

DEPARTMENT of APPLIED PHYSICAL RESEARCHES

**NEAD OF DEPARTMENT of APPLIED
PHYSICAL RESEARCHES**
Harutunyan Vachagan
Dr.of Phvs.Mat. Science

**Laboratory of solid state radiation
physics**

Head Harutunyan Vachagan
Dr. of Phys/Mat. Science

1. Optical measurements team
2. Electro-physical measurements team
3. Linear accelerator operation team

Laboratory of low temperatures

Head Harutunyan Suren
Dr. of Phys/Mat. Science

**Laboratory of radiation
biophysics**

Head Khachatryan Garnik
Ph. D

1. Radiobiology team
2. Biopolymers team

Synthetic diamond research team

Head Navasardyan Hamlet
Ph. D

**High resolution radiation
detectors development team**

Head Mkrтчyn Mkrтчich
Ph. D

Design of experimental devices

Head Avakyan Vardan
Ph. D

**PLANNING EXPENSES FOR CARRY OUT SCIENTIFIC AND
TECHNICAL WORKS IN DEPARTMENT
of APPLIED PHYSICAL RESEARCHES
on 2010-2014 YEARS**

Finance (in USA \$)

Staff: 47

Salary of participants: 987 000

Equipment: 200 000

Travels: 20 000

Goods: 21 000

Infrastructure:

- Power supply – 33 000 kWt

- Water supply –11 500 m³

Miscellaneous expenses: 14 000

Total for 5 years: 1 242 000

Laboratory of Solid State Physics

Head of laboratory

Dr. of Phys. Mat. Science

Vachagan Harutunyan

I. Laboratory Structure and Personnel

History and Staff

In 80's, the laboratory was performing various activities and employed a staff of 40 research and supporting personnel. Special contribution made by Rafael Melkonyan, Slavik Airapetyan, Volodya Gevorkyan, Sergey Babayan, Yuri Nazaryan, Hrachia Abgaryan, Agasi Hovhannisyanyan, Ruben Atabekyan, Rafael Ezoyan, Anzhela Aslanyan, Felix Karapetyan and Levon Tolabchyan was acknowledged and appreciated.

At present highly qualified specialists make the core of the laboratory. Of them Hrant Yeritsyan, Aram Sahakyan, Vachagan Harutunyan, Sergei Nikogosyan, Norik Grigoryan, Eleonora Hakhverdyan, Agasi Hovhannisyanyan and others have to be mentioned. All researchers are involved in International projects.

Special attention is given to study of optical properties of solids in soft X-ray vacuum ultraviolet spectral region using synchrotron radiation (SR).

Thanks to its unique properties (continuous distribution, high intensity, polarization), synchrotron radiation attracts attention of scientists specialized in vacuum ultraviolet and X-ray spectroscopy. Note that among the pioneer investigators of synchrotron radiation in Soviet Union were specialists of accelerator "ARUS" (1971). Since 1972 works on spectroscopy of laser crystals and semi-conductor compounds using SR have been intensively carried out in laboratory. After a year, the employees of Central Institute of Electronic Physics of Academy Sciences of German Democratic Republic and Leipzig University took also part in these investigations within the framework of International cooperation between the USSR State Committee of Atomic Energy and Ministry of Energy of German Democratic Republic. Within the framework of the cooperation, a spectrometer for soft X-ray range was manufactured in German Democratic Republic and mounted in SI-3 channel of accelerator "ARUS" at Yerevan Physical Institute. Using the spectrometer, various materials were measured during 5 years. After shutdown of accelerator "ARUS", and ageing of the channel itself, the works proceed in DESY's HASYLAB.

The structure of radiation physics laboratory is as follows:

- Electro-physical research team;
- Optical research team;
- Linear accelerators operation team.

II. Technical Infrastructure (buildings, premises, energy supply, etc.)

Infrastructure

It should be mentioned that thank to the financing from contractual projects, now the laboratory owns a 3 storied building (**Photo 1**), of 500 m² total area with labs, administrative offices, special facility for 2 linear accelerators (4 and 10 MeV), local library, seminar-hall, special rooms with equipment for optical and electrical-physical studies.

On the ground floor in a special premise meeting the requirements of radiation safety, linear accelerators ELU-4 and ELU-8 are mounted. This premise is adjoined by an experimental hall, where vacuum chamber for imitation of cosmic space (space environment simulator-SES) is mounted;

mechanical workshop; room with a plasma spraying unit BULAT-6, as well as various subsidiary premises.

On the second floor there are premises with experimental devices for electro-physical measurements, automated control of accelerator operation, library, and seminar hall.



Laboratory of solid state radiation physics

Photo1.

On the third floor premises with experimental devices for optical researches (UV and IR spectrometers, vacuum evaporation units VUP-4 are located.

The building is connected to YerPhI electric power and water supply networks as well as to Internet.

Electric power requirement: 10 000 kWtt

Water supply – 5 000m³

III. Scientific Infrastructure (experimental devices, servers, Internet)

Infrastructure

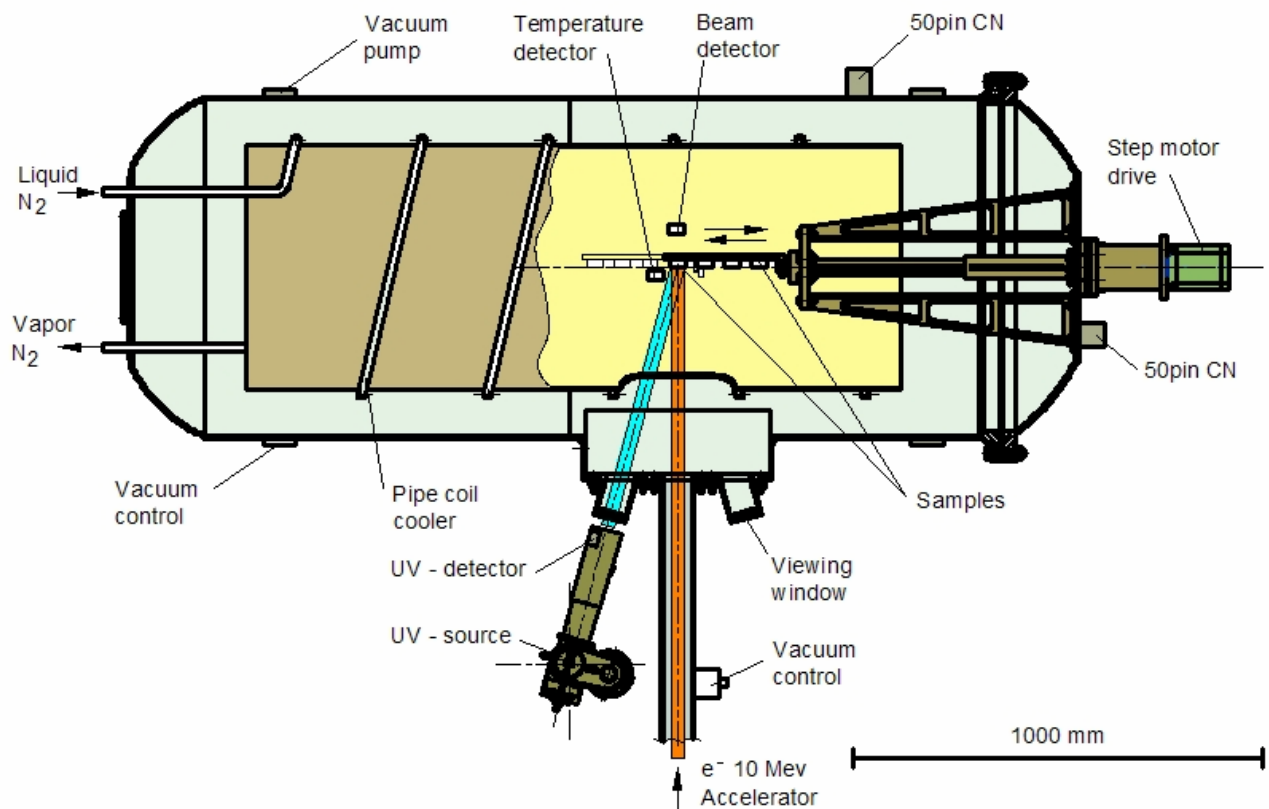
In laboratory there are:

- 2 linear accelerators (4 and 10 MeV), equipment for optical, electrical-physical studies;
- Recently a new facility was created for near Earth environment simulation (Photos 2,3) (electron beam with energy 8-10 MeV, vacuum 10^{-5} Torr, temperature 100K. Note that this it is a unique facility, allowing investigating simultaneously the influence of 4 space factors on the properties of materials and devices;
- Installations for measurement of dielectric constants and electrical conductivity at different temperatures (78 – 370 K) and frequencies from 200 Hz to 1 MHz;

- Installation for measurement of photoluminescence and luminescence excitation at temperatures 77-300 K;
- Photo spectrometer with measuring range from 0.2 to 2.5 microns;
- Vacuum evaporation unit VUP-4.



Connection of space environment simulator (SES) with electron accelerator
Photo 2.



Horizontal section through SES
Photo3.

IV. Scientific Techniques Created and Used in Laboratory

- Techniques of measurement of complex magnetic susceptibility in the range of temperatures 78-370 K for high-temperature superconductive ceramic samples and natural zeolites have been developed. The technique allows measuring of hysteresis losses in high-temperature superconductive environment, superconductive state, density, current.
- Technique of measurement of excitation of luminescence and photoluminescence in UV and VUV spectral ranges for wide-band-gap oxide mono crystals and natural zeolites has been developed.
- Technique of measurement of doses of irradiation of materials by high-energy electrons (10,50 MeV) has been developed.
- Calculation procedure of optical absorption and reflection of semi-conductor materials and natural zeolites has been developed.

