6, 1997.

[10] Parker L., Phys.Rev. **188,** 2287–2292, 1969.

[11] Kreisler M., Am. Scientist, **61**, 201–208, 1973.

[12] Bilaniuk O.M. and Boccio R.J., La Recherche (Paris), 4(40), 1037–1046, 1973

[13] Bilaniuk O.M. and Boccio R.J., Sapere (Italia), **75(773)** 6–16, 1974.

[14] Chodos A, Hauser AI, Kostelecky VA, Phys. Lett. **I50B**, 431–435, 1985.

[15] Particle Data Group, Eur. Jhys. J. **C3,** 23, 1998.

[16] Groom DE, Eur. Jhys. J. **C3,** 312–313, 1998.

[17] Ehrlich R, Phys. Lett. **B493,** 229–232, 2000.

[18] Haisch B, Rueda A, Puthoff H, Phys.Rev. **A49,** 678–694, 1994.

[19] Bilaniuk O. Svit Fizyky (The World of Physics) **1(5)**, 3–7, 1999.

[20] Novosiadlyj B. Svit Fizyky (The World of Physics) **2(4)**, 3–6, 1998.

Svit Fizyky (World of Physics. 2001. No 4. Pp. 3–11)

Oleksa Bilaniuk. Tachyons. Selected publications reprinted at the 40th anniversary of the Tachyon hypothesis. – Lviv: Eurosvit, 2002. – 160 p.: il.

ISBN 966-7343-33-2

This book contains selected publications of Oleksa-Myron Bilaniuk and co-authors dealing with the Tachyon hypothesis. O.-M. Bilaniuk is a foreign member of the National Academy of Sciences of Ukraine, member of the Shevchenko Scientific Society, and President of the Ukrainian Academy of Arts and Sciences in the USA. He has significant accomplishments in experimental and theoretical physics and is one of the authors of the Tachyon hypothesis.

Works are presented in the language of the original languages: English, Russian, Italian, French and Ukrainian. There is also an article of by Professor R. Gajda about the author, and a list of selected scientific and popular scientific publications of O. Bilaniuk.

The volume is meant for the wide readership of students, teachers, researchers and all those who are interested in physics.

ACHIEVEMENTS OF UKRAINIAN PHYSICISTS

Outstanding scientific achievements have a global character. The contribution to science and culture by individual nations determines their prestige and authority.

In spite of a difficult political situation (a long period without independence), Ukraine has managed to express its cultural originality and to contribute to scientific progress.

It may be interesting to the reader to learn, what original achievements and scientific accomplishments belong to Ukrainian physicists. Here are some examples:

1. Design of discharge lamps by Ivan Puluj and his elucidation of the nature of cathode rays.
2. Conception of the noosphere (Volodymyr Vernadskyj, the first president of the Ukrainian Academy of Science).
3. Statistical theory of the systems of interacting particles (Mykola Boholyubov).
4. Structure of the atomic nucleus (Dmytro Ivanenko).
5. Olexander Smakula's optical antireflection coating and crystallographic formula.
6. Pioneering research of nuclear reactions in Kharkiv.
7. Tachyon hypothesis (Oleksa Bilaniuk with George Sudarshan).
8. Synthetic diamonds.
9. Ihor Sikorskyj.
10. Yurij Kondratiuk.
11. Sergij Korolyov.
12. Borys Hrabovskyj.
13. Criocrystals.
14. Polarons and light exitons of S.Pekar.
15. First model of neutron star (G. Gamov).
16. Davydov's disintegration.
17. Optical electric devices, based on heterotransitions, semi-conductor nanostructures (Mykola Holonyak).
18. Shubnikov's phases (superconductors of II type).
19. Model of Stasiv-Telthov in the photo theory.
20. Physics of molecular exithons (Kyiv and Kharkiv scientific schools).
21. Electrogyration (Vlokh-Zheludev)
22. Discovery of marthentic polytops in metals and alloys.

Some of the listed accomplishments have been described in previous issues of the journal „World of physics". We shall continue this heading in future.

At present scientific research in Ukraine is conducted mainly in the institutions of The National Academy of Science and in the universities.

The National Academy of Science of Ukraine was founded in 1918, in the first year of Ukraine as an independent nation after the disintegration of the Russian Empire. Great scholars, such as Volodymyr Vernadskyj and Mychajlo Hrushevskyj, were among the founders of The Academy. Shevchenko Scientific Society, which was founded in 1873 in Lviv and existed until the soviet rule came to West Ukraine in 1939, was the predecessor of The Academy of Science. Shevchenko Scientific Society had wide international relations, scholars from many countries of Europe became its members. Physicists Max Planck and Albert Einstein, mathematicians David Hilbert and Felix Klein etc. are among them.

The leading scientific centers of Ukraine are Kyiv, Lviv, Kharkiv, Donetsk, Odessa, Dnipropetrovsk. A multilevel system of institutes of the National Academy of Science functions in these cities.

Prof. Ja. Dovhyj, R. Platzko

Borys Hrabovskyj and TV

Volodymyr Shevchuk,
Ivan Franko Lviv National University

It is impossible to imagine a modern human society and contemporary science without a system of television (TV). However, not everyone can name the inventors of TV which so naturally entered our lives and the global information medium. An intention to write this material arose after a brief announcement on the "*Ukraine*" radio station at the end of July 1998. The brondcast was concerned with the 70th anniversary of the creation of the world's first acting system of electronic TV and realization with its help of the first transmission in July 26, 1928 in Tashkent by a little known engineer, physicist and talented inventor Borys Hrabovskyj. At the same time, as is known from all appropriate sources, the priorities are usually linked with the names of A.K. Swinton (1863–1930) from England, B. Rosing (1869–1933) from Russia, V. Zvorykin (1889–1982) and F. Farnsworth (1906–1971) from the USA... Not underestimating a great contribution of these and many other scientists and inventors to the development of TV, we shall try to look at Hrabovskyj's work on the creation of TV that was similar to modern television.

It is generally belived [1, 2] that the term "television" was applied for the first time by the engineer K. Perskyj in 1900 at the international electrical and technical congress in Paris. Experts consider that TV is based on fundamental discoveries in physics and is a branch of radio engineering science, that is, of applied science with the help of which the transmission and receipt in the receiving part of a communication system of undistorted images is carried out. It is written in a school text-book [3] that the TV system is a means of transmitting images over a distance with the help of ultra-short electromagnetic waves. Only from these definitions it can be concluded that the solution of a complicated problem of TV became possible thanks to the work of many physicists, inventors, and designers from all over the world. In the encyclopedia BSE [4] we can find dozens of people who were involved in the realization of TV processes in the second half of 19th – at beginning of 20th century.

Borys Hrabovskyj
(26.05.1901–15.01.1966)

There are many different opinions regarding the time when TV was born. Some people refer the idea of TV to the times of Archimedes who actually introduced the law of the spiral. In 1884 the engineer, P. Nipkov, used the Archimedes' spiral for the scanning of a television image. The optical and mechanical device was patented in Germany and was named Nipkov's disk. It was the main knot in the first television systems of mechanical TV. G. Galileo's invention of the first telescope in 1609 can also be considered as the origin of the idea of TV. Undoubtedly TV was greatly influenced by the invention of telegraphic communication (P. Shilling, 1832; B.Yakobi, 1841; A. Ben, 1843), by the development of sequential, element after an element, transmission of images with spiral scanning (À. de Paiva, 1878; K. Senlek, 1880; P. Bakhmetiev, 1880), by the invention of radio at the end of 19th century (O. Popov, G. Marconi). This list can be extended. During the period between 1880 and 1900 over one hundred projects on image transmission appeared in different countries of the world. But only a few of them were important practically.

Brilliant discoveries in physics became the basis for the creation of TV. The phenomenon of an internal and external photoeffect, thanks to which visual information is converted into electrical, was essential for TV. A. Bekkerel was the first to discover the photoelectric effect in 1839. In 1873 U. Smith investigated for the first time the phenomenon of crystal selen photoconductivity. In 1883 T. Edison discovered thermoelectronic emission, and in 1886 H. Hertz observed an external photoeffect and discovered electromagnetic waves. In 1888 O. Stolietov introduced the laws of external photoeffect. The next steps were made by the founders of the quantum theory M. Planck (hypothesis about quantum, 1900). A. Einstein (quantum theory of photoeffect, 1905).

Electronic TV with not inertial cathode-ray tubes became an alternative to mechanical TV. But the latter one had been successfully developing till 1935. In England experimental transfers had been conducted since 1928. The first TV transfers in Ukraine were received in Odessa in 1931. The institute of communication engineers was dealing with the problems of TV. In Kharkiv they were also receiving the transfers. The era of mechanical TV in the USA came to an end in 1931.

The ideological struggle between two directions of TV development influenced Hrabovskyj's destiny and his inventions. In particular it affected B. Hrabovskyj's relations with B. Rosing and P. Shmakov. The former, who was the creator of mixed electronic-mechanical TV (1911) with a cathode-ray tube in the receiver [6], supported B. Hrabovskyi in every possible way. P. Shmakov at first was actively developing the mechanical TV considering the project of an electronic system to be unpromising.

The screen of mechanical telereceivers was about as large as a matchbox and the image was of a poor quality. Disappointment in mechanical systems grew bigger and bigger. And consequently in 1933 P. Shmakov became the co-author of the iconoscope (improved transmitting tube) project. V. Zvorykin created the predecessor of a modern television tube in 1931.

In the early television projects light sources on the basis of an electrical discharge in gas were primarily used. The development of gas discharge light sources is connected with the names of G. Geissler (1815–1879), I. Gittorf (1824–1914) and U. Crooks (1832–1910). The name of a prominent Ukrainian physicist I. Puluj (1845–1918) was rarely mentioned in this connection. But his tubes were known and widely applied in the scientific world and became an important step in the development of vacuum engineering. I. Puluj published the results of his research in gas discharge processes in 1880–1882.

Obviously, on the basis of Crooks', Puluj's and one other researcher K. Brown invented oscillographic cathode tube, and in 1907 Rosing created an "electronic telescope" – a cathode tube for the reproduction of images. The latter differed from Brown's tube by a possibility to adjust the density of the electronic beam.

Borys Hrabovskyj's father, a known Ukrainian poet Pavlo Hrabovskyj (1864–1902), who was persecuted by the Russian imperial regime, was sent to East Siberia. In 1899 he was allowed to move to the city of Tobolsk [7]. Here he married Anastasia Lukianova who was a student at a medical school at that time. On May 26, 1901 their son Borys was born. After P. Hrabovskyj's death the family moved to Ukraine (at first to Kyiv, then Odessa, and then to P. Hrabovskyj's brother in Kharkiv). Later they moved to the city of Tokmak (Kirghizia) in Central Asia [8]. Here Borys finished school. Having learned to read from his father's books, B. Hrabovskyj, however, did not want to devote the rest of his life to literature. He was interested in engineering, designing and laws of physics.

While serving in the army he was constantly designing and inventing things. He was recommended to the University of Central Asia (Tashkent). B. Hrabovskyj obtained a job as a laboratory assistant at the physical and mathematical faculty of the same University. Here he independently carried out complicated experiments, studied new physical theories and constructed various devices. Understanding that knowledge is necessary for serious scientific work, in 1940 B. Hrabovskyj [7] entered the physical and mathematical faculty of the Kirghiz teacher's training institute, which he completed in 1945. In 1933 Hrabovskyj moved to the city of Frunze (now Bishkek) where he lived for the rest of his life, which ended on January 15, 1966.

In the 1920's, while studying at the Tashkent University, B. Hrabovskyj became acquainted with the projects on electro-vision (electrical telescoping, cathode telescoping, telesighting, electronic farseeing, radio vision etc.), which is how they named TV [2, 6] back then. In 1924 Borys Hrabovskyj invented the cathode switchboard, which became the basis for the construction of a cathode-ray converter "light-signal", in other words, of a transmitting television tube. The electron beam in Hrabovskyj's tube ran across the surface of a photosensitive plate [8], on which the image was projected. Interaction of photo-electrons and cathode bundle generated an electrical signal that could be transmitted. A path to creation of an electronic TV system, that had a better chance than the mechanical, was open. A whole year was spent on the development of the project. In 1925 in Saratov together with physicist M. Piskunov and engineer V. Popov Hrabovskyj created the project of an electronic TV system, which he named "radiotelefot". The defence of the project in Saratov University was successful. The authors were provided with means for the trip to Moscow and Leningrad (now St. Petersburg).

Having reported in Moscow to a special section of the military-technical agency in the presence of a well-known at that time radio expert M. Shuleikin, the inventors reported to Rosing in Leningrad. He was an expert in the field of TV. Rosing paid special attention to the construction of the cathode switchboard and advised to immediately submit an application for a patent because it was a discovery. On the next day, November 9, 1925, Hrabovskyj, Popov, and Piskunov submitted the description and the scheme of the radiotelefot to the Inventions Committee. Later they received the patent No 5592 [9]. In four days the application for the transmitter was submitted by O. Chernyshov, who had been working with Rosing.

The commission of experts gathered at the Leningrad consortium of weak-current factories for consideration of the radiotelefot. Among the present were B. Rosing, O. Chernyshov, V. Bursian, V. Gurov, L. Mandelshtam, M. Papaleksi and others. The radiotelefot was approved. B. Rosing in his review of the radiotelefot wrote: "The greatest value of the project is the use of cathode rays on both stations (transmitting and receiving). These rays are not inertial and therefore imply a possibility of the most perfect synchronization of movements" [6].

Later, in June 1926, in his sketch [10] Rosing stated: "The first project of an electronic telescope of a cathode type was made by the author of this article in 1910 but in a particularly pure way this new principle was applied in the project of an Englishman Campbell-Svinton in 1911. This last project remained forgotten over a significant period of time, and only last year it was revived in the electrical telescope developed by Hrabovskyj, Popov, and Piskunov". The radiotelefot advantageously differed from the projects that already existed. It is necessary to point out that the first projects were not embodied in working models [2, 11].

On the basis of studies of archival and patent materials the authors of the article [11] made a conclusion that Hrabovskyj was the first scientist in the world to produce a completely electronic television set. The suggested schemes of the radiotelefot, besides the transmitting and receiving tubes, also included all basic elements that are inherent to modern electronic TV sets: systems of tape and frame scanning, synchronization system based on rigid connection between tape and frame frequencies made with the help of a frequency divider, amplifiers on electronic lamps, radio transmitter and receiver. It was suggested to make the transmitting tube with a continuous photo layer (Svinton suggested a "mosaic" screen made out of separate photo resistors), electrostatic deviation of a ray, and magnetic focusing. Directing grid (net modulation) was present in the receiving tube for the first time. Four-net lamps – hexodes were used in the schemes. The latter ones were also a novelty, because their appearance dates at the beginning of the 30's [8].

Unfortunately, a three-months term provided for the creation of an acting radiotelefot at the Leningrad electrovacuum factory "Svetlana" was obviously insufficient, the separate knots were of poor quality. But B. Hrabovskyj did not give up. On coming back to Tashkent, he continued working together with I. Belianskyj, the laboratory assistant at the research station of weak currents of the Central Asian district of communications.

In 1928 the set began working. The tests were carried out. Hrabovskyj later recalled: "... July 26, 1928 was a happy day for us. On that day we received a moving image on the screen. My laboratory assistant I. Belianskyj, who stood near the transmitter, was lucky to be the first to appear on the screen of a cathode-ray tube... "The experiment was repeated. With the help of the device Hrabovskyj transmitted the images of a tram and the pedestrians, who were moving in the street of Tashkent. The improved variant of the radiotelefot was patented on July 25,

1928. One and a half years later F. Farnsworth demonstrated a completely electronic TV set.

After the successful demonstration of the radiotelefot in Tashkent, the equipment was sent to Moscow. Boxes with the unique consignment arrived at the destination. However, it turned out that the glass details were broken and metal constructions were bent. For the next few years, Hrabovskyj tried to make the scientists interested in radiotelefot. But there was no support. A disk system had won by that time. For the sake of justice, we shall point out that in the 60's the mechanical and electronical systems, in the past the irreconcilable competitors, nevertheless were put together in space TV [2], thanks to which high contrast of the images of the surface of space objects was reached.

While living in Frunze, Hrabovskyj taught physics, worked at the factories and kept on inventing. In a small extension to the house, in which he lived with his family, he made a laboratory. Materials and details for experiments and devices he purchased from his own savings, sometimes from compensations for his inventions, and for fees that he, as a successor, received for his father's publications. He made a number of inventions in diverse areas of engineering. According to the words of the author of a book about P. Shmakov [5], in July, 1962 B. Hrabovskyj received a letter from the Institute of Electrical Welding named after E. Paton of the Academy of Sciences of Ukraine signed by the director of this Institute B. Paton: "We learnt with great interest and pleasure about your patent of the vacuum device for deriving a cathode ray (N 5771). It is most probable that, following this path, we shall use your scheme for putting the electrons into atmosphere..." In six months B. Paton notified B. Hrabovskyj of the first successful experiments. Hrabovskyj is fairly considered [12] as one of the first creators of instantaneous action tubes, as cathode-ray tubes are also called.

