Nuclear Physics Education in Romania

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IFA-CEA Meeting

Măgurele 2.XII.2009

The first Romanian university was those created by the Prince (Domnitor) Serban Canatcuzino, in 1679, developed by the Prince (Domnitor) Constantin Brâncoveanu, in 1694.
The modern University of Bucharest has been created in 1864 through the decree of the Prince (Domnitor) Alexandru Ioan Cuza.
*At the beginnings **Physics** taught at the Faculty of Sciences, founded in October 8th 1863 (up to 1948).*

From 1948 up to 1962 existed the Faculty of Physics and Mathematics. In the last 45 years there is the Faculty of Physics. In 1974 the Faculty of Physics received an special campus on the Physics Platform Măgurele, created at the proposal of Professor Horia Hulubei, member of the Romanian Academy, since 1949. The University has 19 faculties, 1 department and around 30 000 students in this academic year.

General information

** University types classification:*
- after interesting fields: "classical", technical, medical, economical, architecture, arts, mixed (usually, non "complete universities" in EU sense)
-after financial support: state and private (56 and 35, respectively)
•Physics studies – mainly at the classical and technical universities; also, at medical Universities (in decline, although)
5 Faculties of Physics at the state Universities from Bucharest, Craiova, Cluj-Napoca, Jassy and Timişoara, 1 Faculty of Physics at private "Hyperion" University Bucharest
** There are different faculties of Sciences at mixed universities with Physics sections combined with Chemistry and Mathematics, mainly*
•Physics at technical universities – General Physics with 1 semester up to 3 semesters with 2 hours course and 2-3 hours practical classes; Nuclear Physics is taught in 1 up to 3 courses, depending on the faculty field; more time accorded to the practical classes
<u>Remarks</u> - At "Politehnica" University there are two faculties with special courses in different Nuclear Physics fields: Power Engineering Faculty – Nuclear Reactors; Applied Sciences Faculty: non-energetic applications of Nuclear Physics
- A section of Technical/Technological Physics at the University of Piteşti (mixed type) – connected with the Institute of Nuclear Research (Institute for Nuclear Power Reactors)

Romania *– long tradition in Atomic and Nuclear Physics - Professor Ştefan Procopiu, Professor Horia Hulubei – since ’20’s*

- Atomic and Nuclear Physics Chair – a history of 60 years

-1949 Physics Platform Măgurele – Institute of Atomic Physics – 6 institutes now

-Founding member of the JINR Dubna, Associate member at CERN (accepted as Member by the Scientific Committee in 2008), Founding member at FAIR-GSI ...

- A nuclear power plant – CANDU nuclear reactors – Cernavoda

-There are discussions for a second power plant

-3 research nuclear reactors (one in decommissioning), one cyclotron, one Tandem, a linear accelerator (channeling and back scattering – some problems with the national authorities in the control of the activities in the nuclear filed)

- An underground laboratory for low activities measurements

Remark – All at the National Institute for Nuclear Physics and Engineering “Horia Hulubei” Bucharest-Măgurele

- A number of industrial laboratories using non-destructive testing with nuclear radiations – significant decrease of the activities in the last 15 years (different motivations ...)

- A few accelerators for Radiotherapy – in University hospitals

- A few medical computer assisted tomographs, including NMR tomography

- Applications in Biology, Agriculture, Geology, Seismology etc

Bologna system structure of the studies: *2 fields: (i)* ***Exact Sciences – Physics****; (ii)* ***Applied Sciences***

- *(i)* ***Physics****,* ***Medical Physics****,* ***Biophysics****,* ***Computational Physics*** *(Physics and Informatics)* ***-*** *Bachelor: 3 academic years (180 ECTS), Master: 2 academic years (120 ECTS), Ph.D. studies: 3 academic years (180 ECTS) – supported by the national budget*

- *(ii)* ***Technological Physics -*** *Bachelor: 4 academic years (240 ECTS), Master: 1 academic year (60 ECTS), Ph.D. studies: 3 academic years (180 ECTS) – supported by the national budget*

Obs. Academic year – 2 semesters with 14 weeks, separated by examination session – 3 weeks and 1 week vacation. There is a 2 weeks vacation during Winter Holydays, too. The last examination session has 4 weeks.

