Public Lecture for the Moldavian Scientific Community
organized by the Academy of Sciences of Moldova
January 25, 2020

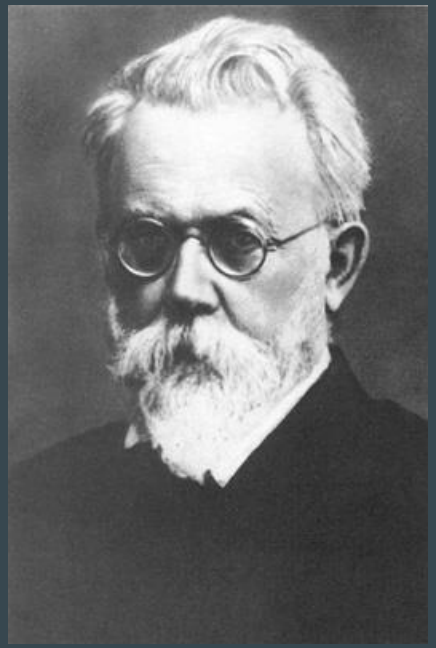
Zoom Meeting
https://us02web.zoom.us/j/82729037775?pwd=T004c0I3aEVnTE1oUHZqQ29xRXVkZz09

RECENT DEVELOPMENTS IN BASIC AND APPLIED RESEARCH AT THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE

Anatoly Zagorodny
President of the National Academy of Sciences of Ukraine

FOUNDATION OF THE ACADEMY

His grace
Hetman of Ukraine
Pavlo Skoropadsky



Founder and
the first President of the Avademy
Volodymyr Vernadsky

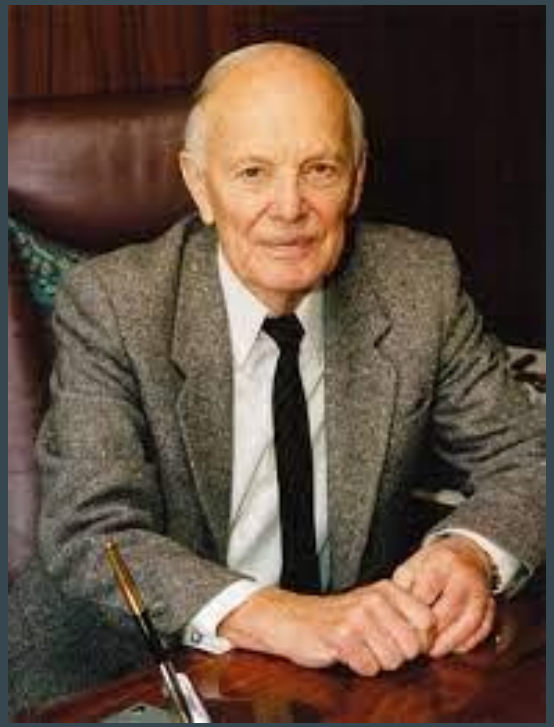
The Ukrainian Academy of Sciences was founded by the edict of Hetman of Ukraine Pavlo Skoropadsky of November 14, 1918.

The Ukrainian Academy of Sciences was founded as an self-governsng institution including 15 institutes, 14 permanent commissions,6 museums, 2 cabinets, 2 laboratories, Botanic and Acclimatization Garden, Astronomic Observatory, Biologic Station, library, pronting-house, and records place.

Editions of the Academy should be printed in Ukrainian.

The Statute of the Academy emphasized its all-Ukrainian nature.

The first General meeting was held on November 27, 1918. Professor Volodymyr Vernadsky was elected the Presisdent of the Ukrainian Academy of Sciences.



Academician BORYS PATON
President of the National Academy of Sciences of Ukraine
in 1962-2020

NATIONAL ACADEMY OF SCIENCES OF UKRAINE TODAY

According to the legislation the National Academy of Sciences of Ukraine is the highest scientific institution of Ukraine. The main purposes are:

- organization and realization of fundamental and applied research of the most important problems of natural, technical, social and humanitarian sciences;
- coordination and expertise of the basic research in Ukraine.

NATIONAL ACADEMY OF SCIENCES OF UKRAINE TODAY

The Academy includes about 150 institutions and organizations: (institutes, scientific centers, museums, libraries, national parks, research and development institutions). About 40 institutions were organized during the years of Independence.

The stuff of the NAS of Ukraine includes about 28 thousand emploees, among them 15 thousand researchers, 2.4 thousand Doctors of Science and 7 thousand Phylosophy Doctors.

Академія забезпечує діяльність 6 регіональних наукових центрів НАН України та МОН України

Regional Structure of the Academy

Department	The number of research institutions	The number of pilot production organizations	The number of objects that have the National Asset status	The number of centers for shared use of equipment
The Section of Physical, Engineering and Mathematical Sciences				
Dpt. of Mathematics	4	—	—	—
Dpt. of Information Science	7	—	—	—
Dpt. of Mechanics	6	3	3	6
Dpt. of Physics and Astronomy	16	3	9	16
Dpt. of Earth Sciences	14	1	—	5
Dpt. of Physical and Technological Problems of Materials Science	11	18	1	12
Dpt. of Physical and Technological Problems of Power Engineering	11	7	2	4
Dpt. of Nuclear Physics and Power Engineering	6	2	2	6
The Section of Chemical and Biological Sciences				
Dpt. of Chemistry	13	7	—	11
Dpt. of Biochemistry, Physiology and Molecular Biology	8	1	5	9
Dpt. of General Biology	22	1	19	12
The Section of Social Sciences and Humanities				
Dpt. of Economics	9	—	—	—
Dpt. of History, Philosophy and Law	17	3	5	—
Dpt. of Literature, Language and Art Studies	9	—	4	—

International Cooperation of the NAS of Ukraine

The international cooperation is performed in the framework of about 120 agreements between the NAS of Ukraine and academies, state institutions, scientific organizations, educational institutions, firms, and industrial companies of about 50 countries of the world.

- NAS of Ukraine - EU programs
- NAS of Ukraine - NATO programs
- NAS of Ukraine – UNESCO program "Man and Biosphere"
- International Atomic Energy Agency (IAEA)
- European Organization for Nuclear Research (CERN)
- International Institute for Applied Systems Analysis (IIASA)
- Science and Technology Center in Ukraine (STCU)
- Joint Institute for Nuclear Research (JINR)
- Central European Initiative

COOPERATION WITH THE ACADEMY OF SCIENCES OF MOLDOVA – IMPORTANT AREA OF INTERNATIONAL ACTIVITY OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE

Agreement on Scientific Cooperation between the National Academy of Sciences of Ukraine and the Academy of Sciences of Moldova (2017)

14 bilateral interinstitutional agreements

Prizes of the Academies of Sciences of Ukraine, Belarus and Moldova (since 1996)

COOPERATION WITHIN THE INTERNATIONAL ASSOCIATION OF ACADEMIES OF SCIENCES

Scientific councils:

Joint Council on Fundamental Geographical Issues

Board of Directors of Scientific Libraries and Information Centers of National Academies of Sciences

Advisory Board on Intellectual Property Protection and Technology Transfer

Council of Physiological Societies

RESEARCH AND INNOVATION PROGRAMME OF THE EUROPEAN UNION, HORIZON 2020

Nanoporous and Nanostructured Materials for Medical Applications (NanoMed) – R. Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology of the NAS of Ukraine, Institute of Chemistry of the Academy of Sciences of Moldova

RI-LINKS2UA – NAS of Ukraine, Center for International Projects of the Academy of Sciences of Moldova

STI International Cooperation Network for Eastern Partnership Countries - PLUS - EaP PLUS – NAS of Ukraine, Center for International Projects of the Academy of Sciences of Moldova

Danube Strategy of the European Union – Institute for Market Problems and Economic and Environmental Research of the NAS of Ukraine, Center for International Projects of the Academy of Sciences of Moldova

7 FR SECURE-R21 – V. Lashkarev Institute of Semiconductor Physics of the NAS of Ukraine, Institute of Applied Physics of the Academy of Sciences of Moldova

THE NATO SCIENCE FOR PEACE AND SECURITY PROGRAMME

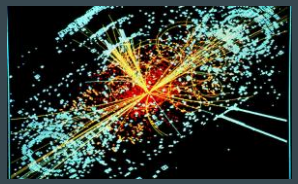
«Modeling and mitigation of social disasters caused by terrorism and disasters»

«Institute of Applied Systems Analysis» of the Igor Sikorsky National Technical University of Ukraine

«Kyiv Polytechnic Institute» of the MES of Ukraine and NAS of Ukraine

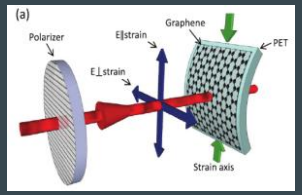
Institute of Mathematics and Informatics of the Academy of Sciences of Moldova

Fundamental Research of the World Level by the scientists of the NAS of Ukraine

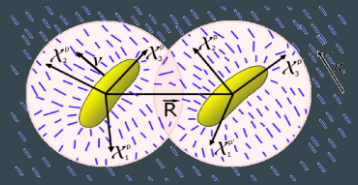


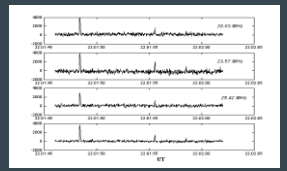
High-energy physics and astrophysics (participation in the experiments at the Large Hadron Collider, discovery of new galactics as the result of the observations using the “Hubble” telescope, search for th psrticles that might be the dark-, atter carriers, participation in the experiments of the Borexino collaboration concerning the measurements of the solar radiation intensity just at the instant of energy release within the Sun).

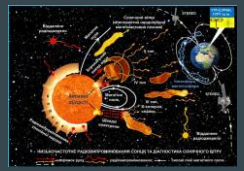
Physics of condensed matter (studies of electron and optical properties of graphene, Bose-condensation in magnetic substances at room temperatures, control of the properties of liquid crystals).

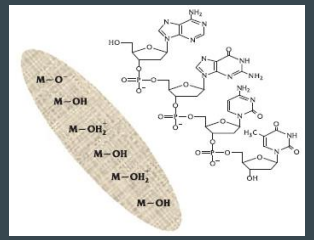


Radio astronomy and physics of geocosmos (detection of highly excited atoms in the interstellar space, discovery of lightnings at Saturn, studies of the solar-terrestrial interactions).

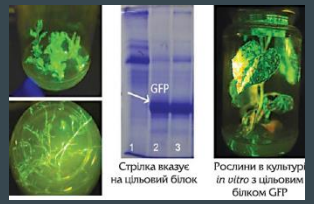




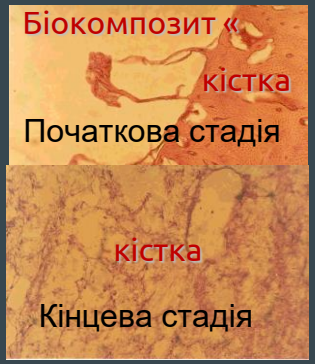




Molecular biology and genetics (discovery of the molecular mechanisms of the pain reception and signal transfer to the brain, creation of new nanobiosensores, creation of effective nanobiopharmaceuticals, studies of the gene structure, systems of gene expression regulation, investigation of the protein interrelation in the organism that provides a possibility to diagnose deseases, to prevent them, and to work out medicine of new generation).



Chemistry (studies of the chemical structure, kinetics and reaction capacity of molecules; nanophotocatalysis; synthesis of potentially bioactive compounds; creation of functional polymers and composites; synthesis of new substances and compounds for medicine and agriculture; new methods of wastes conversion; solution of other ecological problems etc).

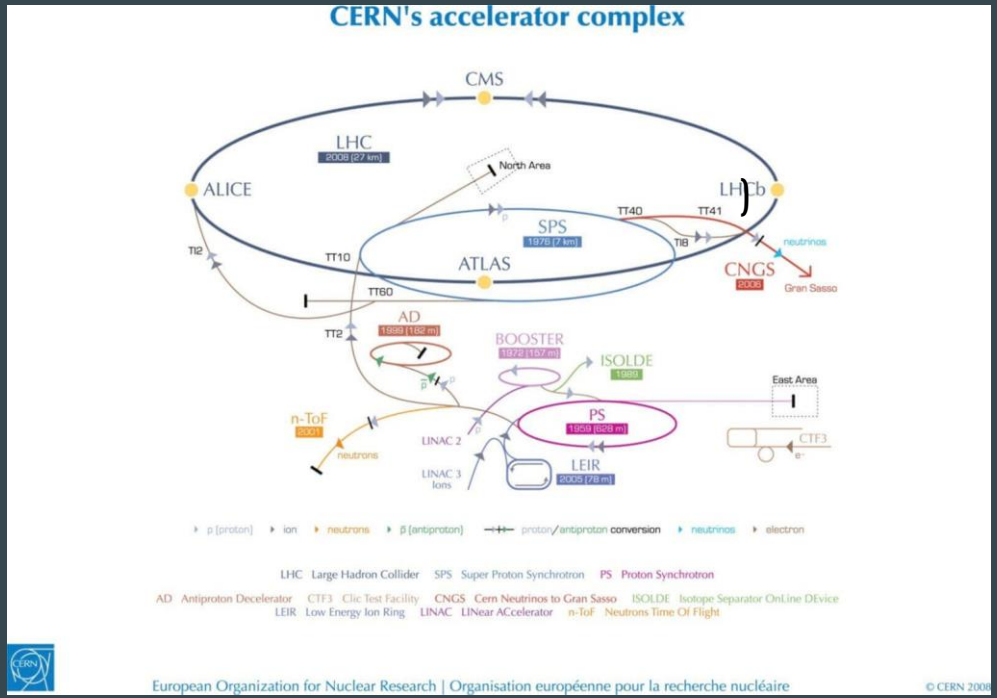


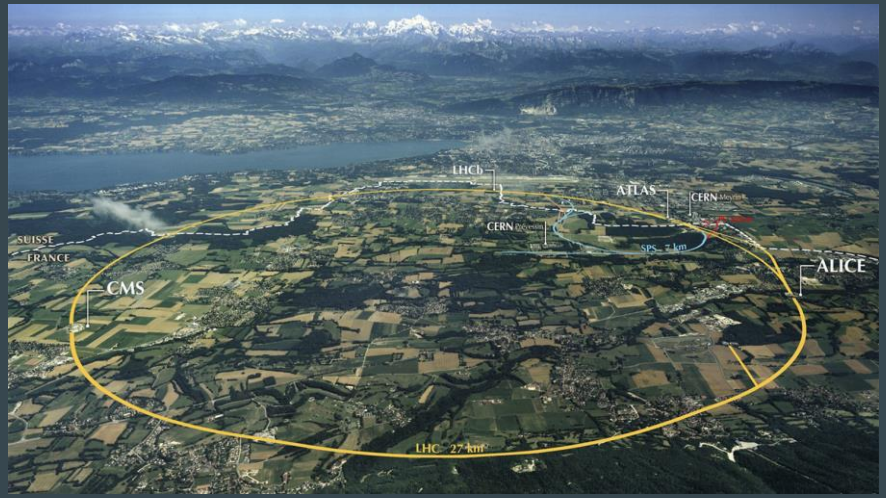
Materials science (new composite materials with predicted properties; new methods of treatment and connection of materials, living tussies in particular; nanotechnologies and nanomaterials).

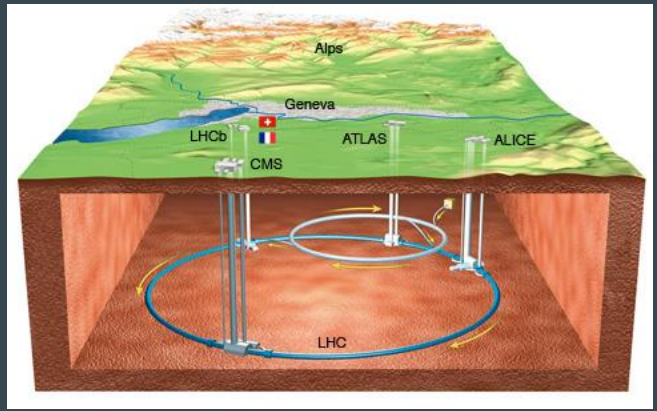
Sociohumanities (studies of social, political, ethnic, national, and cultural development of the Ukrainian society).