Y. Summary of the Projects Implemented For the Last 5 years (2004-2008) Including International Cooperation and Grants.

During 2000-2009: Scientific projects No 0264 (2002-2004) and No 0223 (2005-2007) devoted to complex systematic research of mono crystals and natural zeolites for the purpose of investigation of radiation stimulated processes in a wide spectral range (visible region, UV, VUV, X-ray region, IR) were implemented under financial support of Ministry of science and education. With the advent of opportunity of using SI, the spectral range of the research has been essentially expanded. Besides, new methodical possibilities for VUV spectroscopy were opened, in particular, related to the use of pulse time structure of SI.

Scientific and Practical Significance of 2000-2009 Activities

During several decades, basic investigations in the field of condensed state physics were devoted to the crystals with extreme properties such as wide-band gap oxide mono crystals (laser crystals: corundum ($\alpha\text{-Al}_2\text{O}_3$), ruby ($\alpha\text{-Al}_2\text{O}_3\text{:Cr}^{3+}$), garnet ($\text{Y}_3\text{Al}_5\text{O}_{12}\text{:TR}^{3+}$)), diamonds, semiconductors, high-temperature superconductors, natural zeolites, which are of both scientific and applied interest. This is due to significant extension of the range of their application in various areas.

Thanks to their high irradiation stability, they can be used in zones with increased radiation, for example in the space environment. It is especially important to have fast time response for the detectors operating at high load, for example, in electromagnetic calorimeters, in experiments on high energy physics at modern super-colliders.

The increase of irradiation stability of crystals promoted the increase of reliability and durability of devices, in which the above-stated crystals are used.

Of high interest is also investigation of properties of natural Armenian zeolites, which can be used to treat radioactive wastes at nuclear power plants.

Basic experimental and theoretical results are formulated as follows:

1. It is experimentally revealed that at irradiation by high energy electrons and neutrons, ions are induced in the lattice of single-crystal sapphire and ruby. Stable structural defects are formed in anionic sub-lattice corresponding to F, F⁺ and AiF⁺ color centers.

2. Processes of accumulation of anionic and cationic centers in corundum at irradiation by fast electrons (50 MeV) are presented experimentally and theoretically. Values of oscillator strength are determined for transitions between ground and excited states of color centers at maximum absorption frequencies.

3. Optical “effect of small doses” is revealed in the process of electronic irradiation in corundum

with two competing mechanisms: operate is found out optical: "curing" (ordering) of crystal lattice and recharge of pre-radiation defects, which depend on the crystal history.

4. Substantial growth of intensity of photoluminescence and luminescence excitation of R - lines in ruby after irradiation by fast electrons with subsequent heat treatment at 575-625 K is experimentally received.

5. In corundum crystals irradiated by high-energy particles, strong increase of reflecting capacity is revealed in wide energy range (5-30 eV, 70-200 eV and 530-550 eV) owing to radiation stimulated desorption leading to the formation of reduced Al phase Al on the surface – effect of “mirror reflection”.

6. Features of the processes of multiplication of electronic excitations in a lot of wide-gap crystals and their role in energy transfer to the luminescence centers are studied, as well as effect of irradiation on these processes.

7. UV and VUV luminescence (fast and slow components) of color centers, radiation centers in crystals of corundum, ruby, garnet, phosphorus with high time resolution is studied, nature of which is interpreted on the basis of power levels of energy levels of radiation centers.

8. The effect of “radiation memory” corundum crystals irradiated by fast electrons after heating at 1000°C and irradiation by SI-quanta with energy $h\nu \sim 12$ keV, when concentration of color centers does not reach the levels before heating.

9. For the first time complex research of radiation-optical properties of natural Armenian zeolites, in particular, clinoptilolite was carried out. Opportunity of using the modified zeolites for deactivation of liquid radiating wastes from Armenian nuclear power plant was revealed.

10. Characteristic features of VUV luminescence was studied, in particular, up-conversion luminescence of fluoride crystals activated by Er^{3+} ions. It was shown that spectra of emission and excitation of YAG: Nd^{3+} crystals are caused by intraconfigurational and interconfigurational transitions. Probabilities of the mixed transitions were theoretically simulated.

11. Changes of critical parameters were studied depending on the amplitude of applied the enclosed magnetic field h_0 and frequency f for the samples on the basis of Y and Bi with various doping substitutional elements before and after their irradiation by electrons with energy 4 MeV and 8 MeV.

12. It is determined that at the change electron irradiation dose, T_c^{on} and T_m^{J} reveal a reversible change of their initial values by no more than one degree. Such behavior testifies that the complex multi-stage radiation defect formation processes are responsible for their change.

13. It is revealed that with increase of irradiation dose, J_c , in general, decreases, however at a dose of $8 \cdot 10^{16}$ e/cm² strongly pronounced local minimum is detected coinciding with the same minimum and for the parameters T_c^{on} and T_m^{J} . It is supposed that this minimum is caused by annealing of instable Fraenkel defects heating at $T_{\text{irrad}} = 100^\circ\text{C}$ and formation of more stable secondary radiation defects containing both native and doped atoms. Introduction of doped Fe and Ni atoms results in small displacement of this minimum to the area of low doses and simultaneous deceleration of J_c at higher doses (up to 10^{18} e/cm²).

14. It is revealed, that after irradiation of high-temperature superconductor samples by high energy electrons (4 MeV and 8 MeV), the formed radiation defects migrate after the termination of the irradiation and cause changes of critical parameters over a long period. This effect is named "ageing"

or "memory" effect and was observed by other authors. The observable effect depends on initial structure of samples, irradiation conditions as well as temperature and time of after radiation.

15. Dynamics of Josephson in superconducting ceramics $\text{YBa}_2\text{Cu}_3\text{O}_y$ was studied in a frequency interval 0.01-0.5 Hz in mode of incomplete penetration of magnetic field. It was determined that real χ' and imaginary χ'' parts of magnetic susceptibility have complex frequency dependence. It was revealed that dynamic magnetic susceptibility, depending on frequency and amplitude of magnetic field, shows two important features:

- With increase of frequency growth (starting with 0.01 Hz), constant and variable component $\Delta\chi'$ and χ'' of magnetic susceptibility appear;
- In the first half-period of sinusoidal field, two asymmetric peaks of χ' and χ'' susceptibility components appear.

International cooperation

In a period from 2000 to 2009, complex research of radiation-optical properties of wide-band-gap crystals and natural Armenian zeolites has been carried out. The work was conducted together with a number of the research centers, in particular, those where synchrotron radiation is used.

Among the Centers there are:

1. Lomonosov Moscow State University, Physics Department, Chair of Optics and Luminescence.

Head of the program: Prof. Mikhajlin V.V.

2. Lebedev Physics Institute, Moscow, Russia, Laboratory of high energy physics.

Head of the program: Dr of phys.-math. sciences Makhov V.N.

3. University of Tartu, Physics Institute, Estonia, Laboratory of oxide crystals.

Head of the program: Prof. Kirm Marko.

4. Iv.Javakhishvili Tbilisi State University.

Head of the program: Prof. Kekelidze N.P.

5. Department of Biology and Chemistry, University of Hong Kong, P.R.China.

Head of the program: Prof. Peter A.Tanner.

6. Laboratory HASYLAB, DESY synchrotron, Hamburg, Germany.

Head of the program: Prof. George Zimmerer

7. Physics institute, Syria. Department of theoretical physics.

Head of the program: Prof. S. Sulejman.

8. Istituto per lo Studio dei Materiali Nanostrutturati Dipartimento di Chimica Roma.

Head of the program: E. Kekheyan.

9. Technical University of Crete.

Head of the program: Prof. J. Cristidas

International grants:

4 ISTC projects were implemented in Solid State Radiation Physics Laboratory:

- 1. ISTC A-485**(1999-2003)
- 2. INCO Copernicus**(1999-2003)
- 3. ISTC A-1229** (2006-2009)

Manager Yrityan G. N, Dr of Phys.-math. sciences.

“Simulating Space Conditions and their Effect on Materials and Devices Intended for Application in Space”. The period of implementation is 3 years, i.e. the project will end in 2009, after which the laboratory will have a Space simulating Chamber with the above mentioned parameters. Thus, the Project will offer the possibility of obtaining valuable fundamental scientific information on the influence of the Space environment extreme conditions on the materials and devices (Irradiation by electron with energy 8-10 MeV, Solar ultraviolet, Vacuum 10^{-5} Torr., Temperature 100 K).

4. ISTC A-1605 (2009-2011)

“Development of Highly Effective Filtering Systems on the Basis of a Super-Thin Basalt Fiber for Radioactive Aerosols Purification and Creation of a Work Cycle for Filters Manufacturing with the Purpose of Their Operation at the Nuclear Power Plants”

Manager: Harutyunyan V.V., Dr of Phys.-math. sciences.

Now the team is implemented 2 projects financed by international grant-making organizations. Benefits offered by this working model among others include financial stability and improved international collaboration.

At present the Laboratory is involved in program of International Scientific and Technical Center (ISTC) by the grant “Simulating Space Conditions and their Effect on Materials and Devices Intended for Application in Space.” There are about 25 participants in this project: doctors and candidates of physics, engineers and technicians. The aim of this project is to study the influence of irradiation (electron with energy 8-10MeV and solar ultraviolet) on the main properties of materials and devices under conditions of Vacuum 10^{-5} Torr., Temperature 100K. The predicted finishing period is 3 years, i.e. the end of 2009, after which the laboratory will have a Space simulating Chamber with mentioned above parameters. Thus, the Project will offer the possibility to obtain valuable fundamental scientific information regarding the Space environment effect and extremal conditions on the materials and devices.

For more detailed information on ISTC projects see <http://www.istc.ru>

VI. 2009-2013 Projects with information on needed financing and list of executors.

2009-2013

Plans and Projects

Actuality:

The offered project will promote the development of some perspective directions in Armenia - instrument engineering on the basis of diamonds, semi-conductors and high-temperature superconductors, as well as the use of natural zeolites and basalts for cleaning of radioactive waste and aerosols in zones of increased radiation.