Borys Hrabovskyj's merits were recognized by the UNESCO commission of scientific, educational, and cultural affairs, International press union on radio and electronics engineering, other authoritative organizations, and government only during the last years of his life. Near the sources of world TV, next to the names of other world famous scientists a leading place belongs to the previously forgotten name of our compatriot, experimental physicist Borys Hrabovskyj.

But in TV much remains to be discovered. TV engineering is constantly developing on the basis of successes of modern physics, electronic materials science, and new technologies. The generations of TV sets are changing. According to the press, TV sets of the sixth generation are now produced in Ukraine. Moving away from the early electronic (lamp) TV and first experimental sets of such type, we are still paying homage to the pioneers.

1. Домбругов Р. М. *Телевидение.* К.: Вища шк., 1979. 176 с.
2. Урвалов В. А. *Очерки истории телевидения.* М.: Наука, 1990. 216 с.
3. Гончаренко С. У. *Фізика: пробний навчальний посібник для 11 кл.* К.: Освіта, 1998. 287 с.
4. БСЭ, 3-е изд. М.: Сов. Энциклоп., 1978. Т. 25.
5. Узилевский В. А. *Легенда о хрустальном яйце.* Л.: Лениздат, 1965. 272 с.
6. Горохов П.К. *Б. Л. Розинг – основоположник электронного телевидения.* М.: Наука, 1964. 120 с.
7. *Павло Грабовський у документах, спогадах і дослідженнях/* Ред. О. І. Кисельов, В. М. Поважна. К.: Дніпро, 1965. 415 с.
8. Баранцев А. И., Урвалов В. А. *У истоков телевидения.* М.: Знание, 1982. 64 с.
9. Попов В. И., Грабовський Б. П., Пискунов Н. Г. *Аппарат для электрической телескопии.* Патент № 5592 (СССР) от 9 ноября 1925 г.
10. Розинг Б. Л. *Новейшие достижения в области дальновидения.//* Наука й техника. 1926. № 3О (175). С. 1–3.
11. Белянский И. Ф., Урвалов В. А. *Первые электронные телевизионные установки в СССР//* Радиотехника. 1967. Т. 22, № 5. С. 74–77.
12. Самойлов В. Ф., Хромой Б. П. *Телевидение.* М.: Связь, 1975. 400 с.

Svit Fizyky (World of Physics. 1999. No 1. Pp. 10–13)

Who invented the atomic bomb?

Yurij Ranyuk

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In previous years many publications dealt with the history of the Soviet atomic project [1, 2]. For instance, the names of the inventors of the atomic bomb have been disclosed. Actually, it is not very correct to talk about the inventors in this case, because the appearance of the idea summed up all the previous developments of science, especially nuclear physics.

Still, what is known are the names of the scientists who hold the "copyright" for the atomic bomb, or, to be exact, for the ways to make it. They are Fredrikh Lange, the head of the Shock Science Laboratory of the Ukrainian Physical-Technical institute, Volodymyr Shpinel' and Viktor Maslov, scientists at that same laboratory.

In the beginning of 1939 after the German scientists O. Hahn, F. Strassmann and L. Meitner and O. Frish had discovered the reaction of splitting the atomic nucleus, many prospects opened for scientists all over the world to produce nuclear energy in controlled (reactor) and in uncontrolled (bomb) chain reactions. There were three known scientific facts that implied the possibility of solving the problem. In fission reactions a great deal of energy is released – about 200 MeV, which is over ten times more than in other known nuclear reactions. In the process of division secondary neutrons are radiated, which gave confidence in the possibility of making chain reactions. Thermal neutrons induce fission only in the light isotope of Uranium – Uranium 235, which makes up only 0,7% of natural Uranium. That, at first, chilled the optimism of enthusiasts of nuclear energy. Scientists did not only see the perspectives, that are opened by solving the "Uranium problem", which hinges on the chain reaction. They also understood the need for enrichment of Uranium 235. A big effort was undertaken to convince the heads of science, industry, and also politicians in the possibility and advantages of possessing nuclear power.

Victor Maslov

(1913–13.12.1942)

He was born in 1913 in Kharkiv. In 1936 he graduated from the Kharkiv Mechanical and Machine-Craft Institute as a specialist engineer-researcher. That same year he started his work at the Ukrainian Physical-Technical Institute (UPTI) as physicist-experimenter in the Laboratory of radioactive measurements. In this laboratory, under the direction of O. Leypunskyi, he wrote his dissertation "About the character of uranium disintegration under the action of slow neutrons". The defence of this dissertation took place before the Scientific Assembly of the Kharkiv State University on the 8th of June, 1940.

Fascinated by the idea of creating the A-bomb, V. Maslov proceeded to the F. Lange's Laboratory, because Leypunskyi did not support this idea.

Victor Maslov

V. Maslov was an active proponent of atomic energy and convincingly made the point that use of atomic energy was no longer a dream but had already become just a technical problem.

In 1941 he was mobilized and sent to Moscow where he finished a course of military technology at the Artillery Academy. He was wounded by a splitter of a zenith rocket and died in the hospital in Baku on 13 of December, 1942.

In the spring of 1939 German and English physicists wrote letters to their respective government to put stress on the possibility of building an atomic bomb. But further development of events in Europe – the beginning of the World War II, the occupation of France and the blockade of England stopped the work of the Uranium projects. Nuclear research was continued in the USA, where at that time many European scientists worked, who escaped from fascism. It is they who played an important role in creating the atomic bomb.

One of the first, who realized the possibility of creating nuclear weapons and realized the threat if that weapon had been created in Germany was L. Shillard, an emigrant from Hungary. It is he who convinced Albert Einstein to write a letter to the USA president F. Roosevelt. That letter was written on August 2, 1939.

President F. Roosevelt gave an order to create the Uranium committee immediately, which had its first meeting on October 21, 1939. But the decision to start a big program to create the new weapon was made only in September 1941. On August 13, 1942 by the president's order a special division of engineering army code-named Manhattan was created in Los Alamos, New Mexico, in the desert, not far from Santa-Fe. At that time a great effort started in the USA, which required great material and human resources, but which leid to the creation of a new weapon – a nuclear bomb of great power, that was tested in July 1945.

At the end of February 1939, at the meeting of the Nuclear Physics Committee of the National Academy of Science of USSR a Decree establishing the work plan of LUN for 1939 [2. C. 55] was adapted. The decree of the Committee, dated February 27, 1939, with the signature of its head S. Vavilov, stated: "The committee advises LUN immediately to begin studying the Uranium problem and considers that the most important work in this field should be concentrated in the LUN ... it is necessary to establish a close contact with the laboratories of O. Leupunskyj, K. Synelnikov and I. Kurchatov". In fact, the decree was about crating a Central organization in the country to deal with the Uranium problem.

Kharkiv scientists had no doubt about a real possibility of producing nuclear energy. In his article "Fission of heavy nuclei' and the perspectives of using the energy of nuclear transformations", published in the 7-th volume of "Sovetskaya Nauka" magazine, 1940, V. Maslov wrote that "using inner nuclear energy is no longer a dream, but it already is a technical problem".

There were many such problems, but two were the main ones: how to get a necessary amount of Uranium 235, which was the only element that the nuclear bomb could be made of (there was nothing known about Plutonium and Plutonium bomb at that time, at least not in Kharkiv), and how to obtain an overcritical mass of that isotope.

There was another, third problem, not technical, but financial: where to get the money for so important, but expensive research. Because few people believed that research was the right usage of the money.

A former worker of the Shock Sciences Laboratory, Lev Pyvovar, considers Fridrikh Lange, his previous boss and friend, to be the main figure in the trio (Lange-Shpinnel-Maslov) of atomic bomb developers. It was F. Lange, who started the talk about the atomic bomb. F. Lange's laboratory worked on confidential army projects, and that is why all the talks about the bomb were secret. But L. Pyvovar remembers clearly that the colleagues met the idea of creating the atomic bomb with concern. It seemed to all that its realization is so hard that it borders on impossibility. There was much sarcasm. Still F. Lange managed to find people who believed in his ideas. But to get some money for this research from the institute was hopeless. Then the enthusiasts started to write letters to top institutions to get the necessary funding for the research. We will just name these letters:

Note of V. Maslov, August 22, 1940 to the Academy of Science of USSR about necessary actions for organizing the work on the Uranium problem .

Note of F. Lange to P. Svetlov "The division of isotopes of Uranium" – about the electromagnetic approach to isotope separation. August 26, 1940 to the Uranium problem copmmittee. Technical proposition of F. Lange, V. Maslov, V. Shpinel' "The separation of Uranium isotopes by using the Coriolis acceleration". Not later than October 1, 1940. Confidential.

There was no positive reaction to the letters. But, scientists understood that if their proposals were copyrighted then they could continue to talk about the money. Thus the scientists started to write patent applications for the inventions:

V. Maslov and V. Shpinel' "About the usage of Uranium as an explosive and poisonous element." October 17, 1940. Confidential.

F. Lange, V. Maslov, V. Shpinel' "The way of making a Uranium mixture with mass coeficient 235. Multi-cell centrifuge". Not earlier than October 17, 1940 and not later than December 31, 1940.

F. Lange and V. Maslov "Thermocirculational centrifuge". Not earlier than January 1, not later than February 3, 1941 .

Science was led by people of older generations then, who did not believe in the perspective of nuclear energy. Those, who did see the perspectives, had the lowest ranks in the scientific hierarchy, because nuclear physics by itself was a very young science at that time. That is what P. Kapitsa said about the possibility of using atomic energy in his talk for "Childrens' literature" magazine on February 5, 1940 "... the question about getting hold of atomic energy is an old question. This branch of physics, surely, is a less developed yet. Thanks to Rutherford and his students it got much further. And now the most probable thing is that it will not be easy to use the atomic energy. It is more probable that it will not be possible at all. It plays a big role only in cosmical events – in big masses. It definitely plays a deciding role in stars and space processes, but in the life of people, in microspace, it doesn't, and probably will not play a big role as a source of energy.

The sun, the stars support their radiation with this nuclear energy. We cannot say for sure, but all objective information says, that in Earth conditions nuclear energy will not be used. That is also what E. Rutherford thought". A. Joffe had the same point of view. In the prewar period he stated that "if the possesion of rocket technology is a question of about 50 future years, then using inner atomic energy is a question for the future century".

Nonetheless applications from the Kharkiv Physical-Technical Institute (KPTI) were sent to the Inventions Department of the People's Commissariate. It should be pointed out that applications involved solving technical problems, but not proving the actual possibility to make a bomb – that seemed certain to the authors.

The application for the patent for the bomb made that clear:

"*Air bomb or other ammo, the explosion of which is based on the chain reaction of splitting the isotope of Uranium-235 with overcritical mass, which is triggered by the union of several subcritical masses of the Uranium-235 isotope. The charge of U-235 is divided into several parts by a series of partitions made of explosives of low permeability for the neutrons which is destroyed by an explosion when needed*".

Friedrich Lange

(16.12.1899–25.07.1987)

He was born in Berlin (Fridrixhagen). In 1935 he moved to the Soviet Union where he founded the Laboratory of the Pulsing Voltage that was under contract with the USSR Academy of Science (Ukrainian Physical-Technical Institute – UPTI – was a part of the Narkomtyazhprom system) and was its scientific head. In Kharkiv he was constructing high-voltage discharge lamps with which he was creating neutron generators and X-rays generators. He had built, the largest in the world at that time, Marks Generator that could generate the voltage of 5 million volts.

In April 1940 the Kharkiv State University awarded Lange the Degree of Doctor in Physics and Mathematics without writing a dissertation.

Friedrich Lange

In 1941 F. Lange was evacuated and proceeded to the Kyiv Institute of Physics and Mathematics that was situated in Ufa at that time. Since 1943 F. Lange had been working in the Ural Physical and Technical University in Sverdlovsk, and since 1945 at Moskow Laboratory No. 2. Later he became chief of Laboratory No. 4. During 1951–1952 he was working in Dnipropetrovsk, then once more in Moskow. In 1959 he returned to Berlin.

Below we quote another part of this application: "*...According to the latest data in physics, there will be a very destructive explosion if the amount of Uranium is sufficient (i. e. when the size of the Uranium block is much bigger than the free path of neutrons in it). This is due to the extremely high speed of the fission chain reaction in Uranium and the great amount of energy which is thus released in it (million times more than in usual chemical reactions in ususal explosives).*

The difficulty of making such an explosion in Uranium is that with increasing its amount (before its mass will grow so big that its size will be much greater than the neutron's free path in it) the reaction can take place which would not be explosive.

Chain reacton of unexplosive kind, which takes place when Uranium achieves some critical volume (i. e. when the neutron's free path can be compared to linear sizes of the Uranium's mass), leads to thermal self-regulation, which makes the explosion more difficalt.

So, to create the conditions for an explosion, it is necessary to the critical volume in time less than the one needed for the chain reaction. In their investigation of the conditions for the chain reaction in Uranium Khariton and Zeldovitch wrote "The time needed for processes, which help to overcome the critical conditions, for instance, time of two Uranium masses getting closer, each of which is below the critical conditions for chain fission of that volume, could doubtfully be made so short that it could be compared to the time of the reaction's acceleration".

It is mentioned further that it is possible to make an explosion in Uranium, and there is a description of how to do that.

"*From everything written above it is assumed that the problem of creating an Uranium explosion ends up with creating an overcritical mass of Uranium in a short period of time.*

We offer to do this by filling in the volune with Uranium, which would be divided by partitions, impenetrable for neutrons, so in every isolated volume section- there would be a mass of Uranium lower than the critical one. After filling in such volume the walls are destroyed with the help of regular explosives which results in a mass of Uranium much bigger than critical. This will lead to an immediate Uranium explosion. Acetylanit of silver can be used for such partitions. Such mixtures do not give gas-like products. That is why their explosion will not lead to evaporation of the walls and will not cause the spread of Uranium.

In addition to the great destructive power of the Uranium explosion, (creating a bomb that could destroy London or Berlin will not be a problem), it is necessary to mention another important peculiarity. The products of the explosion of the Uranium bomb are radioactive substances, which have poisonous qualities thousands of times more powerful than the strongest poison known. That is why those, which stay in gas form for some time after the explosion, will spread to a great area, keeping their qualities for a comparetively long time (about an hour, some of them even days or weeks). And it is hard to say which property (destructive power or the poisonous substances) of Uranium explosions are the most attractive in the military seuse."

Physics and mathematics science candidate
V. Maslov

Physics and mathematics science candidate
V. Shpinel'

The authors are researchers at the Ukrainian Physical-Technical Institute of the USSR Academy of Sciences (Kharkiv).

The level of experts which examined this proposal was not very high and it went wandering from Department to Department. From the Inventions Department of the People's Comissariate of Defence (PCD) the application went to the Administration of Military Chemical Defence. From there it went to the Chemical Rescarch Institute of the Red Army. At the end of January 1941, without any in-depth examination, the material was sent to the PCD with a negative decision. According to the article by Khariton and Zeldovich mentioned above (by the way, both of them were three times decorated as Heroes of Socialist Labour for their contribution the development of nuclear weapons), head of the department "A" PRHI of the Red Amry, military engineer of 2nd rank Sominskiy in his secret summation of January 24, 1941, stated that creating the explosion of the Uranium bomb is impossible and that the "proposal of the authors is of no interest for military and chemical actions".

Regarding the centrifuge, the "proposal is interesting, but there is no special military ineterest in it".

In the spring of 1941 the applications arrived at the Radio Institute of the Academy of Science of

USSR. In the decision of that glorious institution, dated on April 17, 1941, it was stated that:

"*As of today noone in the world has managed to create such a chain reaction of the division of Uranium ... concerning this fact it is necessary to say that this application does not have any sound basis. Besides, there is a lot of ficiton in it.*

...Even if one managed to realize the chain reaction, the energy which would be produced should better be spent on getting engines to work, like airplane engines, for instance. What concerns the centrifuge, none of its versions can become a real machine that could produce the separation of isotopes in the needed amount"

Institute director,
V. Khlopin

(V. Khlopin will later became one of the creators of USSR nuclear weapons, Hero of the Socialist Labour and three times holder of the State Trophy).

