**Programul de studii: Photonics, Plasma and Lasers**

Domeniul de studii: Fizică/Physics
Ciclul de studii: Master

## Discipline obligatorii:

DI.101 Quantum Statistical Physics
DI.102 Group Theory and Applications in Physics
DI.103 Experimental Methods in Physics
DI.104 Optical properties of surfaces and nanostructures
DI.105 Ethics and academic integrity
DI.108 Interferential and polarimetric methods in photonics
DI.201 Nonlinear optics
DI.202 Physical processes in intense laser fields
DI.208 Research activity (80 hours)
DI.209 Finalization of master thesis (40 hours)
DI.210 Susţinerea publica a lucrării de disertaţie

## Discipline opţionale:

DO.106.1 Spectroscopy of condensed states and of materials for energy conversion
DO.106.2 Processing with laser beams
DO.109.1 Quantum optics
DO.109.2 Applications of modeling and simulations in photonics
DO.110.1 High-power ultrashort-pulse lasers
DO.110.2 Modern computational methods in spectroscopy and imaging
DO.111.1 Digital processing of images and optical fields
DO.111.2 Photonics and optically anisotropic media
DO.203.1 Plasma spectroscopy
DO.203.2 Advanced plasma physics
DO.204.2 Thin films optics
DO.204.2 Design of optical systems
DO.211.1 Modeling methods in plasma physics
DO.211.2 Homogeneous and inhomogeneous waveguides. Applications

## Discipline facultative:

DFC.107 Volunteering
DFC.112 Fundamental processes in ionized gases
DFC.113 Elemenets of Complexity theory
DFC.114 Volunteering
DFC.205 Volunteering
DFC.206 Applied optics
DFC.207 Plasmonics and metamaterials
DFC.212 Volunteering

# Syllabus

Academic year 2025/2026
DI.101 Quantum Statistical Physics

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Quantum Statistical Physics |
| 2.2. Teacher | Prof. Dr. Virgil Baran |
| 2.3. Tutorials/Practicals instructor(s) | Lect. Dr. Virgil V. Baran |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 1 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 2 | 3.2. Lectures | 1 | 3.3. Tutorials/Practicals/Projects | 1/0/0 |
| 3.4. Total hours per semester | 28 | 3.5. Lectures | 14 | 3.6. Tutorials/Practicals/Projects | 14/0/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 30 |
| Research in library, study of electronic resources, field research | 30 |
| Preparation for practicals/tutorials/projects/reports/homework | 15 |
| Tutorat | 0 |
| Other activities | 22 |
| 3.7. Total hours of individual study | 97 |
| 3.8. Total hours per semester | 125 |
| 3.9. ECTS | 5 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Quantum mechanics, Classical Statistical Mechanics, Equations of Mathematical |
| 4.2. competences | Knowledge about: mechanics, thermodynamics, algebra, solving differential equations |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Video projector |
| 5.2. for tutorials/practicals | |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

### 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Quantum states. Microstates and macrostates of a quantum system. Statistical (density) operator: definition and properties. Time evolution. | Systematic exposition - lecture. Examples | 1 Hour |
| Quantum entropy. Boltzmann-von Neumann formula. Physical interpretation. Principle of maximum entropy. Equilibrium distributions. Statistical operator in equilibrium. BoltzmannGibbs formula. | Systematic exposition - lecture. Examples | 3 Hours |

| | | |
|---|---|---|
| Partition functions: definition and properties. Entropy in thermodynamic equilibrium, natural variables. Equilibrium statistical ensembles. Ensemble averages. Canonical, grand-canonical and microcanonical ensembles | Systematic exposition - lecture. Examples | 2 Hours |
| The indistinguishability of quantum particles. Occupations number representation. Pauli principle. Applications. | Systematic exposition - lecture. Examples | 4 Hours |
| Grand-canonical partition functions for systems of independent fermions. Fermi-Dirac statistics. Applications. | Systematic exposition - lecture. Examples | 2 Hours |
| Grand-canonical partition functions for systems of independent bosons. Bose-Einstein statistics. Applications. | Systematic exposition - lecture. Examples | 2 Hours |

**References:**
1. R. Balian, From Microphysics to Macrophysics Vol. 1, 2, Springer 2006
2. L.D. Landau, E.E. Lifsit, Fizică Statistică, Editura Tehnică
3. K. Huang, Statistical Mechanics, John Wiley and sons, 1987
4. Radu Paul Lungu, Elemente de mecanica statistica cuantica, Editura UB, 2017.

| **7.2 Tutorials** | **Teaching techniques** | **Observations** |
|---|---|---|
| The statistical thermodynamics of the ideal fermionic gas. White dwarf stars. Neutron stars. | Problem solving | 4 Hours |
| The statistical thermodynamics of the ideal bosonic gas. | Problem solving | 4 Hours |
| Statistical mechanics of lattice vibrations. Phonons. Debye model. | Problem solving | 2 Hours |
| Heisenberg model and applications. | Problem solving | 4 Hours |

**References:**
1. R. Balian, From Microphysics to Macrophysics Vol. 1, 2, Springer 2006
2. D. Dalvit, J. Frastai, I. Lawrie, Problems on statistical mechanics, IOP 1999.
3. Radu Paul Lungu, Elemente de mecanica statistica cuantica, Editura UB, 2017

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

This course unit develops some theoretical competences, which are fundamental for a Master student in the field of modern physics, corresponding to national and international standards. The contents is in line with the requirement of the main employers of research institutes and universities.

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | Clarity and coherence of exposition<br>- Correct use of the methods/ physical models<br>- The ability to give specific examples | Written test and oral examination | 60% |
| Tutorial | Ability to use specific problem solving methods | Homeworks | 40% |
| Minimal requirements for passing the exam | At least 50 of exam score and of homeworks. | | |

| | | |
|---|---|---|
| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
| 13.07.2025 | Prof. Dr. Virgil Baran | Lect. Dr. Virgil V. Baran |
| Date of approval | | Head of department name and signature |
| 15.07.2025 | | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DI.102 Group Theory and Applications in Physics

**1. Study program**

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

**2. Course unit**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Group Theory and Applications in Physics | | | | | | |
| 2.2. Teacher | Prof. Dr. Virgil Baran | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | Lect. Dr. Cristian Iorga | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

**3. Total estimated time**

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 2 | 3.2. Lectures | 1 | 3.3. Tutorials/Practicals/Projects | 1/0/0 |
| 3.4. Total hours per semester | 28 | 3.5. Lectures | 14 | 3.6. Tutorials/Practicals/Projects | 14/0/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 49 |
| Research in library, study of electronic resources, field research | | | | | 24 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 24 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 97 |
| 3.8. Total hours per semester | | | | | 125 |
| 3.9. ECTS | | | | | 5 |

**4. Prerequisites (if necessary)**

| | |
|---|---|
| 4.1. curriculum | Linear algebra, Quantum mechanics |
| 4.2. competences | Knowledge about: mechanics, atomic physics, solid state physics, nuclear physics |

**5. Conditions/Infrastructure (if necessary)**

| | |
|---|---|
| 5.1. for lecture | Video projector |
| 5.2. for tutorials/practicals | |

**6. Learning outcomes**

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

**7. Contents**

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Introductory notions:symmetries of a physical system, the role of group theory in physics, groups clasification. | Systematic exposition - lecture. Examples | 1 Hour |
| Group axioms, group multiplication table, subgroups, mappings of groups, direct product of groups. | Systematic exposition - lecture. Examples | 1 Hour |
| Conjugate elements, equivalence classes, invariant subgroups, cosets, quotient group | Systematic exposition - lecture. Examples | 2 Hours |

| | | |
|---|---|---|
| Matrix representation of a group, equivalent representations, irreducible representation. Schur;s lemma. | Systematic exposition - lecture. Examples | 2 Hours |
| Orthogonality relations for irreducible representations of a finite group, inequivalent representations for finite groups, characters and their orthogonality relations, character table. | Systematic exposition - lecture. Examples | 2 Hours |
| Group theory and quantum mechanics. From degeneracy to group representations:classification of the eigenvalues and of the eigenstates of energy according to the irreducible representations of symmetry group. Applications. | Systematic exposition - lecture. Examples | 2 Hours |
| Discrete symmetries. Rotation group in quantum mechanics. Tensor operators. Wigner-Eckart theorem. Aplications in atomic and nuclear physics. | Systematic exposition - lecture. Examples | 4 Hours |

**References:**

1. J.F. Corwell, Group theory in physics. An Introduction. Academic Press, 1997.
2. A. Zee, Group theory in a nutshell for physicist, Princeton University Press, 2017
3. W.K. Tung, Group theory in physics, World Scientific, 1985


| **7.2 Tutorials** | **Teaching techniques** | **Observations** |
|---|---|---|
| Basic group theory. Aplications. | Problem solving | 2 Hours |
| Discrete groups representations. | Problem solving | 2 Hours |
| Permutation groups. Dihedral groups. | Problem solving | 2 Hours |
| Group theory and harmonic motion. | Problem solving | 2 Hours |
| Unitary representations for rotations, Wigner matrices, Spherical tensors. | Problem solving | 4 Hours |
| Discrete translations. | Problem solving | 2 Hours |