Armenia is one of very few countries possessing technologies of synthesis of diamond, including unique ones (for example, synthesis of very pure mono-disperse micro-powders both at high pressure and temperature application and without high pressure).

Diamond, which is often called “the XXI century material”, is a substance with unique properties. For a long time it attracts scientists, including the YerPhI from laboratory of radiation solid state physics. Diamond can become a real alternative to silicon in electronics. Its electric, optical and chemical characteristics are extreme in comparison with similar properties of other materials - corundum, garnet, germanium, etc. For the first time in world practice, super pure diamonds were synthesized in Armenia using cavitations process, i.e. without traditional devices creating ultrahigh pressure and temperature.

Within the framework of the proposed project, diamond detectors for radiation monitoring in the territory of Armenian nuclear power plant, nuclear waste disposal sites, as well as for application in high energy physics will be developed and investigated. These detectors will be also applied for monitoring of ultra-violet radiation in the industry and environmental monitoring.

Project Objectives:

Task 1.

Research of influence of irradiation (electron, UV radiation) on stimulated processes in diamonds.

With this end in view, it is necessary to carry out:

1. Investigation of optical properties of diamond ceramics (disks sized up to 20x5 mm with the following characteristics: porosity of 0.5-1.7 %; heat conduction coefficient: not less than 270 W/mK; dielectric capacitivity: less than 3.0; Young's modulus: not less than 600 MPa) in wide spectral area - visible, ultra-violet, VUV regions at various temperatures.
2. Research of influence of electron and UV radiation on electronic structure and formation of radiation color centers of diamonds at various intensity temperature of radiation.
3. Influence of radiation (electron and UV radiation) on electro-physical, magnetic properties of porous diamond ceramics depending on temperature.
4. Development and manufacturing of radiation resistant detectors, heat removals (1600-200 W m/grad) on the basis of doped diamond mono crystals for the use in zones of increased radiation.

Task 2.

Research of regularities of the processes of excitation of rare-earth elements in wide-band-gap crystals using VUV spectroscopy

Numerous researches have shown [1] that of the greatest interest for VUV spectroscopy are processes of excitation and relaxation of high-energy states of rare-earth ions in crystals such as corundum ($\alpha\text{-Al}_2\text{O}_3$), garnet ($\text{Y}_3\text{Al}_5\text{O}_{12}:\text{TR}^{3+}$) [3], fluorides ($\text{LiYF}_4:\text{TR}^{3+}$, $\text{BaY}_2\text{F}_8:\text{TR}^{3+}$) [4,5], diamond [6,7] characterized by a unique set of both physical and luminescent-optical properties: the presence of a wide band-gap, high mechanical and radiation hardness, low refraction coefficient, Wednesday, low hygroscopicity, chemical inertness in a wide range of operational conditions.

Besides, the interest to study of wide band-gap crystals is related to the use as active medium for UV and VUV lasers, scintillators, detectors of nuclear radiations, optical memory systems, as well as in photochemistry, isotopic separation, etc. [1,2].

Thanks to application of SI, new methodical opportunities for VUV spectroscopy related to the use of pulse time structure of SI have appeared in many international scientific centers.

It is supposed to carry out the following investigations:

- I. Study of fast UV and VUV luminescence in wide-band-gap crystals of ruby ($\alpha\text{-Al}_2\text{O}_3$), garnet ($\text{Y}_3\text{Al}_5\text{O}_{12}:\text{TR}^{3+}$), fluorides ($\text{LiYF}_4:\text{TR}^{3+}$, $\text{Y}_2\text{F}_8:\text{TR}^{3+}$) using high-intensity SR radiation in X-ray range.
- II. Influence of radiation stimulated processes on quantum yield of luminescence in the crystals activated by rare-earth ions.

Task 3.

Research of the influence of electronic and UV radiation on semi-conductors and high-temperature superconductors (YBa₂Cu_{3-x}MxO_y (M = Fe, Ni; x=0; x=0.01)).

It is supposed to carry out following researches:

1. Identification of regions for improvement and degradation of characteristic parameters of samples at a fixed intensity of electron beams [16-18].
2. Revealing of influence of electron beam and UV radiation intensity in situ research of samples at high vacuum (10^{-5} Torr) and various temperatures (100-300) K [19-27].
3. Research of post-radiation phenomena (effects of ageing or memory) after and UV radiation at various doses and temperatures [19, 25, 26].
4. Investigation of radiating stability of samples in the presence of magnetic field and under simultaneous action of all factors simulating space conditions [16,19, 25-28].

Task 4.

Study of influence of stimulated processes on filtration properties of natural zeolites and basalts.

It is supposed to carry out the following research:

1. Study of influence of electron irradiation on adsorption, electro-physical and optical properties of the modified zeolites [8 -12].
2. Study of influence of various types of processing on structure and filtration properties of basalt [13-15].

Technical advantages of new experimental installation "SES" consist in the fact that samples are investigated in the presence of simultaneously four parameters: electron irradiation, UV irradiation, high vacuum and low temperature. At present it is one of the most competitive installations among many known foreign installations available in International research centers, which allow as a rule variation of two or three above parameters. For example, for Cloud Chamber (CERN) only three parameters can be varied: proton beam, vacuum and low temperature.

Techniques of object measurements:

1. Linear electronic accelerators ELU-10 (8-10 MeV) and ELU-50 (50 MeV).
2. Vacuum chamber for irradiation of samples at temperatures 120-140K and vacuum 10^{-5} - 10^{-6} Topp.
3. Installation for UV radiation at wavelengths of 240-350 nm.
4. Spectroscopic installations for UV and IR absorption regions.
5. Devices for measurement of conductivity, magnetic susceptibility, heat processing.
6. PC with specialized software for processing of the obtained experimental results.
7. Installation SUPERLUM1 with high time resolution for spectral kinetic measurements in UV, VUV and X-ray spectral regions at temperatures 8-10K (DESY).
8. Spectral installation for the kinetic research of time resolved spectra in VUV region (10-30eV) at accelerator S-60 (FIAN).

Expected results of Project implementation:

1. Diamond detectors of alpha particles, neutrons and soft X-ray radiation - porous detectors on the basis of diamond powder, which can have 100 % efficiency of registration of nuclear radiation and up to 70 % efficiency of registration of soft X-quanta.

2. Diamond detectors of UV and visible radiation. Forbidden bandwidth in diamonds is 5,5eV, by virtue of which detectors on the basis of diamonds (including doped ones) can be sensitive to visible light too.

These devices should be resistant not only to radiation, but also to high temperature, chemical attack, etc. That is their dissimilarity from the detectors made of other materials (for example, silicon).

For the Armenian nuclear power plant it is necessary to develop diamond detectors of radiation with the following technical characteristics:

Type	Unit	Range	Output signal level, pulses per sec
γ -1	m3V/g	$1,8 \cdot 10^3 - 0,36$	3,5-700
γ -2	m3V/g	$36 - 3,6 \cdot 10^4$	$1,8 \cdot 10^3 - 1,8 \cdot 10^6$

Operating conditions	Temperature	Humidity
Normal	60°C	90%
Emergency	200°C	95%

Expected service life: 30 years.

There is a control and measuring stand for rating radiation and doses at the Armenian NPP. This system will be used at certification and calibration of new diamond detectors.

Finance (in USA \$)

Staff -13 persons

Salary of participants: 273 000

Equipment: 50 000

Travels: 10 000

Goods: 5 000

Infrastructure:

- Power supply - 10 000 kWtt

- Water supply – 5 000m³

Miscellaneous expenses: 4 000

Total for 5 years: 342 000

List of executors

1. Harutyunyan Vachagan - Head of department of applied physical research. Head of radiation laboratory of solid state physics, Doctor of phys.-math. Sciences.
2. Yeritsyan - leading researcher, Doctor of phys.-math. Sciences.
3. Sahakyan Aram - leading researcher, Candidate of phys.-math. Sciences.
4. Grigoryan Norik - senior researcher, Candidate of phys.-math. Sciences.
5. Nikogosyan Sergey - senior researcher, Candidate of phys.-math. Sciences.
6. Baghdasaryan Valery - senior researcher, Candidate of phys.-math. Sciences.
7. Navasardyan Hamlet - senior researcher, Candidate of phys.-math. Sciences.
8. Akhverdyan Eleonora – engineer.
9. Khachatryan Grisha – engineer.
10. Oganesyanyan Agasi - engineer
11. Ohanyan Karen - engineer
12. Aleksanyan Edward – postgraduate student
13. Hakopyan Narek - diploma student.

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1. Арутюнян В.В. Исследование оптических свойств радиационно-примесных дефектов в широкозонных оксидных монокристаллах с применением синхротронного излучения. Докторская диссертация, Ереван, 2000, с.242. (Harutunyan V.V. Issledovanie opticheskikh svoistv radiacionno-primesniih defektov v shirokozonniih oksidnih monokrastallah s primeneniem sinhrotronnogo izlucheniya. Doktorskaia dissertacia, Yerevan, s.242, 2000. (in Russian))
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Low Temperature Laboratory

Head of Low Temperature Lab

Doctor of Phys. Mat. Science

Suren Harutyunyan

1 (Base)

History (till 1990)

The Low Temperature Lab in Yerevan Physics Institute was established in 1967. The first area of investigations was theoretical and experimental researches of Fermi surfaces for various metals (were carried out jointly with the IPhP, Moscow).

In the beginning of experiments on the Electron Accelerator at YerPhI there were set the experiments using liquid hydrogen and deuterium targets based on external cooling with liquid helium. This approach has been applied worldwide on many Accelerators later. The main condition was to have not more 1 l of liquid hydrogen in target in case when operation time of target should be many hundreds of hours. The original concept based on liquid helium evaporation cooling was developed and the liquefier of hydrogen, heavy hydrogen and neon was manufactured. Made targets successfully worked at accelerator about 10000 hours.