Leid by this decision, the vice-chief of administration of military and chemical defence Polyanskiy let the authors know that raising the question about a practical usage of atomic energy in the Red Army had a bad timing. So, F. Lange, V. Maslov nad V. Shpinel were denied "copyright".

It is necessray to say that there was no higher authority in the country than the Radio institute and its director V. Khlopin.

As can be seen, Kharkiv's scientists offered the technology of making an atomic bomb, and the way of creating an overcritical mass. It seems that they were the first ones to decide to use the usual explosives as the fuse to initiate the chain reaction. Later all the nuclear bombs were blown up using exactly this technology. But the staff of the Radio Institute concentrated their critisism not on the construction of the fuse, which was the main topic of the invention, but on the question of the fundamental possibility of creating an Uranium bomb, which they did not accept.

Now about the centrifuge. It is known that the creators of the American Uranium bomb chose a very unproductive method of getting the isotope of Uranium-235, the method of gas difusion. Under their impression that was what the Soviet scientists did. Soon the Americans understood their mistake and switched to the centrifugal way of separating the Uranium isotopes.

Kharkiv inverntors did not accept the negative review of their work. V. Maslov in a prvate letter asked the Narkom of defence, Marshal of USSR Tymoshenko to organize a special laboratory to do research in atomic energy for military goal. In the administration of Narkom asked that same administration of chemical and military defence about the value of the proposal and that previously mentioned Polyanskij stated "the impossibility of usage in SURA the proposals of V. Maslov and others". There was no further research done by the Narkom of Defence.

The war started soon...

At the end of World War II, when the world found out about the birth of the American atomic bomb, when the newspapers contained such words as "Hiroshima" and "Nagasaki", the invention department of Narkom recalled the applications of Maslov-Lange-Shpinel' and told the marshal of artillery M. Voronyi about them. By his order in December of 1945 the

Volodymyr Shpinel

He was born on the 4th of October, 1911 in Bila Tserkva, Kyiv oblast.

He graduated from the Physical Faculty of Kyiv State University in 1936. Educated as a physicist-experimenter, specializing in nuclear physics and in the use of the nuclear and spectrographical methods in the physics of solids.

In the Laboratory of Pulsing Voltage in Kharkiv he finished a post-graduate course under the supervision of F. Lange. In 1940 he presented his dissertation „The impulse generator and discharge lamps of the power 4 MeV". During the World War II he was doing practical work for the metallurgy of Kazakhstan.

Presently he is Professor Emeritus of the M. Lomonosov Moscow State University.

Volodymyr Shpinel
photo 1945

materials were sent to major-general Makhnev. And in May of the next year, i. e. six (!) years after the firs application, the invention department decided to grant the copyrights. So, V. Maslov, V. Shpinel' and F. Lange recieved the copyright for the invention of the atomic bomb named "The atomic bomb, or another ammo". Other proposals were also registered as inventions: "Centrifuge to separate isotopes" and "The way to separate isotopes by using a centrifuge".

The actions of LUN did not have any real affect on the realisation of the Soviet atomic project. There are many reasons for that, but the main ones, as we think, are two. The Kharkiv inventors were ahead of their time – the state was not ready to deal with an atomic bomb. When it was time to make it, (in 1945), the administration of the Soviet atomic project walked the way of copying the American bomb and the technology of making it.

So what mark can the inventors get today? We will quote a part of the letter of the Moscow physics historian without naming him: "The archives of LUN are important for our physics, because they allow to show both the level of the proposals and some aspects connected with the work of reconnaissance". In other words, Soviet physicists, besides making, as the constructor of the atomic bomb J. Khariton said "the American bomb", could have made one themselves.

And one more thing. During that Soviet atomic project a number of laboratories were created. Laboratory No. 2 was headed by Igor Kurchatov himself, the science chief of the Uranium project. Few people know that the Laboratory No. 1 was created on the basis of the pre-war UPTI and was headed by Kyrylo Synel'nikov. It was in the spring of 1946. For "outside usage" Laboratory No. 1 was named the Ukrainian Institute of Physics and Technology of the USSR Academy of Science. Maybe the prestigious name of the Kharkiv laboratory doesn't come too much from Kurchatov's considenration for Kharkiv scientists, and not from the desire to confuse foreign reconnaissance, but comes from the realization that the first official proposal for the future threatening weapon came to the goverment of USSR from UPTI.

Svit Fizyky (World of Physics. 1999. No 3. Pp. 14–20)

About the author

I was born in Voronezh district (FSU, now Russia) in 1935 and graduated from the Physical-Mathematical Faculty of Kharkiv State University in 1958. I served as a junior, and then senior researcher in the "National Scientific Center "Kharkiv Institute of Physics and Technology". Since 1980 I am Chief of the Electron Scattering Research Laboratory at this Institute.

I received Candidate's degree in 1967 and Doctor's degree 1978. I am a Fellow of the Ukrainian and American Physical Societies, Member of a council of UPS, Member of Ukrainian Academy of Science Nuclear Physics Counsel. I am Honorable Member of the American Geographic Society also.

My research interests in experimental nuclear physics are connected with electron accelerators. I have been particularly interested in photo- and electronuclear reaction investigations. My current research includes the electron scattering by nuclei, studies of the heavy hypernuclei production and decay.

We'd like to start a discussion fallowing the publication of the article "Who invented the atomic bomb?" as it reals facts that are little-known not only abroad but also in Ukraine.

The achievements of physicist in the 20th century are a result not only of the research of lone physicists but of the collective work of physicists in the whole world. The article shows that the Ukrainian contribution to the problem of the chain reaction is significant. The author of the article Jurij Ranyuk is Professor at the Institute in which the mentioned scientists worked and where the described events took place.

We can add that Jurij Ranyuk is currently working on a book on this subject.

TOURNAMENT OF YOUNG PHYSICISTS

During 4 years on the pages of "World of Physics" we acquaint young physicists with conditions of problems from Tournament of Young Physicists (TYP) and the information about this tournaments. Ukrainian pupils have written a lot of articles that are scientific and cognitive, using conditions of these problems. Some of them were published on the pages of the journal, and were prazed both in Ukraine and abroad (World of Physics, 2000. No 2).

In 2001 the journal took a direct part in the Tournament of Young Physicists in order to listen to the Jury and pupils as well as to analyze both positive and negative aspects of this creative competition of youth and to form its opinion of it.

What is Tournament of Young Physicists like? What do both the authoritative scholars and pupils gain from it?

The finals of the Tournament of Young Physicists was held in response to the joint order of the Ministry of Science and Education of Ukraine and The Academy of the Pedagogical Sciences from the 1st till 7th of March 2001 in Kyiv.

During nine years TYP has been held in Ukraine. It was founded in Odessa as an idea of physicists-enthusiasts V. Koleboshyn, V. Manakin. Later the team of people sharing the same idea from different regions of Ukraine gathered around them and after some time all of them became members of the Jury, organizers of the Tournaments in their own regions. The Tournaments for younger pupils (6th till 8th forms) appeared, that were founded by The Kamins in Luhansk. The competition appeared to be so fascinating for the pupils that nowadays there are similar contests of young chemists, mathematicians, historians, inventors and rationalizers.

During the discussion

The competition had been developing. It exceeded Odessa and soon had become popular among the pupils of Ukraine. The first who joined the Tournament were those educational institutions that had a high standards of teaching physics, the pupils' interest in scientific creativity. They had the teachers who were able to fascinate their pupils by this sort of scientific creativity. Nowadays teams from both special (physical and mathematical) educational institutions and from the Young Academy as well as modular teams of the areas and separate schools take a part in The Tournament.

Twenty teams from all the regions of Ukraine took part in the final stage of the Tournament. It means that the interest to this part of the work with talented pupils is increasing. Even former participants of the Tournament, now members of the Jury (students and aspirants) suggest holding such a tournament among students. The pupils, students, teachers of the schools, lyceums, grammar schools, lecturers of the maximum educational institutions, the scholars, employees of the Ministry of Science and Education of Ukraine and sponsors. During these years the rules and organization of the Tournament have been worked out good traditions have been established.

The Tournament is a good school of the scientific thought, where it is taught to present scientific reports to a wide audience, to oppose statements and hold scientific discussions. After the ending of every stage of the Tournament members of the Jury and the pupils together analyse in detail the physical essence, methods of solving the different problems as

The team of the Richelieu Lyceum, Odessa: Olexandr Tyahulskiy, Mykhailo Kavetskiy, Anna Tkachenko, Anastacia Levdycova

well as form and content of the statements. Such a benevolent dialogue between scientists, teachers, and students gives a feeling of intellectual height to pupils and inspires reliance on their abilities.

Here is some analysis and thoughts of the participants of the Tournament about such competitions for pupils:

Borys Kreminskyi, *head of a department of Scientific and Methodical Centre of secondary education and science of Ukraine*:

"In February 2001 The President of Ukraine Leonid Kuchma signed The Decree on work with talented youth for 2001–2005 years, that stipulates a lot of aspects of the work with the youth, in particular expanding a system of olympiads and competitions. It's a pity but this year no additional investment came. We plan to hold some new creative competitions, in particular internet-olympiads. Tournaments are certainly promising and the Tournament of Young Physicists as the oldest one of this form of competitions became a prestigeous and mass competition of the Ukrainian pupils.

The ninth TYP brought together a record number of the participants (20 teams) and this is a merit of the Ukrainian Physics and Mathematics Lyceum which had organized the participants in Kyiv. Lecturers of Kyiv universities are able to take a part in the work of the Jury, or just to hold a conversation with talented pupils from other regions of Ukraine.

TYP is the intellectual club, a community of the intellectuals. In contrast to the olymoiads the Tournament has its own peculiarities. The olympiad is the so-called sprint personal competition. Each schoolboy and schoolgirl compete individually. The tournaments are team competitions, prolonged in time. Here children are learning to work with the team, to listen to their colleagues, opponents, it brings up a skill to communicate, intelligent behavior, a skill to hold a scientific discussion. The pupils have a chance to prolong their work on solving the problems, at the same time they should quickly react, catch up on most importent from the statements, scientific discussions, where they need to think smartly and bring correct answers.

At the Tournament the participants communicate with both their peers and elders, who have a heavy experience. Here is a meeting of the famous aces of science who have a great authority with youth whose scientific way is just beginning. When a great scolar is coming to speak to the children it is much more worth than a simple prize.

Those who've got into this club once would never be lost, those who've gone abroad wouldn't lose their contacts with the Tournament. It is worth looking at the authors of the problems. Some of them started at the Tournament in the past. This creative cooperation and just a friendship proceeds and we hope it would last for ever."

Ihor Anisimov, *doctor in physics and mathematics, senior lecturer on the radiophysical faculty of Kyiv Shevchenko National University:*

"... I was ill during the Tournament of Young Physicists five years ago. Then I was impressed by the thing that while the pupils of senior forms are interested olny in law business it is still possible to discuss physical problems with such a true passion."

Iryna Rubtsova, *candidate in physics and mathematics, a teacher at the Ukrainian Physical and Mathematical Lyceum, Kyiv:*

"TYP is an intellectual game for senior the pupils who are interested in physics. Such youth do form a scientific elite and is a pride of the nation. TYP demonstrates how to analyse natural phenomena and what it is possible to determine and forebode by means of the knowledge of a school course of physics with the help of popular-scientific literature that youth is able to acquire basing on this course. Answers have been founded not only to such questions as "Why the sky is blue?" and "Why the snow is cracking in winter and rivers are waving on the planes?" but also to such problems as "Are the ozone holes a cyclic rule or are they an ecological catastrophe?", "What is the reason of the global change of the climate on the Earth?", "What processes can the stars flow in May, 2000 be influenced by?", "Which revolutionary changes in tele- and radiocomunication have already happened and which can be expected in the nearest future? How do they influence people?" etc."

Andriy Fomin, *a scoolboy of The Ukrainian Physics and Mathematics Lyceum, Kyiv:*

"... I love physics because I get to know a lot of new from it and I succeed in it. I see many problems of the people that physics can solve. It hasn't exhausted itself as a science yet. I'd like to devote my life to biophysics, though I think a man should work exactly where he has the best conditions for progress..."

Anna Tkachenko, *a schoolgirl of The Richelieu Lyceum, Odessa:*

"I like it, I can spend a long time with wise people, teachers of our licey and lecturers of The Odessa National University who are our masters. But not only masters help us, but also the graduates of our licey who are now studying at The Odessa National University. The Tournament is a team creativity. The Tournament teaches us to lead our thought up to the result on an intelligent talk, teaches us the rules of the intellectual discussion.

There are good conditions for pupils' work on the olympiads, tournaments in The Richelieu Lyceum, the teachers are doing their bests for us. It is pleasant that somebody's interested in us. Nowadays adults are seldom interested in their children, they seldom have benevolent attitude to them. I'm very thankful to my master Pavlo Victor. I've even thought of whom he spends more time with: with his own children or with our team... especially on preparing us for the Tournament."

Olexander Tyahulskiy, a shoolboy of The Richelieu Lyceum, Odessa:

"I started with the Tournament because it was simply of interest to me to know what it was like. But when I got acquainted with it closer this spirit overwhelved me. It helps me to understand a lot of everyday problems, I learnt how to comunicate with people, realised better how I should behave. I'm so sorry that it is my last year when I can take part in the Tournament. I regret it."

Mykhailo Kavetskiy, a schoolboy of the Richelieu Lyceum, Odessa:

"I have a wonderful teacher in physics and so I got interested in this subject. I have been trying to inflate my sight in this subject more and more. Then I started in the Tournament which gave me a lot, I made progress on the whole, learnt to hold experiments."

Sergiy Nickolayenko, a scoolboy of the Kharkiv Physical and Mathematical Lyceum No 27:

"First I'd like to talk about my team. We prepared for the Tournament a long time. A good preparation brought us a good result. I was sure we'd reach the final.

The problems of this tournament were interesting but some of them were incorrect. There is a tendency (my observations for several tournaments) to decreasing the number of interesting problems. Although there are very interesting problems at each Tournament.

We are satisfied by the Jury's work. But inviting students to the Jury resulted in a great difference in appreciating the reports. I think they should develop more precise criteria of appreciation.

It is interesting for me to solve problems, to manage the statements. The Tournament is not only a sport competition, but we learn physics here."

The team of the Kharkiv Physical and Mathematical Lyceum No 27: Sergiy Nickolayenko, Anton Tkachuk, Sergiy Snehirenko, Olexiy Sariy, Yevhen Nosyk

The girls' team "Amazones" from the Ukrainian physical and mathematical Lyceum, Kyiv

The state must organize such creative competitions for the pupils. It is important that children need funding for a transportation, board, lodging and a cultural program. Analysis of the results of previous years shows that the majority of the TYP participants who devoted their lives to physics, are studying at the best universities of the world.

To involve the Ukrainian pupils to this kind of the creative competition organizers should decide how to bring forward the information about the Tournament rules up to every school, because there are still many talented pupils that are not involved in this kind of work because of absence of information, financial support, teachers enthusiasts that are able to bring pupils together for this work.

In spite of a good tradition of arranging, involving the pupils from the all regions of Ukraine, positive results the Tournament still remains alive only due to the enthusiasts. Let's notify that an importance of such tournaments is realized by the Ministry of Science and Education of Ukraine, but not always we see such a realization. The Tournament has made some sponsors interested. It is pleasant that there are former graduates of the physical faculties among them. For example „Ukrtelecom" (headed by S. Dovhiy) supported the Tournament. It is not only a prize for the winners but also a free connection to the Internet of the UPML, a grant for the winner in the personal account if he studies at a Ukrainian university, invitation to a lot of graduates for a job in the system of "Ukrtelecom".

Kyiv Shevchenko National University presents sets of the journal of "Pulsar" to the teams and invited school graduates for the study.

"Eurosvit" presents scientific books for students and members of the Jury, an educational literature for pupils and an annual subscription to a journal "World of Physics" for teams-winners.

But the greatest present for pupils by Borys Kreminskiy was the conversation with scientists. At the final tournament there were twice winner of the State Prize V. Danylo, Dean of the Physical Faculty of the Kyiv Shevchenko National University L. Bulavin, Academian of the National Academy of Science V. Bar'yakhtar, director of the "Ukrtelecom" S. Dovhiy, the director of "Yuh" and some others who spoke about the situation in modern physics as well as a prospects of its progress and practical application.

It's a pity that there isn't enough attention to such tournaments from Ukrainian press, radio and TV. Probably it would be interesting for the Ukrainian pupils to see how scientific thought is born, how intelligent scientific discussion is to be held by peers, how they hold a dialogue in Ukrainian and in Russian trying to come to terms, and at last persisted on their own after the results had been announced, to see worrying and tears of the participants. I think it would be not less fascinating for a wide group of the spectators than entertaining programs.