**References:**

1. A. Zee, Group theory in a nutshell for physicist, Princeton University Press, 2017
2. W.K. Tung, Group theory in physics: Problems and solutions, World Scientific, 1991
3. S. Sternberg, Group theory and physics, Cambridge University Press, 1994


**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of the methods/ physical models<br>- The ability to give specific examples | Written test/oral examination | 60% |
| Tutorial | - Ability to use specific problem solving methods | Homeworks | 40% |
| Minimal requirements for passing the exam | At least 50% of exam score. | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Prof. Dr. Virgil Baran | Lect. Dr. Cristian Iorga |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DI.103 Experimental Methods in Physics

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Experimental Methods in Physics |
| 2.2. Teacher | Conf. dr. Ovidiu TOMA Conf. dr. Adriana BALAN |
| 2.3. Tutorials/Practicals instructor(s) | Conf. dr. Ovidiu TOMA Conf. dr. Adriana BALAN |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 1 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 3 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/1/0 |
| 3.4. Total hours per semester | 42 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/14/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 42 |
| Research in library, study of electronic resources, field research | 21 |
| Preparation for practicals/tutorials/projects/reports/homework | 20 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 83 |
| 3.8. Total hours per semester | 125 |
| 3.9. ECTS | 5 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Electricity and magnetism, Optics, Solid State Physics I, Electrodynamics, Quantum mechanics |
| 4.2. competences | Using of software tools for data analysis/processing |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Multimedia infrastructure (PC, videoprojector, internet conection) |
| 5.2. for tutorials/practicals | Research infrastructure for morphological, optical, magnetic and microstructural characterizations. |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

### 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Atomic force microscopy (AFM) – physical principles. Working modes (non-contact, contact). Characterization of surface morphology. Magnetic force microscopy (MFM), Scanning tunneling microscopy (STM). Applications. | Systematic exposition - lecture. Examples. | 4 Hours |
| Photoluminescence. Light Emitting Diodes. Laser diodes. | Systematic exposition - lecture. Examples. | 6 Hours |

| | | |
|---|---|---|
| Ellipsometry. Physical principles. Optical coefficients of thin films. Spectroscopic ellipsometry. Measurement principles for ($\Psi$, $\Delta$). Instrumentation, types of ellipsometers (RAE, RAEC, RCE, PME). Data analysis. Construction of optical models. | Systematic exposition - lecture. Examples. | 12 Hours |
| NIR-VIS-UV Spectrophotometry applied in the optical investigations of semiconducting thin films. | Systematic exposition - lecture. Examples. | 6 Hours |

**References:**

1. M. Nastasi, J.W. Mayer, Y. Wang, Ion beam analysis – Fundamentals and applications (CRC Press, Boca Raton, USA, 2015).
2. M. Fox, Optical properties of solids (Oxford University Press, Oxford, UK, 2001).
3. R.M.A. Azzam, N.M. Bashara, Ellipsometry and polarized light, North-Holland, 1999.
4. H. Fujiwara, Spectroscopic ellipsometry: principles and applications, Wiley, 2007.
5. M. Losurdo and K. Hingerl, Ellipsometry at the Nanoscale, Springer, 2013.

| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| AFM in contact and non-contact mode. Surface morphology characterizations. | Guided practical work | 4 Hours |
| Ellipsometrical measurements. Dispersion of optical coefficients of thin films for different material structures. | Guided practical work | 6 Hours |
| The recording of absorption spectra using a double-beam UV-VIS-NIR spectrophotometer. | Guided practical work | 4 Hours |

**References:**

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

This course unit develops some theoretical and practical competencies and skills corresponding to national and international standards, which are important for a master student in the field of modern Physics and technology. The contents and teaching methods were selected after a thorough analysis of the contents of similar course units in the syllabus of other universities from Romania or the European Union. The contents are in line with the requirements of the main employers of the graduates (industry, research institutes, high-school teaching).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Explicitness, coherence and concision of scientific statements;<br>- Correct use of physical models and of specific mathematical methods;<br>- Ability to analyse specific examples; | Written and oral exam | 60% |
| Practical | - Knowledge and correct use of specific experimental techniques<br>- Data processing and analysis; | Colloquium | 40% |
| Minimal requirements for passing the exam | Correct solving of subjects indicated as required for obtaining mark 5. | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Conf. dr. Ovidiu TOMA Conf. dr. Adriana BALAN | Conf. dr. Ovidiu TOMA Conf. dr. Adriana BALAN |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DI.104 Optical properties of surfaces and nanostructures

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Optical properties of surfaces and nanostructures |
| 2.2. Teacher | Associate Professor Doiniţa Bejan |
| 2.3. Tutorials/Practicals instructor(s) | Associate Professor Doiniţa Bejan |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 1 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 47 |
| Research in library, study of electronic resources, field research | 24 |
| Preparation for practicals/tutorials/projects/reports/homework | 23 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 94 |
| 3.8. Total hours per semester | 150 |
| 3.9. ECTS | 6 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Taking courses: Optics, Spectroscopy and Lasers, Quantum Mechanics, Solid State Physics, Fundamentals of Atomic Physics. |
| 4.2. competences | Use of software packages for data analysis and processing |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Multimedia equipped class (videoprojector) |
| 5.2. for tutorials/practicals | Spectroscopy laboratory |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Surface crystallography: direct lattice (three-dimensional lattices, two-dimensional lattices, surface relaxation and reconstruction), reciprocal volume lattice, surface lattice, Brillouin zones. | Systematic exposition - lecture. Examples | 4 Hours |
| Investigation of direct surface structure by scanning tunneling microscope (STM). Investigation of reciprocal structure by X-ray diffraction (S-XRD) and low-energy electron diffraction (LEED). | Systematic exposition - lecture. Examples | 6 Hours |
| Electronic surface structure: jelly (jellium) model; quasi-free electron model, surface states, image states; hard bond model. | Systematic exposition - lecture. Examples | 6 Hours |

| | | |
|---|---|---|
| Ultraviolet photoemission spectroscopy: transition moment; physisorption; chemisorption; band structure characterization. | Systematic exposition - lecture. Examples | 6 Hours |
| Growth and characterization of semiconductor nanostructures: synthesis methods; characterization methods. | Systematic exposition - lecture. Examples | 2 Hours |
| Electronic states in 3D semiconductors: energy bands in 3D semiconductors; effective mass approximation; semiconductor alloys. | Systematic exposition - lecture. Examples | 2 Hours |
| Low dimensionality systems: electronic states in low dimensionality structures; density of states. Excitons. Optical transitions in nanostructures | Systematic exposition - lecture. Examples | 2 Hours |

**References:**


1. 1. A. Zangwill, Physics at surfaces, Cambridge University Press (1988).
2. M. C. Desjonquères, D. Spanjard, Concepts in surface physics, Springer-Verlag, Heidelberg, 1993/ M. C. Desjonqueres, D. Spanjard, Concepte de fizicasuprafetei, Ed. Tehnica, 1998.
3. T. A. Delchar, and D. P. Woodruff, Modern Techniques of Surface Science, Cambridge Solid State Science Series, 1990.
4. H. Ibach, Physics of surfaces and interfaces, Springer Verlag, Berlin Heidelberg, 2006.
5. D. Bejan, Structura si caracterizarea suprafetelor, Ed. Univ. Bucureşti, 2007
6. E. C. Niculescu, Efectul laser asupra sistemelor mezoscopice, Ed. Printech, 2009
7. Kamakhya Prasad Ghatak, Sitangshu Bhattacharya, Debashis De, Photoemission from optoelectronic materials and their nanostructures, Springer 2012
8. Paul Harisson, Alex Valvanis, Quantum wells, wires and dots (theoretical and computational physics of semiconductor nanostructures), John Wiley and Sons, 2016
9. Doina Bejan, Course notes, 2024


| 7.3 Practicals | Teaching techniques | Observations |
|---|---|---|
| Determining the symmetry of surface structures and superstructures. | Guided practical activity | 4 Hours |
| Construction of the first Brillouin zone for CFC and CVC surfaces(111), (110), (100) starting from the volume structure | Guided practical activity | 4 Hours |
| Surface structure determination from LEED images for reconstructed SnFe(100) and SiC(111). | Guided practical activity | 4 Hours |
| Matlab programming of the tunneling effect (STM). | Guided practical activity | 4 Hours |
| Matlab programming of pseudopotentials. | Guided practical activity | 4 Hours |
| Spectral terms of diatomic molecules | Guided practical activity | 2 Hours |
| Optical properties of quantum wells with different confinement potentials | Guided practical activity | 6 Hours |

**References:**


1. 1. A. Zangwill, Physics at surfaces, Cambridge University Press (1988).
2. M. C. Desjonquères, D. Spanjard, Concepts in surface physics, Springer-Verlag, Heidelberg, 1993/ M. C. Desjonqueres, D. Spanjard, Concepte de fizica suprafetei, Ed. Tehnica, 1998.
3. D. Bejan, Structura si caracterizarea suprafetelor, Ed. Univ. Bucureşti, 2007
4. E. C. Niculescu, Efectul laser asupra sistemelor mezoscopice, Ed. Printech, 2009
5. Paul Harisson, Alex Valvanis, Quantum wells, wires and dots (theoretical and computational physics of semiconductor nanostructures), John Wiley and Sons, 2016
6. Doina Bejan, Course notes, 2024