In parallel with this work in 1985 was developed and manufactured continuously working adsorption cryogenic refrigerator (ACR) without low temperature valves.

A considerable success was achieved in ultralow thermometry. In collaboration with Ukrainian physicists (FTINT) was developed and manufactured Crystallization Thermometer based on helium-3 in which the primary signals measurements were done on cryogenic electronics specially developed in LTL.

Another direction of Lab's activities was the researches of overheated superconducting granules as a Detecting medium. The results of these researches enabled to study the physical aspects of overheated superconducting state in micron-sized granules and demonstrated availability of using superconducting granules for building the detectors of elementary particles.

Researches on Josephson environment in high temperature superconducting ceramics (HTSC) were another direction. As a result, it was proved that using the HTSC with Josephson medium for development of magnetometers sensible as SQUID magnetometers is possible.

The applied researches also attract attention in LTL: large scale superconducting magnets for proton-polarized target, magnet systems for transportation of drugs in patient body, superconducting magnet systems for engine of high speed overland railway. LTL provides also investigations in area of high temperature superconductivity.

LTL infrastructure:

LTL is based on the Building N30 of YerPhI including two experimental halls, mechanical workshop, experimental rooms.

Originally, LTL was created as a laboratory of a experimental bias, therefore, there were an equipped machine-shop, a special soldering sector, and two big experimental halls.

II. (Recent results since 1990)

Since 1990 the experiments on the 6 GeV synchrotron were stopped and the activity of the lab were switched mainly on the low temperature investigations (high temperature superconductivity and ultralow thermometry). In frame of INTAS Project (head of Project Ananikyan N.S.) original ultralow thermometer on the vibrating wire base was developed for absolute temperature range about 1 mK.

A new area of activity was expanded aimed to accelerator diagnostics. The main idea was that in limitation of YerPhI accelerators continuous run the better choice is accelerator diagnostic systems

development. Based on the previous investigations of ultrarelativistic beam fields made by lab research workers a new proposal for femtosecond duration electron bunches measurement by electrooptical mechanism of transform of electric fields of bunch into laser beam femtosecond modulation. In future this idea was successfully realized in DESY. Another proposal aimed on channeling radiation usage for beam diagnostics was developed. However realization of these proposals needed modern expensive equipment which was absent.

Understanding that accelerator diagnostics can alive only in presence of experimental activity a new goal was stated: to develop a beam sensitive sensor that react on the low number of particles. Such a sensor was created on the base of unique vibrating wire electromechanical resonators. The developed methods of fixation of wire ends by hard-alloy clips, usage of defined thermomechanical treatment, choose of wires, magnets and housing materials and development of special methods of wires oscillation generation and measurement allowed achieve unprecedented values of accuracy. The important advantages of properly constructed vibrating wire sensors were inherent long-term stability, high precision and resolution, good reproducibility and small hysteresis. As a result relative accuracy of 10^{-6} was achieved. The equivalent beam current accuracy corresponds to picoamps deposited on the wire.

Developed type of resonator was used for original vibrating wire sensors/monitors (VWM) for the measurement of beam transversal characteristics of charged-particle and photon beams.

By means of these devices, measurements of an electron beam in the Yerevan synchrotron, a proton beam at PETRA (DESY), and a hard X-ray undulator beam at the APS (ANL) have been performed.

The first scanning experiments on a charged beam were done on an electron beam at the Injector of Yerevan Synchrotron with an average current of about 10 nA (after collimation) and an electron energy of 20 MeV.

A series of experiments with the VWM were done on proton beam of the accelerator PETRA at DESY.

The vibrating wire scanner was also tested on an ion beam of energo-mass-analyzer EMAL-2. Approximately 16 pA of beam current interacted with the wire and a frequency decrement of about 0.15 Hz was measured.

Hard X-ray flux measurements with a vibrating wire monitor with two wires were conducted at APS. Vibrating wire sensor was used also for laser beam scan. This task is especially actual for infrared lasers.

Taking into account the extreme sensitivity of the vibrating wire sensors was suggested to place the VWM outside of vacuum to detect only very hard x-rays that penetrate the chamber at selected locations. The addition of convective cooling would reduce the response time substantially albeit with reduced sensitivity. The special 5 wire VWM was developed and manufactured. The sensor was mounted on the outboard side of a bending-magnet synchrotron radiation terminating flange in sector 37 at the APS storage ring.

The possibility of neutron beam measurements by VWM in Spallation Neutron Source (SNS) is discussed. SNS now provides the most intense pulsed neutron beams in the world for scientific research and industrial development.

Vibrating wire resonator was used also for original tension sensor development by which the critical parameters of superconductivity were investigated.

On the same principle a special device for magnetic fields gradient measurements was developed. Such device can be very useful for accelerator magnetic field components tests and calibrations.

Short resume

Vibrating wire sensors can be used for any types of beam diagnostics in accelerators because only a very little amount of heat transfer from measured beam to the wire is needed. Therefore vibrating wire sensors can be successively applied for electron, proton, ion, neutron and photon beams monitoring. It is very important that in each of mentioned area due to extreme sensitivity vibrating wire monitor (VWM) can solve specific tasks that impossible to provide by other existing

technologies. In charged beams diagnostics it is possible to monitor the weak beams and to measure beam halo and tails. For photon beam it is possible to measure very hard spectral components. Because of this one can measure only necessary part of radiation from insertion devices and cut unwanted contributions from other accelerator units. Possible area of VWM application can be neutral beam diagnostics (neutrons, ion beams with uncompensated positive and negative charged particles, plasma). New usage of VWM in air allow to decrease important parameter of response time and reduce VWM cost by a large factor. So VWS concept shows a lot of promise in accelerators diagnostics due to its very high sensitivity and overall simplicity in both the mechanical design and electronics

III. (Projects, Grants, Collaborations)

- “RESEARCH AND DEVELOPMENT OF VIBRATING WIRE SENSORS FOR ACCELERATORS BEAMS DIAGNOSTICS AND THERMOGRAVIMETRY”, ISTC Project A-347 (head S.G.Arutunian), **01.01.2001-30.09.2004.**
- In frame of agreement between YerPhI and DESY, “Installation of Vibrating Wire Scanners into Accelerator PETRA, DESY”, **10.03.2003-31.05.2004.**
- Kooperationsvertrag über einen zeitweiligen Personalaustausch zum Zwecke des Know-how-Transfers im Rahmen des Programms Förderung der Erhöhung der INNOVationskompetenz mittelständischer Unternehmen (PRO INNO II) des Bundesministeriums für Wirtschaft und Arbeit (BMWA) zwischen der Firma: HTM Reetz GmbH, Köpenicker Strasse 325, 12555 Berlin und der Forschungseinrichtung: Jerewaner Physikalische Institut (JerPhI), “Wasserstoffdetektor”, **01.03.2005-31.07.2007.**
- Collaboration with Advanced Photon Source (ANL), G.Decker, “Vibration wire monitor for photon beam diagnostics: tests in APS ANL Beamline SBC-CAT-19-ID-D: Sector 19 - Insertion Device Beamline”, **23.01.2007-30.01.2007.**
- Collaboration with Advanced Photon Source (ANL), G.Decker, “HARD X-RAY SYNCHROTRON RADIATION MEASUREMENTS AT THE APS WITH VIBRATING WIRE MONITORS”, **20.01.2008-27.01.2008.**
- Cooperation between LTL of YerPhI and HTM Reetz GmbH is continued under agreement signed in 2007.
- In 2008 Head of LTL S.G.Arutunian was recognized as winner of the 2008 **Faraday Cup Award** in accelerators diagnostics for the development, publication and successful testing of the diagnostic system “**Vibrating wire scanner**”.

List of some recent publications of the Laboratory

1. Arutunian S.G., Dobrovolski N.M., Egiazarian S.L., Mailian M.R., Sinenko I.G., Sinjavski A.V., Vasiniuk I.E., Magnetic field distribution measurement by vibrating wire strain gauge,- Proc. of the 1999 Particle Accelerators Conference, New York, 1999, pp. 1468-1470.
2. Arutunian S.G., Dobrovolski N.M., Mailian M.R., Sinenko I.G., Vasiniuk I.E., Vibrating wire scanner for beam profile monitoring, Proc. of the 1999 Particle Accelerators Conference, New York, 1999, pp. 2105-2107.
3. Arutunian S.G., Dobrovolski N.M., Mailian M.R., Sinenko I.G., Vasiniuk I.E., Vibrating wire for beam profile scanning", Phys. Rev. Special Topics - Accelerators and beams, vol. 2, 122801 (1999).
4. Arutunian S. G; Dobrovolski N. M; Vasinyuk I. E; Mailyan M. R., The miniaturization of the sensor with taut vibrating string, used in ultralow Temperature Thermometer.- YerPhI internal report, 2000.