Strong constraints ***-*** *number of hours per week (24 h Physics, 6 hours complementary courses), financial support per capita, high number of hours for each position (contact hours), distinction among teaching obligations and research obligations (not included in the position structure; it can be included in an additional position in a research center of the faculty etc.*

Additional problems – eclectic background in Physics and Mathematics of the candidates, decline of the interest

Nuclear Physics at the Faculty of Physics, University of Bucharest

- A general course in Nuclear Physics and Particle Physics – 2 semesters in the second and third study years – 2 hours courses, 3/2 hours practical classes

-Special courses for applications of Nuclear Physics and Dosimetry at the Medical Physics and Biophysics specializations (Bucharest, Cluj-Napoca, Jassy)

- Specialization in Nuclear Physics and Particle Physics – only at he Faculty of Physics of the University of Bucharest – including master and PhD studies – since '50s

-Physics filed - ***Nuclear Interactions and Elementary Particles***

-Applied Sciences field – ***Applied Nuclear Physics*** *(older Nuclear Reactors and Nuclear Materials)*

Personal remark – the specialization in Nuclear and Particle Physics, as well as the specialization in other Physics fields is strongly affected by the Bologna education system

Remark: At the Faculty of Physics from the University of Bucharest the teaching and research activities in the Nuclear and Particle Physics filed are performed, mainly, in two chairs (departments), namely: Atomic and Nuclear Physics Chair (Department), Theoretical Physics and Mathematics Chair (Department).

Special courses in Nuclear and Particle Physics

I. Nuclear Interactions and Elementary Particles

I.1. Nuclear Structure Models and Reaction Mechanisms
I.2. Experimental Methods in Nuclear and Particle Physics
I.3. Symmetries and conservation rules in Nuclear and Particle Physics
I.4. Introduction in High Energy Physics and Cosmology
Remarks: In the academic year 2007-2008 graduated the first promotion in the "Bologna style" – only 1 up to 3 courses in the last semester (Physics section, Physics field, 3 study years).

II. Applied Nuclear Physics

II.1. Fundamentals of the Modelations for Nuclear Structure and Interaction Mechanisms
II.2. Experimental Methods in Nuclear Physics
II.3. Fission and Fusion Reactions
II.4. Nuclear Reactor Physics and Nuclear Energetics
II.5. Calculation and Simulation Methods in Nuclear Physics
II.6. Technologies and Installations for Nuclear Energetics. Management of the Nuclear Wastes
II.7. Dosimetry, Radioprotection and Nuclear Management
II.8. Applications of the Nuclear Radiations
II.9. Environment Radioactivity
Remarks: In the academic year 2008-2009 graduated the first promotion in the "Bologna style" – only 6 courses in the last 3 semesters (Technological Physics section – Applied Science filed, 4 study years).

Research in Medical Physics

-Tomography – with X rays and γ rays (rotation-translation geometry, fun geometry and cone geometry)

-Boron therapy

- Radiation damages on tissues

- Elemental composition of tumors – PIXE, PIGME, neutron activation

- Correlations among the weights of different elements in some diseases

- Dynamic behaviour of the brain at different stimuli

- Others

Remark

The main courses in Nuclear Physics and Nuclear Medicine are reflected

Master studies

*Master studies - old structure – in the period 2000-2007, because financial considerations - only one common specialization direction (initially – 3 directions at the Atomic and Nuclear Physics Chair, namely: 2 in Nuclear Physics (**Nuclear Interactions and Elementary Particles** – for Physics section, **Applied Nuclear Physics** – for Technological Physics) and one in **Physics of the Atoms and Molecules and Astrophysics**. In this common Master specialization direction (called **Atomic and Nuclear Interactions, Elementary Particles, Astrophysics and Applications)** each previous specialization kept its identity, as well as the number of courses, only the titles are common, and the professors teaching these courses have o diminished number of hours in their positions to respect the restrictive financial conditions.*

Remark. The new structure for Master studies has been applied from the previous academic year, for Physics field. A more complicated structure with 6 general courses for all specialisations, 6 common courses for a few specialisations and 5 strictly specialised courses, in 4 semesters, is approved by the Professors' Council.