**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

In order to outline the contents, the choice of teaching/learning methods, the subject holders consulted the contents of similar subjects taught at universities in the country and abroad (University of Paris-Sud, Faculty of Applied Sciences (Polytechnic University, Bucharest)). The content of the subject is in accordance with the requirements for employment in research institutes in physics and materials science and in teaching (according to the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity, coherence and brevity of exposition;<br>- Correct use of the methods/<br>physical models<br>- The ability to give specific examples | Written test | 60% |
| Practical | - Application of specific solution methods for the given problem; | continuous evaluation | 40% |
| Minimal requirements for passing the exam | Mandatory attendance: 50% of classes and laboratories<br>Correct presentation of the topics indicated for obtaining a score of 5 in the final exam. | | |

| | | |
|---|---|---|
| Date, | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| 13.07.2025 | Associate Professor Doiniţa Bejan | Associate Professor Doiniţa Bejan |

| | |
|---|---|
| Date of approval | Head of department<br>name and signature |
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DI.105 Ethics and academic integrity

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Matter Structure, Atmospheric and Earth Physics, Astrophysics |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Ethics and academic integrity | | | | | | |
| 2.2. Teacher | lector dr.Sanda Voinea | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 1 | 2.6. Type of evaluation | verificare | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 1 | 3.2. Lectures | 1 | 3.3. Tutorials/Practicals/Projects | 0/0/0 |
| 3.4. Total hours per semester | 14 | 3.5. Lectures | 14 | 3.6. Tutorials/Practicals/Projects | 0/0/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 31 |
| Research in library, study of electronic resources, field research | 15 |
| Preparation for practicals/tutorials/projects/reports/homework | 15 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 61 |
| 3.8. Total hours per semester | 75 |
| 3.9. ECTS | 3 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Moral evaluation frameworks. Fundamental concepts of ethics.<br><br>Ethics and the scientific community.<br><br>Criteria for moral evaluation: consequences / intentions, virtues. | Lecture. Example. Discussion. | 2 Hours |
| Academic integrity: institutional tools.<br><br>Codes and ethics commissions. | Lecture. Example. Discussion. | 2 Hours |

| | | |
|---|---|---|
| Principles of research ethics | Lecture. Example. Discussion. | 2 Hours |
| Challenges and dilemmas in research ethics | Lecture. Example. Discussion. | 2 Hours |
| Publication ethics: authorship and co-authorship | Lecture. Example. Discussion. | 2 Hours |
| Access to resources (fairness and equity in academic organizations and research teams) | Lecture. Example. Discussion. | 2 Hours |
| Deontology of teamwork in scientific research | Lecture. Example. Discussion. | 2 Hours |

**References:**


Julian Baggini, Peter S. Fosl, A Compendium of Ethical Concepts and Methods, Blackwell Publishing, 2014.

Blaxter, L, Hugh, C. Tight, L. How to research, New York, 2006

Angelo Corlett. " The Role of Philosophy in Academic Ethics", Journal of Academic Ethics, Volume 12, Issue 1, pp 1–14, 2014

Codul de etică al Universităţii din Bucureşti https://unibuc.ro/wp-content/uploads/2021/01/CODUL-DE-ETICA-SI-DEONTOLOGIE-AL-UNIVERSITATII-DIN-BUCURESTI-2020-1.pdf

Carta UNIBUC (https://unibuc.ro/wp-content/uploads/2018/12/CARTA-UB.pdf)

Joshua D. Greene, et. al. "An fMRI investigation of emotional engagement in moral judgment." Science, 2001.

Neil Hamilton. Academic Ethics, Westport: Praeger Publishers, 2002

Bruce Macfarlane. Researching with Integrity. The Ethics of Academic Enquiry, London: Routledge, 2009.

James Rachels, Introducere în Etică, traducere de Daniela Angelescu, Editura Punct, 2000.

Ebony Elizabeth Thomas and Kelly Sassi, "An Ethical Dilemma: Talking about Plagiarism and Academic Integrity in the Digital Age", English Journal 100.6, pp. 47–53, 2011

Anthony Weston, A Practical Companion to Ethics, Oxford University Press, 2011

Barrow, R., Keeney, P. (eds), Academic Ethics, New York: Routledge, 2006

Bretag, T. (ed), Handbook of Academic Integrity, Singapore: Springer, 2016


**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

The course addresses the most discussed theoretical issues in the area of academic ethics, along with their practical implications for impact. Not only abstract arguments and positions are discussed and evaluated, but also issues related to the ethical infrastructure of academic organizations or moral decision-making tools that can be used by students in their academic work and future professional life

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | Achieving the grade of ADMISSION in the essay , attending at least 50% of the courses | | |

| | | |
|---|---|---|
| Date, | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| 13.07.2025 | lector dr.Sanda Voinea | |

| | |
|---|---|
| Date of approval | Head of department<br>name and signature |
| 15.07.2025 | Lect. dr. Sanda VOINEA |

# Syllabus

Academic year 2025/2026
DI.108 Interferential and polarimetric methods in photonics

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Interferential and polarimetric methods in photonics | | | | | | |
| 2.2. Teacher | Conf. dr. Ovidiu Toma | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | Conf. dr. Ovidiu Toma | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | exam | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 72 |
| Research in library, study of electronic resources, field research | | | | | 36 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 36 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 144 |
| 3.8. Total hours per semester | | | | | 200 |
| 3.9. ECTS | | | | | 8 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Geometrical and Wave Optics, Spectroscopy and Lasers |
| 4.2. competences | Using software packages for data analyses and processing |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Video projector |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Wave interference (general case, special cases). Coherence of waves. Two-Wave Interference: Wavefront Splitting. Interference devices of the Young – Fresnel type. Two-Wave Interference: Amplitude Division. | Systematic exposition – lecture. Examples | 4 Hours |
| Two-wave interferometers: Michelson, Fizeau, Fizeau – Michelson, Rayleigh, Jamin, Sirks – Pringsheim, Dyson, Twyman – Green, Kösters. Multiple wave interferometers: Fabry – Perot, Fizeau – Tolanski, Lummer – Gehrcke, interference filters. | Systematic exposition – lecture. Examples | 10 Hours |

| | | |
|---|---|---|
| Polarization of light, fundamentals. Interference of polarized light. Elliptically polarized light. Stokes parameters. Poincare sphere. Crystalline plate between nicols. Chromatic polarization in parallel and convergent light. Analyzers and compensators. | Systematic exposition – lecture. Examples | 8 Hours |
| Mathematical description of polarization states. Stokes vectors for different polarization states. Coordinate transformations. The Mueller matrix formalism. Mueller polarization imaging. | Systematic exposition – lecture. Examples | 6 Hours |

**References:**

1. M. Born, E. Wolf, Principles of Optics (6th Ed.), Pergamon Press, London, 1985.
2. G.G.Bratescu, Interferometrie aplicata, Ed. Tehnica, Bucuresti, 1984.
3. G. Chartier, Introduction to Optics, Springer Verlag, New York, 2005.
4. H. Fujiwara, Spectroscopic Ellipsometry, Principles and Applications, John Wiley and Sons, London, 2007.
5. O. Toma, E. Dinescu, "Application of the matrix formalism in a Mueller imaging polarimeter", Rom. Rep. Phys., Vol. 60, No.4, p. 1065 – 1070 (2008).

| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| Study of the Desaine device. Measuring the radii of curvature of lenses. | Directed practical activity | 4 Hours |
| Michelson interferometer (classical and laser). Applications in spectroscopy and interference refractometry. Mach – Zehnder interferometer. | Directed practical activity | 4 Hours |
| Fizeau interferometer (classical and laser). Checking the optical quality on different surfaces. | Directed practical activity | 4 Hours |
| Jamin Interferometer. Measurement of refractive indices in gases | Directed practical activity | 4 Hours |
| Fabry – Perot interferometer. Benoit method of exact fractions. | Directed practical activity | 4 Hours |
| The study of polarized light by reflection at the polariscope and the measurement of the Brewster angle at the air-glass reflection. Experimental verification of Malus law. | Directed practical activity | 4 Hours |
| Study of chromatic polarization in parallel and convergent light. Wavelength dependence of birefringence in liquid crystals. | Directed practical activity | 4 Hours |

**References:**

1. Interferometry and Polarimetry, O.Toma, C. Sima, Ed. Univ. Buc. 2016.

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

In order to outline the contents, the choice of teaching/learning methods, given the special importance of the discipline for applications in modern technology, the teacher consulted the content of similar disciplines from other universities (for example, Universite Angers, France). The content of the discipline is according to the employment requirements in research institutes in Photonics, Physics of lasers and in education (in accordance with the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | Clarity and coherence of exposition<br>- Correct use of the methods/ physical models<br>- The ability to give specific examples | Written test/oral examination | 70% |
| Practical | - Knowledge and use of experimental techniques<br>- Interpretation of results | Laboratory colloquium | 30% |
| Minimal requirements for passing the exam | Completion of all laboratory work.<br>At least 50% of exam score. | | |

| | | |
|---|---|---|
| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
| 13.07.2025 | Conf. dr. Ovidiu Toma | Conf. dr. Ovidiu Toma |

| | |
|---|---|
| Date of approval | Head of department name and signature |
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DI.201 Nonlinear optics