5. Sarkisyan A. G., Agababyan K. Sh., Dobrovolski N. M. et al, Study of the possibility of new Type magnetometer design with sensitive elements from HTSC ceramics with Josephson medium, International Seminar: Conversion potential of Armenia and ISTC program, Reports, part 1, pp. 188-192, Yerevan, 2000.
6. Arutunian S. G.; Dobrovolski N. M.; Vasinyuk I. E.; Mailyan M. R. Superconducting thermomemeter on the base of vibrating wire resonator.- internal report, 2000.
7. Arutyunyan S.G., Vasinyuk I.E., Dobrovol'skii N.M., Egiazaryan S.L., Mailyan M.R., Sinenko I.G., Measurement of magnetic field gradients using a vibrating wire gauge.- Instruments and Experimental Techniques, v. 43, 5, p.701, 2000.
8. Arutunian S.G., Vasinyuk I.E., et al. Nonselective receiver of laser radiation on the basis of vibrating wire, - Proc. Conference Laser 2000 (November 2000, Ashtarak, Armenia).
9. Arutunian S.G., Werner M., Wittenburg K. Beam tail measurements by wire scanners at DESY.- ICFA Advanced Beam Dynamic Workshop: Beam HALO Dynamics, Diagnostics, and Collimation (HALO'03) (in conjunction with 3rd workshop on Beam-beam Interaction) (May 19-23, 2003 Gurney's Inn, Montauk, N.Y. USA).
10. Arutunian S.G., Dobrovolski N.M., Mailian M.R., Oganessian V.A., Vasiniuk I.E. Vibrating wires fence as a negligibly destructive beam profile and beam position monitor.- Proc. of the NATO Advanced Research Workshop on Electron-Photon Interaction in Dense Media, (25-29 June 2001, Nor Amberd, Armenia), NATO Science Series; II Mathematics, Physics and Chemistry, v. 49, pp. 303-308.
11. Arutunian S.G., Avetisyan A.E., Dobrovolski N.M., Mailian M.R., Vasiniuk I.E, Wittenburg K., Reetz R., Problems of Installation of Vibrating Wire Scanners into Accelerator Vacuum Chamber.- Proc. 8-th Europ. Part. Accel. Conf. (3-7 June 2002, Paris, France), pp. 1837-1839.
12. Arutunian S.G., Bakshetyan K.G., Dobrovolski N.M., Mailian M.R., Soghoyan A.E., Vasiniuk I.E., First experimental results and improvements on profile measurements with the vibrating wire scanner.- Proc. DIPAC'2003, (5-7 May, Mainz, Germany 2003), pp.141-143.
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14. Arutunian S.G., Bakshetyan K.G., Dobrovolski N.M., Mayilyan M.R., Oganessian V.A., Soghoyan A.E., Vasiniuk I.E., Wittenburg K., Vibrating wire scanner parameters optimization.- Proc. 9-th Europ. Part. Accel. Conf. (5-9 July 2004, Lucerne, Switzerland), pp. 2457-2459.
15. V.Sh. Avagyan, A.Z.Babayan, N.M. Dobrovolski, I.V. Tunyan, Diffusion welding of heterogenous materials in accelerating technique, Proc. 9-th Europ. Part. Accel. Conf. (5-9 July 2004, Lucerne, Switzerland), pp. 1586-1587.
16. Aginian M.A., Arutunian S.G., Hovhannisyan V.A., Mailian M.R., Wittenburg K., Vibrating wire scanner/monitor for photon beams with wide range of spectrum and intensity.- "Advanced Photon Sources and Their Application" (Nor Amberd, Armenia, August 29 - September 02, 2004).
17. Arutunian S.G., Bakshetyan K.G., Dobrovolsky N.M., Mailian M.R., Poghosyan L.A., Sinenko I.G., Soghoyan H.E., Vasiniuk I.E. (YerPhI), Wittenburg Kay (DESY) PETRA proton beam profiling by vibrating wire scanner, DIPAC 2005.
18. Aginian M.A., Arutunian S.G., Mailian M.R., Vibration wire monitor for photon beams diagnostics: preliminary tests on laser beams. - NATO Advanced Research Workshop, CANDLE (17-21 July, 2006 Yerevan, Armenia), "Brilliant Light Facilities and Research in Life and Material Sciences", pp. 475-478.
19. Arutunian S.G., Review of Electron and Photon Beam Diagnostics in Advanced Light Sources. - NATO Advanced Research Workshop, CANDLE (17-21 July, 2006 Yerevan, Armenia), "Brilliant Light Facilities and Research in Life and Material Sciences", pp. 429-439.
20. S.G. Arutunian, M.R. Mailian, Kay Wittenburg, Vibrating wires for beam diagnostics, Nuclear Instruments and Methods in Physics Research A 572 (2007) 1022–1032.
21. Decker G., Arutunian S., Mailian M., Rosenbaum G., First vibrating wire monitor measurements of a hard X-ray undulator beam at the Advanced Photon Source. – DIPAC 2007.

22. Arutunian S.G., Decker G., Mailian M.R., Rosenbaum G. Transition thermal processes in vibrating wire monitor. DIPAC 2007.
23. Decker G., Arutunian S., Mailian M., Vasiniuk I. Hard X-ray synchrotron measurements at the APS with vibrating wire monitor. – Beam Instrumentation Workshop, BIW08, (May 4-8, 2008, Lake Tahoe, USA).
24. Arutunian S.G. Vibrating wire sensors for beam instrumentation. - Beam Instrumentation Workshop, BIW08, (May 4-8, 2008, Lake Tahoe, USA).
25. Arutunian S.G., Decker G., Harutyunyan G.S., I.E. Vasiniuk I.E. – Heat coupling in multi-wire vibrating wire monitor. – 21st Russian Particle Accelerators Conference (28 Sept. - 3 Oct., 2008, Zvenigorod, Russia).
26. Arutunian S.G., Gevorkian Zh.S., Diffusive radiation from rough surfaces for beam diagnostics.- Presented at DIPAC 2009.
27. Arutunian S.G., Bergoz J., Davtyan M.A., Decker G., Harutyunyan G.S., Vasiniuk I.E., Impact of Environmental Variability on Vibrating Wire Monitor Operation.- Presented at DIPAC 2009.

IY. (New suggestions)

The main aims for next 5 years:

1. Development of vibrating wire scanners/monitors for accelerators beam diagnostics and more wide usage (vibrating wire monitors/scanners of charged particle, neutron and photon beams).
2. Development of ultralow thermometers.
3. Development of High Temperature Superconducting magnetometer with Bismuth ceramics for geomagnetic monitoring.
4. Development of cryogenic targets for high energy experiments based on essentially new principle of cooling with cryorefrigerators.
5. Development of unique cryogenic targets for xenon isotope separation and extraction.

Specific targets

6. To extend of VWM usage on the electron beams with short bunches it is necessary to avoid to avoid electromagnetic disturbances induced by electromagnetic wake-fields on the wire very perspectives will be the development of sensors on basis of dielectric wires, including new type of oscillations exciting and data acquisition bunches.
7. Development of electronics for simultaneous excitation of oscillations of wires, interface PC boards and software for data acquisition and processing; development of two fixed position wire electromechanical resonator for positioning of the beam).
8. Adaptation of VWP to industrial ion beam sources for precise measurement of intensity of its ion current component (comparative theoretical and experimental investigations of wire heating under ion and electron irradiation; comparison of information about ion current obtained from VWP via nonelectromagnetic interaction with the traditional current meters based on measurement of total charge transfer; development of the VWP based sensors for measurement of electron and ion components in industrial ion sources).
9. Profiling of the electromagnetic radiation beams of wide range of wavelength by means of fence of vibrating wires. Monitoring of synchrotron, laser and noncoherent radiation by VWP (theoretical investigation of wire heating irradiated by electromagnetic radiation beams of different wavelength and intensity; development of a specialized sensor based on the fence of vibrating wires for electromagnetic radiation accompanying the beam; calibration of the fence of vibrating wires using lasers with different wavelengths and pulse durations; comparison of obtained results with traditional methods; development and application of VWP for alignment of accelerator components by means of laser beam tracing; application of the VWP and tracing laser for detecting of laser beam center of mass with respect to each component to be aligned).

10. Neutron beams diagnostics in Spallation Neutron Source (SNS) type machines. Theoretical and numerical estimations of influence of neutron fluxes with wide energy spectrum on wire oscillations frequency; development of vibrating wire resonators sensitive to neutron fluxes; Calibration of developed resonators in neutron flux of Armenian Nuclear Power Plant.
11. Research and technological investigations on vibrating wire electromechanical resonators. Development and investigation of vibrating wire electromechanical resonators with nonround wires; investigation of the normal oscillation damp for measuring of Q-factor of the vibrating wire based resonators as an additional source of information (passive mode vibrating wire resonators); development of the frequency and Q-factor measurements based on the piezoelectric scheme of information acquisition; development of schemes for electrically impact excitation of oscillations and methods of the oscillations decrement measurement; development of the piezo, electrostatic and/or mechanical impact excitation methods of the oscillations including parametric excitation; search of heat resistance materials for vibrating wire electromechanical resonators;
12. Development of miniature ultralow sensors with taut vibrating wires on the capsule model.
13. Development of High Temperature Superconducting magnetometer with Bismuth ceramics for geomagnetic monitoring. The aim is long-term measurements of the earth magnetic field fast and slow variations in parallel with another measuring systems. The suggested method is unique because of his independence of field heterogeneity.
14. Development of cryogenic targets for high energy experiments based on essentially new principle of cooling with cryorefrigerators. In this proposal we suggest to replace the whole volume H^2 or D^2 target liquation by liquid Helium to the liquefaction of these elements on the surfaces cooled with compact refrigerators.
15. In radiomedicine is used only from six isotopes of Xenon and development of unique cryogenic targets is aimed to extract necessary xenon isotope. The task is very complicated because of low chemical activity of noble gases and need new methods of rectification in case of very narrow gap about 4-6 K between temperatures of freezing and liquefaction will needed.

Needed equipment

- temporary low temperature and ultralowtemperature equipment,
- noble gases helium and xenon,
- vacuum equipment (forevacuum oil-free membrane and mechanical pumps, hermetic vacuum pumps, turbomolecular pumps, vacuummeters, helium leak detector, gas flowmeters, gas controllers, mass-spectrometer facility for gas composition analysis),
- electronic analyzer for mechanical oscillation system analysis (Q-factor, amplitude-frequency and amplitude-phase characteristics),
- equipment for piezoelectric effects analysis,
- micromechanical equipment, instrumental microscope,
- high quality materials (wires from different alloys, piezoceramics with stable mechanical characteristics, special alloys, heat-resisting alloys),
- magnitometric equipment (vectorial 3D megnitometer, scalar proton NMR magnitometer, fluxgate-magnitometer, variometer, atomic-type magnetometer).