And one more thing. The pupils use a lot of literature (directories, dictionaries, textbooks) and this testifies to the feel that the children's interest in reading hasn't disappeared completely, but we have not enough books, especially in Ukrainian, we haven't got the problem of scientific terminology solved yet.

Partisipants from the L'viv physical and mathematical Lyceum are discussing their results with their teacher Dariya Bida

The winners are teams of The Kharkiv Physical and Mathematical Lyceum No 27 – The First Diploma,

The Richelieu Lyceum of Odessa and The Ukrainian Physical and Mathematical Lyceum (the team of "Suzir'ya" – Ivan Sadovskiy, Dmytro Tereshonok, Andriy Fomin, Andriy Lazaryev, Ivan Levkivskiy) – The Second Diploma. I think all the participants are the winners on the Tournament because they were lucky to enjoy intellectual conversation for a week and to get acquainted with Ukrainian scientists, universities and beautiful Kyiv.

The editors of the journal truly congratulate all the participants of the Tournament: "We wish you good success and happiness!"

We ask you to send us materials for the journal "World of Physics".

Halyna Shopa

George Gamov

Oleksa Bilaniuk

Everyone who heard about the "Big bang" hypothesis, or about the genetic code of DNA should know that when Professor George Gamov, who was one of the authors of these epochal ideas, died on August 29, 1968 in Boulder, Colorado, the scientific world lost one of its leading physicists. And very few Ukrainians (and even less so-foreigners) know that George Gamov was proud that his mother was a descended of the Lebedynets' family who traced their family tree to the Zaporizhski Cossacks. Gamov loved to joke that Gamovs and Lebedynets' met for the first time not in the persons of his father and mother but as his two grand-grandfathers when imperial officer Gamov and Zaporizhskyi Cossack captain Lebedynets crossed their sabers in the battle for Zaporizhska Sich.

George Antonovych Gamov was born on March 4, 1904 in the city of Odessa where his grandfather Metropolitan Arseniy Lebedyntsev (Lebedynets in Ukrainian), was a cathedral dean and a leading hierarch of the Orthodox church of "New Russia". Gamov spent his childhood in Odessa where he went through World War I and where he started his first university studies which he completed in 1926 in Leningrad. There he quickly made his way through the ranks and became one of the so-called "three musketeers" (Lev Landau from Baku, Dmytro Ivanenko from Poltava and George Gamov from Odessa) who soon appeared on the world arena of theoretical physics.

At that time the Soviet Union had not yet erected the "iron curtain" and talented scientists were able to go "on assignments" to foreign scientific institutions. So, in 1928–1931 Gamov was lucky to work in such outstanding scientific centres as Göttingen, Copenhagen, and Cambridge. World-wide recognition came to Gamov for the first time in 1928 when on the basis of the new at that time quantum mechanics he suggested a theory of alpha-particle penetration through a nuclear potential barrier. His theory not only qualitatively, but also quantitatively, explained the phenomenon of a radioactive alpha-decay.

George Gamov
04.03.1904–29.08.1968

When in 1931 Gamov came back to Leningrad, the sitnation became worse in the Soviet Union and Gamov began trying to go abroad "on assignment" again, but with a secret intention not to return. Though Gamov received official invitations from Rome and from Ann Arbor (Michigan), he was not granted a visa for departure. Furthermore, the situation became even more complicated because Gamov had married and did not want to leave the Soviet Union without his wife. Then they came up with a courageous plan of fleeing from the USSR to Turkey by crossing the Black Sea in a row-boat! In spite of all the difficulties they put their plan into action during their vacations in Crimea. But Gamov and his wife were caught by a storm and, barely alive, were thrown out by the sea again on the Crimean coast. Everybody felt sorry for them and nobody guessed what was the true purpose of that boat ride...

In the beginning of 1933, Gamov received the invitation to take part in an international Solvey Congress, which was held in autumn of 1933 in Brussels (Belgium). Unexpectedly, he received the visa for departure. But he refused to go unless his wife received a visa too. For his "impudence" Gamov expected to be arrested but instead he and his wife received visas. Only later in France Gamov found out that it was thanks to the outstanding French physicist Paul Langevin, a member of the French Communist Party, that the Soviet Government nominated Gamov as the official delegate to this prestigious Congress. So Gamov owed his visa to Langevin. But it should be pointed out that the visa for his wife was the result of his reckless obstinacy.

Having gone through some untoward adventures after the Solvey Congress, Gamov moved to America. From 1934 up to 1956 he had been the professor of physics at the George Washington University in Washington, D.C. From 1956 and until his death Gamov had been the professor of physics at the University of Colorado.

Gamov's interests included the full range of the physical world. Besides a great success in explaining the alpha decay, Gamov made another significant contribution to nuclear physics: in cooperation with Edward Teller he improved Fermi's theory of beta decay. Subsegnently Gamov became widely known for his work in cosmology. He integrated nuclear physics with George Lemaître's cosmological hypothesis of primeval explosion and initiated a comprehensive theory of cosmic evolution, now known as the "Big Bang". He made a significant contribution to the theory of formation of chemical elements in association with the theory of stellar development.

When in 1954 James Watson and Francis Creek discovered the DNA structure, the main component of genetic substance, Gamov was the first who put forward a scientifically grounded theory that this structure comprises a genetic code according to which life reproduces itself. Today this theory is commonly accepted in its main features.

To the general public Gamov is known by his popular scientific books in which he most unusually explains the concepts of modern physics. Many beginning physicists took their first look at the strange world of relativity and quantum theory through the eyes of Mr. Tompkins in the book "*Mr. Tompkins in Wonderland*". For his great achievements in popularization of science, UNESCO awarded Gamov its prize in 1956.

An interested reader will derive much pleasure from George Gamov's autobiography "*My World Line*" (Viking Press, N.Y., 1970), which is both informative and full of humor.

Svit Fizyky (World of Physics. 1998. No 1. Pp. 18–19)

True story

Professor Gamov was a very humorous man. When he wrote a paper with L. Alpher, he invited H. Bethe to be a co-author so that the list of authors world read "Alpher, Bethe, and Gamov".

On the composition made by Gamov in order to make his friends laugh he depicts himself as a genie who appears out of a bottle filled by primeval matter created when the World was born.

The Universities of Ukraine

Kyiv-Mohyla Academy. The first Ukrainian high school

At all times education was an important element of public life in Ukraine. It is well-known that in the 11-12th centuries in Kyivan Rus education and culture reached a high level. Literacy was not the sole privilege of dukes or annalist monks; it was also widespread among simple people and craftsmen. Kyivan Rus also had a special school for women. Princess Anne – the daughter of King Yaroslav, who later married Henri I, King of France, was literate, she brought books with her to France, while the French King was himself illiterate.

The Arabian traveller P. Alepian, while traveling in Ukraine in the 17th century wrote: "In this land we have seen a most precious feature, which caused us to wonder – all of them, but a small number, even their wives and daughters can read. In Kyiv the monks could not only read, but knew philosophy, logic and wrote treatises".

Till the end of the 16th century the schooling in Ukraine was more wide-ranging than deepening; Ukrainian schools were taking the schools of the Dukes period as exsamples. In these schools the pupils were taught Slavic reading and writing, the basic arithmetic, notation in music, Latin. In order to enhance their education Ukrainian youth went to the countries where schools of new and higher kind were already available – namely, Universities and Academies. In the 16–17th centuries hundreds if met thousands of Ukrainian students studied at different European Universities – in Italy, Poland, Germany, England. Two principal factors contributed to the rise and formation of higher schools in Ukraine. It was the spirit of new European science and culture, the spirit of Renaissance that Ukrainian youth brought with them when returning to the native land after completing their studies. Educated people were honored in Ukraine; their opinion was most highly valued. In order to maintain and develop the spirit of high education and culture in the native land, institutions and schools that would meet higher standards were required. The first school of the kind was the Ostroh School in Volyn founded in the 70s of the 16th century by a celebrated Ukrainian political and cultural figure and philanthropist Duke V. Ostrozky. This school, often referred to as Ostroh Academy, gathered leading scientific forces of the time and produced a great influence upon the development of Ukrainian culture.

Another factor that stimulated the development of education in Ukraine was the activity of Catholic and protestant missionaries on Ukrainian lands. In order to widen and enhance their influence on the local population they were founding schools called Collegiums, with which older Ukrainian schools found difficult to compete. The Orthodox population of Ukrainian cities opposed this by congregating into specific public organizations – Brotherhoods. One of the most important tasks of Brotherhoods was founding schools that would not be inferior to Collegiums. Thus the spirit of rivalry, which often grew into open confrontation and even armed struggle, had a positive impact upon the development of education in Ukraine. Education was becoming one of the links in the struggle for national identity.

The first Brotherhood School was opened in Lviv in 1586. By the end of the 16th century Brotherhood Schools were already present in many Ukrainian cities, in particular – in Luts'k, Rohatyn, Peremysl, Kamyanets-Podilsky, Kholm, Kremenets, Vinnytsja. The standards of training in these Schools were being elevated to those of the European schools. In Kyiv, as well as in other cities, the Brotherhood, founded in 1615, was am important factor of public life. The same year, on October 15, the Kyiv Lady Elisabeth (Galshka) Hulevychivna granted the Brotherhood her lands on condition that a monastery, a house for pilgrims and a school "for children of both nobles and commoners" should be established there. The Brothernood has fulfilled Elizabeth's conditions, the school was constructed and opened and the day of October 15 was since then celebrated as the day of foundation of Kyiv Brotherhood School, the predecessor of the Kyiv Mohyla Academy. The Patriarch of Jerusalem Theophane after his trip to Kyiv in 1620 wrote with admiration about "the school of Hellenic-Slavic and Latin-Polish writing, where science through teachers is delivered in abundance".

In the fall of 1613 another school of higher level was opened in Kyiv – the Lavra School. It was founded by the Archimandrite of Kyiv-Pechersk Lavra Petro Mohyla (1596–1647). The Lavra School was created as a European higher school. It contained preparatory classes, where students mastered Charch Slavonic, Latin, Greek and Polish; middle, where Pietics and Rhetoric were taught; and higher, where the students obtained instruction in Philosophy and Theology. Thus, the Lavra School was becoming a competitor of Kyiv Brotherhood School. Yet the rivalry didn't last long, because already in 1623 these two schools were united and Petro Mohyla became the "perpetual protector and instructor" of this newly created school, which was called the Kyiv Brotherhood Collegium. At the time of his death he willed all his property to the school and since then the School was called Kyiv-Mohyla Collegium.

The students of the Collegium studied "seven free sciences", which were the basis for training in contemporary Universities. They were divided into "trivium" – Grammar, Rhetoric and Dialectic and "quadrivium" – Arithmetic, Geometry, Astronomy and Music. One of the privileges of higher schools in Europe was the right to found schools of lower level. Although the Polish King did not grant Kyiv-Mohyla academy the status of a higher school, launched and administered a number of such schools (in Kremenets, Vinnytsia and Hoshi).

The Ukrainian people and its hetmans supported their higher schools. In the treaties of Bogdan Khmelnytskyi with the Polish King in 1649 and 1651 it was stated that "the Kyiv Collegium has to remain in former rights according to the old privileges". These rights were confirmed by Khmelnytskyi in his Universals in 1651 and 1656. Khmelnitskyi's successor, hetman I. Vyhovsky found agreement with the King to grant Kyiv-Mohyla Collegium the same rights as Kracow University had, but the Collegium still was not recognized as a higher school. The times of "Interlunation" (the period between the death of Bogdan Khmelnytskyi till the election of I. Mazepa for hetman) were difficult for the Collegium too. Only after Mazepa took over the hetmanship, things changed for the better. Hetman Mazepa constructed a new building and was continuously making significant contributions for the maintenance of the Collegium. Finally the Collegium won its official recognition as a higher school. This happened in 1701; since then it was called Kyiv-Mohyla Academy.

The highest scientific, moral and ethical requirements were established for the teachers of the Academy. Their positions were elective and advantage was given to those of them, who, apart from scientific and pedagogical skills, were noted for high value as persons. "The figures of science should always be the highest standard of modesty for their students" was noted in the Academy's Statutes. Foreigners were also invited to each in the Academy. "We grew among people trained not only in Kyiv, but also in Königsberg, Leipzig, Leiden, Göttingen, Oxford and Edinburg." – one of the Academy's graduates wrote later. The right to become a student of the Academy was not reserved only for aristocracy; the majority of the students were children of Cossacks and commoners. Students were divided into two congregations (brotherhoods) – senior for the students of senior years and junior for the students of the first four years. They were electing their own councils and courts. The academic process was supported by the students themselves; there were *censors* (students in charge of behavior), *decurions* (students in charge of keeping silence) and *auditors* (students who checked the knowledge of their fellows). In the second half of the 18th century the conservative policy of the Russian monarchy towards Ukraine became stricter. It was prohibited to publish books and compile official documents in Ukrainian. And when in 1763 hetman K. Rozumovskyi wanted to turn Academy into a University, he did not get permission for that.

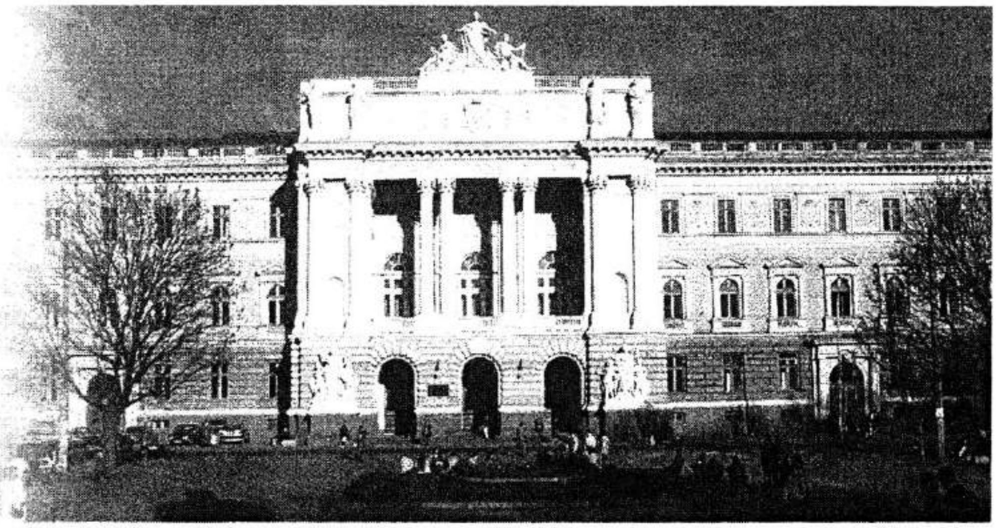
Since 1784 the teachers of Kyiv-Mohyla Academy were forced to instruct "with pronunciation as it is found in Greater Russia and observe the rules of Russian orthography" on penalty of dismissal. In 1786 the Russian Queen Elizabeth II wanted to move Academy to the territory of Lavra and subordinate it to the monastery, but the inhabitants of Kyiv protected their Academy. Yet not for long...

In 1817 Kyiv-Mohyla Academy was closed.

As we look back, we cannot help noting the great influence that Kyiv-Mohyla exerted upon the culture of Ukraine, Russia, Byelorus, Moldova and other countries. Till 1687 Kyiv-Mohyla Academy was the only higher educational institution on Eastern Slavic lands. When in that year Slavic-Greek-Latin Academy was founded in Moscow, its first rectors and professors were the graduates of Kyiv-Mohyla Collegium. In 1701–1762 as many as 95 professors were transferred to Moscow Academy. During that period 21 individuals assumed the position of the Rector, among them – 18 graduates of Kyiv-Mohyla Academy; 25 persons became professors, 23 of whom were the alumni of the celebrated Kyiv School.

The dream of many generations of Ukrainian intellectuals came true on September 19, 1991, when the Speaker of the Supreme Council of Ukraine signed the decree to recreate Kyiv-Mohyla Academy. On the 23th of August 1992 the University "Kyiv-Mohyla Avademy" was officially restored.

Today the National University "Kyiv-Mohyla Academy" consists of three faculties and three departments, where 1500 students are studying. The University currently has two branches (in Ostroh and in Mykolaiv) and six Collegiums in different regions of Ukraine.



Ivan Franko Lviv National University

The oldest Universities of Ukraine are Ivan Franko Lviv National University and Karazin Kharkiv National University. They have made a great contribution to the development of education, science, culture, to the restoration and strengthening Ukrainian Statehood.

More than 300 years passed the since foundation of Lviv University.

