

# Physics - basic lectures

A summer school student is required to attend all lectures in his or her primary discipline.

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### 1. Structure of matter

#### **Prof. Janusz Gluza, Prof. Jan Kisiel**

In the first part of the lecture the following will be discussed: the structure of the atomic nucleus (including the Rutherford experiment), nuclear decay (including natural radioactivity, i.e., the one around us), the interaction of nuclear radiation with matter (including their use for particle detection) and the basis of nuclear reactions. The lecture will end with a presentation of 2-3 selected contemporary experiments in particle physics.

Afterwards, the concept of lepton numbers and the theoretical basis of its introduction related to massive neutrinos will be discussed. The processes that break the lepton number will be considered in the context of the phenomenon of neutrino oscillations and processes which take place both at low energies (e.g. neutrinoless double beta decay) and high energies (e.g. proton-proton collisions with Majorana neutrinos).

## 2. Nano physics and magnetism

**Anna Bajorek, PhD, MSc, Assoc. Prof., Prof. Grażyna Chełkowska**

In the first part of the lecture, the following topics will be discussed:

### **Introduction to physics of nanostructures and nanomaterials**

- nanotechnologies and nanomaterials,
- a short history of nanotechnology and nanophysics,
- general classification of nanosystems,
- application of nanomaterials in various industries,
- examples of 1D (nanotubes and nanowires), 2D (thin films and coatings) and 3D (nanoparticles and nanocomposites) nanomaterials.

### **How to produce nanoobjects - selected synthesis methods**

- top-down and bottom-up approaches,
- several preparation methods of thin films and multilayer systems,
- optical lithography.

### **Selected examples of the quantitative description of nanomaterials**

- determining the size distribution by dynamic laser light scattering,
- analysis of crystallites size by X-ray diffraction,
- determining the thickness of thin films by X-ray reflectivity,
- using electron microscopy in the visualization of nanostructures.

### **Afterwards, we will present the following topics:**

- magnetic field, magnetic field vector  $B$ ,
- earth's magnetic field, Gauss's law of magnetic field, motion of electric charge in magnetic field, Lorentz force,
- the magnetic field around a current-carrying wire, conducting wire frame in a magnetic field, magnetic dipole moment,
- magnetism on the atomic scale, orbital and spin magnetic moment, basic quantities (magnetic moment, magnetization, magnetic susceptibility, magnetic field strength),
- types of magnetism (dia-, para-, ferro-, antiferro-, ferri-, heli-, meta-, mikto- spin glasses),
- methods used for testing magnetic materials,
- examples for the application of magnetic materials.

## 3. Experiment in physics

**Marcin Łaciak, PhD, Assoc. Prof., Aneta Szczygielska-Łaciak, PhD, Assoc. Prof.**

What is an experiment and what role does it play in physics? During the lecture, we will analyze simple experiments and together we will consider whether the explanation is always simple and obvious?

## 4. Introduction to the physics of the amorphous phase

### **Prof. Sebastian Pawlus**

The lecture will present the differences between stable and metastable states and explain what the amorphous phase is. In particular, it will present the properties of supercooled liquids as a large group of metastable systems from which amorphous glasses are formed. Ways of achieving this state and selected methods of testing its properties (e.g., dielectric spectroscopy, rheology) will be presented. Unique methods of testing the effect of high pressure during isothermal compression and isobaric cooling of supercooled systems, used at the Institute of Physics, will be presented. Examples of the practical use of materials in an amorphous state (medicines) will be presented. Selected examples will show how research methods used to study supercooled liquids are used to study other systems, including metal-organic hybrid materials

## 5. From analog to digital technology

### **Prof. Artur Chrobak**

The subject matter of the lecture covers the fundamentals of electrical circuit theory, simple semiconductor devices, and integrated circuits used in analog processing techniques and digital systems. In particular, the evolution of basic semiconductor devices on the path to advanced microprocessor systems is discussed.