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Electricity, Solid State and Biophysics |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Nonlinear optics |
| 2.2. Teacher | Prof. dr. Daniela DRAGOMAN |
| 2.3. Tutorials/Practicals instructor(s) | C.S. I dr. Adrian PETRIS |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 2 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 3 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/1/0 |
| 3.4. Total hours per semester | 42 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/14/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 67 |
| Research in library, study of electronic resources, field research | 33 |
| Preparation for practicals/tutorials/projects/reports/homework | 33 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 133 |
| 3.8. Total hours per semester | 175 |
| 3.9. ECTS | 7 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Electricity and magnetism, Optics, Equations of Mathematical Physics |
| 4.2. competences | Computational physics abilities. Using of software tools for data analysis/processing |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Multimedia infrastructure (PC, videoprojector, internet connection) |
| 5.2. for tutorials/practicals | Specifically equipped laboratory |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | R2. The student/graduate understands, explains and interprets concepts, theories, models and principles of physics, highlighting practical applications of electromagnetism and light-matter interaction<br>R5. The student/graduate correctly describes physical systems, using specific theories and tools to characterize them.<br>R9. The student/graduate identifies methods, techniques, and laboratory instruments necessary for designing and conducting physical experiments. |
| Skills | R2. The student/graduate applies the principles and laws of physics in solving theoretical or practical problems in electromagnetism and light-matter interaction, including in partially unpredictable situations<br>R5. The student/graduate collects and interprets data resulting from the application of appropriate scientific methods, integrating the results obtained into an analytical framework.<br>R9. The student/graduate correctly interprets the data and deduces working formulas for calculations with physical quantities, appropriately applying specific fundamental principles and laws. |

| | |
|---|---|
| Responsibility and autonomy | R2. The student/graduate manages technical or professional activities or projects, making decisions, including in partially unforeseen situations<br>R5. The student/graduate efficiently organizes his/her schedule and resources, respecting deadlines and safety regulations.<br>R9. The student/graduate demonstrates autonomy in operating and maintaining laboratory equipment, respecting safety and quality standards. |

## 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Introduction: Maxwell's equations in dielectric media. Polarization mechanisms. Parametric nonlinear optical phenomena | Systematic exposition - lecture. Examples. | 4 Hours |
| Coupled-mode formalism in three-wave mixing | Systematic exposition - lecture. Examples. | 2 Hours |
| Birefringent crystals. The ellipsoid of refractive indices. Light propagation in anisotropic media. Phase-matching | Systematic exposition - lecture. Examples. | 3 Hours |
| Second harmonic generation. The tensor of second order nonlinear polarization | Systematic exposition - lecture. Examples. | 2 Hours |
| Efficiency of second harmonic generation. Design strategies to maximize the efficiency | Systematic exposition - lecture. Examples. | 2 Hours |
| Sum- and difference frequency generation, parametric oscillations | Systematic exposition - lecture. Examples. | 3 Hours |
| Linear and quadratic electro-optic effect. Symmetry of polarization tensor. Polarization matrices. Applications in electromagnetic field modulation | Systematic exposition - lecture. Examples. | 4 Hours |
| Coupled-mode formalism in four-wave mixing. Third harmonic generation, phase conjugation | Systematic exposition - lecture. Examples. | 3 Hours |
| Propagation of light pulses in nonlinear media. Propagation regimes. Optical solitons | Systematic exposition - lecture. Examples. | 5 Hours |

**References:**


1. R. Dabu, I. Gruia, A. Stratan, Noţiuni fundamentale de optică neliniară şi lucrări de laborator, Editura Univ. Bucuresti, 2005
2. B.E.A. Saleh, M.C. Teich, Fundamental of Photonics, 2nd edition, Wiley, 2007, Chapter 21: Nonlinear Optics
3. G. New, Introduction to Nonlinear Optics, Cambridge University Press, 2011
4. R. Boyd, Nonlinear Optics, 3rd edition, Academic Press, 2008
5. C. Manzoni, G. Cerullo, Design criteria for ultrafast optical parametric amplifiers, J. Opt. 18, 103501, 2016, open access
6. D. Dragoman, Optică neliniară, Editura Univ. Bucuresti, 2022
7. D. Dragoman, Lecture notes


| 7.3 Practicals | Teaching techniques | Observations |
|---|---|---|
| Laboratory presentation. Safety instructions | Guided practical work | 1 Hour |
| 1. Determination of the third-order nonlinear optical susceptibility by third-harmonic generation (bibliography 1.1 to 1.4) | Guided practical work | 4 Hours |
| 2. Measurement of third-order optical nonlinearities by the Z-scan method (bibliography 2.1 to 2.6) | Guided practical work | 4 Hours |
| 3. Investigation of third-order nonlinear optical processes by pump-probe interferometry. All-optical spatial light modulation (bibliography 3.1 to 3.4) | Guided practical work | 4 Hours |
| Laboratory colloquium | Guided practical work | 1 Hour |

**References:**
1.1 R. Boyd, Nonlinear Optics, Third Edition, Elsevier, Academic Press (2008)
1.2 P. Butcher, D. Cotter, The Elements of Nonlinear Optics, Cambridge University Press, Cambridge (1990)
1.3 A. Petris, P. Gheorghe, T. Braniste, I. Tiginyanu, "Ultrafast third-order nonlinear optical response excited by fs laser pulses at 1550 nm in GaN crystals", Materials 14(12), 3194 (2021)
1.4 A. Petris, P. S. Gheorghe, V. I. Vlad, E. Rusu, V. V. Ursaki, I. M. Tiginyanu, Ultrafast third-order optical nonlinearity in SnS2 layered compound for photonic applications, Optical Materials 76, 69-74 (2018)
2.1 R. Boyd, Nonlinear Optics, Third Edition, Elsevier, Academic Press (2008)
2.2 R. L. Sutherland, Handbook of Nonlinear Optics, Second Edition, Revised and Expanded, Marcel Dekker, Inc., New York, Basel (2003)
2.3 M. Sheik-Bahae, A. A. Said, E. W. Van Stryland, "High-sensitivity, single-beam n2 measurements", Optics Letters 14 (17), 955 (1989)
2.4 M. Sheik-Bahae, A.A. Said, T.-H. Wei, D.J. Hagan, E.W. Van Stryland, "Sensitive measurement of optical nonlinearities using a single beam", IEEE Journal of Quantum Electronics 26 (4), 760 (1990)
2.5 E. W. Van Stryland, M. Sheik-Bahae, "Z-Scan Measurements of Optical Nonlinearities", in Characterization Techniques and Tabulations for Organic Nonlinear Materials, M. G. Kuzyk and C. W. Dirk, Eds., page 655-692, Marcel Dekker, Inc. (1998)
2.6 I. Dancus, V. I. Vlad, A. Petris, T. B. Rujoiu, I. Rau, F. Kajzar, A. Meghea, A. Tane, Z-scan and I-scan methods for characterization of DNA optical nonlinearities, Rom. Rep. Phys 65 (3), 966 (2013)
3.1 R. Boyd, Nonlinear Optics, Third Edition, Elsevier, Academic Press (2008)
3.2 A. Petris, P. Gheorghe, I. Rau, A. M. Manea-Saghin, F. Kajzar, "All-optical spatial phase modulation in films of dye-doped DNA biopolymer", European Polymer Journal 110, 130-137 (2019)
3.3 A. Petris, P. Gheorghe, V. I. Vlad, I. Rau, F. Kajzar, "Interferometric method for the study of spatial phase modulation induced by light in dye-doped DNA complexes", Rom. Rep. Phys 67 (4), 1373-1382 (2015)
3.4 I. Dancus, S. T. Popescu, A. Petris, "Single shot interferometric method for measuring the nonlinear refractive index", Optics Express 21(25), 31303-31308 (2013)

## 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

The content of this course is designed to lead to the formation of instrumental-application specific competences (such as the design of optical systems for special applications; the use of models and simulation methods, as well as generating and investigation techniques, of electromagnetic fields with relevant characteristics for certain applications), of interest for research institutes in Laser Physics and/or Physics of Materials and education. Because of the importance of the course for modern applications of high-power lasers, the content and the teaching methods have been put into correspondence with similar courses taught at other universities (Univ. Friedrich Schiller Jena, Germany, Institute of Optics, Univ. of Rochester, USA, Institut d'Optique, Palaiseau, France) as well as with the experimental facilities of the research institutes on the Măgurele platform

## 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity, coherence and concision of exposition;<br>- Correct use of physical models and of specific mathematical methods for solving a given problem;<br>- Ability to exemplify | Written exam | 67% |
| Practical | - Use and correct application of experimental techniques;<br>- Data interpretation | Exam/Laboratory colloquium | 33% |
| Minimal requirements for passing the exam | Correct solving of subjects totaling the number of points required for obtaining mark 5 at the written exam.<br>Attendance of all practicals/lab works and mark 5 at colloquium | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
| --- | --- | --- |
| 13.07.2025 | Prof. dr. Daniela DRAGOMAN | C.S. I dr. Adrian PETRIS |

| Date of approval | Head of department name and signature |
| --- | --- |
| 15.07.2025 | Assoc. prof. Adrian RADU |

# Syllabus

Academic year 2025/2026
DI.202 Physical processes in intense laser fields

**1. Study program**

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

**2. Course unit**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | | | Physical processes in intense laser fields | | | | | | |
| 2.2. Teacher | | | Conf. Madalina Boca | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | Conf. Madalina Boca | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | | | |

**3. Total estimated time**

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 2/0/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 28/0/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 72 |
| Research in library, study of electronic resources, field research | | | | | 36 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 36 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 144 |
| 3.8. Total hours per semester | | | | | 200 |
| 3.9. ECTS | | | | | 8 |

**4. Prerequisites (if necessary)**

| | |
|---|---|
| 4.1. curriculum | Classical electrodynamics, Quantum Mechanics, Numerical methods in Physics |
| 4.2. competences | Knowledge of basic topics in classical electrodynamics and quantum mechanics, ability to understand basic numerical algorithms |

**5. Conditions/Infrastructure (if necessary)**

| | |
|---|---|
| 5.1. for lecture | Room with videoprojector, acces to internet |
| 5.2. for tutorials/practicals | Room with videoprojector, acces to internet |

**6. Learning outcomes**

| | |
|---|---|
| Knowledge | R1. The student/graduate understands and interprets the concepts, theories, principles, phenomena and fundamental laws of electromagnetism and of light-matter interaction<br>R2. The student/graduate understands, explains and interprets concepts, theories, models and principles of physics, highlighting practical applications of electromagnetism and light-matter interaction<br>R3. The student/graduate establishes appropriate analysis methods for specific situations in the field of physics.<br>R4. The student/graduate deduces working formulas for calculations with physical quantities, correctly using fundamental principles and laws of physics, with emphasis on electromagnetism and light-matter interaction<br>R5. The student/graduate correctly describes physical systems, using specific theories and tools to characterize them.<br>R8. The student/graduate identifies and specifies relevant scientific information and legislative regulations specific to the field of physics, with an emphasis on electromagnetism and light-matter interaction<br>R10. The student/graduate identifies the appropriate mathematical models and algorithms for analyzing experimental data in electromagnetism and light-matter interaction |
| Skills | R1. The student/graduate uses the concepts and methods specific to the modeling of physical phenomena related to electromagnetism and light-matter interaction<br>R2. The student/graduate applies the principles and laws of physics in solving theoretical or practical problems in electromagnetism and light-matter interaction, including in partially unpredictable situations<br>R3. The student/graduate correlates statistical analysis methods with experimental data, integrating the results and critically interpreting the information obtained.<br>R4. The student/graduate critically evaluates a scientific communication or a specialized report with a low degree of difficulty, analyzing the arguments and conclusions presented.<br>R5. The student/graduate collects and interprets data resulting from the application of appropriate scientific methods, integrating the results obtained into an analytical framework.<br>R8. The student/graduate compares theoretical results from the specialized literature with experimental ones, integrating the data into a professional report or project.<br>R10. The student/graduate uses the appropriate models and algorithms to make predictions on phenomena specific for electromagnetism and light-matter interaction |
| Responsibility and autonomy | R1. The student/graduate presents scientific or popularization papers and seminars on the fundamentals of electromagnetism and light-matter interaction, adapting the content<br>R2. The student/graduate manages technical or professional activities or projects, making decisions, including in partially unforeseen situations<br>R3. The student/graduate takes responsibility for the personal professional development, planning and evaluating their own progress.<br>R4. The student/graduate responsibly performs independent work tasks and contributes to interdisciplinary approaches<br>R5. The student/graduate efficiently organizes his/her schedule and resources, respecting deadlines and safety regulations.<br>R8. The student/graduate critically analyzes a specialized paper or a scientific communication with a medium degree of difficulty, assuming the conclusions and recommendations.<br>R10. The student/graduate identifies and uses appropriate mathematical tools in agreement with ethical and deontological principles |

**7. Contents**

| **7.1 Lecture [chapters]** | **Teaching techniques** | **Observations** |
|---|---|---|
| Theoretical description of laser beams; particular solutions of the Maxwell equations: plane waves, Gaussian beams, helical beams. | Systematic exposition - lecture. Examples | 4 Hours |
| Classical motion of the charged particle in the presence of a laser field | Systematic exposition - lecture. Examples | 2 Hours |

| | | |
|---|---|---|
| Classical description of radiation scattering: linear and non-linear Thomson scattering | Systematic exposition - lecture. Examples | 2 Hours |
| Quantum description of electrons in electromagnetic fields; the Volkov solutions | Systematic exposition - lecture. Examples | 2 Hours |
| Quantum description of radiation scattering: linear and non-linear Compton process | Systematic exposition - lecture. Examples | 2 Hours |
| Simple systems interacting with the quantized electromagnetic field: the two level system, one electron atom | Systematic exposition - lecture. Examples | 4 Hours |
| Quantum transitions in the perturbative and non-perturbative regime; analytical and numerical approaches | Systematic exposition - lecture. Examples | 6 Hours |
| Elements of plasma physics interacting with intense electromagnetic fields, analytical and numerical approaches | Systematic exposition - lecture. Examples | 4 Hours |
| Angular momentum of the electromagnetic field, transfer of angular momentum in elementary processes | Systematic exposition - lecture. Examples | 2 Hours |

**References:**

J. D. Jackson, Classical electrodynamics, John Wiley and Sons, 1999
C. Joachain, A. Kylstra, R. M. Potvliege, Atoms in intense laser fields, Cambridge University Press, 2012
A. Di Piazza, C. Muller, K. Z. Hatsagortsyan, and C. H. Keitel, Extremely high-intensity laser interactions with fundamental quantum systems, Rev. Mod. Phys. 84, 1177 (2012)
A. Gonoskov et al, Charged particle motion and radiation in strong electromagnetic fields, REv. Mod. Phys. 94, 045001, 2022
D. Suter, The Physics of Laser-Atom Interactions (Cambridge Studies in Modern Optics), 1997
M. Fox, Quantum Optics (Oxford Master Series in Atomic, Optical and Laser Physics), 2006
F. V. Hartemann, High-field electrodynamics, CRC press, 2002
P. Michel, Introduction to Laser-Plasma Interactions, Springer International Publishing, 2023
J. P. Torres (ed), Twisted photons: applications of light with orbital angular momentum, Wiley-VCH (2011)

| **7.2 Tutorials** | **Teaching techniques** | **Observations** |
|---|---|---|
| Calculation of energy density, momentum, angular momentum of the electromagnetic field, application for some particular cases | Supervised practical activity, problem solving | 4 Hours |
| Analytical and numerical solution of the classical equation of motion for charged particles in electromagnetic field | Supervised practical activity, problem solving | 4 Hours |
| Properties of Volkov solutions, packets of Volkov states | Supervised practical activity, problem solving | 4 Hours |
| The rotating waves approximation, the Jaynes-Cummings model, | Supervised practical activity, problem solving | 2 Hours |
| Systems in mixed states interacting with the electromagnetic field; the time evolution problem | Supervised practical activity, problem solving | 4 Hours |
| Calculation of differential cross sections for some elementary processes in atom-laser interaction | Supervised practical activity, problem solving | 6 Hours |
| Numerical study of angular momentum transfer in atom-laser interaction | Supervised practical activity, problem solving | 2 Hours |
| | | 2 Hours |

**References:**

J. D. Jackson, Classical electrodynamics, John Wiley and Sons, 1999
C. Joachain, A. Kylstra, R. M. Potvliege, Atoms in intense laser fields, Cambridge University Press, 2012
A. Di Piazza, C. Muller, K. Z. Hatsagortsyan, and C. H. Keitel, Extremely high-intensity laser interactions with fundamental quantum systems, Rev. Mod. Phys. 84, 1177 (2012)
A. Gonoskov et al, Charged particle motion and radiation in strong electromagnetic fields, REv. Mod. Phys. 94, 045001, 2022
D. Suter, The Physics of Laser-Atom Interactions (Cambridge Studies in Modern Optics), 1997
M. Fox, Quantum Optics (Oxford Master Series in Atomic, Optical and Laser Physics), 2006
F. V. Hartemann, High-field electrodynamics, CRC press, 2002
P. Michel, Introduction to Laser-Plasma Interactions, Springer International Publishing, 2023
J. P. Torres (ed), Twisted photons: applications of light with orbital angular momentum, Wiley-VCH (2011)

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

| |
|---|
| This course unit develops some theoretical competences, which are fundamental for a Master student in the field of modern physics, corresponding to national and international standards. The contents is in line with the requirement of the main employers of research institutes and universities. |

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of the methods/physical models<br>- The ability to give specific examples | Written test + oral examination | 70% |
| Tutorial | - Ability to use specific problem solving methods | Homeworks | 30% |
| Minimal requirements for passing the exam | Requirements for mark 5 (10 points scale):<br>- At least 50% of exam score and of homework.<br><br>Requirements for mark 10 (10 points scale):<br>- At least 95% of exam score and of homework. | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Conf. Madalina Boca | Conf. Madalina Boca |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DI.208 Research activity (80 hours)

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Research activity (80 hours) | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 2 | 2.6. Type of evaluation | verificare | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 8 | 3.2. Lectures | 0 | 3.3. Tutorials/Practicals/Projects | 0/8/0 |
| 3.4. Total hours per semester | 80 | 3.5. Lectures | 0 | 3.6. Tutorials/Practicals/Projects | 0/80/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 210 |
| Research in library, study of electronic resources, field research | | | | | 105 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 105 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 420 |
| 3.8. Total hours per semester | | | | | 500 |
| 3.9. ECTS | | | | | 20 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