On the 20th of January, 1661 the King of Poland Jan Kazymir granted Lviv Jesuit Collegium "the dignity of the academy and the status of a University". At that time physics did not exist as a formed University course and a separate science. The modern history of science associates the appearance of physics as an independent science with the names of Galileo, who posted the principle of physical equality of inertial coordinate systems and Newton, who formulated the basic laws of classical mechanics in his work "The mathematical principles of natural philosophy" in 1687. Till 1773 physics was not mentioned as a separate subject in the University, but was a part of the course of philosophy.

The subject was reading and commenting the works of Aristotle and explaining the physical phenomena and properties of matter:

Heat, cold, humidity, dryness, flexibility and fragility of solids based on the elements of fire, air, earth and water. As the main aim of studies was higher theological education, in case the lectors were too deeply involved in purely physical issues, prohibitions to teach physics were issued at times, in part, in 1706 and 1728. But the development of natural sciences and growing needs of technology, fortification and different techniques of measurement was breaking its way to educational institutions. By the diploma of King August III of the 24th of March 1759 physics was legally recognized as an integral part of the course of philosophy.

In 1773 after the First Division of Poland Lviv became a part of the Austro-Hungarian Empire. The Jesuit order was abolished along with its institutions, including Lviv Academy (University). Its parts became the base of Josephine University, founded in October 1784, which included four faculties: philosophical, theological, legal and medical. Philosophy, Mathematics and Physics were taught as separate subjects at the Faculty of Philosophy. The first professor of the department of Physics in Lviv University was Austrian scientist Franz Huisman (1741–1806).

Before the division of the Department into theoretical and experimental sections the Department of Physics was chaired by Aloisium Handl from 1859 till 1872. Professor Handl published his scientific works in the journals of the Vienna Academy of Sciences, in which he discussed the structure of fluids, the composition of salt crystals, absoption of light, magnetic deviation in Lviv and many other topics.

In the 1871–1882 academic year Physics was divided into mathematical (theoretical) and experimental.

Celebrated scientists, such as Marian Smoluchowski, Konstant Zakrzevski and Stanislaw Loria worked in Lviv University at that time.

Apart from pedagogical activity, Stanislav Loria entered history of science as an investigator in the field of dispersion and light absorption in metal vapors, fluorescence, radioactivity and diffraction of electrons. He reconstructed and upgraded physical laboratories and created the Institute of Physics that employed 10 persons. The Institute had a glass workshop, mechanical workshops, a separate building with a special isolated basement for interference studies with Jamen interferometer. The Institute of Physics also possessed the machine of Linde for liquefaction of air, channels for introducing a collimated sunbeam and automatic monitoring of the movement of the Sun. Ventilation was provided by gas burners in ventilation channels. A powerful accumulator battery park was created with the corresponding electrical network.

The first Chair of the Department of Theoretical Physics was Oscar Fabian – a gifted and industrious scientist. The most valuable contributions that he made were the works "On light refraction and length of waves", "On the phenomenon of gravity", "On the radiant state of matter".

After the death of O. Fabian in 1899 the department was chaired by Marian Smoluchowski (1872–(1914–1918?) – one of the most recognized physicists in the world, who left his name in the history of science as one of the creators of modern molecular-kinetic theory. Thirty five scientific papers of Professor Smoluchowski reached our days. In these works he presented his attempts to solve the problems of kinetic theory, where he developed the ideas of Bolzman on the theory of Brownian motion, which appeared simultaneously with the works of A. Einstein, the theory of fluctuations, which promoted a total completion of molecular theory and became the basis of connection of statistical physics to thermodynamics. In general, the area of scientific interests of advanced scientists is not limited to a narrow field of research. This is quite characteristic of M. Smoluchowski. He had works on the processes of mountain formation, aerodynamics and theory of planet atmospheres. And when today we speak about the theory of Brownian motion according to Smolukhovski, we are proud of the fact that it was created within Lviv University.

Before World War I, in 1913 M. Smoluchowski moved to Kracow, and his traces disappeared in the whirl of the war. In these years (1913–1918) the Department was chaired by professor Konstant Zakrzeski, known for research in electron theory of metal and optical properties of liquids. World War I rolled through Lviv in several waves. The front line was bringing interruptions to the academic process, hindered research work. Many gifted scientists and students left science, some died during the war or were deported. After the downfall of the Austro-Hungarian Empire the statehood of Poland was restored. Polish authorities were actively performing polonization of Lviv University. In 1919 the majority of the professors were Poles. The professors of Austrian origin moved to their fatherland, with a few remaining in Lviv. Ukrainians were gradually barred from teaching activity (the majority of them did not want to swear their allegiance to the Polish state).

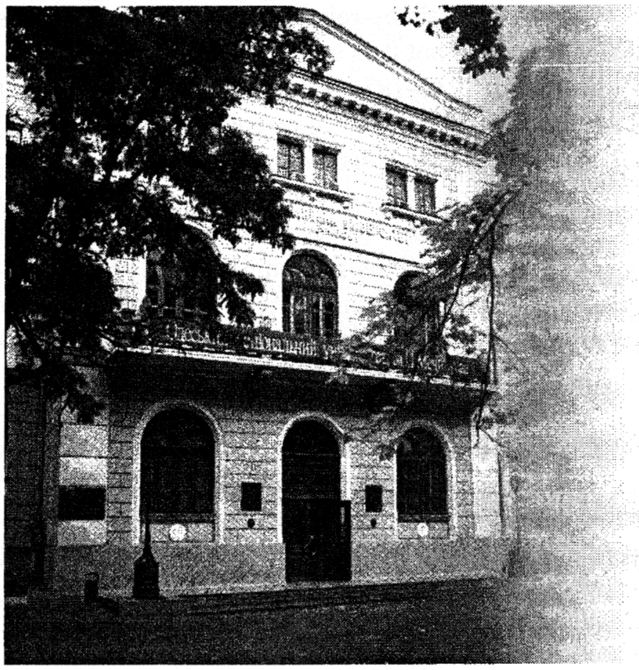
In 1919 Lviv University was named "The University of Jan Kazimierz in Lwów". Yet these changes did not have a significant impact on the development of natural sciences and physics in particular. The same two departments were functioning – the Departments of Theoretical and Experimental Physics with the relevant Institutes. The University also possessed an astronomic observatory.

During World War II the life of Lviv University has stopped for three years. The occupation destroyed and emptied the University: the laboratories and rooms were robbered more than 20 thousand valuable books were taken from the library, among which there were 4000 very old printed books and 50 precious manuscripts.

After the war Lviv University resumed its activities. The academic process, inclusive at the Department of Physics, officially started on the 1st of October, 1944. After Wojciech Rubinowicz the Department of Theoretical physics was chaired by Vasyl Milianchuk (1905–1958) – one of the most prominent Ukrainian physicists at the time. V. Milianchukwas born in Kolomya distinct of Ivano-Frankivsk oblast. He acquired higher education in Lviv University, later – in Polytechnical University, where he completed his studies in 1933 with the degree of Master in Physics. He started his activity at the University the same year. Combination of natural gifts with industrious character multiplied by profound scientific skills allowed him already in his student years to master the most recent achievement of theoretical physics of his time – relativistic quantum mechanics of Dirac and put it as a base of his own original research. In 1935–1936 V. Milianchuk was staying at the University of Leipzig where he directly communicated with W. Heisenberg. Already as a young scientist, he published articles in the world's leading physical journals. Professor Milianchuk chaired the Department until his sudden death in 1958. He belonged to the most prominent physicists of the former USSR in the area of theory of atomic spectra. His cooperation with such recognized scientists as G. Landsberg and others gave a possibility to many graduates of the 50s to study in Ph.D. programs or train at the leading physical institutions of the country. Among the students of V. Milianchuk were the Academician of the Academy of Sciences of the USSR E. Fradkin, Doctors of Siences A. Svidzinskyi, R. Gaida, I. Taliansky, PhD.'s M. Sen'kiv, P. Tatsunuiak and others.

In the 50s the Department hosted professors A. Glauberman, S. Kaplan, and in 1954 the current Academician of the Academy of Sciences of Ukraine I. Yukhnovskyj started his activity. Later, in 1958 he chaired the Department and remained in this position until 1970. From then on Academician I. Yukhnovskyj has been working in the National Academy of Sciences of Ukraine and chairs the Institute of physics of Condensed Systems which he created in 1990. The main achievements of I. Yukhnovskyj deal with statistical thermodynamics of systems of interacting particles, in particular, theory of phase transitions.

From 1971 the Department was headed by Mykhailo Sen'kiv (1923–1993) – until 1973, then – Roman Gaida – until 1978, Lavrin Blazhievskyj – until 1984. From 1984 on the Department has been headed by Professor Ivan Vakarchuk. The Department works on the problems of classic and quantum statistical mechanics, theory of quantum fluids, stochastic systems, magnetism in amorphous and liquid bodies, phase transitions, theory of spectral lines in star atmospheres and others. Today Professor Ivan Vakarchuk is the Rector of the Ivan Franko Lviv National University. A powerful cohort of young physicists is growing under his leadership. This safeguards the scientific traditions of the Department and raises it to a new level. It allows to view the future of one of the oldest Departments of Lviv University with optimism.



I.I.Mechnikoff Odessa National University

The oldest University in the South of Ukraine is Odessa National University named after I.I. Mechikoff. It was founded in 1865 on the basis of the Richelieu Lyceum. The first academic year started on the 7th of September, 1865 at three Faculties – Physics and Mathematics, History and Philology, and Law.

From the very day of its foundation the University has occupied a leading place in formation of the educational system, in the development of scientific research and culture in Ukraine. It is one of the oldest Universities in our country and along with Kyiv, Lviv and Kharkiv Universities determines the condition and perspectives of the development of the educational network in Ukraine. Among the celebrated scientists that worked there and contributed to the outstanding prominent pages in the history of the University, it is worth noting such figures as I Mechnikoff – the Laureate of the Nobel Prize, physiologist I. Sechenov – the founder of Ukrainian physiology, the first President of the Academy of Sciences of Ukraine, microbiologist D. Zabolotnyi, theoretical physicist, the founder of the mathematical Department of Novorussian Society of Natural Sciences M. Umov, Academician, botanist V. Lipsky, biologist O. Kovalevsky, physicist F. Shvedov, Academician of the Academy of Sciences of the USSR, founder of the recognized school of Organic Chemistry, M. Zelinsky, Academician of the Russian and Soviet Academies of Sciences, historian and archeologist F. Uspensky, Academician, member of the Presidium of the National Academy of Sciences of Ukraine, the founder of the Physico-Chemical Institute of the National Academy of Sciences of Ukraine O. Bogatsky, a Corresponding Member of the Academy of Sciences of the Ukrainian SSR, founder of Odessa planetarium, astronomer V. Tsesevich, mathematicians M. Krein, O. Lyapunov and I. Zanchevsky, a celebrated historian M. Slabchenko, slavist V. Grygorovich, zoologist D. Tretyakov, geologist A. Kryshtofovich, chemist L. Pysharzevsky and many others, among them the world renowned physicist George Gamov who began his universitystudiers at the Odessa University.

Three of the six Presidents of the Academy of Sciences of Ukraine worked as professors of the University: Academicians D. Zabolotny, V. Lyps'ky, O. Bogomolets, the acting Vice-President of the National Academy of Sciences of Ukraine Academician I. Kuras is an alumnus of Odessa National University. 8 Laureates of State Prizes (4 of them became Laureates in the last 5 years), 7 honored figure of education and science of Ukraine are working at the University today.

The majority of higher educational institutions in the South of Ukraine were founded on the basis of the Departments of the University: Odessa State Medical University, Odessa State University of Economics, Odessa National Academy of Law.

The Faculty of Physics of Odessa National University is the oldest of the University's Departments. It is 137 years old. The first Dean of the then Physical-Mathematical Department (1865–1868) was chemist M.M. Sokolov. His successor, Professor V. Lapshin, was a physicist (1868–1870). The outstanding scientist Professor F. Schvedov also made a great contribution to the development of physics at the Department and creation of the experimental base. He was Dean in 1877–1880 and 1889–1895; in 1895–1903 he was Rector of the University.

A large cohort of prominent scientists had been working at the Faculty – professors F. Schwedov, M. Umov, V. Lapschin, V. Tsesevich, V. Fedoseev, I. Fisher, V. Presnov, A. Glauberman, V. Serdiuk and others. In the early 70s of the last century scientific schools of theoretical physics, physics of semiconductors and dielectrics, physics of air-disperse systems, physical electronics, astrophysics came to be formed. The staff of the Faculty, by actively performing research, acquired a leading place among other Faculties of Odessa University.

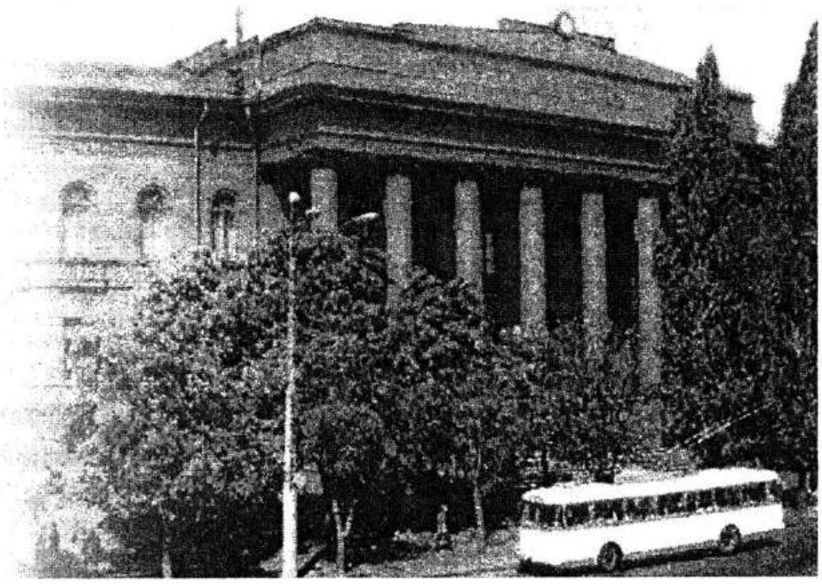
How did Odessa University enter the new Millenium? Today the base for scientific research work is provided by the network of research divisions created at the Faculty.

Currently scientific research, especially that of applied character, has abundantly developed, much was done to equip the general and physical laboratories with contemporary devices. In 1975–1981 the Faculty was headed by Professor M. Chesnokov, who greatly improved the material base of the Faculty. From 1981 the Dean of the Faculty is Professor G. Chemeresiuk.

The scientific research in the divisions of the Faculty is performed in the following high-priority realms: theory of condensed conditions, physics of stochastic systems, physics of disperse systems, physics of semiconductors and dielectrics, physics of solid bodies, macroelectronics, gas dynamics of burning and explosions, kinematics and physics of stars.

The results of this research are known in Ukraine and far beyond its borders. The University cooperates with nearly 40 recognized Universities worldwide – USA, Russia, Germany, Italy, Israel, Slovakia, Poland, Belarus, Kazakhstan and others.

National Taras Shevchenko University of Kyiv



Svit Fizyky (World of Physics. 1998. No 2. Pp. 7–12; 1999. No 1. Pp. 19–23; 2001. No 3. Pp. 23–26)

„The Nobel Prize Winners" is a regular heading in the journal „World of Physics". It popularizes achievements of physicists, who became Nobel laureates.

NOBEL PRIZE WINNERS

1992

George Charpak

Nobel prize laureate who was born in Ukraine ...

In 1992 The Swedish Royal Academy of Sciences awarded a well-known physicist-experimenter George Charpak a Nobel Prize in Physics "for the invention and improvement of a particle detector – multi wire proportional chamber."

George Charpak was born on the 1st August 1924 in the city of Sarna, Rivne region (back then it belonged to Poland). The future Noble laureate made his first steps on the Ukrainian sail. He spent the first eight years of his life here. In 1932 George and his parents moved to France. During World War II he participated in the French Resistance movement and spent a whole year in the Dahau concentration camp.

After the war George studied at the Mining School in Paris and later at the College de France where he received his PhD in Physics. Since 1959 and till the beginning of the 90's he had been working in the European Center ofNuclear Research (CERN, Geneva). There he was head of a research group that was engaged in the development of new nuclear research methods.

G. Charpak's award confirms that the methodological work is important for contemporary physics. The Nobel Committee singles out methodological inventions that significantly influence the development of physics and broaden the field of scientific research. C. Wilson (1927) was awarded the Nobel Prize for the invention of the cloud chamber, S. Powel (1950) for the development of a nuclear photoemulsion method, and D. Glazer (1960) received a Nobel Prize for the creation of the bubble chamber.