Large Hadron Collider (LHC)

Length of the accelerator ring — 27 km
Committed in 2009



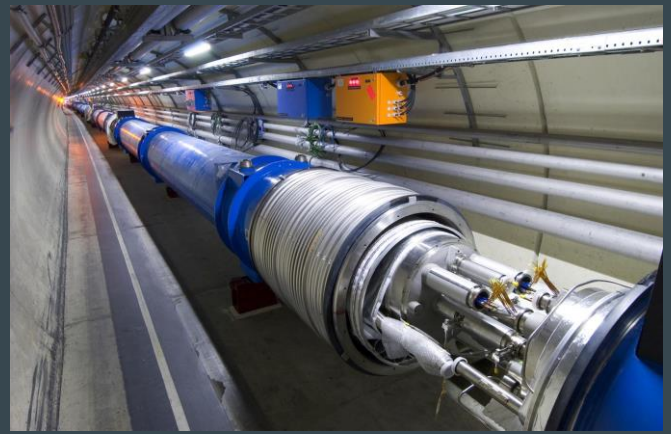




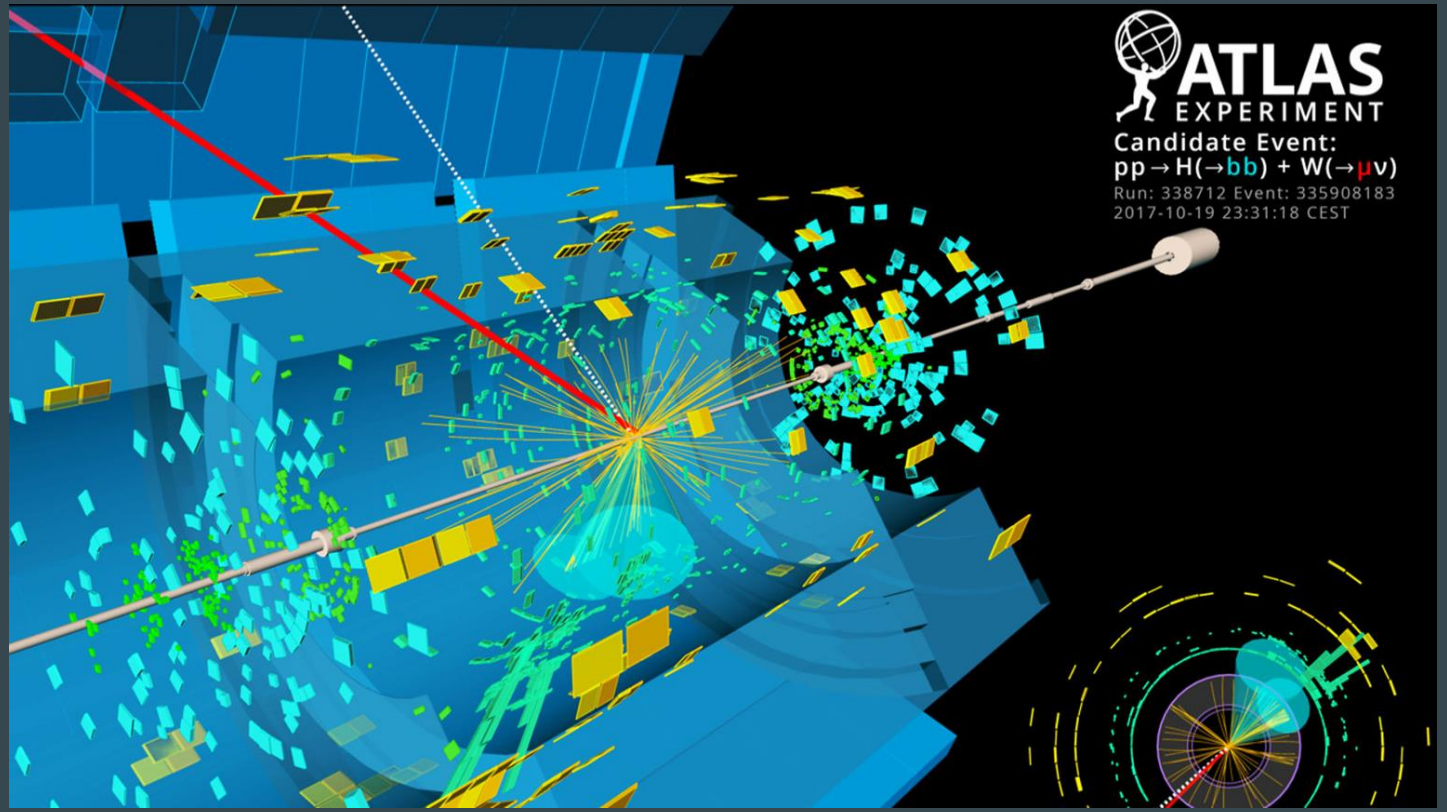
Large Hadron Collider (LHC)

- Collision energy of the proton beams — 14 TEV
- Advanced superconductor technologies provide the operation of the LHC at 2.71°C, i.e., slightly above the absolute zero
- The accelerator is 27 km long, i.e., it is the greatest superconductor accelerating device in the world

Credits: Symmetry Magazine



CMS & ATLAS Higgs boson discovery: Higgs boson transforming into bottom quarks as it decays

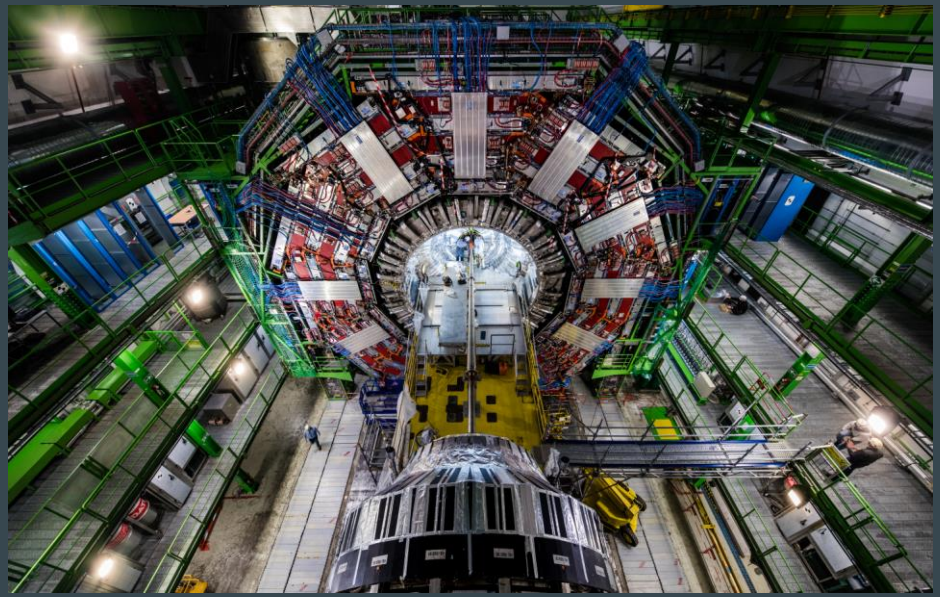


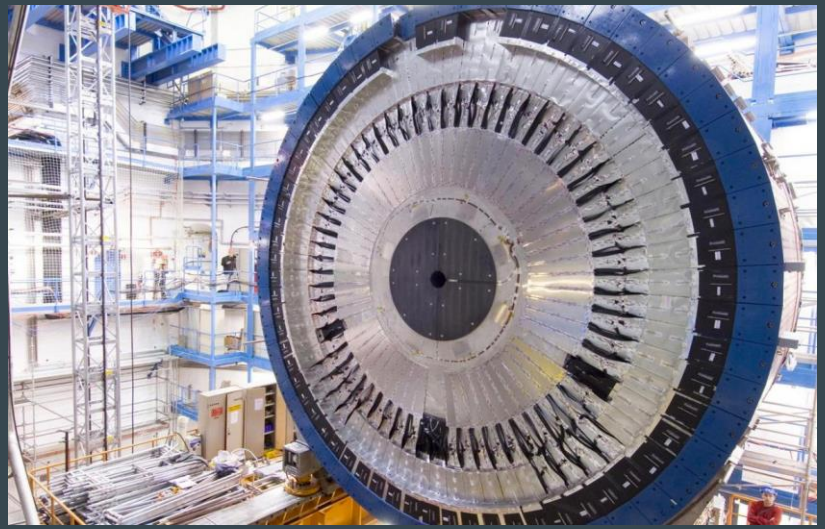
CMS Detector

Ukrainian participants:

Kharkiv Institute of Physics and Technology, Kharkiv

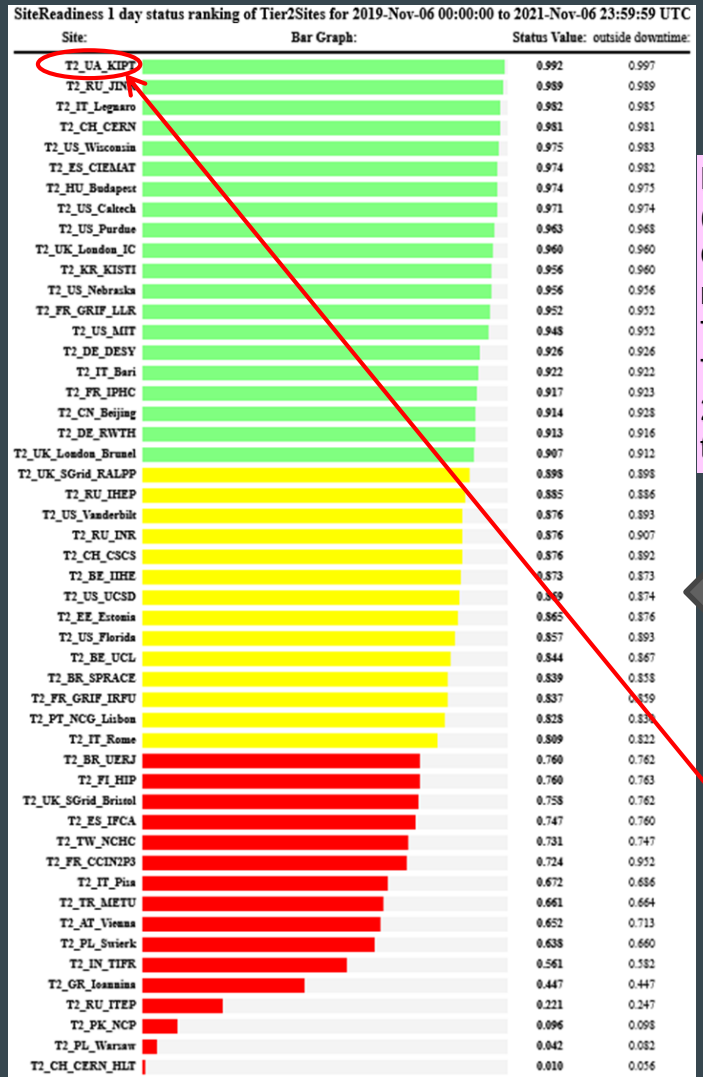
Institute for Scintillation Materials, Kharkiv





ATLAS, Tile detector,
500,000 plastic scintellators

Participation in CMS computing infrastructure



Kharkov Institute of Physics and Technology (KIPT), Kharkov, Ukraine, actively participates in CMS data processing. KIPT computing facility was registered in CMS grid infrastructure as T2_UA_KIPT in 2008 and commissioned as CMS Tier-2 centre in 2009. Since LHC startup (late 2009), ~20 Petabytes of CMS data has been transferred to site T2_UA_KIPT for processing.

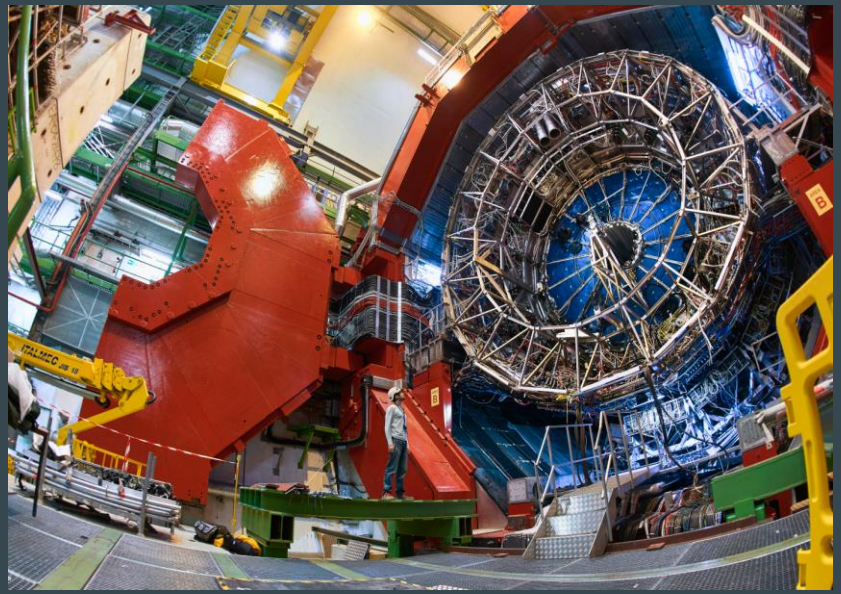
Quality ranking of CMS Tier-2 sites for the last 2 years (Nov18 – Nov21) based on CMS site 'readiness' metrics (see https://cmssst.web.cern.ch/ranking)

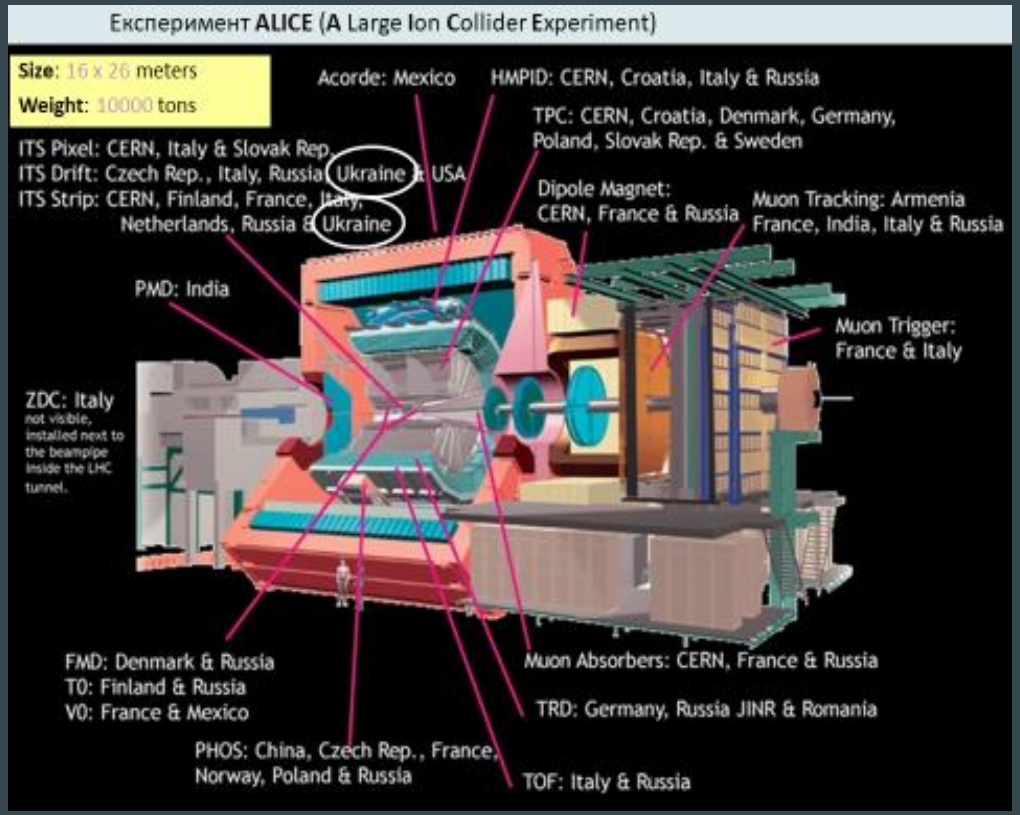
At present, T2_UA_KIPT is one of the most stable and reliable CMS Tier-2 centres providing the maximum (>99% of time) site readiness.

Detector ALICE

Ukrainian participants:

Bogolyubov Institute for Theoretical Physics, Kyiv
Kharkiv Institute of Physics and Technology, Kharkiv
LED Technologies, Kharkiv





Ukrainian contribution

Hybrids, Al-kapton micro cables for the ITS Drift And ITS Strip

CERN COURIER
VOLUME 58 NUMBER 3 APRIL 2018

TOTEM

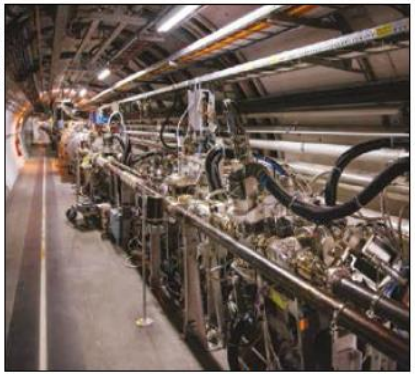
Oddball antics in proton–proton collisions

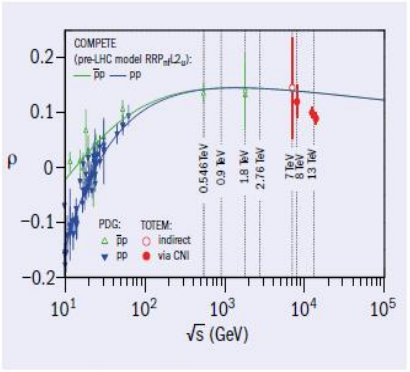
The TOTEM collaboration at CERN has uncovered possible evidence for a subatomic three-gluon compound called an odderon, first predicted in 1973. The result derives from precise measurements of the probability of proton–proton collisions at high energies, and has implications for our understanding of data produced by the LHC and future colliders.