Needed staff

Position	Function
1	Management, general physics development

2	Theoretical investigations, processing of experimental data, numerical simulation of interactions of electrons, protons, ions and neutrons with media
3	Experimental work on sensors for particle beams scanning development
5	Experimental work in low temperature physics (ultralow thermometers, superconductivity)
6	Experimental work in low temperature physics (monoisotope xenon target development for radiomedicine)
7	Engineering developments
8	Physicist specialized in acclerator physics and radiation
9	Electronic development, experiments automation
10	Electronic development, experiments automation
11	Thermomechanical numerical simulations, aspirant
12	Mechanic

Toda lab have 6 employees on 2.5 thematic staff and 1.5 of institute basic staff.

Collaborators

1. Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439 USA.
2. HTM Reetz GmbH, Berlin, 12555, Koepenicker St. 325, info@htm-reetz.de.

Laboratory of Radiation Biophysics

Head of laboratory

Ph. D Garnik Khachatryan

1. The laboratory is actually divided on two research groups. The main staff (Ph.D., sci.res., Ts.Avakyan – Dr. of Sciences, the leading sci. res., N.Simonyan – Ph.D., senior sci.res., N.Mkrtchyan – jun.sci.res., A.Ovakimyan - the engineer, G.Unanjan - the mechanic) carried out the research works in the field of radiation biology, preparative and applied biochemistry, the general and applied microbiology, radiation ecology. The separate group investigates the mechanical properties of macromolecules and biopolymers (S.Gevorgyan - jun.sci.res., S.Kherolyants - the engineer).

Items 2, 3. The Laboratory is located partially on the 1st and occupies all the 2nd floor of the 22a building. The laboratory has the bunker at ECA. We believe the laboratory will need approximately 5000 kW/h of electricity during a calendar year in order to implement the presented Projects. The laboratory is supplied with water. There are installations for water distillation. The laboratory has computers connected to the Internet.

There are specially equipped premises for carrying out the radio biological, microbiological and biochemical investigations that include the following:

1. The premises, in which the ionizing radiation sources (X-Ray, alpha particles), laser radiation of various capacities, UV-radiation are mounted;
2. The laboratory rooms with thermostats, cold boxes, microscopes, centrifuges, and also other equipment and toolkits, those are necessary to carrying out microbiological and radio-biological researches;
3. The autoclave room equipped with a device for disinfecting and sterilization: autoclaves, drying oven, sterilizers, etc.;
4. The sterile boxes, the premise for medium cooking, washroom, equipped with the corresponding devices providing the possibility of sterile and safe works with the microorganisms;
5. A refrigerating room;
6. The temperature-controlled rooms equipped with the corresponding devices for cultivation and biomass escalating;
7. Premises for carrying out the biochemical researches, equipped with devices for reception and research highly purified protein preparations (spectrophotometers, device for research of processes of chemiluminescence, centrifuges, collectors of the fractions, chromatographic columns, sorbents for the dividing of macromolecules, chemical reactants);
8. The laboratory has a collection of microorganisms: identified and not identified strains of the yeasts, bacteria and the fungi differing on sensitivity to the various physical and chemical factors. In the collection the strains of cultures highly tolerant to the presence of various concentrations of pesticides and other toxic chemical compounds are available. Some of them are investigated on the ability of biotransformation of the number of toxic compounds. From this point of view perspective cultures are isolated. A number of cultures stand out for high radio-sensitivity to an irradiation by ionizing radiation. The strains with considerable radio resistance are also found out;
9. The arrangements with a number of divisions inside the institute regarding to collaboration with the use of their equipment (chemical laboratory - V.Gavalyan, laboratory of the radiation and solid state physics - V.Harutyunyan, group of laser micro processing - L.Poghosyan) are reached.

Items 4,5. The laboratory of radiation biophysics of YerPhI was founded in 1968 due to the initiative of Dr. T.M. Avakyan under the direct support of academician A.I. Alihkanyan by analogy to the radiobiological laboratories functioning at other accelerators. During the years of its work the laboratory achieved considerable success in the investigation of influence of an ionizing radiation of various natures on seeds of plants, on the cells of pro- and eukaryotes, bayer lipid membranes,

artificial modeling structures on the basis of lecithin and other lipids, including the research in the presence of the radio-protectors. Radio-protective properties of some natural biological compounds were studied, for example, β -carotin at influence of an ionizing radiation on radio sensitive cultures of prokaryotes and some enzymatic preparations.

Besides the specified large-scale researches on the creation of biosensors and flow-through enzymatic analytical systems on the basis of bacterial enzymes and the cells of microorganisms for determination of various natural biological compounds in complicated multi-component liquid mediums, such as blood or fermentative mediums were carried out [1]. The working breadboard model of the flow-through enzyme analyzer ARFA-L on the basis of enzyme L-lysine-2-monooxygenase, developed by us for definition of L-lysine in the microbiological industry, was awarded with the silver medal of VDNKh (exhibition of national economy attainments) of USSR in 1988. The computerized version of the flow-through analytical system capable to determine in the liquid mediums concentrations of: L-lysine, uric acid, glucose, ethyl spirit, due to the replaceable active module has been developed. It is necessary to note especially a unique method of determination of amino acid L-proline on the basis of bacterium isolated by the employees of laboratory and possessing exclusive selectivity on biotransformation of L-proline. On the basis of this microorganism the unique analytical system for determination of L-proline in the liquid media has been created [2], and the technique of definition of degree of impurity of water by ions of heavy metals, particularly, by lead ions is developed. In 1989 the laboratory was involved in performance of four years All-Union program "Biosensor" of the Council of Ministers of the USSR, as one of the leading organizations. The laboratory together with JINR was also involved in the performance of the "Genome" and "Rhythm" projects.

After the collapse of the Soviet Union, despite of economic and financial difficulties, it was possible to continue the researches, giving them more applied character. In particular, large-scale researches of radiation conditions around the Armenian Nuclear Power Plant, the works on studying of the ability of microorganisms, mainly of aerobic nature, to destroy toxic chemical compounds were carried out as well. Here it is necessary to notice, that from the middle of 80-s' up to this day works on creation of a collection of microorganisms-producers of the various enzymes possessing specific activity on biodegradation of various substrates were performed. From 96th the collection has been essentially expanded and enriched by the bacterial cultures possessing high tolerance to presence of high concentration of various toxic compounds, in particular, of pesticides among which there are also the cultures capable on biodegradation of some pesticides. As a result, by present time the laboratory became the owner of a unique collection of microorganisms with a wide spectrum of activity to the different type of chemical compounds. A number of the interesting methodical work outs executed by the experts of laboratory in the sphere of radio-biology, are discussed in the presented long-term plans.

For a number of years up to 2007 theoretical researches were also carried out. The kinetics of the enzymatic reactions in real conditions when the quantity of molecules of enzyme and a substrate in the reaction medium is limited was investigated. In such a case there is a necessity of the likelihood description of the kinetics of enzyme reactions describes the real process of enzymatic reactions more precisely. Linkage of a substrate with enzyme is described within the limits of stochastic model with attraction of the apparatus of the Mark's processes theory. Such approach allows to calculate not only average speed of enzymatic reactions, but also its dispersion, correlation function and spectral density of the speed of enzymatic reactions.

In real conditions enzymatic reaction occurs in the environment the properties of which is not strictly constant, and casually fluctuates. These casual fluctuations of environment (external noise) influence on the kinetics of the enzymatic reactions. For the first time the fluctuations of speed of enzymatic reactions, and also correlation function and spectral density of the speed of enzymatic reactions are calculated.

Similar researches allow to do a number of recommendations at the designing of micro-biosensors, the formation of an output signal in which occurs as a result of linkage of the substrate to the active centre of the enzyme [3-7].

During the Post-Soviet period employees of laboratory actively worked in order to provide the financial support of laboratory, directing scientific projects both to the Republican, and to the international financing organizations.

The list of the international grants received due to the initiative of some employees of laboratory (A.L.Simonyan, V.B.Arakelyan, Ts.M.Avakyan, G.E.Khachatryan) is presented below:

1. International Science Foundation (Soros), Grant No. RYV000, 1994/95; the theme: "Electrostatic effects on enzymatic reactions".
2. NATO Linkage Grant LG 94/411, 1995/96 (jointly with Texas AMU, w/o labour cost).
3. NATO Network Grant 94/412, 1995/96 (jointly with Texas AMU, w/o labour cost).
4. American University of Armenia Grant (w/o number), 1996/97; the theme: "Investigation on the concentration levels of heavy metals in soil, and vegetation".
5. Joint CRDF/NFSAT grant AB??/ABT-??_98, 1998/2000; the theme: "Development of microfabricated fluoride sensitive films for biosensor".
6. Joint CRDF/NFSAT grant AB1-978/ABT-029_98, 1998/2000; the theme: "Aerobic Bacteria as a Biodegradative Factor in Environment Decontamination".
7. ANSEF grant NS-33-00, 2001, the theme: "Capabilities of several aerobic strains to transform 2,4,6-TNT".
8. ISTC Project A-773, 2002-2005, the theme: "Net Effect of the Armenian Nuclear Power Plant on Environment and Population in the Background of Global Radioactive Fallouts".

For the same period the number of projects was directed to the various funds (CRDF, NFSAT, ANSEF, ISTC, INTAS), but unfortunately was not honored with financing. Among of them the most considerable were the Projects directed:

- to ISTC "The Investigation of Some Aerobic Bacteria's capability to Transform Number of Widely Used Toxic Compounds" submitted to ISTC and approved w/o financing, No A-724 (foreign collaborator: Ronald L. Crawford, Environmental Biotechnology Institute of the University of Idaho, Moscow, ID, USA, crawford@uidaho.edu; project manager: G. Khachatryan; 2001).
- to INTAS "Bioavailability Issues in the Remediation of Metal Polluted Sites" (Team Coordinator - Bernd Nowack, ETA, Switzerland, current address: nowack@empa.ch <http://mail.yerphi.am/mail/src/compose.php?send_to=nowack%40empa.ch>; Head of the Team-participant: G. Khachatryan 2003).
- to INTAS "Metabolism and bioenergetics of bacterial EDTA degradation" (Team Coordinator - Bernd Nowack, ETA, Switzerland, nowack@empa.ch; Head of the Team-participant: G. Khachatryan 2005).