The three generic titles of the courses and their substructures, for Nuclear and Particle Physics, are the following (some courses are common or are taught for 2 semesters):

I. Modern Problems in Atomic Physics, Nuclear Physics and Astrophysics

I.1. Anomal States and Phase Transitions in Nuclear Matter

I.2. Cosmology and High Energy Physics

I.3. Modern Problems of the Nuclear Physics. Theoretical Aspects

I.4. Modern Problems in Particle Physics

I.5. Reactor Physics. New trends and perspectives

II. Experimental Atomic Physics, Nuclear Physics and Astrophysics

II.1. Relativistic Nuclear Physics

II.2. Heavy Ion Reactions

II.3. Hadronic Spectroscopy

II.4. Nuclear Spectroscopy

II.5. Modern Problems of the Nuclear Physics. Experimental Aspects

III. Experimental Methods. Experimental Data Bases and Calculation Codes

III.1. Processing of the information from detectors

III.2. Processing of the Experimental Data and Using of the Programs Libraries

III.3. Nuclear Methods for Structural Analysis

III.4. Informational Systems. Nuclear Models. Nuclear Data Bases and Calculation Codes in Nuclear Science

III.5. Radiations, Nuclear Instrumentation and Applications

Ph.D. studies

Since the academic year 2005-2006 - Doctoral School of Physics - 7 departments – a department is ***Atomic and Nuclear Interactions, Elementary Particles, Astrophysics and Applications.***

Ph.D. studies - 2 semesters of courses and seminars

4 semesters only for research.

-first two semesters - 2 general courses with a structure in agreement with the scientific fields of the department

- 2 specific courses taught by the Ph.D advisor and his collaborators.

-From the third semester - 2 specific reports, in agreement with the thesis filed.

Obs. 1. After each course the students are tested. After the last examination, the students will present and work with a subject related to the thesis field at the department commission. This last and major examination will permit to the Ph.D. student to work only to the Ph.D. thesis.

2. The direction has the highest number of PhD advisors and students, too.

3. Initially, the structure was with 3 semesters courses and 3 semesters research. The new structure was adapted for fitting with the financial support for Ph.D. students from national authorities

Post university courses in Nuclear Physics and applications

At the Atomic and Nuclear Physics Chair, Faculty of Physics, University of Bucharest is organized in each academic year a study direction, at post university level, for bachelors in different fields, named ***Using of the Radioactive Isotopes*** *(since '50s). The expertise of the chair members permits courses in 4 directions (Applications of Nuclear Physics in Medicine and Biology, Nondestructive Testing with Nuclear Radiations, Nuclear Spectroscopy for different fields, Nuclear Reactors and Energy). There are 3 periods of two weeks each with 9 courses (243 hours of courses and laboratories). In the first period four courses are taught, namely:* ***Fundamentals of Nuclear Physics***, ***Dosimetry***, ***Processing of the Experimental Data in Nuclear Physics***, ***Detection Methods of the Nuclear Radiations***. *In the second period are taught 3 courses, depending of the professional interests of the participants. Other two courses (****Legislation in Nuclear Sciences and Applications***, ***Work with Nuclear Radiation Sources and the Environment****) are taught in the third period. At the end of the courses the participants present a Diploma Thesis. After this they can obtain from the national authority in the field (National Committee for the Control of the Nuclear Activities) the right to work with radioactive sources.*

Obs. There are – periodically – courses for teachers for obtaining different didactic degrees, as well as for long-life learning. Nuclear Physics is taught with an equal number of hours like other disciplines.