In addition to probing the proton structure, TOTEM is designed to measure the total cross section of proton–proton collisions. Physically it is by far the longest experiment at the LHC, comprising two detectors located 220 m on either side of the CMS experiment. While most proton–proton interactions at the LHC cause the protons to break into their constituent quarks and gluons, TOTEM detects the roughly 25% of elastic collisions that leave the protons intact. Such collisions merely cause the path of the protons to deviate, by around a millimetre over a distance of 200 m.

Elastic scattering at low-momentum transfer and high energies has long been successfully explained by the exchange of a pomeron – a colour-neutral state made

M Brice/CERN





CERN-EP-2017-335

Left: one side of the TOTEM apparatus in the LHC tunnel. Right: dependence of ρ on energy, showing pp (blue) and $p\bar{p}$ (green) data taken from the Particle Data Group and TOTEM measurements at 13 TeV (red). Contrary to the traditional QCD picture, based on results from the COMPETE collaboration, the rate of growth of ρ slows at high energies.

measurements ranging from 2.76 to 13 TeV (see figure). Combining the two measurements, TOTEM finds better agreement with models that indicate the exchange of three aggregated gluons.

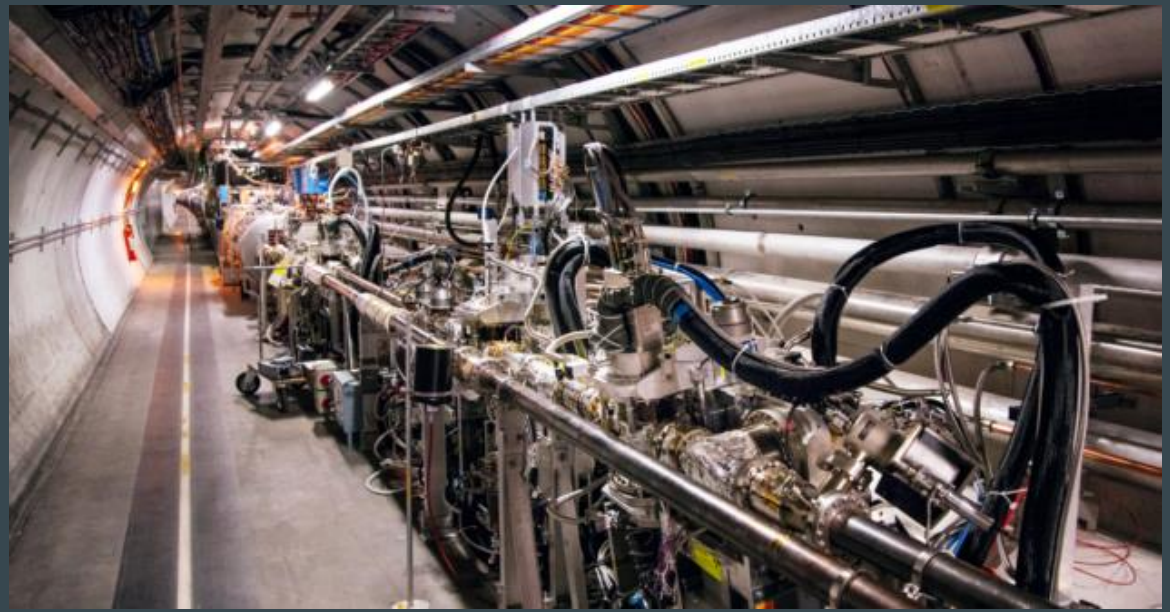
The odderon started out in the early 1970s as a purely a mathematical concept. After the advent of QCD, however, theorists showed

University in Romania – who co-invented the odderon with the late Leszek Lukaszuk – and Evgenij Martynov of the Bogolyubov Institute for Theoretical Physics in Ukraine go further. In a paper published shortly after the TOTEM result, they write that the new data "can be considered as the first experimental discovery of the odderon".

Odderon discovered

CERN COURIER
VOLUME 58 NUMBER 3 APRIL 2018

CERN COURIER
VOLUME 61 NUMBER 2 MARCH/APRIL 2021



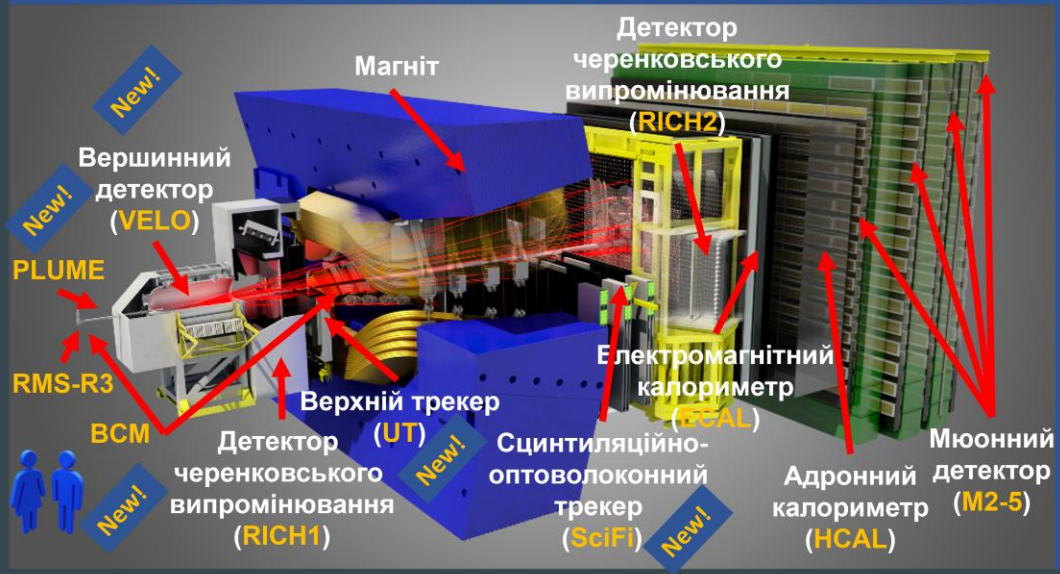
The latest data of the TOTEM experiment for the energy of 13 TeV and the data on the total cross-sections of the proton-proton and proton-antiproton elastic scattering for the interaction energy above 5 GeV were analized. The conclusion is that the TOTEM experiment was the first one to confirm the existence of the “odderon” (with the participation of the Bogolyubov Institute for Theoretical Physics of the NAS of Ukraine

LHCb Experiment

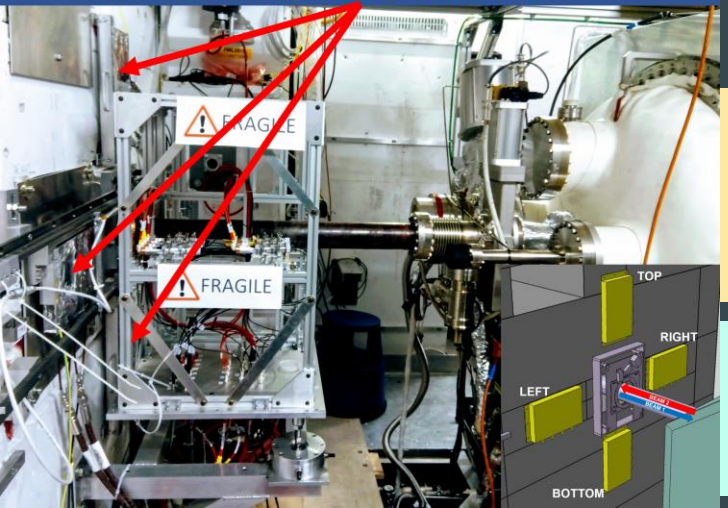
Main purposes for the modernization of LHCB:

- Studies of the cause for the asymmetric evolution of the Universe → higher-precision measurement of the CP-symmetry violation in the B-meson decay
- Search for and studies of the features of the new physics → higher-precision investigation of the rare modes of the heavy-hadron decay
- Search for the new state of the matter → the quark-gluon plasma (QGP)

Глибоко модернізований детектор LHCb (конструкція від 2019 року до 2030 року)*



Детекторні модулі RMS-R3



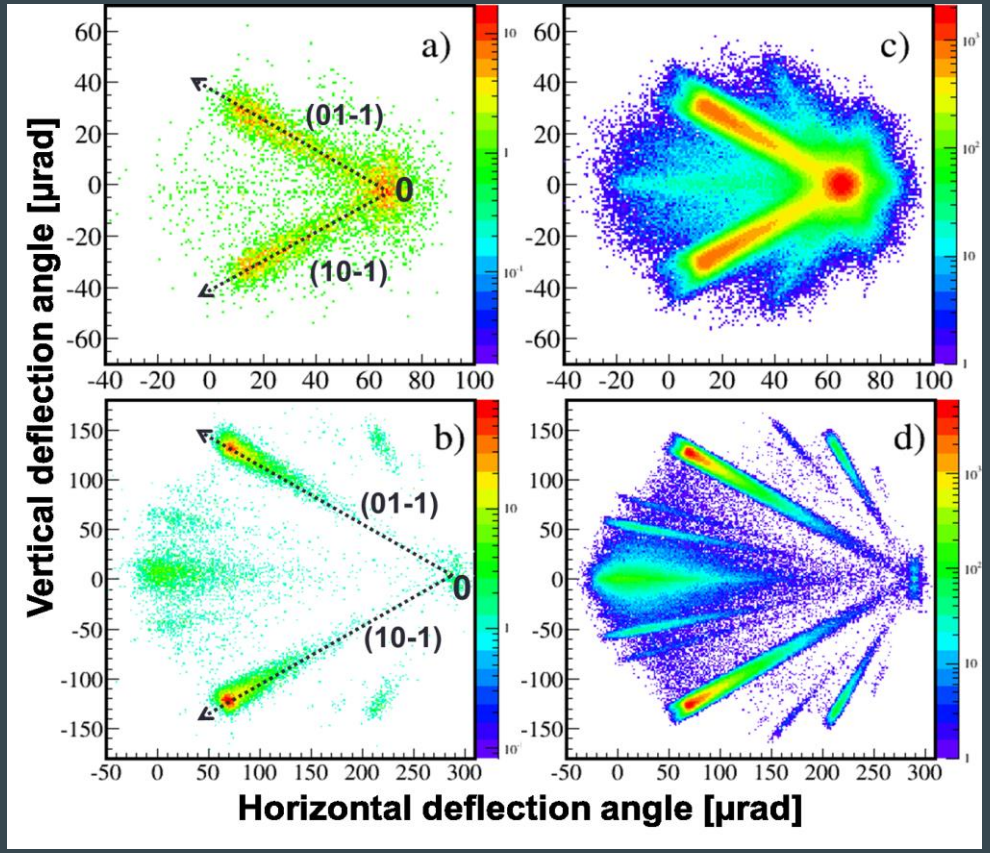
Participance of Ukrainian scientists:

- ✓ More than 300 scientific papers with the participance of the scientists from the NRI were published in the journals of Q1-Q2 level during 2016-2020
- ✓ In 2021, ISMA of the NAS of Ukraine and Kiev Shevchenko National University joined the LHCb collaboration

In terms of the LHCb modernization, a **radiation monitoring system RMS-R3** was commissioned on October 21, 2021. Its purpose is to permanently measure the conditions of the Large Hadron Collider (LHC) operation in LHCb, namely, the interaction of the LHC beams and the background of their scattering by collimators

Splitting of a 400-GeV proton beam under particle penetration through a bent crystal

experiment theory



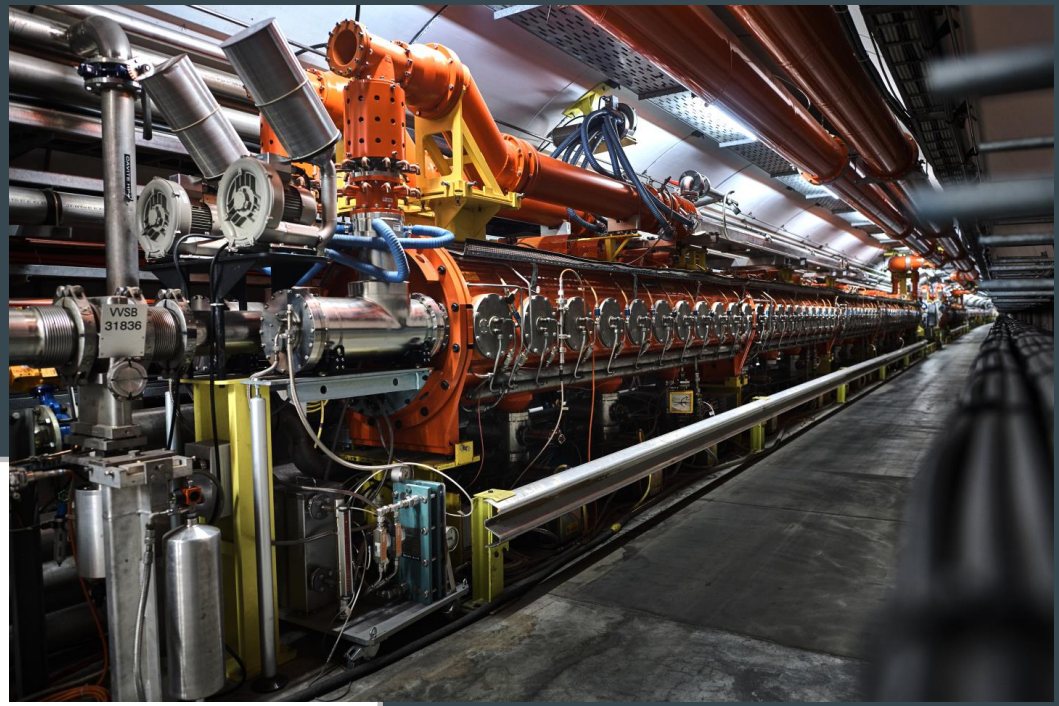
Theoretical prediction: National Scientific Center of the Kharkiv Institute of Physics and Technologies (NSC KIPT)

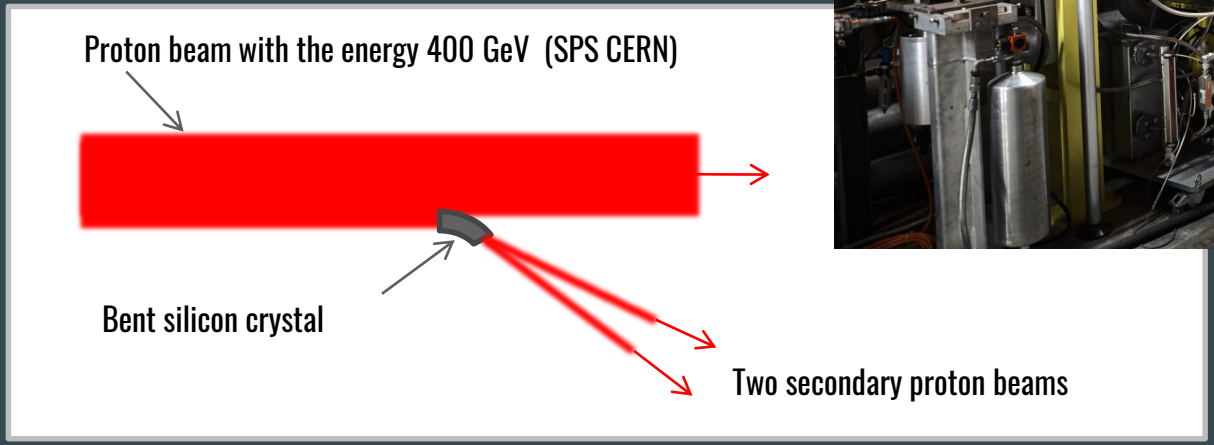
Experimental evidence: SPS CERN (crystal thickness 2 mm, crystal curvature radius R: a), c) — R=30,3 m; b), d) — R=6,9 m

Bandiera L., Shul'ga N.F., Kirillin I.V. et al.
Eur. Phys. J. C. 2016, vol. 76, 80 (1–6)
Eur. Phys. J. C. 2021, vol. 81, 238 (1–10)

Super Proton Synchrotron (SPS CERN)

The collaboration CENR UA9, IJCLab (France), Ferrara University (Italy), National Scientific Center of the Kharkiv Institute of Physics and Technology (Ukraine) has performed a series of special experiments with the purpose to discover the effects of deviation of a charged particle beam by a bent crystal (2008-2021)

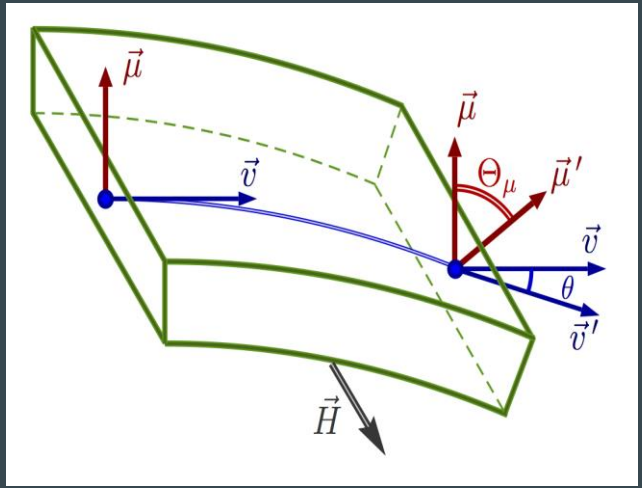




MEASUREMENTS OF ABNORMAL MAGNETIC MOMENT OF SHORT-LIVED CHARMED BARIONS WITH THE USE OF BENT CRYSTALS

Relying on the studies of orientation effects in the interactions of high energy particles with crystals, it was shown that due to high gradients of atomic fields and coherent effects during light scattering, under certain conditions, high efficiency of particles scattering by a bent crystal which corresponds to a magnetic field of thousands tesla can be achieved.