During the period from 2004 to 2005 the laboratory was involved in works in the frame of the ISTC project A-773 «Net Effect of the Armenian Nuclear Power Plant in the Environment and Population on the Background of Global Radioactive Fallouts». Within the frameworks of the Project the staff of laboratory carried out all the scope of works on the topic «Research of the possible changes of soil microbiota, as consequence of influence of ANPP on the environment». Besides the statistical investigations, additional radiobiological experiments were made in laboratory conditions, during which the radiobiological parameters of the radiosensitive (*Pseudomonas putida* and *Pseudomonas fluorescens*) and radioresistant (*Bacillus* genus) cells of the appropriate cultures that were defined on the base of it's statistically authentication in all soil samples selected from the districts along a (compass) point on a wind rose by which the centre was accepted ANPP (extent about 34 km) were determined. The received results were compared with the control data for which the samples of the soils had been taken on removal about 57 km from ANPP on a point of a wind rose were investigated. As a result, the cultures of *Bacillus* genus, possessing the raised radio resistance have been revealed.

From the mid-80th up to date works on the maintenance of vital functions of the collection of cultures of the microorganisms stored in laboratory were performed. Maintenance of vital functions of a collection of cultures is the labor-intensive process including a large scope of preparatory technical

procedures and renovation of the strains by a method of inoculation of the cells of the cultures, stored in a laboratory museum, on fresh mediums. Throughout a number of years the group investigates the biotransformation of various xenobiotics by aerobic microorganisms, mainly of *Pseudomonas* genus. During the implementation of ISTC project the collection of aerobic bacteria has been expanded, and the spores of bacillus are included in a collection, particularly, *Bacillus mesentericus*, *Bac. cereus*, etc. The period from 1996 till 2007 has been also devoted to the search of cultures tolerant to the toxic compounds, and among them the strains, capable to destroy such a toxic and quasi-toxic compounds as p-nitrophenol, 2,4,6-trinitrotoluol, hexogen, a number of pesticides, etc. On the basis of these works the group hopes, in particular, to develop biotechnological methods of bioconversion of toxic compounds, remediation of the soils, and also to elaborate new biosensors on various toxic compounds.

The further researches are supposed to be carried out in three directions:

1. Research of biological action of the electrons of different energies, causing genetic damages at microorganisms, and also research of the biological factors directional on the reparation of these damages.
2. Modeling of consequences of accidents on the nuclear power plants with purpose of investigation of their influence on the chain: soil - vegetation - human.
3. Research of processes of microbiological destruction of toxic compounds, used in a number of spheres of national economy, receipt of the mutant strains possessing the raised destroying activity to them by means of an ionizing radiation.

For performing the specified investigations the laboratory as it can be inferred from the aforesaid, possesses the necessary equipment, toolkit, specially equipped for microbiological researches premises, high-professional scientific and technical staff. It would be desirable to underline, that additional staff and adequate financing will allow to expand the material resources, to prepare young experts for the realization of works which become year to year more actual.

6. Projects for 2009-20013

Research of biological influence of electrons of different energies on microorganisms

**(International collaboration JINR-YerPhI)
{Within the Protocol No 3725 on 24.08.07}**

The problem of relative biological efficiency (RBE) of the different quality of radiations and protection of an organism against their damaging action was always a key problem of radio biology. With the beginning of the space age, developing of circumterrestrial space and flights of the human to the space, this problem became more actual. The launching of the space vehicles has allowed to find out high level of doses of various types of an ionizing radiation in the space. As it was found out, radiation fields in a space are characterized by wide charging structure from electrons and protons to uranium nuclei, a power range from tens eV to 10^{18} - 10^{19} eV and a spectrum of a linear transmission of energy (L), defining character of local influence on cells and tissues of bio-objects, from the tenth percentage of a keV/micron to $2 \cdot 10^3$ keV/microns [8].

In the sector of biological researches of JINR (Dubna) under the guidance of professor E.A.Krasavin multi-planned experiments on modeling of radiation-genetic effects of space radiations using the accelerated heavy ions beams and to finding out of the mechanisms defining distinctions in biological efficiency of radiations, differing on L, on cells of a different genotype have been made. On the basis of a number of experimental and theoretical researches they had been formulated thesis that biological efficiency of radiations of different quality is determined as physical features of micro-distribution of energy of different types of radiations in genetic structures of the cells therefore induces a wide spectrum of primary damages of DNA, and the biological factor directional on a reparation of these damages. Decrease of reparation ability of the cells with the increase of L, and accordingly the increase of biological efficiency, are substantially connected with the induction of non-repairable DNA

damages - direct double strand break (DSB), playing an essential role in lethal action of dense ionizing radiations [9-13].

Earlier the researchers of our laboratory took part in these experiments within the frames of projects "Genome" and "Rhythm", in particular, the experiments on irradiation of *E. coli* strains of different reparation genotype in various conditions of experience by the X-ray and α -particles were performed in YerPhi, and with the same strains on the accelerator of heavy ions U-200 of the Laboratory of nuclear reactions at JINR [14]. As the logical continuation of these joint works during the 2009 the investigations on studying of biological efficiency of influence of accelerated electrons on their lethal action on cells of pro- and eukaryotes of different genotype in different conditions of experience, ability of these cells to repair the damages caused by an irradiation by high energy electrons of different doses will be carried out.

In the course of performance of the project "Genom" the conception that during the action of radiations with the small values L, registered double breaks of DNA (DSB) are mainly of enzymatic double stand breaks (EDSB) nature, arising from the enzymatic single strand breaks (SSB) as a result of in-co-ordinate work of reparation enzymes have been stated. With the increase of value of L the increases of DSB of DNA and they become prevailing in total exit of EDB and DSB. At the same time exit of EDSB with the growth of L decreases proportionally to decrease of SSB. For the check of the above-stated concepts, besides of the usage in experiments of the cells with different ability to reparation of beam damages, the researches of biological efficiency of the influence of accelerated electrons on above specified cultures in the presence of the radio-protectors realizing the radio protective action both at the level of a enzymatic reparation, and at the level of primary physical and chemical processes will be carried out. Besides, as the failure of reliability of the cells genom functioning under a beam is not only defined by their lethal outcome, but also by an induction of mutations, we plan the investigation of biological efficiency of electrons influence on their mutagenic effect for the cells of pro- and eukaryotes of a different genotype.

MATERIALS and METHODS

Strains.

In the works the cells of wild-type bacteria *E.coli*, of sensitive and resistant mutants, also both haploid and diploid cells of yeast *Saccharomices cerevisiae* will be used.

Techniques.

1. For the determination of survival rate of cells the standard technique of the macro-colonies consisting in the inoculation of corresponding dilutions of control and irradiated samples of cellular suspensions on high-grade nutrient mediums (MPA, WA, YEPD) and the subsequent calculation of viable colony-forming cells will be used.
2. As for definition of survival rate of cells, and observation in phase-contrast the forms of inactivation of micro-colonies of the irradiated cells (weight of damages) the technique of micro-colonies will be used.
3. The classical technique of Lederberg for revealing of straight lines of the *lag*⁻ mutations of *E.coli cells modified by us* will be used. For elimination of lacks of Lederberg's technique complicating application of the given method for exact calculation of mutant colonies, and also reduction of labor input and the expense of materials, certain microbiological methods of the cell inoculation (the method of sandwich) and the special devices providing not only exact calculation of mutant colonies, but also mutant sectors will be used during the inoculation of up to $2-7 \cdot 10^5$ cells on a dish.
4. A technique of definition of frequency of an exit of the spontaneous and induced reverse-mutations at yeast auxotrophic to different metabolites. The given technique developed by us jointly with JINR [13], allows to estimate more correctly than traditional methods the quantitative maintenance of mutants in culture during any demanded moment during the cell cultivation on medium of the different composition. It is a combination of techniques of the

ordered inoculation of the cells on nuclear filters, with the subsequent transfer of these filters together with colonies of yeast on the selective medium.

5. A method of registration of reparation of the irradiated cages (dependence of restoration of beam damages of cages on an irradiation dose) with those serious amendments which we have brought in the given method after detailed researches LHR of bacteria [15].

**Modeling of consequences of accidents on the nuclear power plant, for the purpose of researches of their influences on the chain soil - vegetation - human.
(The joint project of Armenian NPP, Yerevan State University, YerPhI)**

Accidents on the nuclear power plants represent the serious radiation danger for the population. For an adequate estimation of possible consequences of such failures modeling of radiating conditions, typical for emergencies, on skilled allotments is represented expedient. For this purpose the soil of the experimental allotments to water or irrigated with air-drop way (by means of special sprinklers) the water containing the radio-nuclides in various concentration, typical for emergencies. Concentration of radio-nuclides will vary in a wide interval. On the experimental polluted allotments some cultivars of fruit-trees and vegetables, and also known vegetative test objects on radiating pollution will be grown up (tradescantia and onions). The analysis of changes of microbial system of the soil in allotments will be carried out. The general quantity of microorganisms and the species of microorganisms most sensitive to radionuclide pollution of soil will be determined. Exact definition of factors of the radionuclide transition in the system water□soil□plants and plants□soil, and also mathematical modeling of distribution of radio-nuclides will be performed. Modeling of consequences of accidents of the nuclear power plant is expected that will allow to estimate possible real consequences of radiation pollution.

Radio biological researches of soil microorganisms.