VA RUGAM
SA INTERCALATI
CORECT LA RAFT CARTILE
CONSULTATE!
VA MULTUMIM!
limba
FRANCEZĂ

TLD Laboratory
Etalonation and reading

General Dosimetry Laboratory

Gamma and X rays Spectroscopy Laboratory

Course room for Doctoral School in Nuclear and Particle Physics, Astrophysics, Radiation Protection and Dosimetry

List of practical classes for Fundamentals of Nuclear Physics

- Cycle I Bachelor - Second academic year, the 4th semester -

1. Dosimetry and radioprotection

2. Interaction of the charged particles with the matter

2.1. Alpha particle ranges in nuclear emulsions and different materials – different sources and different elements

2.2. Beta particle ranges in different materials (Tl-204 sources, no gamma rays)

2.3. Backscattering of the beta particles – same type de source, dependence de Z

3. Gamma rays spectroscopy with scintillation detectors

4. Measurement of the activity of the radioactive sources (solid angle method and etalon source method)

5. Interaction of the gamma rays with the matter. Lambert-Beer law (dependence on the atomic number, as well as dependence on gamma rays energies)

6. Gamma rays spectroscopy with multichannels analyzer

7. Computer assisted tomography – with X rays and gamma rays

Remarks

-At the Atomic Physics practical classes the students study: photoelectric effect, Compton scattering and statistical fluctuations

- Fundamentals of Nuclear Physics – 2 hours course, 3 h practical classes

List of practical classes for Nuclear and Particle Physics

- Cycle I Bachelor - Third academic year, the 5th semester -

1. Beta spectroscopy with gold barrier semiconductor detectors
2. Internal conversion
3. Alpha spectroscopy – comparison for vacuum and non-vacuum measurements
4. Gamma-gamma coincidences method
    4.1. Measurement of the activity (coincidence method)
    4.2. Measurement of the life time of the excited nuclear states
5. Study of the properties of the elementary particles in experiments with bubble chamber as detection device (life time, disintegration channels, identification)
6. Gamma rays spectroscopy with multichannels analyzer and semiconductor detector (frontal practical classes)
7. Verification of the neutron activation law
8. Neutron moderation
9. Induced radioactivity by neutron activation. Measurements of the half time of the new radioisotopes from the beta decay curves

Remarks. There are modules in NIM standard, as well as, complete system as "black boxes". A better understanding using the modules (verification with the oscilloscope of the signals ...).

A few comments

- A similar post-graduation course is taught at the Institute for Nuclear Physics and Engineering.

- At "Politehnica" University Bucharest, Faculty of Power Engineering – course for the staff of the nuclear power plants from Cernavoda and other courses related to the nuclear power reactors and engineering

- Good teaching results are related to good scientific results of the teaching staff (the members of the Atomic and Nuclear Physics Chair published around 60 papers in Physics journals in each year and participate at many national and international conferences

- Many problems related to the transition and the transition at the "Bologna style" concerning the students interests in study and research

-Many problems related to the "continuum reform" in Education, especially in Sciences

-The huge and frequent oscillations of the different international political organizations affected significantly the Romanian education at all levels

- Significant decline of the population

-Significant decrease of the interest of young peoples for hard and organized working without immediate perspectives to gain many moneys

- Financial/global crisis kills the hopes that manifested in the previous years (reasonable support for research and the perspective to increase the interest for the field)

Recent International Collaborations

Research Center "Nuclear Matter in Extreme Conditions"

- *Direct involving*
- ***SKM 200 Collaboration (JINR Dubna)***
- ***MARUSYA Collaboration (JINR Dubna)***
- ***BRAHMS Collaboration (BNL Upton, New York)***
- ***NA50 Collaboration (CERN Geneva) – only at the beginning of '90's***
- ***CBM Collaboration (FAIR-GSI Darmstadt Germany)***
- ***LAGUNA Collaboration (ZTH Zurich, Switzerland)***
- *Indirect involving*
- ***ALICE (CERN Geneva) – Ph.D. students, members of different Romanian research institutes***
- ***ATLAS (CERN Geneva) – Ph.D. students, members of different Romanian research institutes***
- ***CMS (CERN Geneva) – Ph.D. students, members of different Romanian research institutes***
- ***BECQUEREL Collaboration (JINR Dubna) - Ph.D. students, members of different Romanian research institutes***