Using a bent germanium crystal on the Large Hadron Collider LHC CERN provides a unique opportunity to measure the abnormal magnetic moment of such short-lived particle as Lambda C charmed baryon. The corresponding experiment is planned in the framework oh LHCb collaboration on LHC accelerator at CERN.



Precession of magnetic moment μ by angle Θ_μ when the particle is deflected by a bent crystal at angle θ.

National Science Center ‘Kharkov Institute of Physics and Technology’

Nuclear subcritical assembly “Neutron source”

Experimental hall

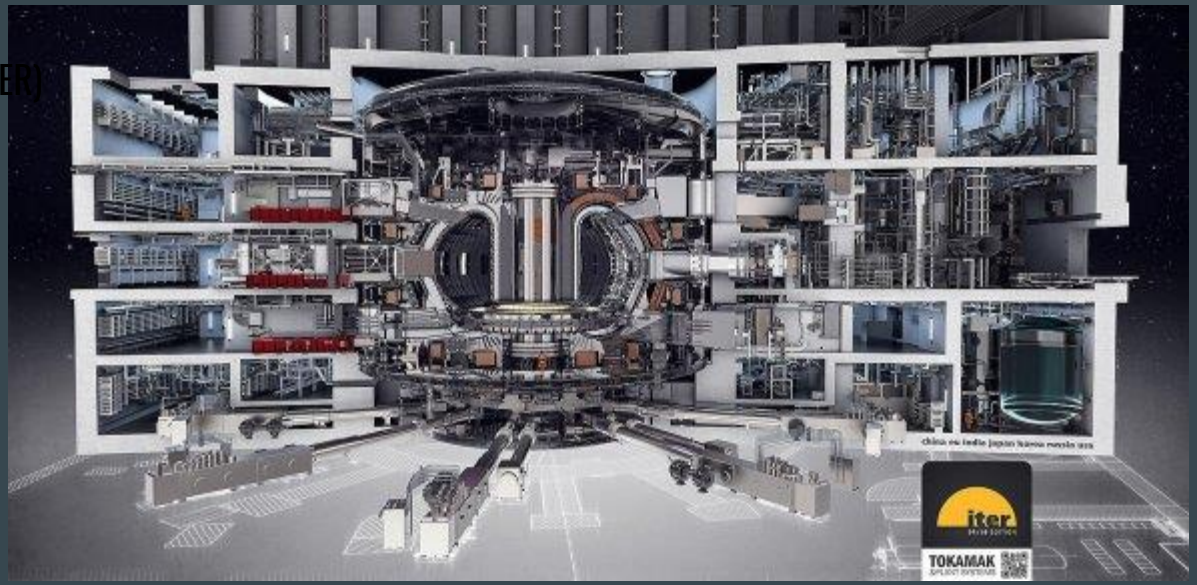
Radio isotope laboratory

In the nearest future this assembly will make the basis for the creation of a unique international nuclear center with the participance of IAAE, American and European partners

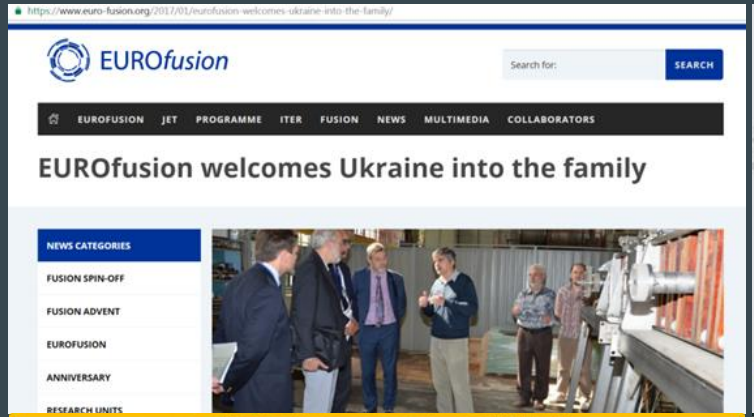
International Experimental Fusion Reactor (ITER)

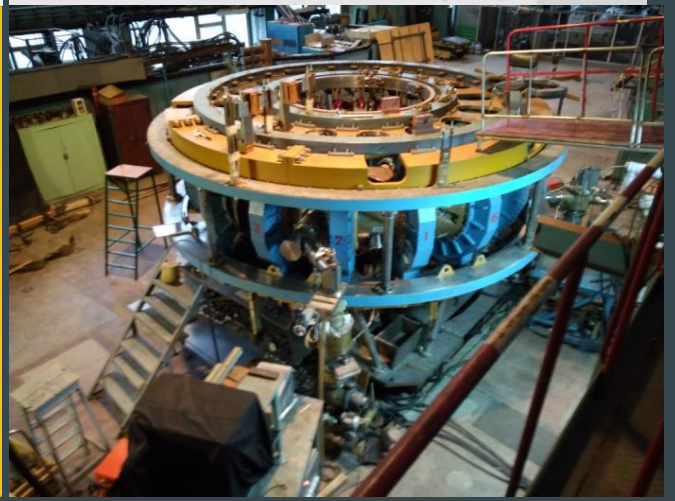
(ITER)

Mass - 23 thousand tonn, Height – 60 m, Magnetic field – 5 teslas,
Major plasma radius – 6 m, Minor plasma radius – 2 m,
Temperature – 100 mln degrees, Plasma density – 10 sup14



Ukraine in EUROfusion





Ukrainian Physicists in ITEP
Joint Ukraine-Belgium experiment with the stellarator Urahan-3M

Director of the EUROfusion Tony Donne greets the participants

The initial stage of the RF discharge in the Urahan-3M is studied in the joint experiment with the Plasma Physics Laboratory (Brussels, Belgium)

The results and knowledge thus obtained will be employed to optimize the RF discharge in European fusion devices and the International Reactor ITER

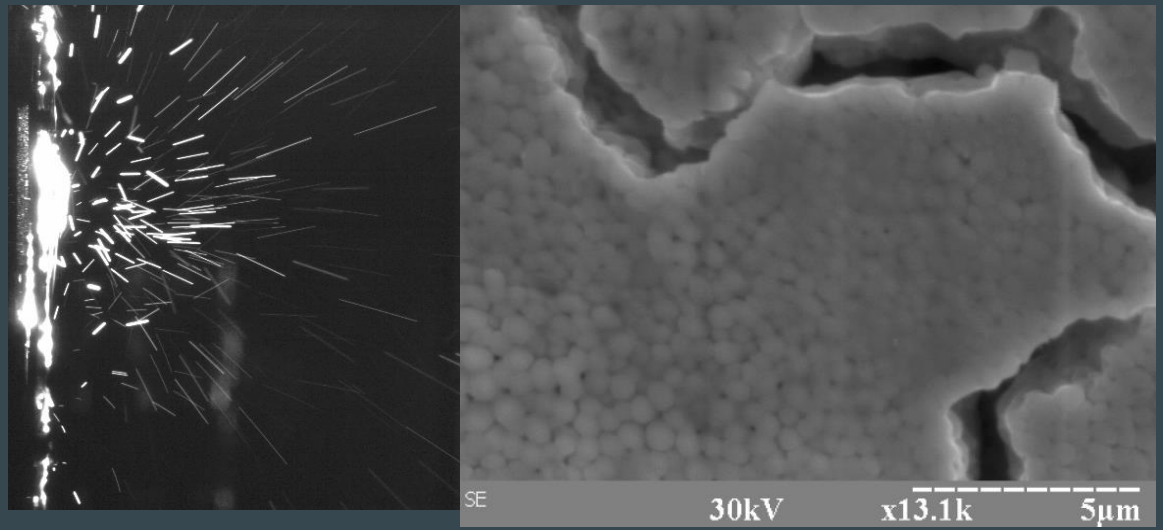
Ukrainian Physicists in ITEP
Studies of the plasma-wall interaction

Quasi-stationary plasma accelerator QSPA X-50
(NSC KIPT)

Plasma accelerator of the new generation QSPA M
(NSC KIPT)

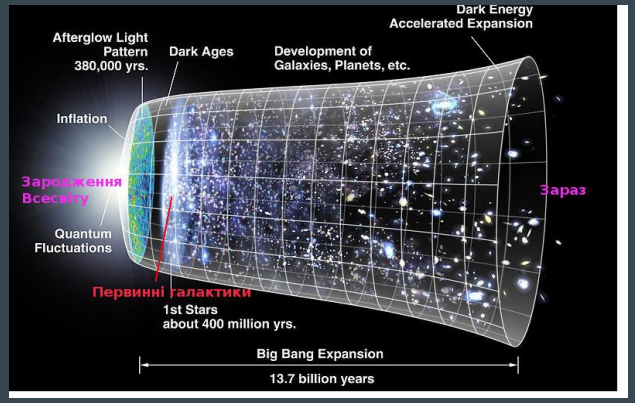
Ukrainian Physicists in ITEP
Studies of the plasma-wall interaction

Experimental reproduction of the conditions on the first wall and divertor plates of the fusion reactor ITER. Modification of the material surfaces. Dominant mechanisms are revealed of the radiation-induced erosion of the divertor materials (W, C etc.) under the extremal modes of the fusion reaction



A Discovery in the Field of Extragalactic Astronomy and Cosmology

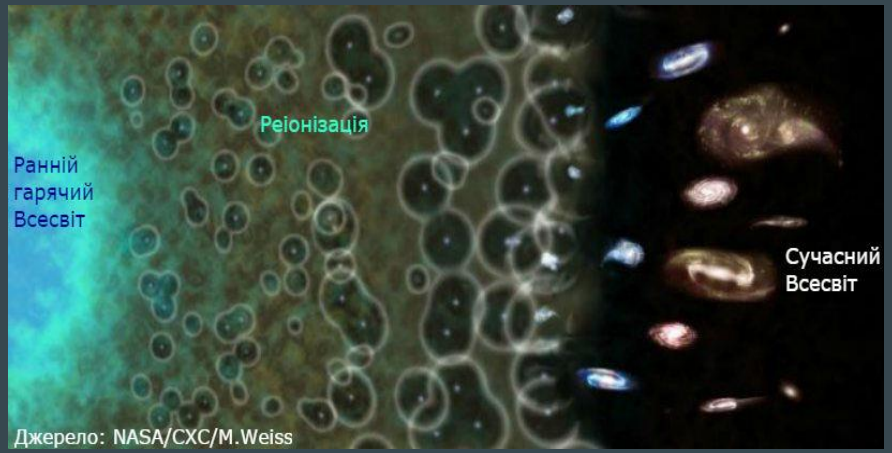
A galaxy is discovered with the *lowest* content of chemical elements heavier than He, i.e., radiation is detected of a real object that exists in the young Universe with the age less than 1 billion years



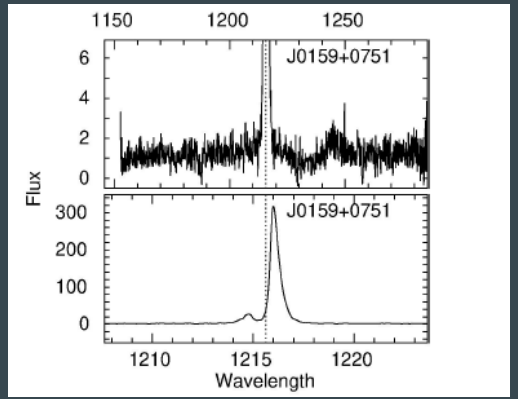
Graph of the Universe evolution from the birth (on the left) to the present time (on the right). The first galaxies began to form when the age of the Universe was about 400 million years

Combination of the images of the open galaxy J0811+4730 and a typical spiral galaxy. Actually the galaxies are located in different regions of the space and are shown together just in order to compare their linear dimensions

Astrophysics and Cosmology



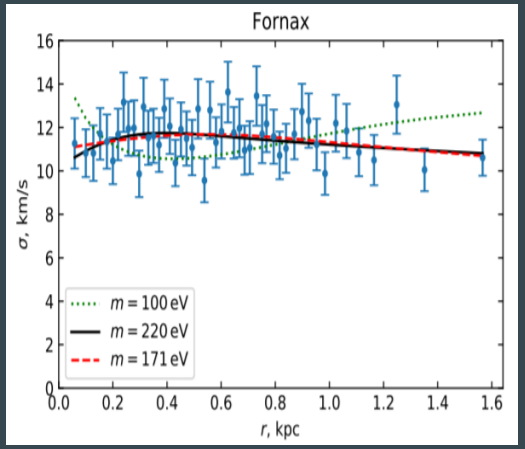
The Cosmic Hubble telescope was used to observe 8 compact galaxies with star formation in order to study the properties of their Lyman-alpha emission. The shape of the Lyman-alpha line makes it possible to determine the portion of the Lyman emission continuum that goes off the galaxy region and thus may be employed to solve the problem of the secondary ionization of the Universe



Profile of the Lyman-alpha line

Fermionic dark matter in the dwarf spherical galaxies

Spherical dwarf galaxy Fornax



Observed data on the kinematics of the stars of the Fornax galaxy and examples of the best theoretical predictions for the masses of dark-matter particles

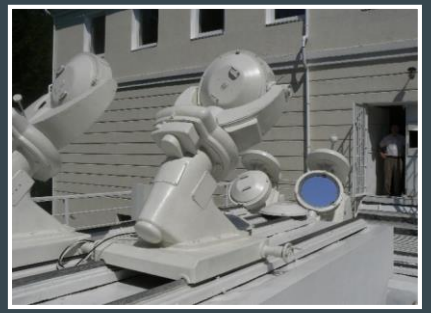
The author's model of the fermionic dark matter distribution in the halo and combined analysis of the data on the kinematics of 7 classical spherical dwarf galaxies, satellites of our Galaxy, were used to obtain **a new restriction for the mass of a fermionic dark-matter particle** ($m \geq 190$ eV, confidence level 2σ)

LONG-TERM MONITORING AND STUDY OF THE VARIATIONS IN TEMPERATURE, STRUCTURE AND DYNAMICS OF THE QUIET COMPONENT OF SUN'S ATMOSPHERE

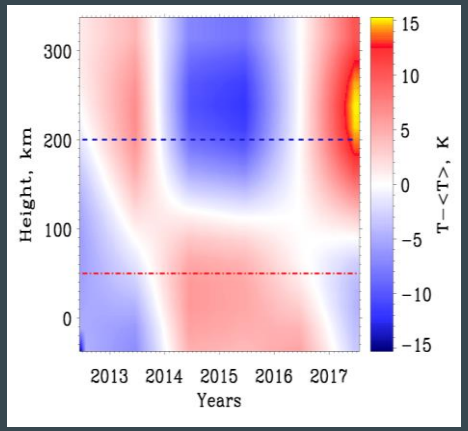
The observations have been conducted with Ernest Gurtovenko horizontal solar telescope since 2012.

The correlation between the long-term variations of the structure and dynamics of the quiet component of Sun's atmosphere and geomagnetic activity indices was determined for the first time ever.

That is necessary for understanding the nature of solar activity and its effect on climate, biosphere and socio-economic system of the Earth.