One of the primary goals of the project is the investigation and the analysis of the changes occurring in microbial system of the soils on the experimental allotments subjected to radio-nuclide pollution. The received results will be compared with the results received from the soils of control allotments. The general quantity of soil microorganisms from experimental and control allotments through certain time intervals will be defined. The most sensitive to the radio-nuclide pollution species of microorganisms will be chosen from the mass of the soil micro-biota and the phenotypic and physiological characteristics of them isolated from the experimental and control allotments will be investigated. Along with the researches of soil in field conditions, control and additional researches will be carried out in laboratory conditions, in the conditions of sharp and chronic modes of an irradiation of the microorganisms modeling a situation of radionuclide pollution of experimental sites.

Problem

1. Determination of the general number of microorganisms of the soils of the experimental and control allotments through certain time intervals.
2. Investigation of phenotypic and physiological characteristics of the species of microorganisms chosen as the objects of observation.
3. Definition of the radio-biological parameters chosen as the objects of research of species of microorganisms in the conditions of sharp and chronic modes of an irradiation, modeling a situation radio-nuclide pollution of the experimental sites.

Research of processes of microbiological destruction of toxic compounds, used in the number of branches of national economy, and possibility of receipt of the mutant strains, possessing the activity raised to them, by means of an ionizing radiation.

The mankind in the various areas of the activity, for example, in the industrial, military sphere etc., and also in a routine life, uses the most various toxic compound. And, year to year increases both the assortment, and the quantity of used chemical compounds [16]. As a result, there is a gradual accumulation of these compounds in various chains of biological circulation as the speed of destruction of these compounds essentially concedes the speeds of their entrance to environment [17]. Eventually, these compounds immediately or through the trophic chains get to the human organism. The most significant chains where the accumulation of the toxic compounds is occurred are the soil and reservoirs. As consequence, the greatest stressful loading is felt by the microbial communities occupying the soils and reservoirs [18]. Obvious negative consequence of this process is the sharp deterioration of soil that can negatively affect on the future of agriculture [19].

During the last 2-3 decades intensive researches for finding-out of negative consequences of environmental contamination by pesticides, insecticides and others toxic compounds [18, 20] are carried out. At the same time the attempts are made to receive by the methods of selection, gene engineering and so on the cultures of microorganisms, which could be applied for the directed cleaning of soil. It is necessary to notice, that there are number of problems complicating direct inoculation of cultures, received in laboratory conditions, to an environment. Despite of it, the specified researches can bring the powerful contribution to the struggle against the environmental contamination, and can serve as an essential addition to such methods of clearing of environment, as photo-oxidation, chemical destruction etc. However, it is necessary to consider for now that the most actual problem is the isolation from various sources (soil, silt, sewage) the cultures possessing necessary activity, their reproduction in laboratory conditions and entering into the soil of the polluted areas. During the similar entering it is possible to use as native, as immobilized cells of bacteria. On the basis of the immobilized cells it is possible to develop bioreactors for cleaning of the waters polluted with various toxic compounds. It is natural, that the question of the maximal increase of efficiency of action of the selected cultures is raised. It is necessary to recognize that the simplest way of the receipt of such the highly active cultures is the receipt of mutant strains, for which aim it is possible to use, for example, sources ionizing and non ionizing radiations.

Main objectives and Problems:

1. Selection of the cultures, capable to split investigated chemical compounds, from among microorganisms, tolerant, to high concentration of toxic chemical compounds of the nitro-aromatic nature (2,4-dinitrotoluola, p-nitrophenol) and of some other compounds (for example, hexogen, chlorine- and phosphorous-containing pesticides, etc.), cultures of microorganisms of our laboratory stored in a collection of microorganisms.
2. Choice of the most active strains among the selected cultures, their microbiological, biochemical and morpho-physiological description.
3. Reception of the mutant strains with raised catabolic activity by means of an irradiation their cells by the sources of ionizing and non ionizing radiations.

7. List of some recent publications of the Laboratory

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PROSPECTIVE STAFF of the LABORATORY and AVERAGE LABOR COST

No	Name	Position	Degree
1	Khachatryan Garnik	Head of Labor.	Ph.D.
2	Simonyan Nvard	senior sci. res.	Ph.D.
3	Mkrtchyan Nina	jun. sci. res.	
4	Avagyan Tsovak	leading sci. res.	Dr. of Biological Sciences
5	Hovakimayn Arsen	engineer	
6	Hunanyan Gevorg	mechanic	
7	Durgaryan Andranik		university graduate
8	Babayan Bella		university graduate
9			university graduate
10			university graduate

Finance (in USA \$)

Staff- 10 persons
 Salary of participants – 210 000
 Equipment: 50 000
 Travels: 10 000
 Goods: 5 000
 Infrastructure:
 - Power supply – 2 000 kWt
 Water supply – 1000m³
 Miscellaneous expenses: 3 000
Total for 5 years: 278 000

THE LIST OF THE NEW EQUIPMENT

Model UV1900 Double Beam UV/VIS Scanning Spectrophotometer (Beckman)	-	\$ 15,200
Model WGD IRrating Spectrophotometer (Beckman)	-	\$ 8,900/9,800
HP 1050 Series HPLC System with UV/VIS Detector (refabricated, Beckman)	-	\$ 8,500
100-Sample Tray for the HP 1050 Autosampler	-	\$ 2,500
Additional equipment (columns, tubes, chemicals)	-	\$ 3,000
{DNA/RNA-sequenator ABI Prism 310	-	
Analytical and precise balances Sartorius (LA 120 S)	-	Eur 5,930
Analytical and precise balances Sartorius (LA 620 S)	-	Eur 5,602
Micropocessor-based pH/mB/C-merp PH-211 with tripod and HI 1131 electrode	-	Eur 650
Laboratory glasses and accessories	-	\$ 5,000
Chemical reagents	-	\$ 3,000
Total		\$ 50 000

Division “Vacuum brazing and welding group”

Head of group

Ph. D Vardan Avakyan

1. Staff:

1. Vardan Avakyan, Group leader
2. Davit Melikyan, engineer-technologist
3. Tunyan Ivan, electric engineer
4. Poghosyan Vladimir, junior scientist
5. Laboratory assistant/ junior scientist
6. Equipment operator
7. Equipment operator

2. Technical infrastructure:

Territory: 216 m²

Electricity: 15 000 kWtt

Water: 2500m³

3. Scientific infrastructure:

Vacuum brazing equipment: chamber diameter - 0.7m, length-6m, heating temperature – 1500°C;
vacuum diffusion welding equipment; vacuum- hydrogen furnace.

4. ISTC Project A-1229: Development of vacuum equipment for LUE-5 accelerator.

5. Finance (in USA \$)

Staff – 7 persons

Salary of participants:– 147 000

Equipment: 45 000

Travels: -

Goods: 5000

Infrastructure:

- Power supply –15 000 kWtt

Water supply –2500m³

Miscellaneous expenses: 2000

Total for 5 years: 199 000

Project: Study and development of the technology for the ceramics and metal diffusion joining

Introduction

Ceramic vacuum chambers are widely used in the accelerator technology for the transfer of electron and proton beams. Here vacuum chamber has small electric conductivity and the space between the electric magnets poles is completely used without changing the magnetic field in the gap. The ceramic vacuum chambers should meet the following conditions:

1. Vacuum chamber and vacuum system must create and keep at least 10⁻⁷ torr vacuum in order to have the minimum loss of the particles.
2. Provision of the required density for the joining and vacuum impermeability, vibration stability.
3. Elimination of the fragile junctions emergence during the joining process.

4. Radiation stability of the vacuum chamber materials.
5. The vacuum chamber internal capacity allowing to be coated by thin metallic intense layer.

Project Narrative

The present project is aimed at the study and development of the technology for the ceramic vacuum chamber joining with the metallic ring by means of vacuum diffusion welding, which will be used for Yerevan Physics Institute synchrotron accelerator vacuum chamber upgrading.

It is well-known that ceramic vacuum chambers are used in operating modern accelerators, which consist of separate-part ceramic chamber with metallic ring welded in the ends, and by welding together with melting method the separate parts by means of metallic rings the vacuum chamber of the required length is completed and placed in the gap between the poles of accelerator magnets.

The joining of ceramics and metal is achieved in two ways. In the first way the ceramics is initially coated by 7-10 μm width mix of Mo-Mn metal compounds, and intense layer is achieved by heating in the hydrogen furnace up to 1400°C, then applying different methods the obtained layer is covered by nickel layer of several micrometers width and is welded in the vacuum furnace using Ag-Cu eutectic welding material [1]. In the second method contact reactive welding method is used based on the interphase active added material absorption by introducing the welding material. Titanium, zirconium, magnesium, oxygen and others [2] can be used as interphase active additions. Being in the contact of ceramics and metal those interphase additions generate contact reactive melting, diffusion process and liquid phase take place. That phase with high surface activity is well wet with the joining materials and during crystallization produces welding compound.

The disadvantage of the mentioned methods is that the intense mixes (mixture) and intermetal compounds occurring during the welding later become the reason of the compounds destruction during the operation.

The purpose of the current project is to study and develop a technology for the diffusion welding method of ceramics and metal joining, which will have advantage over welding and will be applied in accelerator and other technologies.

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3. Վ. Ավագյան, «Նրբաթիթեղի և դետալի դիֆուզային եռակցման եղանակ», Թ23Խ 20/14, Հ2000400041, Գյուտերի հայտեր, Հ5 (46), 24.03.2004.(V.Avagyan. Nrbatitexi ev detail difuzain eraktsman exanak. T23X 20/14, H2000400041, Giuteri haitei, H5 (46), 24.03.2004. In Armenian).
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Development of highly permission radiation detectors

Head of group

Mr. Mkrtich Mkrtchyan

Staff – 5 persons

Salary of participants:– 105 000

Equipment: 5 000

Travels:

Goods: 3000

Infrastructure:

- Power supply –2 000kWtt

Water supply –1 000 m³

Miscellaneous expenses: 2000

Total for 5 years: 115 000 \$