The progress in nuclear physics is closely related to the improvement of elementary particle detectors. E. Rutherford, the founder of this science, used a luminescent screen to register the particles. Later, when the investigation of more complicated nuclear reactions began, a necessity arose to register every particle, and so scientists began using Wilson's chamber. This made it possible to see and take a picture of a particle's trajectory in Wilson's chamber because the ions of air ionized by the particle became the centres of condensation of oversaturated vapor. Similar processes are observed in bubble and spark chambers. The particles' trajectories in these detectors are registered by the photographic method.

When new powerful accelerators appeared scientists began making millions of pictures that had to be analyzed. This was slowing down the advancement of nuclear research: the overwhelming amount of experimental data prevented scientists from clarifying the basic physical relations quickly and effectively.

The research methods were significantly improved by George Charpak's invention of the multi-wire proportional chamber (MPC) that enabled the scientists to connect the detector to a computer and to increase the speed of gaining useful information by millions of times. The ability of MPC to work faster and more precisely was important for the study of complicated nuclear reactions where only one out of billion particles is the one which is being "hunted down".

Charpak's inventions gave the physicists a possibility to study those rare interactions that carry information about fundamental properties of matter.

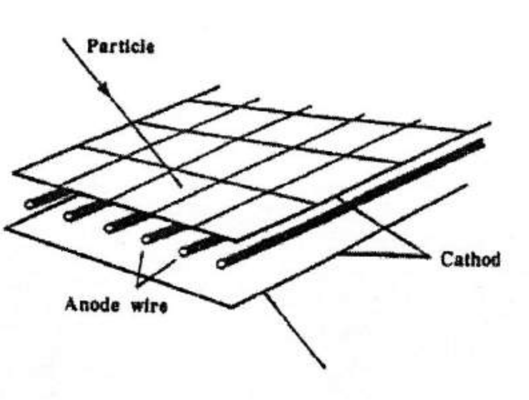


Fig. 1. *MPC Scheme – particle, cathode, anode wires*

What is MPC and how does it work?

It consists of a row of parallel thin wires (their radius is 20 micrometers) with a positive potential applied to them. There are cathode planes above and beneath the wires. The detector is filled with an inert gas, usually argon with CO_2 and CH_4 admixtures. Every anode wire works as an independent detector – this is the very core of G. Charpak's invention. Near the wire (in the area of a high electrical field gradient) electrons receive enough energy for ionization of gas atoms. Secondary electrons created during this ionization also ionize the atoms. The quantity of the electrons increases rapidly: instead of n_0 electrons created by ionizing radiation, kn_0 electrons are created where k is the coefficient of "gas multiplication". Proportional chamber consists of two parts: a thin layer near the wire where striking ionization takes place and the rest of the volume that works as on ionization chamber. Drift of the electrons created near the wire to the wire itself and of positive ions to the cathode induces an electrical signal in the wire which is proportional to the quantity of primary electrons. The signals that appear in other wires are small and have a different polarity. This gives the scientist a possibility to determine the coordinates of the ionizing particle by the localization of the anode wire, which produced the signal. If, for example, the distance between two wires is equal to 2 mm, then indeterminancy of a particle's track coordinate is going to be the same. The time separation of a proportional chamber is equal to 30 ns and the efficiency of registration is equal to 100% for many particles. The time needed for the device to get ready to register the next particle is 10^{-6} s. MPC can work in strong magnetic fields and that is why it is widely used in magnetic spectrometers. It also works in intensive particle beams. This helps to use effectively the valuable time of accelerators. MPC registers all particles that go through it, in contrast to other track particle detectors that work impulsively and register only selected (certain) particles. The analysis of a large data stream is now managed by the computer, of which the speed of response and memory allows to analyze and save all the information.

Nevertheless, at the beginning of their "career" MPCs where an expensive and unreliable detector with a lot of problems such as high requirements for the production of wires, their aging, many electronic channels that were not reliable enough. It took much of Charpak's energy and experimental mastery to make this detector technically perfect. He developed a reliable technology of MPC production, selected the needed construction materials, improved the electronic blocks and designed the computer programs for signal processing. He also suggested the gas mixes, including the four-component ones that allowed to receive homogenous signals irrespective of the energy loss of a particle that is ionizing gas and in this way to lower the cost of electronic devices. The size of MPC grew as the power of accelerators increased. By 1992 there had already been MPCs with the area of 5×5 m² and 10^5 wires working at the gigantic LEP collider.

Later there appeared other multi-wire detectors the author of which was also G. Charpak: drift chamber, time projecting chamber, multi-row avalanche detector, gas detector with solid photocathode, etc.

The latest modifications of multi wire chambers have improved characteristics, as well as better production technology. At the present stage of the development of this branch of physics the use of localization of electrons near the MPC wire and measuring of their drifting time give a high-quality picture of the interaction of parttles that successfully competes with the picture obtained in bubble chambers. Figure 3 illustrates this statement. In this figure one can see a collision of electron and positron that was registered by the detector fixed at gigantic accelerator in CERN.

The multi row avalanche detector allows to preserve the trace of an ionizing particle over the time needed to make the decision of whether to register it. Gas detector with a solid photocathode has a significantly higher efficiency of registering the ultraviolet and X-ray radiation. This allows to use this device as a substitute for an ordinary X-ray film. In this case the advantages of MPC have been revealed again: visualization and data processing with the help of computer, as well high sensitivity allowed to reduce the dose of irradiation. The use of computer allowed to process a dreat amount of data according to special algorithms and to save it in memory. This gave rise to a new stage in the X-ray science.

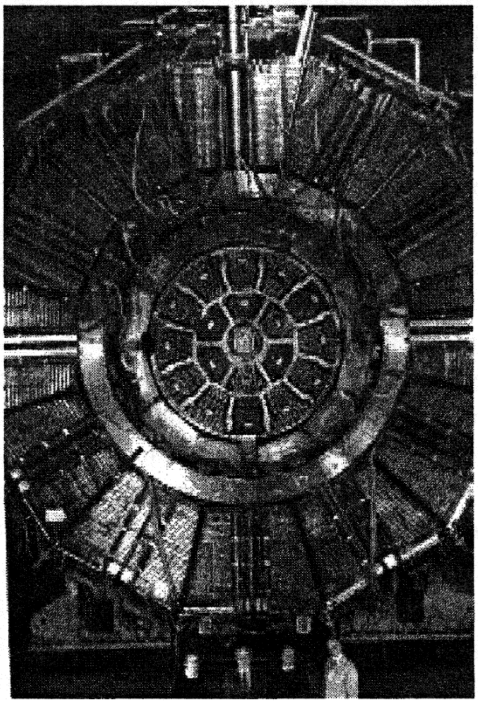


Fig. 2. *Appearance of the MPC detector at the LEP collider*

These examples show that we are at the threshold of a wide use of radiation detectors in other branches of science and technology.

On being notified by the Nobel Prize G. Charpak said that his future efforts would be directed towards the use of MPC in biology and medicine and that the prize would provide the means for this. He expressed his hope that his and his colleagues' efforts would lead to a revolution in these branches of science.

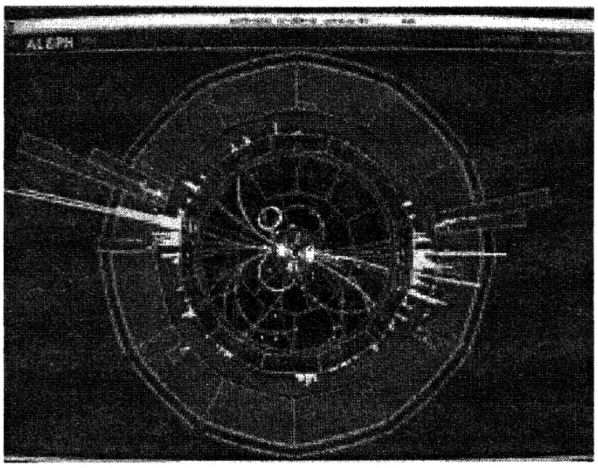


Fig. 3. *Computer image of the collision of electron and positron received during the experiment at the LEP collider*

Olexandr Halchynskyj

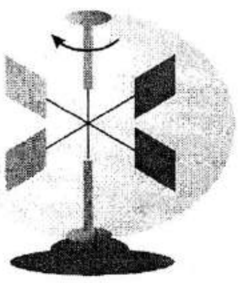
Svit Fizyky (World of Physics. 2000. No 3. Pp. 31–33)

Radiometer

The task of The VII Ukrainian Tournament of Young Physicists:

Establish dependence of the angular speed of the radiometer's wings rotation depending on the intensity of a light flux and concentration of molecules in its balloon.

Most readers know the school radiometer whose wings are revolving under light action. In the 19th century such well-known scientists as Crooks, Hitdorff, Zelner, Puluj and others had been already experimenting with the radiometer. They had established that due to action of light wings of a radiometer are certainly rotating in the direction to the light side of wings, though sometimes in the other direction. The discussions were centered on the mechanism, which leads to the rotation of the radiometer's "Mill". Some scientists explained the phenomenon of the "Mill" rotation by thermal effects, (increase of the pressure of the residual gas near the side of wings heated up by light); others – by the emission of particles from the illuminated sides of wings; or by friction of gas against the wings of the radiometer. We shall try to explain the action of the "Light Mill" too.



Let us consider all forces, which act on the wings of the radiometer (let the radiometer have two rectangular wings: on the one side they are light, and dark on the other), therefore it is clear, that different sides of the wings are heated differently under the action of light; hence different pressure of light and gas inside the radiometer acts on the panels.

1. Let as consider two (diametrically) opposite wings of the radiometer. The pressure of light on the wing, whose light side faces the light source is:

$$P_{I_l} = \frac{2I_0 \cos\alpha}{c}$$

with the dark side of the wing facing the light source the light preasure is:

$$P_{I_d} = \frac{I_0 \cos\alpha}{c}.$$

Where α is an angle between the direction of the light rays and the normal to the wing plane.

We assume that the light side completely reflects light, and the dark side completely absorbs it (the model of absolutely elastic and that of absolutely non-elastic impacts).

The impulse which is transferred to the wings of the radiometer during the time dt by the a force of light pressure is:

$$dP_l = (P_{I_d} - P_{I_l})S \cdot dt.$$

Assume that the wings are rotating in the direction to the light sides of the wings, then

$$dt = \frac{d\alpha}{d\omega}.$$

Therefore,

$$dP_l(\alpha) = -\frac{I_0 S}{\omega \cdot c}\cos\alpha \cdot d\alpha. \qquad (1)$$

In formula (1) I_0 is intensity of the light flux; S is an area of the surface of the wings; c is the speed of light.

The impulse, which is transferred to the wings of the radiometer by the force of light pressure during one revolution is:

$$P_l = 4\int_0^{\pi/2} dp_l(\alpha) = -\frac{4I_0 S}{\omega \cdot c}\int_0^{\pi/2}\cos\alpha \cdot d\alpha = -\frac{4I_0 S}{\omega \cdot c}. \qquad (2)$$

2. As a result of a difference between temperatures of different sides of the wings (they are considered to be heat-isolated) the temperature of the dark side is T_d and the light side T_l, that is a different gas pressure acts on them.

Let the concentration of gas molecules be n, the molar weight μ, average speeds at temperatures T_d and T_l are c_d and c_l, respectively; the pressure of gas on the dark and light sides of the wings are p_d and p_l accordingly; r is the distance between the axis of the radiometer and the centre of its panels. Then:

$$c_d = \sqrt{3RT_d/\mu};\ c_l = \sqrt{3RT_l/\mu},$$

where R is the universal gas constant.

$$p_d = \frac{\mu}{3N_A} n(c_d - \omega r)^2, \qquad (3)$$

$$p_l = \frac{\mu}{3N_A} n(c_l + \omega r)^2, \qquad (4)$$

$$\Delta p = p_d - p_l =$$

$$= \frac{\mu}{3N_A} n(c_d^2 - c_l^2 - 2\omega r(c_d - c_l))^2. \qquad (5)$$

The impulse, which is transferred to the two wings during the time dt is:

$$dp_T = 2\Delta pS \cdot dt, \qquad (6)$$

$$dt = \frac{d\alpha}{d\omega}.$$

By substituting (3) and (5) in (6), we receive:

$$dp_T = \frac{2\mu}{3N_A} nS \frac{d\alpha}{d\omega}\left(\frac{3RT_d}{\mu} - \frac{3RT_l}{\mu} - 2\omega r\sqrt{\frac{3R}{\mu}}\left(\sqrt{T_d} - \sqrt{T_l}\right)\right).$$

As temperature of the radiometer's wings cannot be much higher than temperature of the environment T_0, so $\sqrt{T_d} \approx \sqrt{T_l} \approx \sqrt{T_0}$, if $\Delta T = T_d - T_l$ then

$$dp_T \approx \frac{2\mu}{3N_A} nS \frac{d\alpha}{d\omega}\left(\frac{3R\Delta T}{\mu} - 4\omega r\sqrt{\frac{3RT_0}{\mu}}\right). \qquad (7)$$

Therefore, the impulse, which is transferred to the wings by force of gas pressure for one revolution, is equal:

$$P_T = \frac{4\pi Sn}{3\omega}\left(3k\Delta T - 4\omega r\sqrt{\frac{3RT_0}{\mu}}\right). \qquad (8)$$

Where $k = R/N_A$ is Bolcemann constant.

3. The differently heated up sides of the radiometer's wings radiate light energy outside. It also creates some pressure on the wings. An impulse, which is transferred during time dt to two wings by the force caused by radiation equals:

$$dp_\sigma = 2\frac{\Delta Q}{c} = 2\frac{\Delta Q_d - \Delta Q_l}{c}.$$

Where ΔQ_d and ΔQ_l are energies, which are radiated by dark and light sides accordingly.

Under the Stephan-Bolcemann law:

$$\Delta Q_d = \sigma T_d^4 S \cdot dt, \ \Delta Q_l = \sigma T_l^4 S \cdot dt, \qquad (9)$$

where σ is Stefan-Bolmann constant.

So,

$$dp_\sigma = 2\frac{\sigma S \cdot dt}{c}(T_d^4 - T_l^4) \approx 8\frac{\sigma S \cdot d\alpha}{\omega c} T_0^3 \Delta T. \qquad (10)$$

For one revolution an impulse transferred to the wings by force caused by radiation is:

$$P_\sigma = \int_0^{2\pi} dp_\sigma = 16\pi\frac{\sigma S}{\omega c} T_0^3 \Delta T. \qquad (11)$$

The total impulse caused by the action of light on the radiometer's wings, which is transferred to them for one revolution, is equal:

$$P = P_T + P_\sigma + P_I. \qquad (12)$$

Next we find ΔT. Under the action of light of intensity I_0 a thermodynamic balance is formed on the wings:

$$W_p + AI_0S \cdot dt = \sigma T^4 S \cdot dt + \Delta E_{gas}, \qquad (13)$$

where W_p is the energy which acts on each side of the wings; A is the coefficient of absorption of the appropriate side, T is its temperature, ΔE_{gas} is the total change of cinematic energy of gas molecules which hit the appropriate side during the time dt. According to the kinetic theory of gas we have:

$$\Delta E_{gas} = \frac{3}{2} k(T - T_0) nS\upsilon \cdot dt,$$

where $\upsilon = \sqrt{3RT_0/\mu}$ is the speed of gas molecules.

For the dark side $T = T_d$, $A = 1$; for the light side $T = T_l$, $A = 0$, therefore equality (13) can be written as:

$$\begin{cases} W_p + I_0 S \cdot dt = \sigma T_d^4 S \cdot dt + \frac{3}{2} nk(T_d - T_0)\sqrt{\frac{3RT_0}{\mu}} S \cdot dt, \\ W_p = \sigma T_l^4 S \cdot dt + \frac{3}{2} nk(T_l - T_0)\sqrt{\frac{3RT_0}{\mu}} S \cdot dt. \end{cases}$$

Substracting one equality from the other, we obtain:

$$I_0 = \sigma(T_d^4 - T_l^4) + \frac{3}{2} nk(T_d - T_l)\sqrt{3RT_0/\mu}. \qquad (14)$$

As $T_d^4 - T_l^4 \approx T_0^3 \Delta T$, we have:

$$\Delta T \approx \frac{I_0}{4\sigma T_0^3 + \frac{3}{2} nk\sqrt{3RT_0/\mu}}. \qquad (15)$$

Let us enter the variable, which characterizes the measure of underpressure of gas in the radiometer:

$$\delta = \frac{n}{n_0}.$$

Where n_0 is the concentration of gas molecules under normal conditions.

Then

$$n = n_0\delta = \frac{N_A}{V_\mu}\delta, \qquad (16)$$

where V_μ is the molar volume.