Ernest Gurtovenko telescope with two flat mirrors of 44 cm diameterThe map of temperature vattriations



The map of temperature variations (T-<T>) of the quiet Sun's atmosphere with height and time (2012 – 2018)

Main Astronomical Observatory

DECAMETER RADIO ASTRONOMY

The largest radio telescope in the world UTR 2
(antenna south-north, 1,9 km x 60 m)
Frequency range 8 — 30 MHz
number of elements 2040
effective area 150 000 square meters

Network of Decameter Radio Telescopes

The network consists of:
- largest decameter radio telescope in the world UTR-2 (frequency range 8 — 32 Mhz)
- interferometers with four radio telescopes Uran spaced to about 1000 km
- broadband radio telescope of the new generation GURT (frequency range 8-80 MHz

It has record-breaking sensitivity and resolution. Was made use of in obtaining a great number of results in the study of the Universe

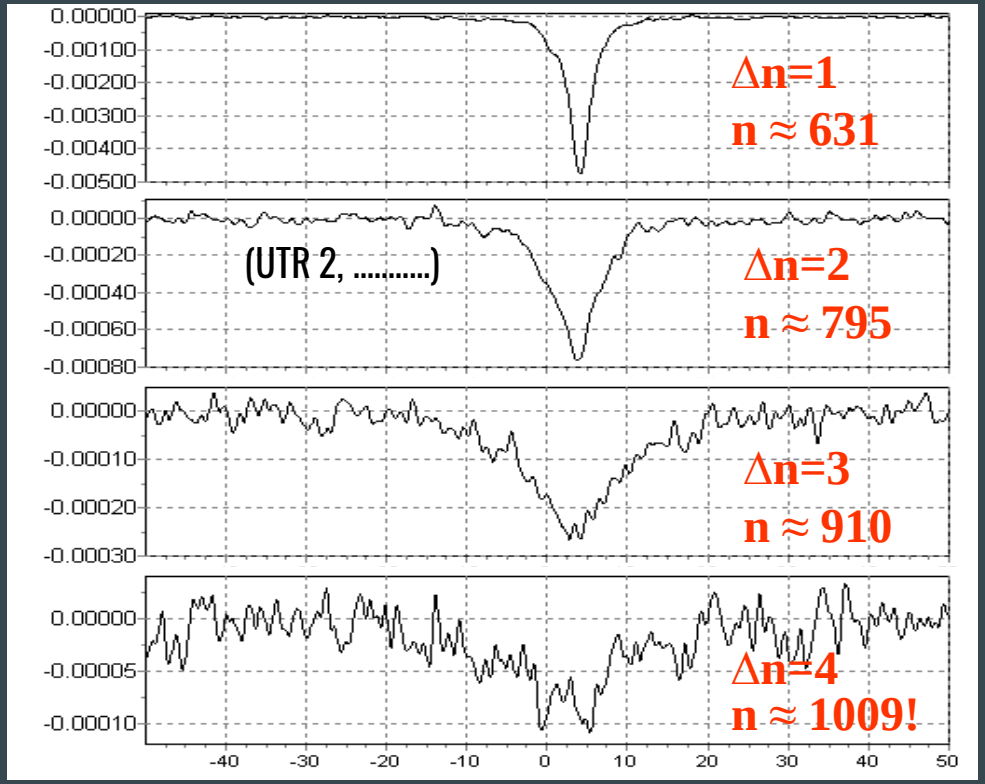
It is intensely employed in the studies of th terrestrial and terrestrial-space radio astronomy, is widely used by the international scientific community

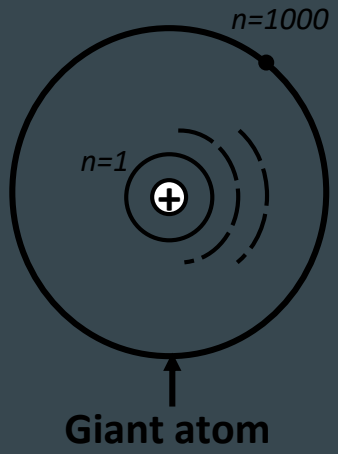
Arrangement of the radio telescopes UTR-2, URAN, GURT in Ukraine

Low-frequency radio telescopes in Europe (UTR-2, URAN-1, URAN-2, URAN-3, URAN-4, GURT, LOFAR, E-LOFAR, Nenu FAR, NDA)

LF: 10...30 MHz (dkm); 30...300 MHz (m)

Discovery of record-breaking highly excited (giant) interstellar atoms whose spectral lines provide a new method of precise diagnostics of the cold space plasmas (UTR-2, $\nu \approx 30$ MHz, $\Delta n = 1...4$, $n \approx 1009$) - 2007



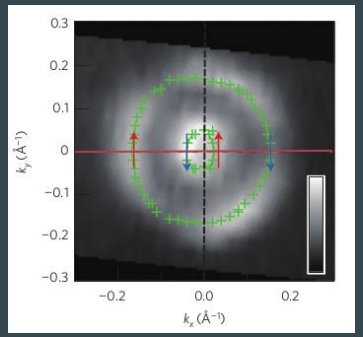


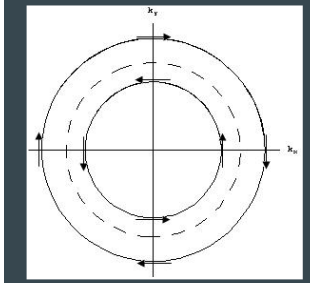
D ≈ 0.1 мм !

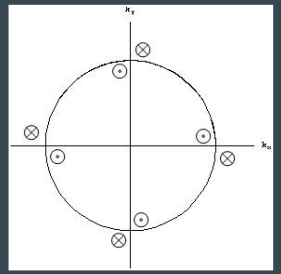
Konovalenko, Sodin, Nature, 1981; Stepkin et al., MNRAS, 2007

NEW ASPECTS OF THE SPIN-ORBIT INTERACTION IN THE FUNCTIONAL MATERIALS

Effect of the external field on the electron spin states is studied in the nonrelativistic approximation. The generalized spin-orbit interaction operator is obtained. It is shown to contain, along with the known Thomas-Frenkel correction, a new additional contribution that has not been known before. This result concerning the spin-dependence of particle states even under nonrelativistic conditions is confirmed by the experimental data. Along with the fundamental importance it provides practical usage of functional materials in modern technologies (spintronics, spin-chemistry etc.) whose principles are based on the control of the properties of operational elements of the device just due to the spin-orbit interaction



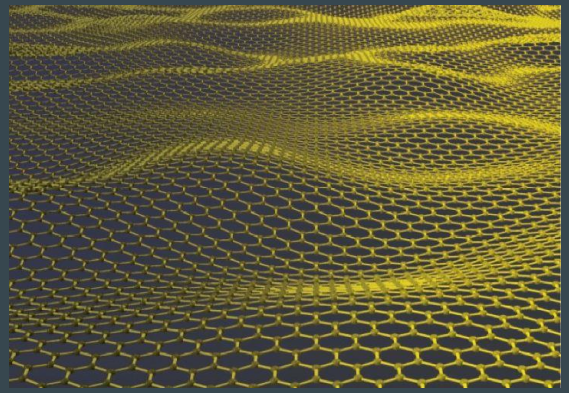




a) Experiment. Spin splitting of bands in Bi Tel. The arrows show the spin direction in the band, arrow colors — deviation of the spin orientation from the *xy* plane.

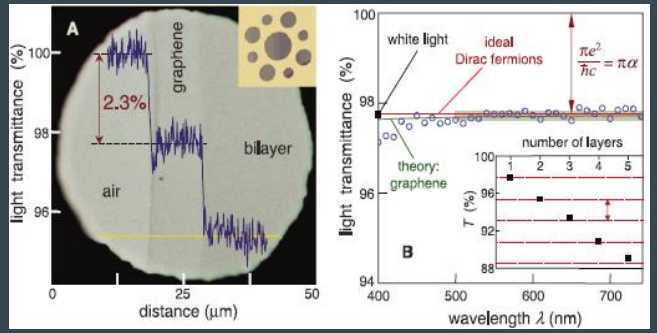
b), c) Theory. Calculation of the spin orientation for two values of the parameter ($\varepsilon_{z=const}$ and $\mu_{z=const}$). Arrows show the spin direction, symbols - deviation of the spin orientation from the *xy* plane

Electronic and Optical Properties of Graphen

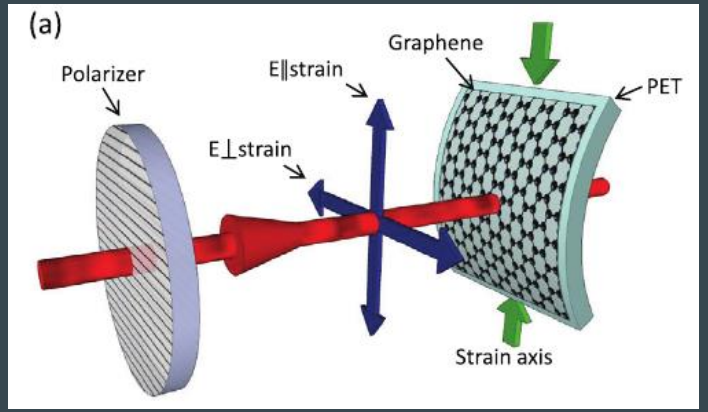


It is shown that single-layer graphene absorbs 2.3% of the light incident on it, regardless of the wavelength of light.

Theory: V. Gusinin, S. Sharapov, et al., Physical Review Letters, 2006.
Experiment: A. Geim, K. Novoselov, et al., Science, 2008



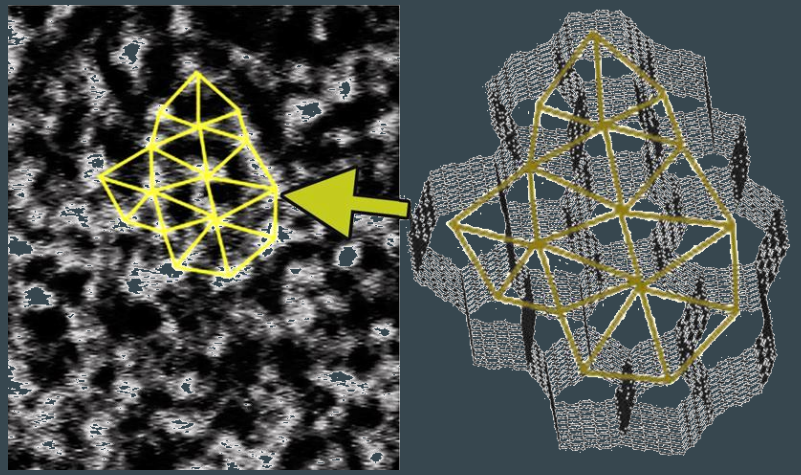
Control of properties of the newest materials by means of deformation



3D GRAPHENE OR “CARBON HONEYCOMBS”

A new modification of carbon is discovered and studied. It is the three-dimensional form of the graphene (carbon honeycombs) with unique properties:

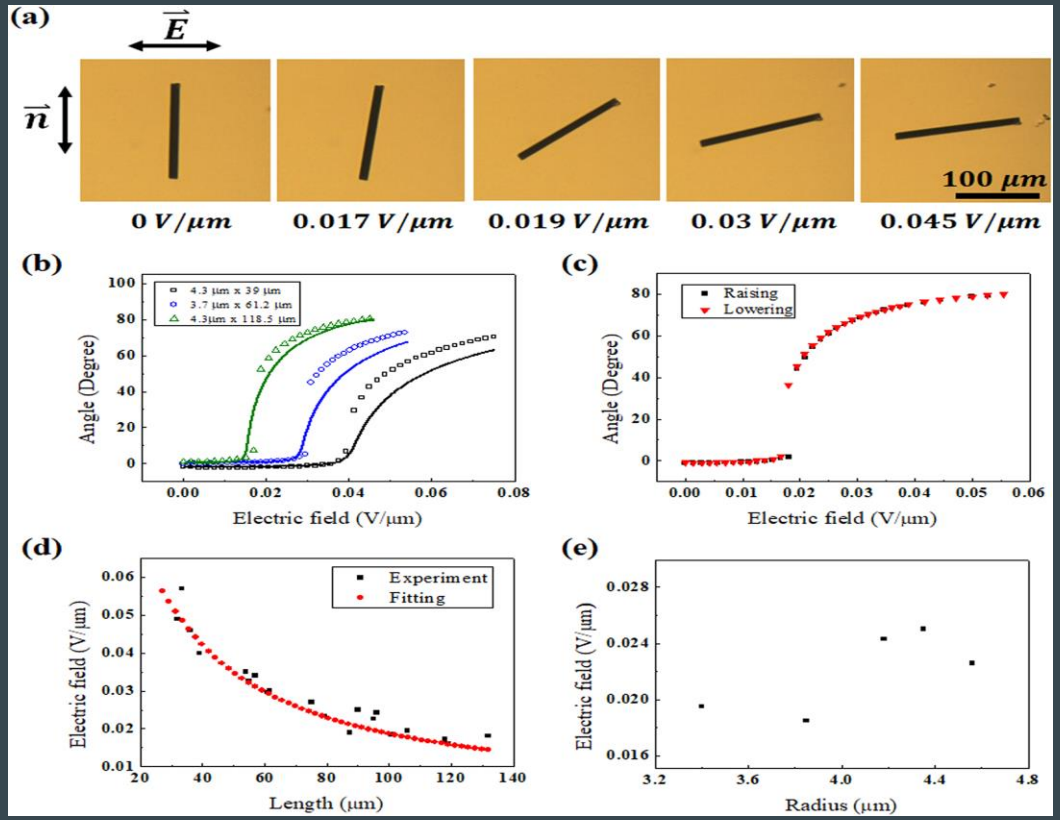
- the capacity to accumulate and large amounts of hydrogen that is promising for the accumulation of the hydrogen fuel;
- the possibility of structural symbiosis with other carbon forms that makes it possible to use the honeycombs as a matrix for complex composite compounds;
- filling the honeycomb channels with metal atoms improves both electric and magnetic properties, this effect may be employed in micro- and nanoelectronics



Images of random honeycombs obtained with the use of high-resolution transmission electron microscopy (left) and their reconstruction (right)

N. Krainyukova et al.
Phys. Rev. Lett. 2016.
Carbon. 2017.

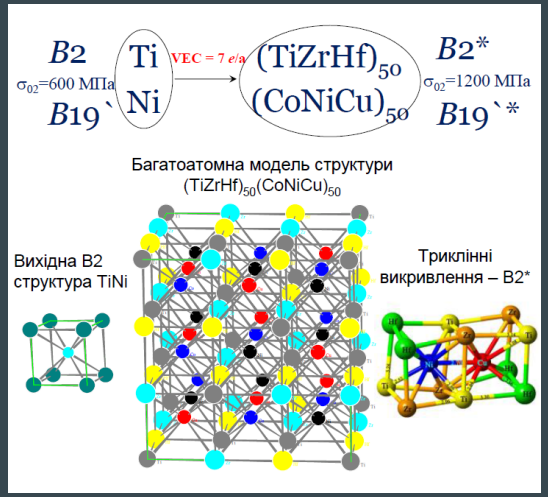
Features of orientation of carbon fibers in liquid crystals under the action of an electric field



1. Junyong Lee, Bohdan Lev, Jong-Hyun Kim Scientific Reports *(2019) 9:20223*|
2. Bohdan Lev, Jong-Hyun Kim EPJE (2020),43,1.