### 7. Contents

### 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| |

### 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | | | |

| | | |
|---|---|---|
| Date,<br><br>13.07.2025 | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| Date of approval<br><br>15.07.2025 | | Head of department<br>name and signature<br>Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026

DI.209 Finalization of master thesis (40 hours)

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Finalization of master thesis (40 hours) | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 2 | 2.6. Type of evaluation | verificare | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 0 | 3.3. Tutorials/Practicals/Projects | 0/4/0 |
| 3.4. Total hours per semester | 40 | 3.5. Lectures | 0 | 3.6. Tutorials/Practicals/Projects | 0/40/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 43 |
| Research in library, study of electronic resources, field research | | | | | 21 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 21 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 85 |
| 3.8. Total hours per semester | | | | | 125 |
| 3.9. ECTS | | | | | 5 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

## 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| |

## 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | | | |

| | | |
|---|---|---|
| Date, | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| 13.07.2025 | | |
| Date of approval | | Head of department<br>name and signature |
| 15.07.2025 | | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DI.210 Susţinerea publica a lucrării de disertaţie

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Susţinerea publica a lucrării de disertaţie |
| 2.2. Teacher | |
| 2.3. Tutorials/Practicals instructor(s) | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 2 | 2.5. Semester | 2 | 2.6. Type of evaluation | 0 | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 0 | 3.2. Lectures | 0 | 3.3. Tutorials/Practicals/Projects | 0/0/0 |
| 3.4. Total hours per semester | 0 | 3.5. Lectures | 0 | 3.6. Tutorials/Practicals/Projects | 0/0/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 125 |
| Research in library, study of electronic resources, field research | 63 |
| Preparation for practicals/tutorials/projects/reports/homework | 62 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 250 |
| 3.8. Total hours per semester | 250 |
| 3.9. ECTS | 10 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

## 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| |

## 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | | | |

| | | |
|---|---|---|
| Date, | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| 13.07.2025 | | |

| | |
|---|---|
| Date of approval | Head of department<br>name and signature |
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.106.1 Spectroscopy of condensed states and of materials for energy conversion

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Spectroscopy of condensed states and of materials for energy conversion |
| 2.2. Teacher | Conf. dr. Iulian Ionita |
| 2.3. Tutorials/Practicals instructor(s) | Conf. dr. Iulian Ionita |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 1 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 47 |
| Research in library, study of electronic resources, field research | 24 |
| Preparation for practicals/tutorials/projects/reports/homework | 23 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 94 |
| 3.8. Total hours per semester | 150 |
| 3.9. ECTS | 6 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Wave Optics, Spectroscopy and Lasers, Fundamentals of Atomic Physics, Solid State Physics, Quantum mechanics |
| 4.2. competences | Knowledge about: Linear algebra |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Video projector |
| 5.2. for tutorials/practicals | Computers, Instruments for spectral analyses in visible, ultraviolet and infrared |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Molecular symmetry and symmetry groups of some molecules and crystalline systems, examples | Systematic exposition - lecture. Examples | 2 Hours |
| Crystal field theory: Splitting the levels of ions introduced into the crystal field, Estimation of orbital energy, Selection rules and polarization, The relationship between the level diagram and optical spectra | Systematic exposition - lecture. Examples | 4 Hours |

| | | |
|---|---|---|
| Symmetry of molecular vibrations and selection rules: Vibronic coupling, Vibronic polarization, Symmetry and normal modes of vibration, Selection rules for fundamental vibrational transitions | Systematic exposition - lecture. Examples | 6 Hours |
| Basic optical spectroscopy techniques: Dispersion Spectrometry, FTIR Spectrometry, Raman Spectrometry | Systematic exposition - lecture. Examples | 2 Hours |
| Spectroscopy in materials characterization for energy conversion | Systematic exposition - lecture. Examples | 2 Hours |
| Characterization of non-crystalline materials by Raman spectrometry: vibrational modes, Stokes and anti-Stokes lines, standard vs. Resonance spectrometry, Raman microscopy. | Systematic exposition - lecture. Examples | 4 Hours |
| Characterization of non-crystalline materials by FTIR spectrometry: vibrational modes, stationary mode vs. time dependence, applications in energy conversion. | Systematic exposition - lecture. Examples | 4 Hours |
| Experimental methods of spectroscopy in the characterization of materials for energy conversion: determination of band gap and type of semiconductor. | Systematic exposition - lecture. Examples | 4 Hours |

**References:**


1. I. Ionita, ”Optical Spectroscopy and Group Theory: An Illustrated Introduction”, Taylor and Francis, 2014.
2. F. Cotton, Chemical Applications of Group Theory 3rd edition(1990)
3. Richard L. McCreery, ”Raman Spectroscopy for Chemical Analysis”, John Wiley and Sons
4. Wei Liu, Ying Fu, ”Spectroscopy of Semiconductors”, Springer, 2018


| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| Presentation of the laboratory, activities and work regulations in the laboratory (safety work rules) | Directed practical activity | 2 Hours |
| Modeling of molecular complexes using the Jmol program. | Directed practical activity | 4 Hours |
| Calculation of states and transitions of transition metals atoms with d<br>n<br>configuration in a cubic symmetry. | Directed practical activity | 4 Hours |
| Measurement of absorption and luminescence spectra of ionic crystals doped with transition metals and rare earths. | Directed practical activity | 4 Hours |
| Presentation of Raman and FTIR spectrometry components (radiation source, detector, measurement modes). | Directed practical activity | 2 Hours |
| Raman spectrometry of carbonaceous materials and evaluation of the degree of graphitization. | Directed practical activity | 4 Hours |
| Determination of the chemical structure of materials doped with heteroatoms. | Directed practical activity | 4 Hours |
| The solar spectrum, compatibility with the solar spectrum. | Directed practical activity | 4 Hours |

| References: |
|---|
| 1. I. Ionita, ”Optical Spectroscopy and Group Theory: An Illustrated Introduction”, Taylor and Francis, 2014.<br>2. Richard L. McCreery, ”Raman Spectroscopy for Chemical Analysis”, John Wiley and Sons. Sternberg, Group theory and physics, Cambridge University Press, 1994<br>3. Wei Liu, Ying Fu, ”Spectroscopy of Semiconductors”, Springer, 2018 |

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

In order to outline the contents, the choice of teaching/learning methods, given the special importance of the discipline for applications in modern technology, the holders of the discipline consulted the content of similar disciplines taught at universities in the country and abroad (Princeton University – Chemistry Dep, Universidad Autonoma de Madrid Department of Condensed Matter Physics, Denmark Technical University – Department of Energy Conversion and Storage, Trinity College Dublin – School of Chemistry). The content of the discipline is according to the requirements for employment in research institutes in physics and materials science and in education (under the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of the methods/ physical models<br>- The ability to give specific examples | Written test | 80% |
| Practical | - Knowledge and use of experimental techniques;<br>- Interpretation of the results | Laboratory colloquium | 20% |
| Minimal requirements for passing the exam | Requirements for mark 5 (10 points scale)<br>Getting the average 5.<br>Completion of all laboratory works and grade 5 in the colloquium – for the laboratory<br>The correct exposure of the indicated subjects to obtain a score of 5 in the final exam. | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Conf. dr. Iulian Ionita | Conf. dr. Iulian Ionita |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.106.2 Processing with laser beams

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Processing with laser beams | | | | | | |
| 2.2. Teacher | Marian ZAMFIRESCU | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | Raluca IVAN | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 47 |
| Research in library, study of electronic resources, field research | 24 |
| Preparation for practicals/tutorials/projects/reports/homework | 23 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 94 |
| 3.8. Total hours per semester | 150 |
| 3.9. ECTS | 6 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Optics, Spectroscopy and Lasers, Quantum mechanics, Basics of atomic physics |
| 4.2. competences | Knowledge about: Solid State Physics, Statistical Physics |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Lecture hall with multimedia equipment (computer, video projector, white board, internet connection) |
| 5.2. for tutorials/practicals | Access to a research laser facility (CETAL) with lasers for industrial processing, specialized software for laser materials processing and CAD. Safety equipment. |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

### 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Basic knowledge about lasers. Generation of laser radiation. Rate Equations. | Systematic exposition - lecture. Examples | 2 Hours |
| Resonant optical cavity, resonator stability, Thermal lens, Gaussian beam, spectral and spatial modes, modes selection. | Systematic exposition - lecture. Examples | 2 Hours |
| Industrial lasers: CO2, Nd:YAG, excimer, laser diodes, ultrashort pulsed lasers | Systematic exposition - lecture. Examples | 2 Hours |
| Laser beam transport and laser focusing (optical transport systems, beam pointing) | Systematic exposition - lecture. Examples | 2 Hours |

| | | |
|---|---|---|
| Fundamental phenomena in the interaction of the laser beam with matter | Systematic exposition - lecture. Examples | 2 Hours |
| Theory of laser ablation. The heat equation. The Saha-Boltzmann equation. Deposition of thin layers with pulsed laser beams. | Systematic exposition - lecture. Examples | 2 Hours |
| Laser processing systems and components. Laser cutting. Laser beam welding | Systematic exposition - lecture. Examples | 2 Hours |
| Laser surface treatment: hardening, resolidification, alloying, cladding, texturing. | Systematic exposition - lecture. Examples | 2 Hours |
| Additive manufacturing. Laser 3D printing of metallic parts | Systematic exposition - lecture. Examples | 2 Hours |
| 3D Laser lithography. One-photon and two-photon photopolymerization | Systematic exposition - lecture. Examples | 2 Hours |
| Laser processing at nanoscale: Laser nanotexturing, Laser near-field ablation. Optical trapping | Systematic exposition - lecture. Examples | 2 Hours |
| Optical methods of diagnosis and processing control a. Optical microscopy; b. Contact and non-contact profilometry; c. Fluorescence microscopy; d. Two-photon microscopy (SHG); e. Optical coherence tomography (OCT); f. Thermography | Systematic exposition - lecture. Examples | 2 Hours |
| Optical methods of diagnosis and processing control a. Optical microscopy; b. Contact and non-contact profilometry; c. Fluorescence microscopy; d. Two-photon microscopy (SHG); e. Optical coherence tomography (OCT); f. Thermography | Systematic exposition - lecture. Examples | 2 Hours |
| Cleaning works of art with a laser beam. Processing of biotissues with a laser beam. | Systematic exposition - lecture. Examples | 2 Hours |