Having substituted formula (16) in (15), we receive:

$$\Delta T = \frac{I_0}{4\sigma T_0^3 + \frac{3R}{2V_\mu}\delta\sqrt{3RT_0/\mu}}. \qquad (17)$$

Our estimates have shown that if the underpressure is close to $\delta = 10^{-2}$ the second component in the denominator is much less than the first one. Therefore we can write:

$$\Delta T = \frac{I_0}{4\sigma T_0^3}. \qquad (18)$$

So, we have established a difference between temperatures of different sides of the radiometer's wings.

The moment of forces caused by the action of light upon the radiometer's wings is:

$$M_P = \frac{P}{2\pi/\omega}r = \frac{rP\omega}{2\pi} = \frac{2Sr}{c}\left(4\sigma T_0^3\Delta T - \frac{I_0}{\pi} + \right.$$

$$\left. + \frac{c\delta}{V_\mu}\left(R\Delta T - 4\omega r\sqrt{\frac{RT_0\mu}{3}}\right)\right). \qquad (19)$$

Estimates show that even at high underpressure ($\delta = 10^{-9}$) the component $\delta R\Delta Tc/V_\mu$ prevails above the component $4\sigma T_0^3\Delta T - I_0/\pi$, therefore we can ignore the last one. So, at gas underpressure down to $\delta = 10^{-9}$ the dominant action on the „light mill" is the differece of gas pressure between the heated and non-heated sides of the wings. Taking this fact into account, we can rewrite the formula (19) as:

$$M_P \approx \frac{2S\delta}{V_\mu}\left(R\Delta T - 4\omega r\sqrt{\frac{RT_0\mu}{3}}\right). \qquad (20)$$

It is clear, that on the radiometer's axle-bearing at a place forces of friction which create a braking moment M are active. This breaks the movement (rotation) of the wings. M is proportional to the weight of the wings m, $m = N\rho S$, where N is the number of wings, c is surface density of the wings (in kg/m^2).

Thus,

$$M = \alpha m = 2\alpha\rho S, \qquad (21)$$

where α is the coefficient of proportionality. A condition for the wings to rotate is:

$$\frac{2S\delta\, R\Delta T}{V_\mu} \geq 2\alpha\rho S. \qquad (22)$$

If condition (22) is satisfied, we can determine the angular speed of rotation of the radiometer's wings from the equation $M_P - M = 0$.

$$\frac{2S\delta}{V_\mu}\left(R\Delta T - 4\omega r\sqrt{\frac{RT_0\mu}{3}}\right) - 2\alpha\rho S = 0. \qquad (23)$$

Taking (18) into account, we obtain:

$$\omega = \left(\frac{I_0 R}{16\sigma r T_0^3} - \frac{V_\mu\alpha\rho}{4r\delta}\right)\sqrt{\frac{3}{RT_0\mu}}. \qquad (24)$$

Formula (24) is valid under the approximations which we have applied: $10^{-9} < \delta < 10^{-2}$.

For values $\delta > 10^{-2}$, the angular speed of the rotation of the radiometer's wings is:

$$\omega = \frac{RI_0V_\mu\sqrt{3}}{16rV_\mu\sigma T_0^3\sqrt{RT_0\mu} + 6R^2r\delta T_0\sqrt{3}} - \frac{V_\mu\alpha\rho}{4r\delta}\sqrt{\frac{3}{RT_0\mu}}. \qquad (25)$$

The analysis of expressions (24), (25) enables us to make the conclusion, that the angular speed of the rotation of the radiometer's wings is proportional to the intensity of the light flux and does not depend on the number N of wings, because the moments of forces M_P and M are both proportional to N.

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Svit Fizyky (World of Physics. 1999. No 4. P. 34–36)

THE STONE FROG

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Preface

The author of the article started his teaching activity in Odessa Richelieu Lyceum in the late 80's when he was a student of Odessa University, just when first International Young Physicists Tournaments (IYPT) were held. There were a lot of problems proposed for solution. Unfortunately, the majority of them did not allow clear theoretical analysis due to the specificity of this kind of Physics competition. Yet there is a number of problems which do allow an exact solution under some specific assumptions not far from reality. Here is one of them. The author does not insist on this solution as the only possible one. In fact he expresses his own opinion on the specific statement of the problem given. Moreover the statistical approach to some phenomena whose exact consideration is not realizable due to tremendously many degrees of freedom involved is demonstrated. The following problem was proposed at one of the Ukrainian Tournaments of Young Physicists.

"The stone frog". Describe the process of skipping of a flat stone over a water surface. How does the number of skips depend on the initial velocity and other relevant parameters?

A possible approach to the solution: It is clear that the process of skipping depends on the losses of energy at the moments of striking the water surface. Since the exact description of the interaction between a solid body and the surface of a liquid is a very complicated hydrodynamical problem we will use the probabilistic approach. It is natural to assume that the value of the loss of energy of a stone is a stochastic variable due to the unpredictability of exchange of momentum between stone and water (splashes, water flow, waves etc.). The problem stated thus becomes as following:

Determine the probability distribution for the relevant parameters of skips such as the number of skips, the lengths of the jumps, etc.

Let us find the probability distribution for the number of bounds of a stone. For the length of the k-th bounce we can write

$$L_k = \sum_{k=1}^{N} \frac{\upsilon_k^2}{g} \sin 2\alpha_k, \; \frac{\upsilon_{k+1}^2}{\upsilon_k^2} = q \; ,$$

where q is the energy loss coefficient which we assume to be the stochastic variable. Here we neglect the air resistance, which acts on the stone during the time between subsequent skips. Just for simplicity we put the angles of falling and bouncing off equal to each other ($\alpha_k = \alpha_{k+1}$). From the physical point of view such an assumption means that we neglect the momentum of the splashes. The assumptions made above allows to get an exact analytical solution.

Let us use a dimensionless length in the units of

$$L_0 = \frac{\upsilon_0^2}{2g} + h \; ,$$

that is the initial length of the throw, h is the height from which the stone was thrown. It is natural to assume that, at least for a sufficiently high kinetic energy, the loss of energy does not depend on the absolute value.

The solution is based on introducing the following variables:

$$\zeta_k = \ln L_{k-1} - \ln L_k + \ln \lambda > 0, \quad k = 1, \ldots, N \, . \quad (1)$$

$0 < \upsilon_{n+1}^2 / \upsilon_n^2 < \lambda < 1$ is an interval for the losses of energy. To simplify the analytic expressions, we assume that the losses for every bounce do not depend on their number and have a uniform distribution. This means that ζ_k (1) are independently distributed variables and have an exponential distribution:

$$P(\zeta_k \le x) = 1 - \exp(-x) . \qquad (2)$$

It is obvious that

$$\ln L_0 - \ln L_N + N \ln \lambda = \sum_{k=1}^{N} \zeta_k \qquad (3)$$

and the skipping process becomes the so-called stochastic process of independent differences with respect to the logarithm of the length. Therefore the characteristic function for the logarithm of the length of the N-th bounce is just the N-th power of the characteristic function of the distribution of the bounce:

$$\psi(y) = \varphi^N(y) , \qquad (4)$$

$$f_N(x) = \frac{x^{N-1}}{(N-1)!} \exp(-x) . \qquad (5)$$

Thus the probability density for the distribution of the length of the N-th bounce is

$$g_N(L) = \frac{1}{L_0 \lambda^N (N-1)!} \ln^{N-1}\left(\frac{L_0}{L}\lambda^N\right),$$

$$0 < \frac{L}{L_0} < \lambda^N . \qquad (6)$$

It is clear that if the length of the bounce is small enough, compared with some characteristic size (for example, the average size of waves under wavy conditions) or the other characteristic scale (for example, the size of stone itself when there are no waves), which we denote as a, then we should stop to count the bounces. Using such spatial cut-off, we can get the probability of having exactly N bounces in the trial:

$$P_N = \Pi(2N, 2z_N) - \Pi(2(N+1), 2z_{N+1}),$$

$$P_0 = 1 - \sum_{N=1}^{N_{\max}} P_N , \qquad (7)$$

$$z_N = N \ln \lambda + \ln\left(\frac{L_0}{\alpha}\right) > 0 ,$$

$$N = 1, 2, \dots, N_{\max} = \left[-\frac{\ln\left(\frac{L_0}{\alpha}\right)}{\ln \lambda} \right] . \qquad (8)$$

Here Π is the Pearson's distribution:

$$\Pi(n, x) = \frac{\int_0^x t^{n/2-1} \exp(-t/2) dt}{\Gamma\left(\frac{n}{2}\right) 2^{n/2}} . \qquad (9)$$

The comparison of the results of the numerical experiment and the analytic calculation based on (7) and (8) is shown in Fig. 1.

Note that if $\lambda = 1$, distribution (7) is just a well-known Poisson distribution:

$$P_N(\lambda = 1) = \frac{z^N}{N!} \exp(-z), \quad z = \ln \frac{L_0}{\alpha} . \qquad (7)$$

The obtained analytical results can be used for checking the adequacy of the simplifying assumptions made against reality. More sophisticated stochastic models can be used which include the probabilistic process for the angle of bouncing. We will not discuss them here.

Unfortunately the author has not systematized and proceeded the data obtained at the sea shore during hot summer days in Odessa. Everyone is welcome to contribute to the experimental part of the problem.

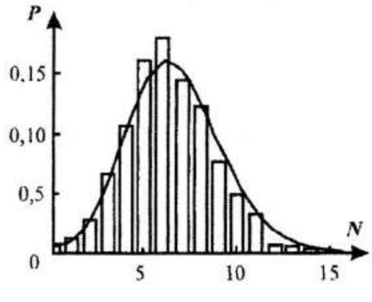


Fig. 1. The numerical data (bar chart) obtained in computer simulations for the bouncing process and the analytical results (line) given by (7). The values of the parameters $\lambda = 0{,}9$, $L_0/a = 100$ were used.

About the author

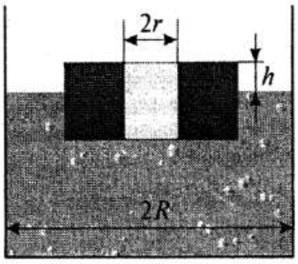
Dr. Kulinskii Volodymyr (born in 1968 in Odessa) is Assistant Professor at the Department of Theoretical Physics of Odessa National University. His work is devoted to the theory of critical phenomena in complex systems (Ising model, complex fluids, electrolytes). His main scientific interests include: statistical physics, quantum mechanics.
Hobby – basketball, volleyball.

The XXXIX All-Ukrainian olympiad of young physicists, the theoretical round Yevpatoria, 2002

8th form

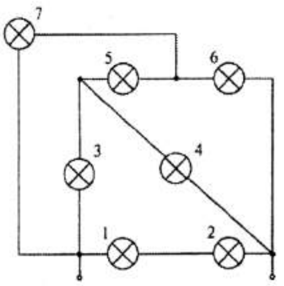
1. Two tourists have to arrive at the base simultaneously and as fast as possible. They are $S = 40$ km away from the base. The tourists have only one bicycle. They decided to use it in turn and arranged to leave the bicycle in the intermediate points. One tourist is supposed to walk from one point to another and the other one is supposed to ride the bicycle. Having set off simultaneously, one of them walked at the velocity $\upsilon_1 = 5$ km/h, and the other rode the bicycle at the velocity $\upsilon_2 = 15$ km/h. What is the average tourists' speed? How much time will the bicycle be unused?

2. A cylindrical vessel with the inside radius R is partially filled with water. A wooden circle with a round hole in it is floating in the vessel (see figure).



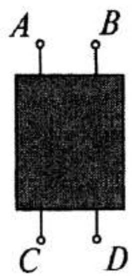
The radius of the hole is r. The highest point of the circle protrudes from the water at the height h. The hole was filled with oil to the top. As a result of it, the level of the water outside the circle rose to the height x. Find x if the density of oil ρ_o is less than the density of water ρ_{wt} and the density of wood ρ_{wd} is more than the density of oil.

3. Seven identical lamps are connected as shown at figure. Which lamp shines independently from the voltage applied to A and B.



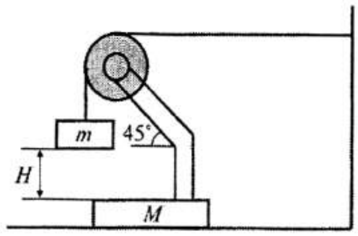
4. A thin aluminum rod is falling from the deck of the naval motor ship at the height $h = 1{,}5$ m over the water surface. The length of the rod $l = 50$ cm. What speed will the rod have when it reaches the bottom of the sea. The depth of the water is $H = 3$ m. The density of seawater is $\rho_w = 1{,}03\cdot10^3$ kg/m^3, the density of aluminum is $\rho = 2{,}65\cdot10^3$ kg/m^3. Water resistance and air drag can be neglected. The rod falls vertically.

5. There is an electrical circuit inside the "black box". The circuit includes only resistors. Four cleats are outside the box (figure). Find the resistance of the resistors, connected in the "black box" and describe the way they are connected if $R_{AB} = 2$ ohm, $R_{AC} = 3$ ohm, $R_{AD} = 2$ ohm, $R_{BC} = 5$ ohm, $R_{BD} = 0$, $R_{CD} = 5$ ohm.

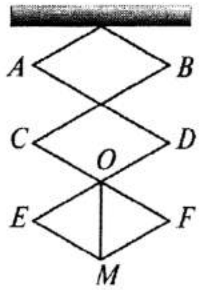


9^{th} *form*

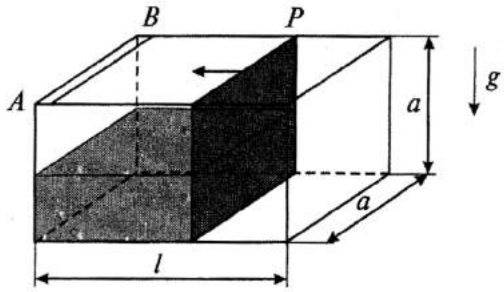
1. A standpipe with a block is fixed on a slab, which is situated on the horizontal surface (see figure). The constant of friction between the surface and the slab is μ. An imponderable cord with a weight is thrown over the block. The mass of the weight is m. The other end of the cord is attached to the wall so that the cord remains horizontal. At the initial time the weight is at the height H over the slab. Under what conditions will the slab and the weight start moving? What distance will the slab pass if the mass of the slab with the upright is M and it stops without having reached the wall. The angle of the inclined part of the standpipe is 45°.



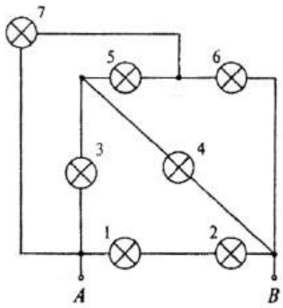
2. A hanger consists of four jointed rods (figure). The rods AD, BC, DE and CH are solid. Points O and M are connected with a thread. Find the tighting force of the rope if the mass of the whole system is m.



3. A vessel in the form of a parallelepiped (its size is shown at figure) holds a tightly fit piston P. There is a chink AB in the top cover of the vessel on the left. At the initial time the piston was near the right wall. The vessel is filled with water so that its level is at the height h_0. What is the minimum work one should do to force the air out of the vessel (the piston is moving slowly)? The atmosphere pressure is P_0.



4. Seven identical lamps are connected as shown at figure. Which lamp shines independently from the voltage applied to A and B.



5. There is an electrical circuit inside the "black box". The circuit includes only resistors. Four cleats are outside the box (figure). Find the resistance of the resistors, connected in the "black box" and describe the way they are connected if R_{AB} = 2 ohm, R_{AC} = = 3 ohm, R_{AD} = 2 ohm, R_{BC} = 5 ohm, R_{BD} = 0, R_{CD} = 5 ohm.

10th form

1. Find the molecular heat capacity of the ideal monatomic gas if the heating is performed so that the mean square velocity of the thermal motion of its atoms increases directly proportionately to pressure.

2. The deep-freezer works by the Carno cycle. The temperature of the deep-freezer's chamber $t_1 = -3$°C. The quantity of heat that enters through its walls every $t = 1$ h is $q = 0{,}1$ *megajoule*. The temperature of the deep-freezer's radiator $t_2 = 57$°C. The efficiency of the deep-freezer $h = 0{,}8$. What power does the engine of the deep-freezer have.

3. The conveyer's tape length is l. It is moving at the velocity υ_0. A brick is pushed in the direction opposite to the tape velocity direction. The mass of the brick is m. What should the velocity of the brick be to reach the highest possible quantity of heat emerged at the expense of friction work? Find this quantity of heat. The constant of friction is $m.\ \upsilon_0^2 < 2\ mgl$.

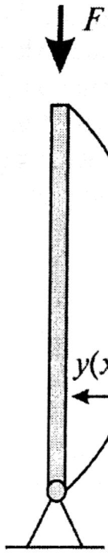
4. Two copper spheres are charged. The charge of the first sphere is Q, the charge of the second sphere is $-Q$. The radius of the spheres are R_1 and R_2 accordingly ($R_1 > R_2$). Both spheres have been divided into two equal parts without the charge repartition. Evidently, the halves of the spheres will repel one another. In which sphere will the halves move apart faster?