MECHANIC PROPERTIES OF THE NITINOL AND SYNTHESIZED INTERMETALLIDES WITH THE SHAPE-MEMORY EFFECT

Properties	TiNi	Synthesized materials
Temperature interval, K	77–390	77–900
Young modulus	45	70–80
Yield point	70–600	1200–1500
Renewable deformation, %	8 → 1	stable 3
Work-in-process, Дж/см^3	10–20	30



A new family of high-entropy (6-component) intermetallides ..... with polysublattice structure is formed and studied. It manifests shape-memory stability within broad temperature and pressure intervals as well as high operational performance

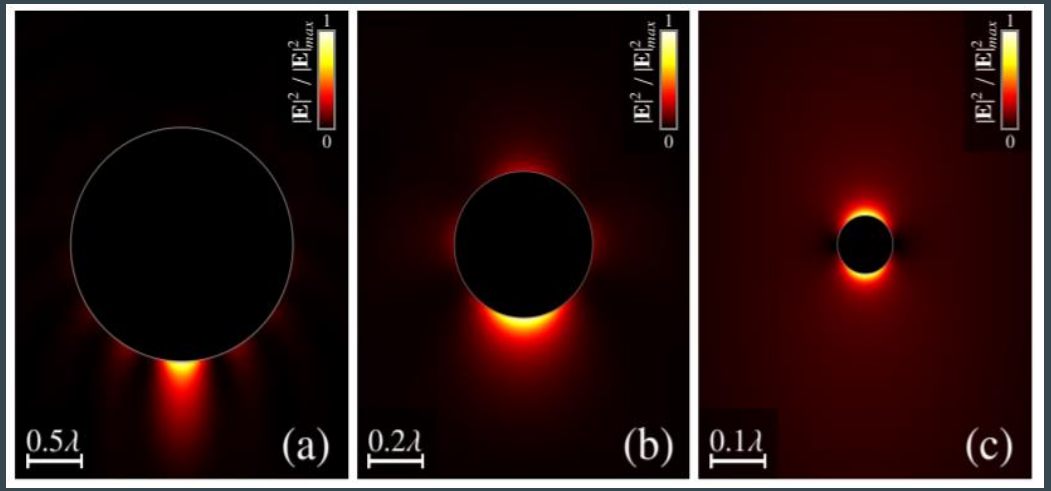
CONTROL OF OPTICAL STRUCTURES BY MEANS OF THE SINGULAR-OPTICS METHODS

Light focusing by spherical metallic particles — a new idea

(a) particle size is greater than the wavelength

(b) particle size is equal to the wavelength

(c) particle size is smaller than the wavelength



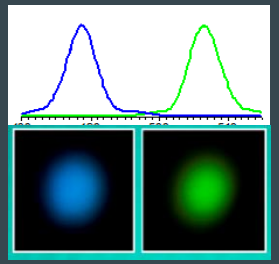
The particle is shown by the black circle. Before and behind it there appears light nanostreams. Light focusing is performed with the use of transparent materials. For the first time nontransparent spherical metallic particles are proposed whose irradiation by a specific laser beam provides a possibility of high concentration of electromagnetic energy in narrow streams with sizes smaller than the wave length (nanostreams). Such nanostreams may be used for the material processing with an accuracy that is not possible with their processing by conventional methods

HOLOGRAPHIC RECORDING BY ULTRASHORT LIGHT PULSES OF VARIOUS COLORS

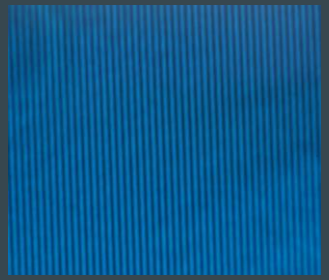
The use of ultrashort light pulses is shown to provide observarion of the interference and hologram recording even by noncoherent light beams of various colors

For the first time the hologram is recorded by multicolored pulses and the object image is reproduced by means of continuous red light

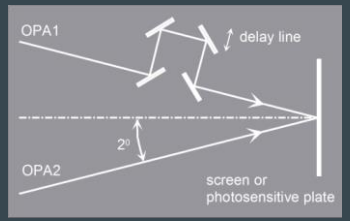
Usually in order to record a hologram the light wave that carries the image is complemented with a coherent wave of similar frequency. Together they form stationary interference bands that are called the hologram



Beam spectra and intensity distribution



Interference of blue and green beams



Sketch of the interference observation

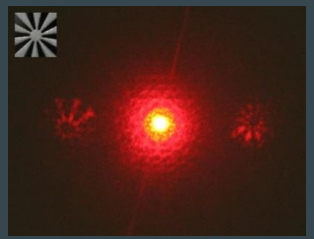
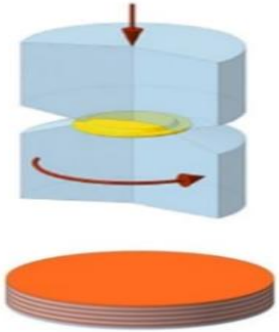
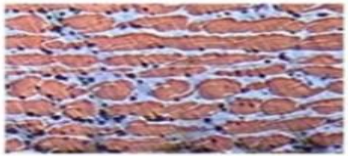
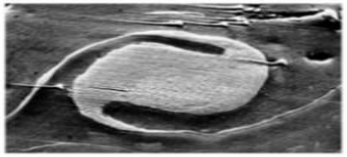


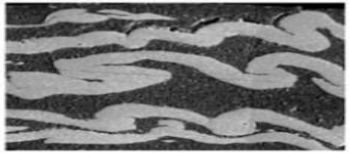
Photo of an object and its image

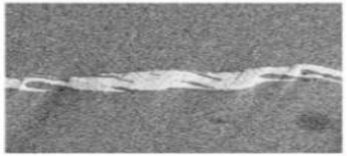
Torsion under pressure



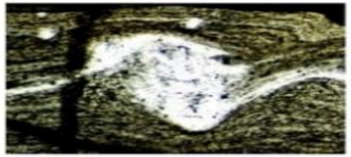




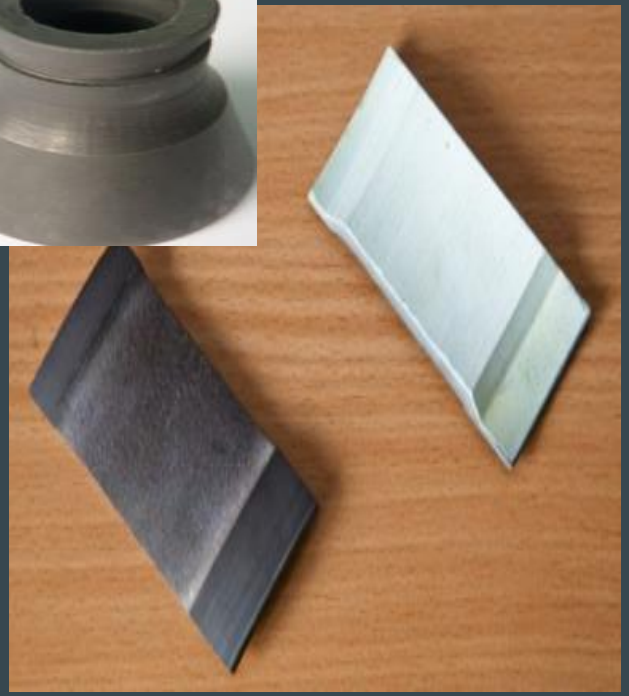




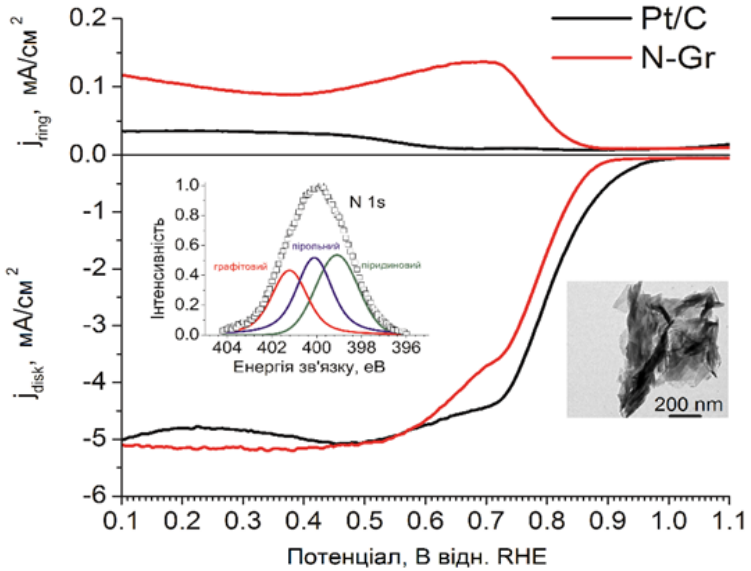
Lithosphere



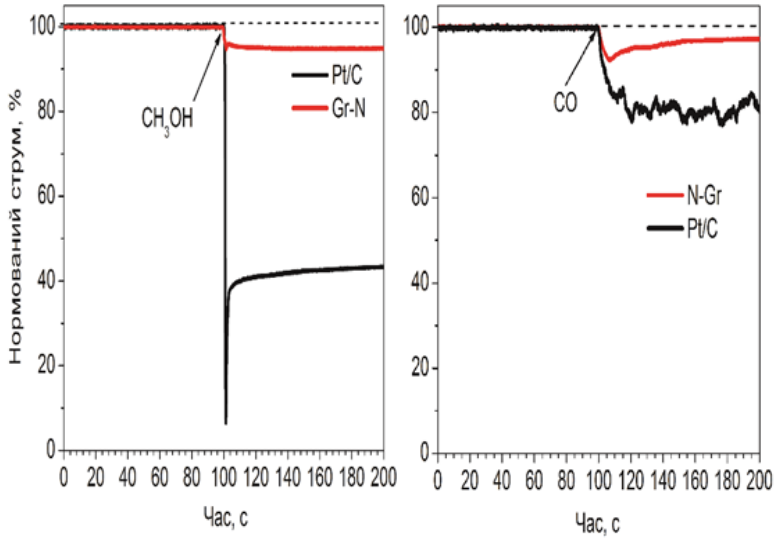
The left block presents 4 mesostructures formed by shear of metal layered compositions under pressure. There is also a diagram of the process of torsion under high pressure, which is used to obtain these mesostructures. The right block shows similar mesostructures of the lithosphere that arise in it during pressure shifts.



Plates of ultrahigh-temperature ceramics in the size of 200x90x15 mm for lining of a fire tube of the aerodynamic reactor of combustion of coal aero mixture ,combustion chamber nozzle, segments of a fire tube from ceramics of the perspective gas turbine engine



Volt-ampere charts for the graphene and platinum catalysts under the electrode rotation rate 1600 revolutions per minute and potential scanning 10 mV/sec.Insertions: RFS spectrum N 1s of the graphene catalyst



Tolerance of the graphene catalyst with respect to the methanol and carbon monoxide

Electrocatalytic characteristics of the low-temperature doped multilayer graphene

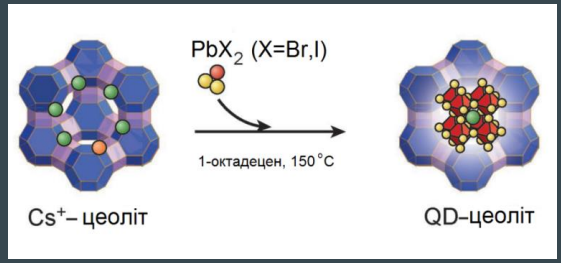
NEW LUMINOPHORES BASED ON INORGANIC HALOID PEROVSKITE FOR LED LIGHTING SYSTEMS

Novel materials based on quantum dots of inorganic perovskites were produced.
$CsPbBr_{3-y}I_y$ inside X and Y zeolite matrices всередині матриць цеолітів X та Y, which are characterized with longer photoluminescence lifetimes in various spectral ranges and increased stability

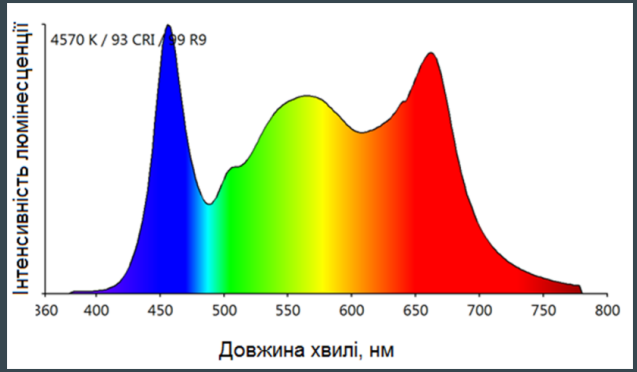
X/QD CsPbBr1,2I1.8 with luminescence quantum yield ~80% in the red spectral region allows the index of transmitting white light based on blue light emitting diodes to be increased to 95.

V.D. Pokhodenko, V.G. Koshechko, O.Yu. Posudiievskyi

1. ACS Appl. Nano Mater. – 2018.
2. Теор. и эсперим. химия. – 2019.
3. Теор. и эсперим. химия. – 2019.



Producing quantum dots (QD) of $CsPbX_3$ type perovskites in zeolite matrices



The spectrum of efficient light diodes

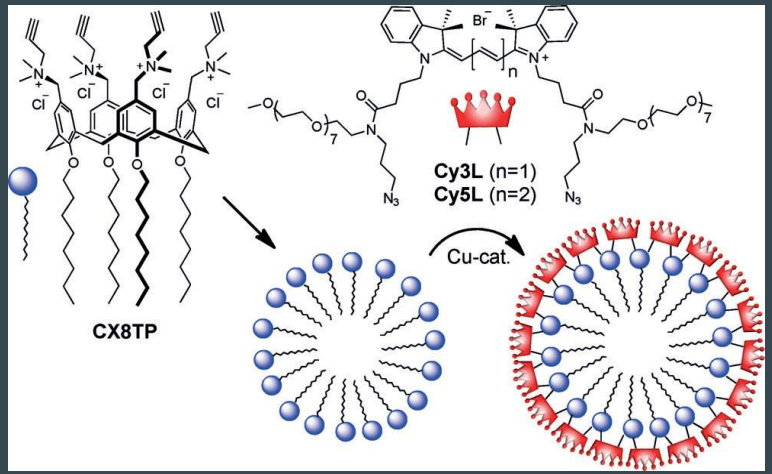
L.V. Pisarzhevsky Institute of Physical Chemistry

FLUORESCENT CALIXARENE NANOPARTICLES FOR MEDICAL DIAGNOSTICS

In collaboration with Strasburg University scientists, nano-composites based on calixarenes and fluorescent cyanine dyes were developed.

The 7nm nano-particles produced demonstrate significantly higher brightness in comparison with commercial inorganic cadmium-tellurium nano-particles (quantum dots QD-585), which are used as biomarkers.

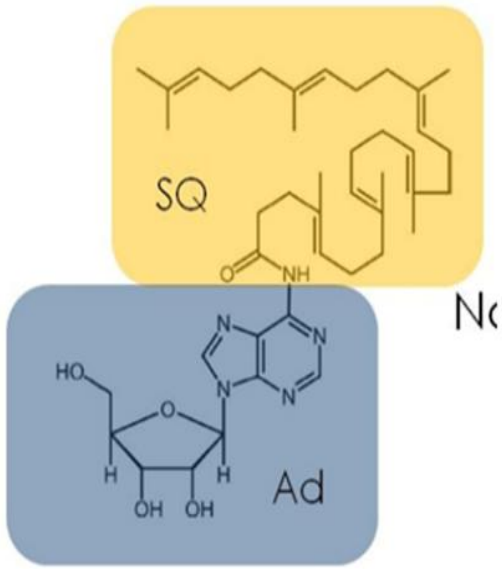
The developed calixarene nano-particles are bio-compatible, they easily penetrate biological membranes and selectively color different areas inside cells, which opens broad prospects of using them in cytological and histological examinations and in molecular biochemistry.



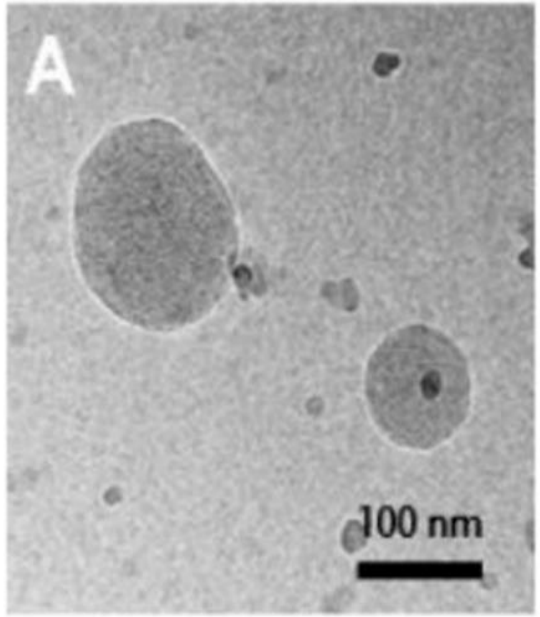
V.I. Kalchenko, V.V. Rodik, A.S. Klymchenko
Angew. Chem. Int. Ed. – 2016.

d 7nm, λem 590 nm

Institute of Organic Chemistry



Chemical structure of SQAd



SQAd nanoparticles in water

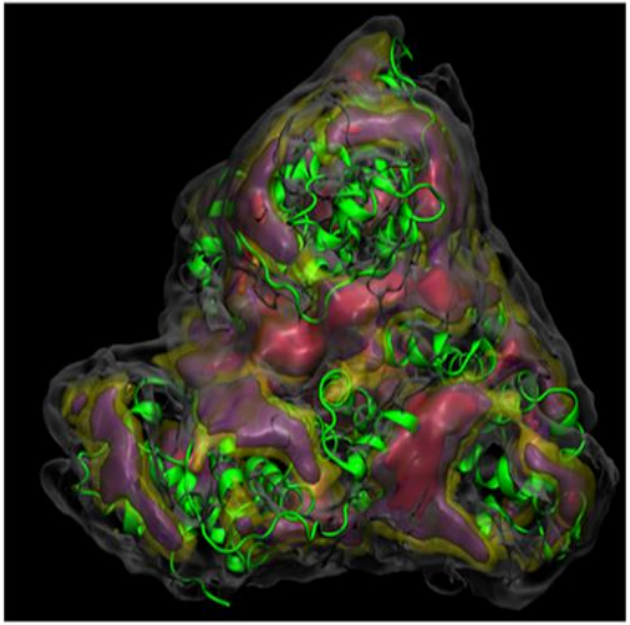


Chart of the probability density of SQAd binding with the protein surface

Molecular “scanning” doking for the conformation enesemble of SQAd with the whey albuminum of a man

THE EFFECT OF NEUROINFLAMMATION ON THE DEVELOPMENT OF ALZHEIMER DISEASE SYMPTOMS AND THE METHODS OF OVERCOMING THEM

It was found that the neuroinflammation resulting from the administration of bacterial lipopolysaccharide to mice leads to the reduction of nicotine acetylcholine receptors (nAChR) of the α7 subtype in their brains, the accumulation of pathogenic peptides of β-amyloid, brain mitochondria lesions and the impairment of episodic memory, which is a sign of the Alzhemer disease early form.