**References:**


1. F. Trager (ed), Handbook: Lasers and Optics, Springer, 2007
2. I. Ionita, M. Zamfirescu, Teeth material ablation by femtosecond laser, Proc. SPIE vol. 7715-61, Biophotonics: Photonic Solutions for Better Health Care II, 77151S-11 (2010)
3. I. Ionita, M. Zamfirescu, "Femtosecond laser: the finest tool for hard tissue ablation", Proc. SPIE 8092, 80921D (2011); doi:10.1117/12.889285, in Medical Laser Applications and Laser-Tissue Interactions V, eds. Ronald Sroka, Lothar D. Lilge, 2011
4. Iulian Ionita, Compared NIR and UV Hard Tissue Drilling by Femtosecond Laser Beam, IEEE Proc. IQEC/CLEO Pacific Rim, Sydney, 2011
5. A. Stanculescu, A.-M. Albu, G. Socol, F. Stanculescu, M. Socol, N. Preda, O. Rasoga, M. Girtan, I. Ionita - MAPLE deposited thin monomer films of maleimidic derivatives for photonics, J. Opt. Adv. Mat. 12, no. 3, p. 731-739, 2010
6. M. Zamfirescu, M. Ulmeanu, F. Jipa, I. Anghel, S. Simion, R. Dabu, I. Ionita, Laser processing and characterization with femtosecond laser pulses, Rom. Rep. Phys., vol.62, no.3, p. 594-609, 2010
7. C. Constantinescu, A. Matei, I. Ionita, V. Ion, M. Dinescu, I.C. Vasiliu, A. Emandi, Ferrocene thin films grown by matrix-assisted pulsed laser evaporation for non linear optical applications, EMRS 2013
8. D. Dumitras, "Biofotonica", All, 1999
9. W. Koechner, "Solid-State Laser Engineering", Springer Series in Optical Sciences, ed. 2006.
10. Anthony E. Siegman, "Lasers" University Science Books, 1986.


| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| Laser safety measures and protocols. Optical sensors. Laser beam characterizations. | Assisted practical activity | 4 Hours |
| Numerical modelling of laser beam propagation in free space and optical media. | Assisted practical activity | 4 Hours |
| Experimental study of laser ablation. Laser ablation threshold. | Assisted practical activity | 4 Hours |
| Laser processing systems for laser cutting and laser beam welding. | Assisted practical activity | 4 Hours |
| Comparative study of photopolymerization with UV laser vs. femtosecond lasers. | Assisted practical activity | 4 Hours |
| Comparative study of laser patterning with ns pulses vs ultrashort pulses | Assisted practical activity | 4 Hours |

| | | |
|---|---|---|
| Microscopic study of the profiles made with a laser beam | Assisted practical activity | 4 Hours |

**References:**
1. F. Trager (ed), Handbook: Lasers and Optics, Springer, 2007
2. I. Ionita, M. Zamfirescu, Teeth material ablation by femtosecond laser, Proc. SPIE vol. 7715-61, Biophotonics: Photonic Solutions for Better Health Care II, 77151S-11 (2010)
3. I. Ionita, M. Zamfirescu, "Femtosecond laser: the finest tool for hard tissue ablation", Proc. SPIE 8092, 80921D (2011); doi:10.1117/12.889285, in Medical Laser Applications and Laser-Tissue Interactions V, eds. Ronald Sroka, Lothar D. Lilge, 2011
4. Iulian Ionita, Compared NIR and UV Hard Tissue Drilling by Femtosecond Laser Beam, IEEE Proc. IQEC/CLEO Pacific Rim, Sydney, 2011
5. A. Stanculescu, A.-M. Albu, G. Socol, F. Stanculescu, M. Socol, N. Preda, O. Rasoga, M. Girtan, I. Ionita - MAPLE deposited thin monomer films of maleimidic derivatives for photonics, J. Opt. Adv. Mat. 12, no. 3, p. 731-739, 2010
6. M. Zamfirescu, M. Ulmeanu, F. Jipa, I. Anghel, S. Simion, R. Dabu, I. Ionita, Laser processing and characterization with femtosecond laser pulses, Rom. Rep. Phys., vol.62, no.3, p. 594-609, 2010
7. C. Constantinescu, A. Matei, I. Ionita, V. Ion, M. Dinescu, I.C. Vasiliu, A. Emandi, Ferrocene thin films grown by matrix-assisted pulsed laser evaporation for non linear optical applications, EMRS 2013

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

In order to outline the contents, the choice of teaching/learning methods, given the particular importance of the discipline for applications in modern technology, the holders of the discipline consulted the content of similar disciplines taught at universities in the country and abroad. The content of the discipline is according to the employment requirements in research institutes in optics, lasers and in education (under the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of the methods/ physical models<br>- The ability to give specific examples | Written test | 80% |
| Practical | - Knowledge and use of experimental techniques<br>- Processing of experimental data and interpretation of the results | Hands-on laboratory assessment | 20% |
| Minimal requirements for passing the exam | Requirements for mark 5 (10 points scale):<br>- Completion of all laboratory work and score 5 on the laboratory test.<br>- The correct presentation of the indicated subjects to obtain a score of 5 in the final exam. | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Marian ZAMFIRESCU | Raluca IVAN |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.109.1 Quantum optics

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Quantum optics | | | | | | |
| 2.2. Teacher | Prof. dr. Iulia Ghiu | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | Lect. dr. Andreea Croitoru | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | exam | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 72 |
| Research in library, study of electronic resources, field research | | | | | 36 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 36 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 144 |
| 3.8. Total hours per semester | | | | | 200 |
| 3.9. ECTS | | | | | 8 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Optics, Algebra, Quantum mechanics |
| 4.2. competences | Equations of Mathematical Physics |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Video projector |
| 5.2. for tutorials/practicals | Video projector |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | R3. The student/graduate establishes appropriate analysis methods for specific situations in the field of physics.<br>R5. The student/graduate correctly describes physical systems, using specific theories and tools to characterize them.<br>R7. The student/graduate explains the operating principle of a measuring device or a physical method, highlighting the algorithm used. |
| Skills | R3. The student/graduate correlates statistical analysis methods with experimental data, integrating the results and critically interpreting the information obtained.<br>R5. The student/graduate collects and interprets data resulting from the application of appropriate scientific methods, integrating the results obtained into an analytical framework.<br>R7. The student/graduate prepares scientific reports and presentations, building logical and coherent arguments on general physics topics. |

| | |
|---|---|
| Responsibility and autonomy | R3. The student/graduate takes responsibility for the personal professional development, planning and evaluating their own progress.<br>R5. The student/graduate efficiently organizes his/her schedule and resources, respecting deadlines and safety regulations.<br>R7. The student/graduate carries out research internships in specialized units, writing reports on the activity and results obtained. |

**7. Contents**

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Quantization of the electromagnetic field | Systematic exposition. | 2 Hours |
| Entanglement. Condition that the two-photon state to be inseparable | Systematic exposition. | 4 Hours |
| The quantum description of the beam splitter. Applications | Systematic exposition. | 4 Hours |
| Bell's inequalities | Systematic exposition. | 4 Hours |
| Quantum random number generator | Systematic exposition. | 2 Hours |
| Quantum key distribution | Systematic exposition. | 4 Hours |
| Michelson interferometer | Systematic exposition. | 2 Hours |
| Interference phenomena with single and double photodetection. The experiment of Hong, Ou, Mandel. | Systematic exposition. | 2 Hours |
| The theory of quantum eraser | Systematic exposition. | 2 Hours |
| The proposal of Hanbury Brown-Twiss experiment | Systematic exposition. | 2 Hours |

**References:**


1. C. Gerry, P. Knight, Introductory Quantum Optics, Cambridge University Press, 2005.
2. M. O. Scully, M. S. Zubairy, Quantum Optics, Cambridge University Press, 2002.
3. Cohen-Tannoudji, Dupont-Roc, and Grynberg, Atom-Photon Interactions, Wiley, 1998.
4. D. F. Walls, G. J. Milburn, Quantum Optics, Springer Verlag, 1994.
5. C. W. Gardiner, Quantum Noise, Springer Verlag, 1991.
6. M. D. Al-Amri, M. M. El-Gomati, M. S. Zubairy (Editors), Optics in Our Time, Springer Open, 2016.
7. quED - Entanglement Demonstrator - A Science Kit for Quantum Physics, www.qutools.com, 2025.


| 7.3 Practicals | Teaching techniques | Observations |
|---|---|---|
| Generation of entanglement. Entanglement visibility | | 4 Hours |
| The experimental proof of CHSH Bell inequality | | 4 Hours |
| Quantum Random Number Generator | | 4 Hours |
| Correlation curves | | 2 Hours |
| Quantum key distribution based on the BB 84 protocol | | 4 Hours |
| Michelson interferometer | | 4 Hours |
| Quantum eraser | | 2 Hours |
| Hong-Ou-Mandel interferometer | | 2 Hours |
| Hanbury Brown-Twiss experiment | | 2 Hours |

**References:**


1. C. Gerry, P. Knight, Introductory Quantum Optics, Cambridge University Press, 2005.
2. M. O. Scully, M. S. Zubairy, Quantum Optics, Cambridge University Press, 2002.
3. D. F. Walls, G. J. Milburn, Quantum Optics, Springer Verlag, 1994.
4. quED - Entanglement Demonstrator - A Science Kit for Quantum Physics, www.qutools.com, 2025.