5. There is a small round hole in one of the plates of a plane condenser. The radius of the hole is r. The hole is overextended by a soap lamina. The voltage at the condenser is U. It is turned off from the battery. The distance between the plates of the condenser is d. This distance is small in comparison with the size of the plates. The coefficient of surface tension of the suds is σ. Evaluate the size of the flexure of the lamina. It can be considered to be a small one.

11th form

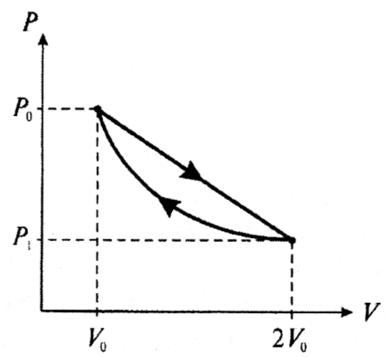
1. A vertical rod hinged at the bottom can bend (but not shrink) when affected by force F (figure). Its form can be described by the function

$$y(x) = Q\sin\frac{\pi x}{L},$$



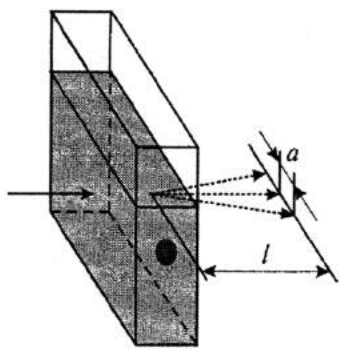
where x is the coordinate of the point along the deformed rod, L – length of the rod, $y(x)$ – transverse deviation of the point x of the deformed rod from the vertical line. Assuming the bend of the rod to be a small one find the amplitude of the bend Q. Take into consideration that:
(a) the energy of the rod bend deformation element $dU = 0{,}5M\chi \cdot dx$, where $M = EI\chi$ is the bending moment, E – the module of Jung, I – the moment of inertia of the cross-section ($[I] = m^4$), $\chi = d\theta/dx$ – the velocity of the row tangent angle of inclination relative to the vertical line changing;
(b) the stable equilibrium of the system is in the position where its potential energy is minimal.

2. The ideal monatomic gas is realizing the circular process shown at figure (1 – adiabatic process, 2 – segment of a line). Find the efficiency of the cycle if $p_1 = p_0/3{,}17$.

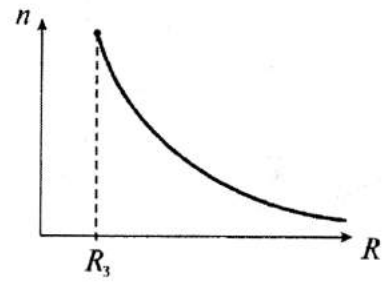


3. The radius of a superconducting circle is r. Its cross-section area is S and the concentration of electrons is n. The circle has been put into the homogeneous magnetic field. The field induction is B. The vector B is in the flat of the circle. Find the current strength in the circle after it was turned so that the vector B became perpendicular to the flat of the circle. Analyse the influence of the electron inertia on the result. When is this influence considerable? The circle inductance is L.

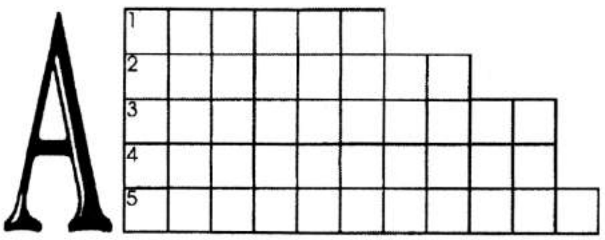
4. A cuvette has the form of a rectangular parallelepiped. It is filled with liquid (figure). There is a piezoelectric sound generator fixed to one of the walls. The frequency of the generator ν = 4,5 MHz. A narrow beam of light is passing the cuvette. The wave-length of the beam λ = 0,66 mkm. There is a screen fixed behind the cuvette at the distance l = 9 m. Three light spots appear at the screen. The distance between the spots a = 1,8 cm. Find the velocity of sound in the liquid.



5. The cosmonauts passed a thin light layer (complete reflection of light in the atmosphere) when they were orbiting a spaceship at a certain height H_0. Find H_0 using the diagram (figure) of dependence of the atmosphere refraction index n on the distance R to the centre of the Earth.

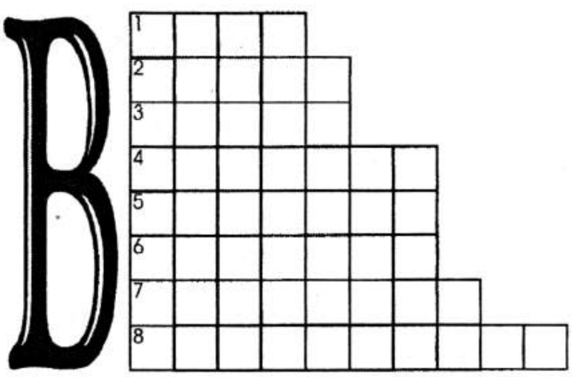


Fill the gaps with surnames of famous physicists that begin with letters A and B

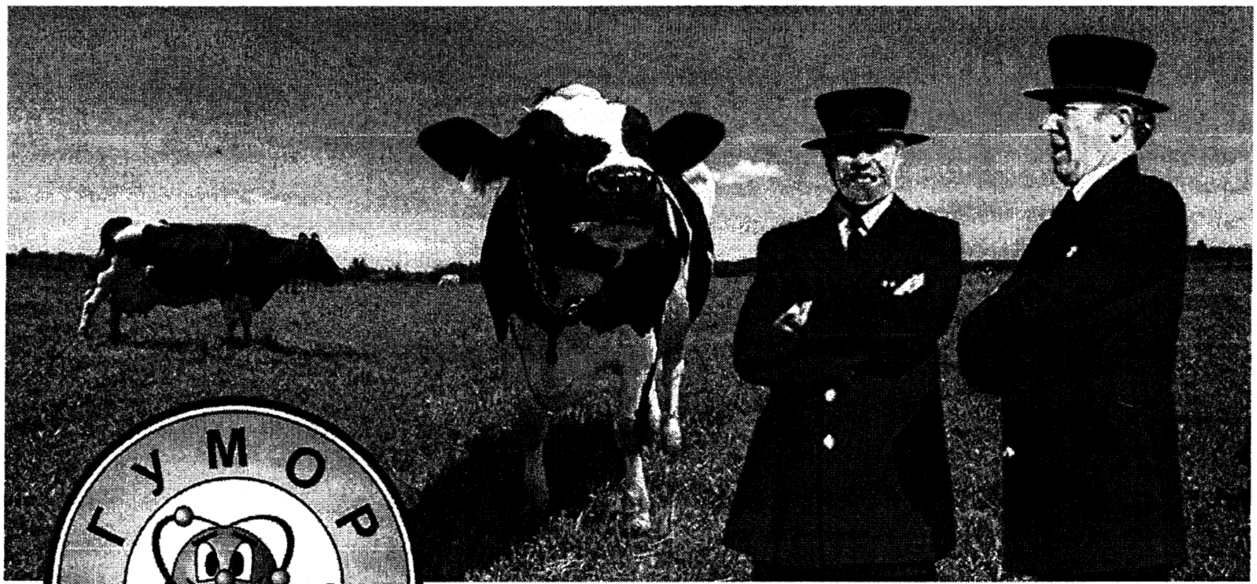


1. French physicist. 2. Italian scholar. 3. Ancient Greek physicist. 4. A physicist who has discovered a phenomenon of the resonant absorbing the electrons. 5. A philosopher who was the first to form a series of problems in cinematics and dynamics.

1. Danish physicist. 2. English scientist. 3. One of the authors of the first quantum generator. 4. French physicist. 5. A scholar who had been the first to determine a formula for calculating the wave longity. 6. Austrian scholar. 7. The academician who has written the book of „Hydrodynamics". 8. French physicist who has discovered a phenomenon of the radioactivity.



From the book by M. Horban „At the lesson and after it..."



Witty physics

At the end of 20th of the 20th century twice a year in the house of a famous Danish scholar Niels Bohr in Kopenghagen the greatest physicists-theorists from the whole Europe were coming together for discussing current problems. The participants of these seminars were cheerful and witty people. They loved to joke during free time.

Once the great physicist-theorist Pasqual Jordan saw a small herd of the cows, which were laying on the meadow and ruminating, while going for a walk with his friend, also a physicist, in the country near Kopenghagen. The scientists noticed that some cows moved the lower jaw from right to left, and others – from left to right. They counted up the right- and left-chewing cows and became convinced, that the numbers of those and others are about equal.

After they came back home, the friends decided to make a joke at the expense of the well-known editor of the popular English scientific journal "Nature", the famous physicist Aston. They wrote a small article "About the importance of right and left reference in biology". Having employed a strict scientific terminology, adhered to all requirements for the arrangement of a scientific article, the authors discussed in most serious way their observation on the herd of cows, and at the end of the article they included some absolutely fantastic data of the "mathematical and statistical analysis". They emphasized with all modesty in the article, that this observation concerned only cows of the Danish breed.

The article, that the authors had sent to the editor of "Nature", was quickly printed in the section "letters to the editor". The authors sent a copy of to the editor with appropriate acknowledgement. They also included a note that at least sometimes it is useful for the editor to look at the submissions to his journal.

The renowned editor, was not deprived of humour, and wasn't offended. He sent a reply to his follow-phisicists in which he admitted that although it is rather boring to read all the nonsense, maybe it is necessary to look at it from time to time.

Such "scientific" articles sometimes appear on the pages of scientific journals even now!

The greatest physicist in America is me

At the beginning of the large power a long time famous "Niaghara Falls Company" couldn't make a choice: what is the best – variable or constant current. At last it decided to consult physicist Henry Roland. He recommended to stay on the generator of a variable current. And he appeared to be right. However company, having assumed the fee was too large, made attempt to reduce it. Roland submitted to court. The businessmen employed an abrupt lawyer, and the scientist had got an opportunity to train at humour.

– Professor! – the lawyer addressed to Roland.

– Say, whom do you consider to be the greatest physicist in America?

– As I swored to tell the truth, the truth and only the truth, – the scientist has answered in despair, – I can not put by, that greatest physicist in America is me.

Roman Gajda, Roman Plazko. Johann Puluj – Rätsel des universalen talents. – Lviv: Eurovelt, 2001. – 264 P.

The present book is about life and creativity of Johann Puluj, who was one of the most interesting figure in science at the beginning of XX and the end of XXI centuries. Johann Puluj was a physicist and an electrical engineer, one of the authors of the Ukrainian translation of The Bible, a politologist and publicist. In Strasburg university he received a degree of the doctor of philosophy, and he was the private senior lecturer of the Viennese university, professor and rector of German maximum technical school in Prague, a honourable member of the Viennese electrotechnical association.

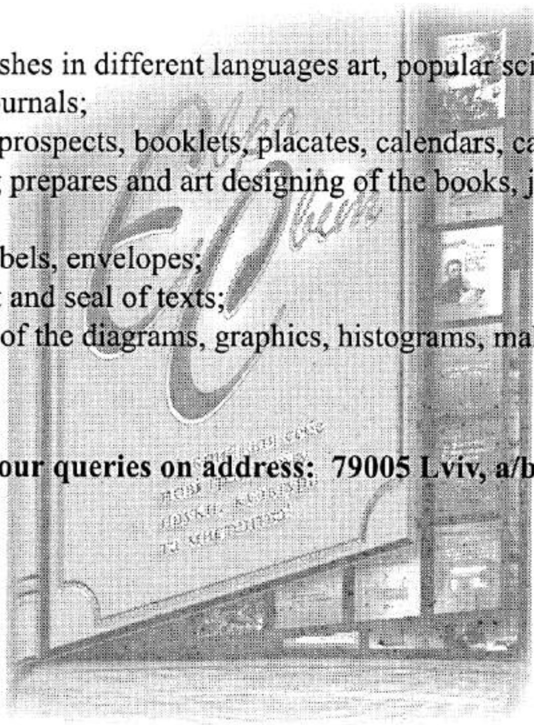
The book is published in German.

Jaroslav Dovhyi. A Magic Phenomenon of Superconductivity. – Lviv: Eurosvit, 2000. – 440 p.: ill.

The present book is a scientific monograph on the physics of superconductivity. It is targeting primarily young scholars. The first pan of the volume tackles the superconducting metals and alloys. The second part offers a description of high-temperature superconductors.

The phenomenological approaches to explaining superconductivity are given, major guidelines of the microscopic theory are adduced. The present-day conceptions of high-temperature superconductivity are closely studied. A string of problems calling for further research has been singled out.

The volume is meant for the wide readership of students, teachers and researchers.



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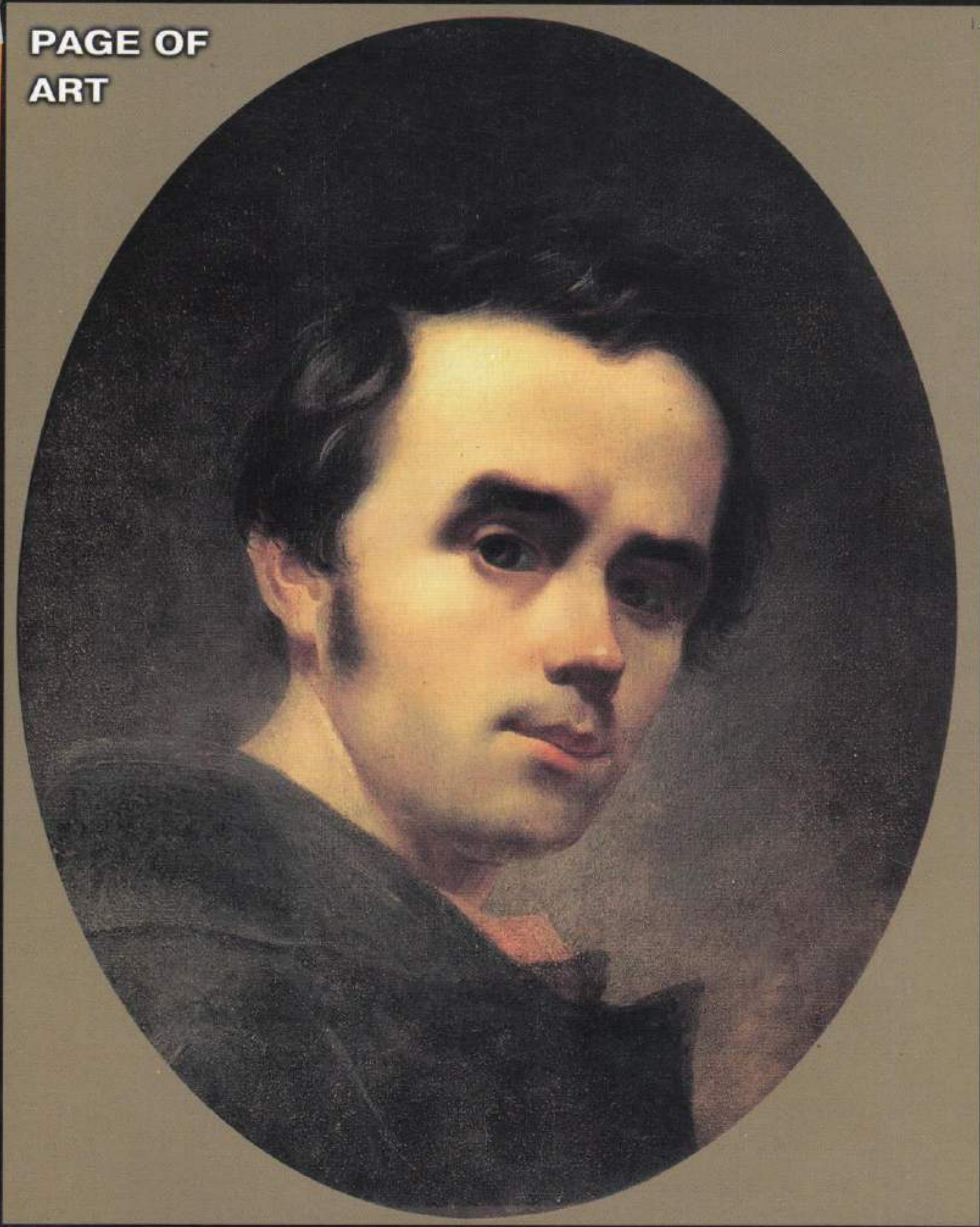

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