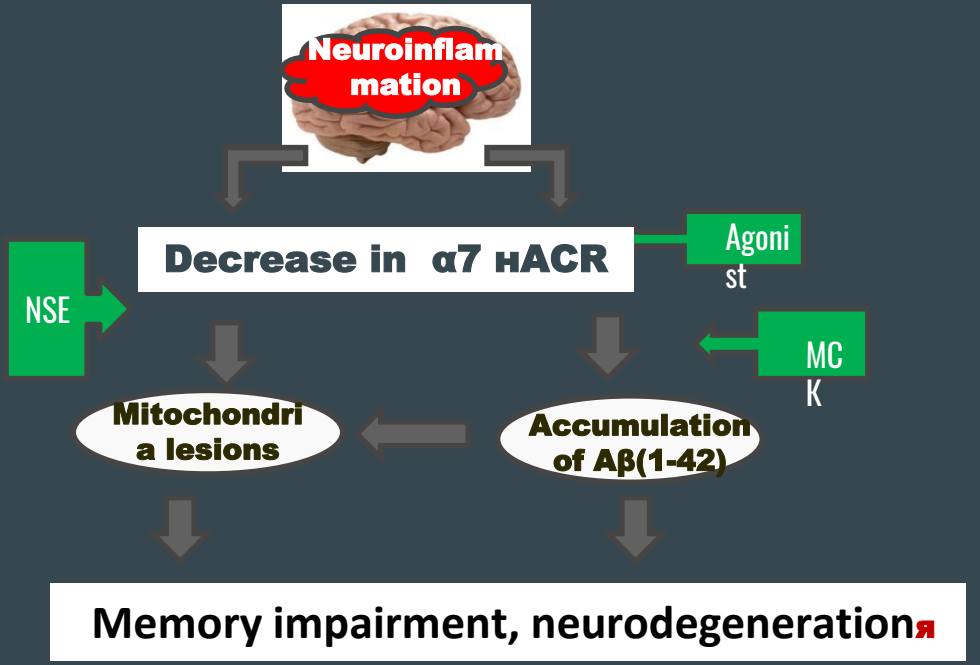
It was shown that the development of such symptoms can be prevented or cure them at the early stages of neuroinflammation by administering the agonist of α7 nAChR PNU28298,

N-steroiletanolamine (NSE) or mesenchymal stem cells (MSC).

The data obtained propose new ways of therapy of cognitive impairment caused by neuroinflammation.

M.V. Skok, O.Yu. Lykhmus

Frontiers in Pharmacolody. - 2019.



The scheme demonstrates the key role of α7 nAChR in the development of neuroinflammation pathological effects and the proposed methods of their correction

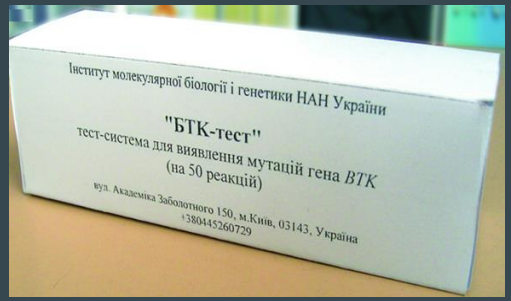
Palladin Institute of Biochemistry

A SYSTEM FOR MOLECULAR GENETIC DIAGNOSTICS OF BLOOD SAMPLES FOR PRIMARY IMMUNODEFICIENCIES

The first Ukrainian test system permits the detection of BTK gene mutation and diagnostics of patients in hospitals.

ГG.D. Telegeiev, M.V. Dybkov

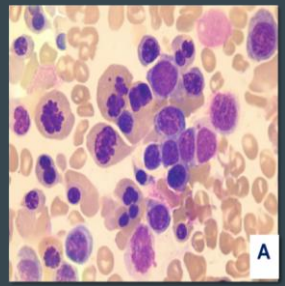
Фактори експериментальної еволюції організмів. – 2018.

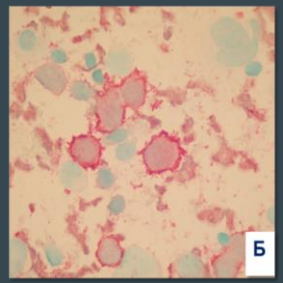


CYTOCHEMICAL AND IMMUNOCYTOCHEMICAL METHODS OF DIAGNOSING VARIOUS FORMS OF MYELODISPLASTIC SYNDROMES

Advanced laboratory methods of myelodisplastic syndromes diagnostics were upgraded and introduced to the clinical practice of onco hematological departments of medical institutions of Ukraine.

D.F. Glusman, L.M. Sliarenko , T.S. Ivanivska et al.
Онеклогія. – 2018.





Institute of Molecular Biology and Genetics
R.E. Kavetsky Institute of Experimental Pathology , Oncology and Radiobiologyro

Ukrainian doctors share their experience in the USA

E.O. Paton Electric Welding Institute
Electric welding of live tissues

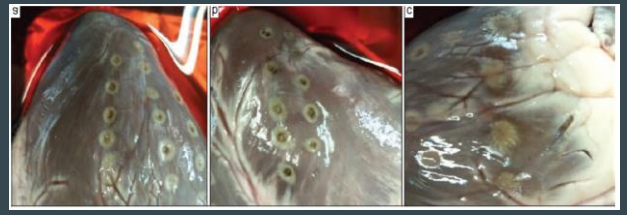
130 breakthrough technologies in various areas of surgery:
reduced blood losses,
the absence of suture material, fast healing (tissue regeneration)
> 100 thousand surgeries in clinics

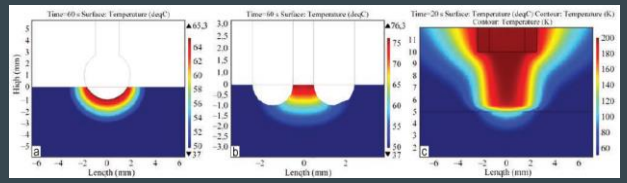
ELECTROTHERMOSURGICAL TECHNOLOGIES IN THE TREATMENT OF ARRHYTHMIA DURING OPEN HEART SURGERIES (WELDING AND TREATMENT OF LIVING TISSUES)

Appointment:
Creation of medical equipment for cardiac surgery, which surpasses the best world models.

Development readiness level:
The model was created and tested in laboratory conditions. Patent of Ukraine for utility model 131947, No 3/2019 dated February 11, 2019

Advantages:
regulated zone of destruction of pathological heart tissue;
the possibility of concomitant treatment of arrhythmias during heart surgery during bypass surgery;
no side effects;
absence of necrosis and damage to surrounding healthy tissues.



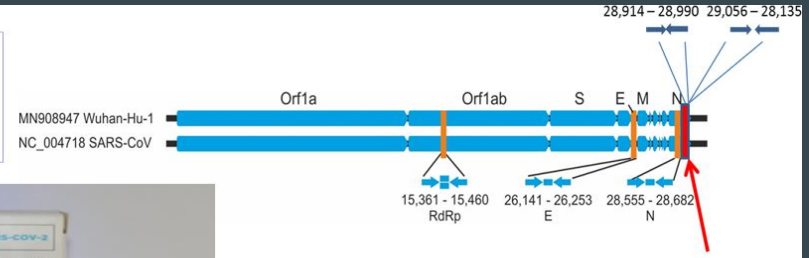


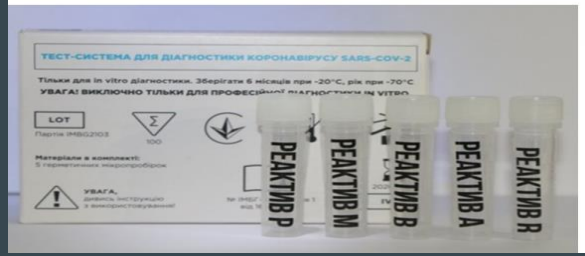
MAGNETOCARDIOGRAPHIC SCANNER WITH SQUID SENSORS

Magnetocardiography provides a possibility to predict, safely for the patient, appearance of cardiac arrhythmias, to reveal miocardial ischaemia and other most dangerous cardial deseases at early stages. The srudies were performed in collaboration with Oxford University.

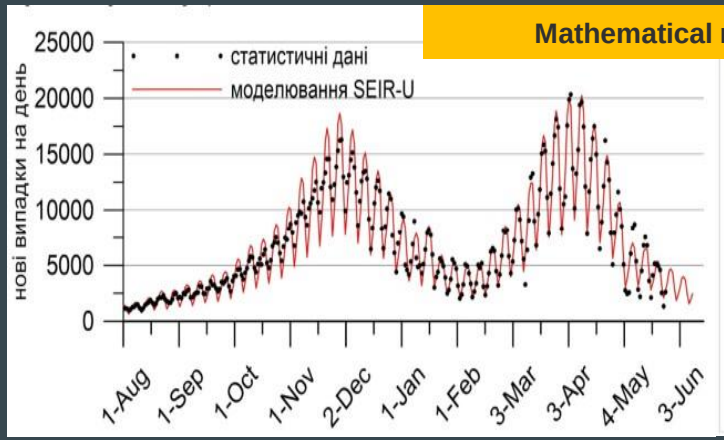
The first test system for the diagnosis of SARS-Cov-2, created and registered in Ukraine.

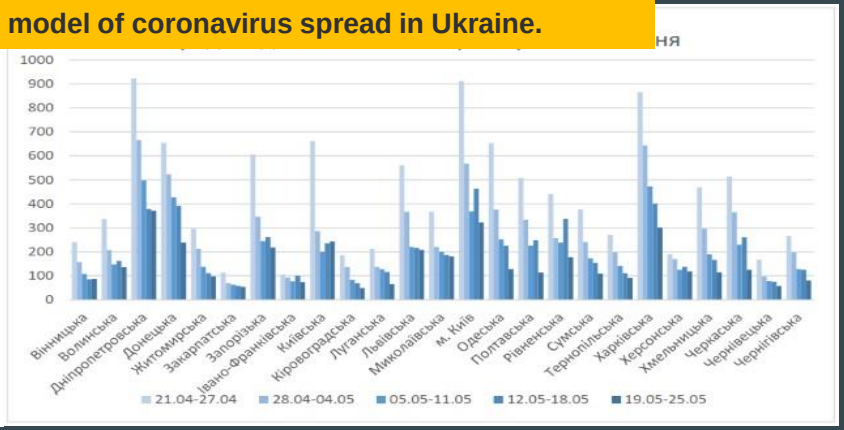
Схема розташування праймерів для кПЛР у порівнянні з німецькою тест-системою [Corman V. et al]





Mathematical model of coronavirus spread in Ukraine.





Estimated values of the number of new cases for Ukraine, taking into account weekly variability.

MODERNIZED DIGITAL CONTACT THERMOGRAPH

Purpose

For diagnostics of tumor diseases at the pre-clinical stage in clinics and diagnostic centers of specialized and prophylactic medical examination

Level of product readiness

Direct supplies, sale of licenses.

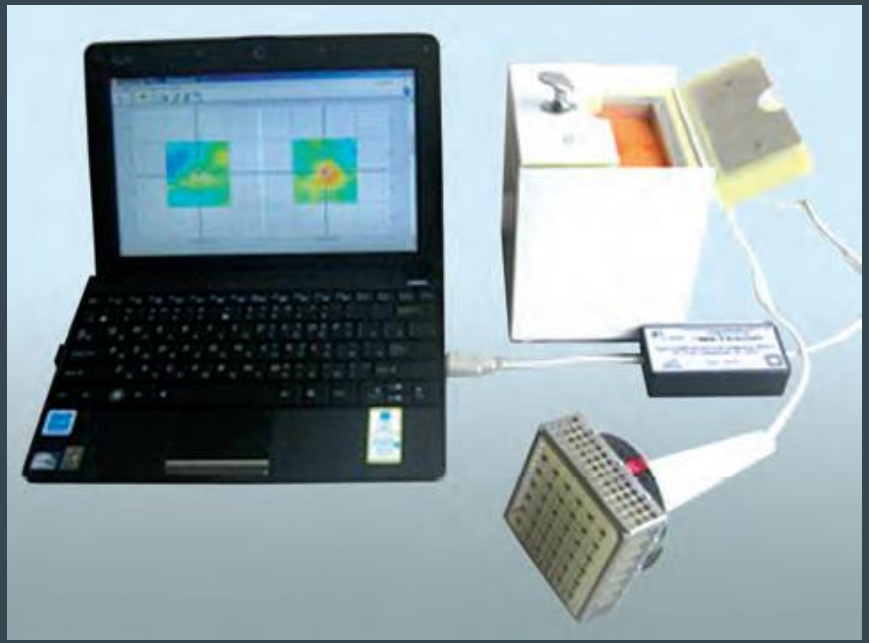
The device is manufactured at orders by ‘Metekol’ enterprise (Nizhyn) pursuant to the agreement of license provisioning and Supplementary Agreement of # 6 of !6 December 2019. The production capacity is up to 100 devices annually.

Advantages

- high precision (close to X-ray analysis);
- harmless for human organism;
- a much lower price in comparison with imported analogs;

portability and the ease of use;

- It is recommended for use by the Health Ministry of Ukraine.



O.O. Galkin Donetsk Institute for Physics and Engineering

Extension of service life of nuclear power units

The conditions of irradiation, current and accumulated radiation load of WWER-1000 reactor vessels are determined. The works allowed to postpone the decommissioning of 11 of the 15 existing NPP units and the construction of new facilities for 10-20 years (in the future - for 30 years). The economic effect of extending the life of one power unit per year is about 1.5 billion UAH.

The period of safe operation of the reactor f Unit 3 of the South Ukrainian Nuclear Power Plant has been extended until 2050.

The period of safe operation of the reactor f Unit 4 of the Zaporizhzhya Nuclear Power Plant has been extended until 2047.

TECHNOLOGIES OF CONTACT BUTT WELDING OF LONG RAIL LASHES

Purpose

- Creating conditions for integrating Ukrainian railways into the international system of transport corridors, increasing train speed.
- Meeting international standards of train motion smoothness and safety due to the introduction of all-welded jointless track made of high-strength rail steels of modern manufacturing, transport corridors, higher train speed.

Level of development readiness

The upgraded technology of contact butt welding by reflowing long rail lashes by reflow pull and an innovative control system were tested and proposed for deployment at mobile rail welding complexes of 'Ukrzaliznytsia' company.

Advantages

- automated calculation of reflow pull parameters in accordance with rail temperature and lash laying parameters.
- Checking welding process parameters, assessment of their conformity to the Specifications, preparing protocol and its transfer to the Diagnostic Center of 'Ukrzaliznytsia' Joint Stock Company.

Mobile rail welding machine

KCM-005 mobile rail welding complex

TTRANSFORMERS BASED ON NANO-CRYSTALLINE BAND MAGNETIC CIRCUITS

Purpose

To meet the needs of Ukrainian mechanical engineering, including that for special purposes (in particular, armored vehicles and systems for testing military equipment). Level of product readiness

Рівень готовності розробки

License agreement #125 of 16 December 2016. Manufacturing and supplies of pilot batches is provided by the licensee – 'MELTA' Ltd.

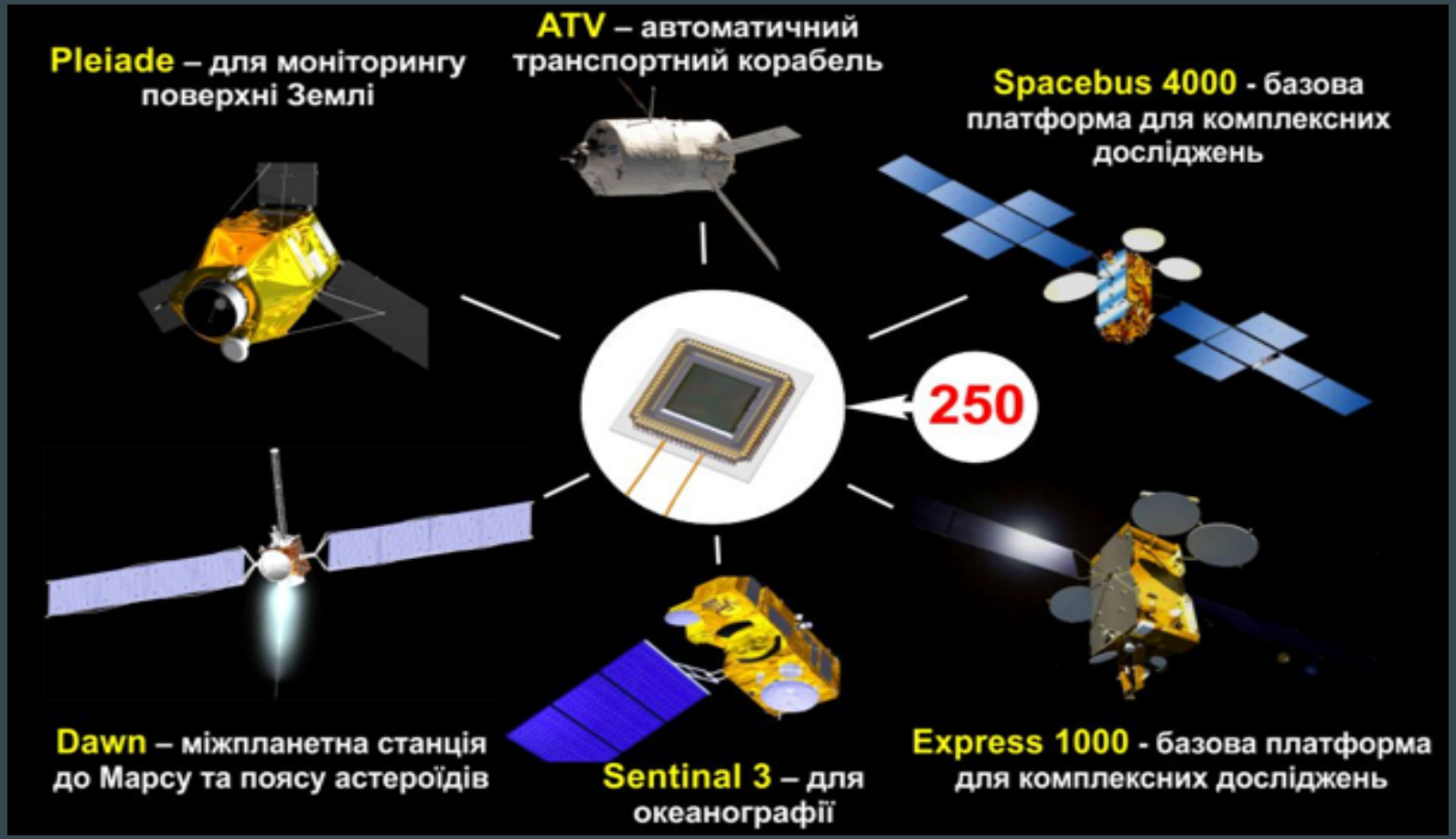
Advatages

- much higher values of inductance, inductive reactance and quality factor of all windings in comparison with imported permalloy transformers;
- Extremely low values of input windings leakage inductance in new transformers.

Transformers of static converters of ТПр13 type

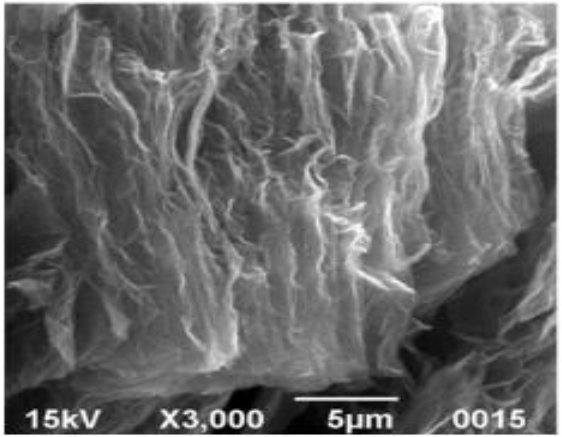
Miniature transformers for high-frequencyspecial-purpose telecommunication control systems

G.V. Kurdyumov Institute for Metal Physics

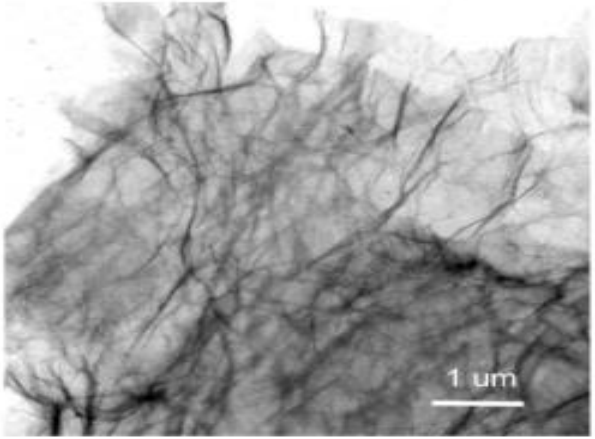


Thermal stabilization systems for spacecraft orientation by stars (250 applications).

а)



б)

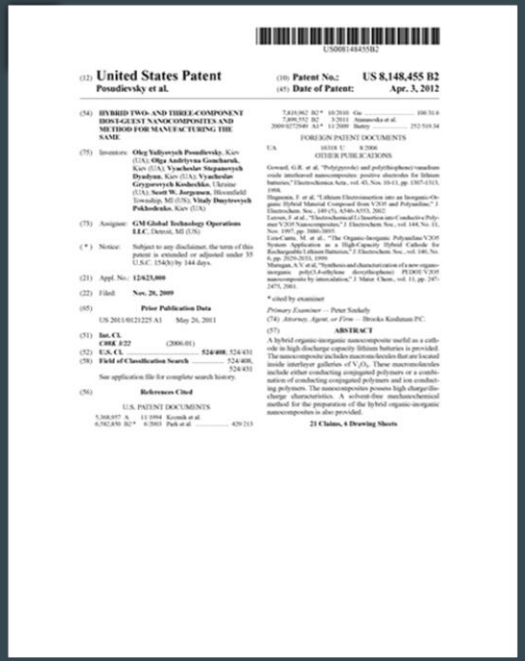


в)

Couplings of adhesive joints for shear tests (a). Graphene planes in the area of the adhesive seam (images obtained by scanning (b) and illuminating (c) microscopy).

Sample adhesive joint for shear tests.

Hybride nanocomposites based on the electric-conductor polymers and metal oxides for advanced lithium batteries (in collaboration with General Motors Corp., USA)



US008148455B2

(12) **United States Patent**
Posudievsky et al.

(10) **Patent No.: US 8,148,455 B2**
(45) **Date of Patent: Apr. 3, 2012**

(54) **HYBRID TWO- AND THREE-COMPONENT HOST-GUEST NANOCOMPOSITES AND METHOD FOR MANUFACTURING THE SAME**

(75) Inventors: **Oleg Yuliyovych Posudievsky**, Kiev (UA); **Olga Andriyna Goncharuk**, Kiev (UA); **Vyacheslav Stepanovych Dyadyun**, Kiev (UA); **Vyacheslav Grygorovych Koshechko**, Ukraine (UA); **Scott W. Jorgensen**, Bloomfield Township, MI (US); **Vitaly Dmytrovych Pokhodenko**, Kiev (UA)

(73) Assignee: **GM Global Technology Operations LLC**, Detroit, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 144 days.

(21) Appl. No.: **12/623,000**

(22) Filed: **Nov. 20, 2009**

(65) **Prior Publication Data**

US 2011/0123225 A1 May 26, 2011

(51) **Int. Cl.**
C08K 3/22 (2006.01)

(52) **U.S. Cl.** **524/408**; 524/431

(58) **Field of Classification Search** 524/408, 524/431
See application file for complete search history.

(56) **References Cited**

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Leroux, F. et al., "Electrochemical Li Insertion into Conductive Polymer/V2O5 Nanocomposites," J. Electrochem. Soc., vol. 146, No. 11, Nov. 1997, pp. 3886-3891.

LiraCantu, M. et al., "The Organic-Inorganic Polyaniline/V2O5 System Application as a High-Capacity Hybrid Cathode for Rechargeable Lithium Batteries," J. Electrochem. Soc., vol. 140, No. 6, pp. 2029-2033, 1999.

Mistegan, S.V. et al., "Synthesis and characterization of a new organo-inorganic poly(3,4-ethylene dioxythiophene) PEDOT/V2O5 nanocomposite by intercalation," J. Mater. Chem., vol. 11, pp. 2471-2475, 2001.

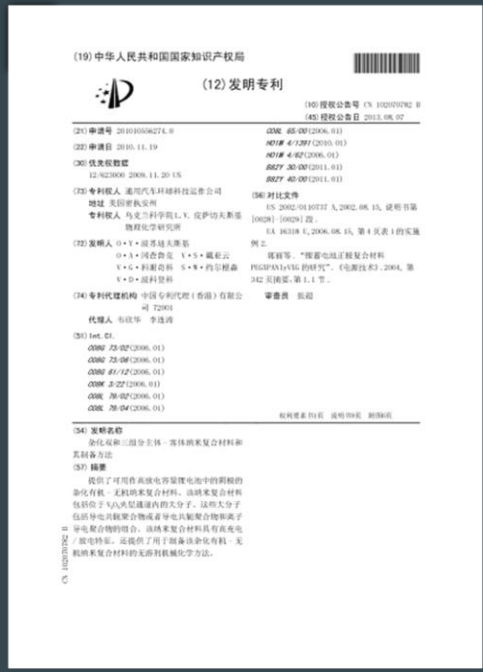
* cited by examiner

Primary Examiner — Peter Szekely
(74) Attorney, Agent, or Firm — Brooks Kushman P.C.

(57) **ABSTRACT**

A hybrid organic-inorganic nanocomposite useful as a cathode in high discharge capacity lithium batteries is provided. The nanocomposite includes macromolecules that are located inside interlayer galleries of V_2O_5. These macromolecules include either conducting conjugated polymers or a combination of conducting conjugated polymers and ion conducting polymers. The nanocomposites possess high charge/discharge characteristics. A solvent-free mechanochemical method for the preparation of the hybrid organic-inorganic nanocomposites is also provided.

21 Claims, 6 Drawing Sheets



(19) 中华人民共和国国家知识产权局

(12) 发明专利

(10) 授权公告号 CN 102070742 B
(45) 授权公告日 2013.08.07

(21) 申请号 201010506274.0

(22) 申请日 2010.11.19

(30) 优先权数据
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V·D·波科登科

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(51) Int. Cl.
C08K 3/22(2006.01)
C08G 73/02(2006.01)
C08G 73/06(2006.01)
C08K 61/12(2006.01)
C08K 3/22(2006.01)
C08L 79/02(2006.01)
C08L 79/04(2006.01)

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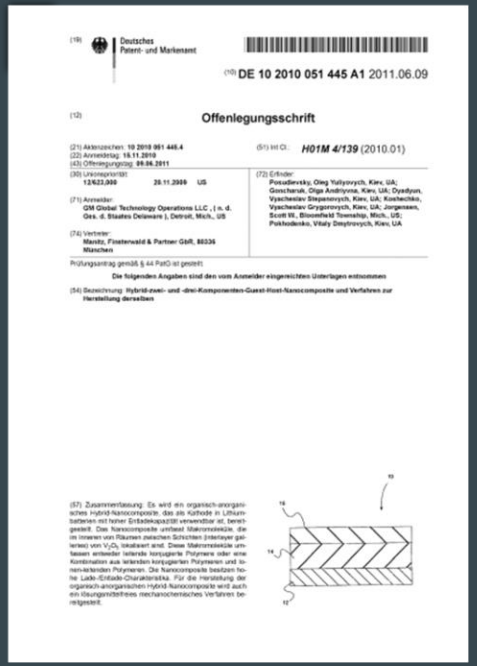
审查员 张超

(54) 发明名称
杂化双相三组分主体-客体纳米复合材料和其制备方法

(57) 摘要
提供了可用作高放电容量锂电池中的阴极的杂化有机-无机纳米复合材料。该纳米复合材料包括位于V_2O_5层隧道内的大分子。这些大分子包括导电共轭聚合物或者导电共轭聚合物和离子导电聚合物的组合。该纳米复合材料具有高充电/放电特征。还提供了用于制备该杂化有机-无机纳米复合材料的无溶剂机械化学方法。

CN 102070742 B



(19) Deutsches Patent- und Markenamt

(10) **DE 10 2010 051 445 A1** 2011.06.09

(12) **Offenlegungsschrift**

(21) Aktenzeichen: **10 2010 051 445.4**
(22) Anmeldetag: **10.11.2010**
(43) Offenlegungstag: **09.06.2011**

(51) Int Cl.: ***H01M 4/139*** (2010.01)

(30) Unionspriorität:
12/623,000 **20.11.2009** **US**

(71) Anmelder:
GM Global Technology Operations LLC, (n. d. Ges. d. Staates Delaware), Detroit, Mich., US

(72) Erfinder:
Posudievsky, Oleg Yuliyovych, Kiev, UA; Goncharuk, Olga Andriyona, Kiev, UA; Dyadyun, Vyacheslav Stepanovych, Kiev, UA; Koshechko, Vyacheslav Grygorovych, Kiev, UA; Jorgensen, Scott W., Bloomfield Township, Mich., US; Pokhodenko, Vitaly Dmytrovych, Kiev, UA

(74) Vertreter:
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Prüfungsantrag gemäß § 44 PatG ist gestellt.

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Bezeichnung: **Hybrid-zwei- und -drei-Komponenten-Gastet-Host-Nanocomposite und Verfahren zur Herstellung derselben**

(57) Zusammenfassung: Es wird ein organisch-anorganisches Hybrid-Nanocomposite, das als Kathode in Lithiumbatterien mit hoher Entladekapazität verwendbar ist, bereitgestellt. Das Nanocomposite umfasst Makromoleküle, die im Inneren von Räumen zwischen Schichten (Interlayer galleries) von V_2O_5 lokalisiert sind. Diese Makromoleküle umfassen entweder leitende konjugierte Polymere oder eine Kombination aus leitenden konjugierten Polymeren und ionen-leitenden Polymeren. Die Nanocomposite besitzen hohe Lade-/Entlade-Charakteristika. Für die Herstellung der organisch-anorganischen Hybrid-Nanocomposite wird auch ein lösungsmittelfreies mechanochemisches Verfahren bereitgestellt.

Joint patents with General Motors Corp. in USA, (#8148455), Germany (#102010051445), China (#102070742) and othe counries

Pisarzhevsky Institute of Physical Chemistry of the NAN of Ukraine

IN 5 YEARS CREATED WERE: 34 VARIETIES OF WINTER WHEAT, A TRITICALE VARIETY, A HYBRID AND 5 PARENT FORMS OF CORN

Purpose

Agriculture.

Level of product readiness

The varieties have been introduced in the State Register. They are ready for broad introduction.

Advantages

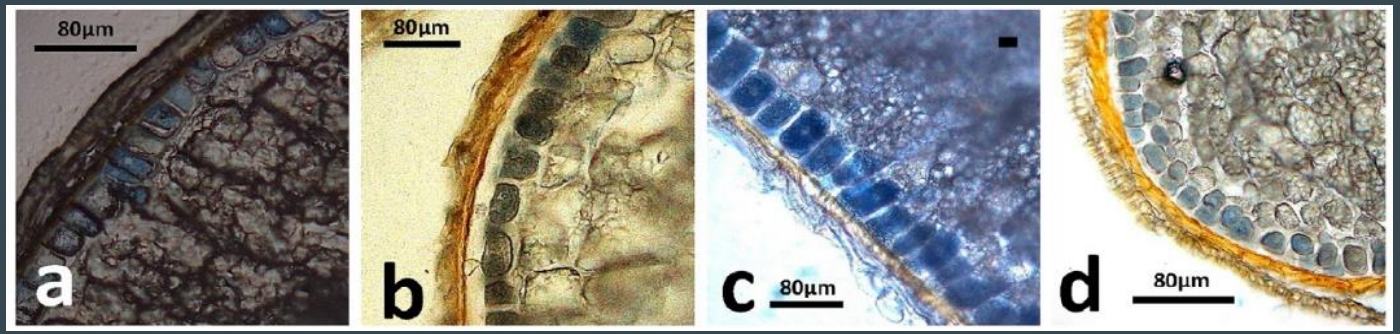
- have been recognized at the state level as a breeding achievement of Ukraine and several other countries;
- in 2019, the varieties created produced nearly 30% (8,0 million tons) of the wheat gross harvest, which was a significant contribution to enhancing the food security and well-being of Ukraine;
- the annual economic effect of their cultivation amounts to nearly UAH 6.7. billion.

Innovative varieties of winter wheat created by the NAS Institute of Plant Physiology and Genetics

New species with colored grains

Bare-grain barley woth ordinsry and black grains

Slices of winter-wheat colored grains through a microscope



HIGHLY EFFECTIVE FISH PASSING FACILITIES AT SMALL HYDROPOWER PLANTS

Purpose

To provide free migration for fish to their spawning grounds at the construction of small hydropower plants.

Level of development readiness

Fish passes designed by scientists are being built and operate on the rivers of the Caucasus, the Balkans and the Alps. Respective activities are going on the Carpathian rivers of Ukraine.

Advantages

The fish pass structure developed can simultaneously effectively let pass both carp fish, which are benthic migrants, and salmon fish, which inhabit upper water layers.

Fish pass on the Nakra River (Georgia), built relyin on the calculations of the Institute of Hydrobiology

Institute of Hydrobiology

Financing of Science in Ukraine

In 2021, 0.17% of GDP was allocated for science from the State Budget of Ukraine.

In absolute figures it is about 350 million USD including:

NAS of Ukraine about 190 million USD;

universities about 80 million USD;

three years ago the National Research Foundation of Ukraine was founded. This fund finances projects on a competitive basis and last year the fund spent 27 million USD for these purposes.

In 2022 it is planned to allocate about 380 million USD for science, including 215 million USD for the Academy, 88 million USD for universities and about 29 million USD for the National Research Foundation of Ukraine.

This trend gives us some optimism.

Thank you for your attention