**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

| |
|---|
| This course unit develops some theoretical competences, which are fundamental for a Master student in the field of modern physics, corresponding to national and international standards. The contents and teaching methods were selected after a thorough analysis of the contents of similar course units in the syllabus of other universities from Europe (Oxford University, Royal Institute of Technology - Stockholm). The contents is in line with the requirement of the main employers of research institutes and universities. |

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of equations/mathematical methods/physical models and theories<br>- The ability to give specific examples | Written examination | 80% |
| Practical | - Ability to give the interpretation for the experimental results | Evaluation through practical activity | 20% |
| Minimal requirements for passing the exam | Attending minimum 50 % of the lectures and 100% for the lab activities.<br><br>Mark 5<br>Minimum 50 % of the requirements for the final mark. | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Prof. dr. Iulia Ghiu | Lect. dr. Andreea Croitoru |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.109.2 Applications of modeling and simulations in photonics

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Applications of modeling and simulations in photonics | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | exam | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 72 |
| Research in library, study of electronic resources, field research | | | | | 36 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 36 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 144 |
| 3.8. Total hours per semester | | | | | 200 |
| 3.9. ECTS | | | | | 8 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | R1. The student/graduate understands and interprets the concepts, theories, principles, phenomena and fundamental laws of electromagnetism and of light-matter interaction<br>R2. The student/graduate understands, explains and interprets concepts, theories, models and principles of physics, highlighting practical applications of electromagnetism and light-matter interaction<br>R8. The student/graduate identifies and specifies relevant scientific information and legislative regulations specific to the field of physics, with an emphasis on electromagnetism and light-matter interaction<br>R9. The student/graduate identifies methods, techniques, and laboratory instruments necessary for designing and conducting physical experiments.<br>R10. The student/graduate identifies the appropriate mathematical models and algorithms for analyzing experimental data in electromagnetism and light-matter interaction |

| | |
|---|---|
| Skills | R1. The student/graduate uses the concepts and methods specific to the modeling of physical phenomena related to electromagnetism and light-matter interaction<br>R2. The student/graduate applies the principles and laws of physics in solving theoretical or practical problems in electromagnetism and light-matter interaction, including in partially unpredictable situations<br>R8. The student/graduate compares theoretical results from the specialized literature with experimental ones, integrating the data into a professional report or project.<br>R9. The student/graduate correctly interprets the data and deduces working formulas for calculations with physical quantities, appropriately applying specific fundamental principles and laws.<br>R10. The student/graduate uses the appropriate models and algorithms to make predictions on phenomena specific for electromagnetism and light-matter interaction |
| Responsibility and autonomy | R1. The student/graduate presents scientific or popularization papers and seminars on the fundamentals of electromagnetism and light-matter interaction, adapting the content<br>R2. The student/graduate manages technical or professional activities or projects, making decisions, including in partially unforeseen situations<br>R8. The student/graduate critically analyzes a specialized paper or a scientific communication with a medium degree of difficulty, assuming the conclusions and recommendations.<br>R9. The student/graduate demonstrates autonomy in operating and maintaining laboratory equipment, respecting safety and quality standards.<br>R10. The student/graduate identifies and uses appropriate mathematical tools in agreement with ethical and deontological principles |

**7. Contents**

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| MODELING AND SIMULATION OF PHYSICAL SYSTEMS. THE THEORY OF MODELING AND SIMULATION, COMPLEXITY THEORY | Systematic exposition - lecture. Examples | 4 Hours |
| Modelling formalisms and their simulators: DT; DEQ; DEV; Checking, Validating, Morphisms Approximately. | Systematic exposition - lecture. Examples | 4 Hours |
| DIFFERENTIAL EQUATIONS, FINITE DIFFERENCES - Modeling with ODE.. Cellular vending machines. PHASE CONFIGURATION SPACE | Systematic exposition - lecture. Examples | 4 Hours |
| LINEAR OPTICAL SYSTEMS. FOURIER OPTICS. OSPL Applications | Systematic exposition - lecture. Examples | 4 Hours |
| PROPAGATION OF OPTICAL FIELDS. MAXWELL EQUATIONS Solving Maxwell equations by finite method Difference Time Domain | Systematic exposition - lecture. Examples | 4 Hours |
| THE FLUID MODEL AND THE plasma kinetic model. Vlasov equations and Fokker–Planck equations | Systematic exposition - lecture. Examples | 4 Hours |
| DYNAMICS OF LASER SYSTEMS Semiclassical theory. Chaotic dynamics solutions. Laser diode with extended cavity. | Systematic exposition - lecture. Examples | 4 Hours |

**References:**

Bibliography: •M. Bulinski, ”Modelare si simulare – Aplicatii in OSPL”, Ed Universitatii Bucuresti 2011 •”Introduction to Fourier Optics”, Joseph W. Goodman (Roberts and Company Publishers, 2004) •”Theory of Modeling and Simulation”, Bernard P. Zeigler, Herbert Praehofer, Tag Gon Kim, Academic Press (2019); •Olaf Stenzel, Light–Matter Interaction (A Crash Course for Students of Optics, Photonics and Materials Science), Springer Nature Switzerland 2022; •Prem B. Bisht, Introduction to Photonics and Laser Physics with Applications, IOP Series in Advances in Optics, Photonics and Optoelectronics 2022

| 7.3 Practicals | Teaching techniques | Observations |
|---|---|---|
| AUTOMATE CELULARE. Grile de curgere (cuplate), ECUAŢII CU DIFERENŢE FINITE | Directed practical activity | 4 Hours |

| | | |
|---|---|---|
| ECUAŢII DIFERENŢIALE FUNDAMENTALE Semnificaţia geometrică a soluţiilor ecuaţiilor diferenţiale. Modelarea cu ODE | Directed practical activity | 4 Hours |
| SPAŢII VECTORIALE. ECUAŢIA SCHRODINGER. Apicatii OSPL | Directed practical activity | 4 Hours |
| METODE SPECTRALE Metoda sintezei Fourier. Spectrul energetic | Directed practical activity | 4 Hours |
| ROPAGAREA CÂMPURILOR OPTICE – spectrul unghiular. Difracţia si interferenta. Holografia digitala | Directed practical activity | 4 Hours |
| MEDII NELINIARE Metoda de propagare ”Split-Step” Solitoni optici.Rezolvarea ecuaţiilor Maxwell prin METODA FDTD | Directed practical activity | 4 Hours |
| DINAMICA SISTEMELOR LASER Dioda laser cu cavitate extinsă. | Directed practical activity | 4 Hours |

**References:**

Bibliography: •M. Bulinski, ”Modelare si simulare – Aplicatii in OSPL”, Ed Universitatii Bucuresti 2011; •”Nonlinear Time Series Analysis”, Holger Kantz, Thomas Schreiber, Cambridge University Press (2004); •”Engineering Optics with MATLAB”, Ting-Chung Poon, Taegeun Kim, (World Scientific Publishing Company 2006); •Electromagnetic and Photonic Simulation for the Beginner, Artech House Publishers 2022

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

The choice of teaching/learning methods and the drawing of the guidelines of the content were corroborated with the content of similar disciplines taught at universities in the country and abroad (Massachusetts Institute of Technology; Georgia Tech; University of Waterloo). The content of the discipline is according to the requirements of employment in research institutes in optics, plasma and lasers and in education (under the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | Clarity, coherence and brevity of exposure; •Proper use of models, formulas, computational relationships and routines; •Exemplification capacity | Written test/oral examination | 50% |
| Practical | Apply specific resolution methods to the given problem | Homeworks | 50% |
| Minimal requirements for passing the exam | | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | | |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.110.1 High-power ultrashort-pulse lasers

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | | | High-power ultrashort-pulse lasers | | | | |
| 2.2. Teacher | | | Marian ZAMFIRESCU | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | Raluca IVAN | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 3 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/1/0 |
| 3.4. Total hours per semester | 42 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/14/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 67 |
| Research in library, study of electronic resources, field research | | | | | 33 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 33 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 133 |
| 3.8. Total hours per semester | | | | | 175 |
| 3.9. ECTS | | | | | 7 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Optics, Spectroscopy and Lasers. |
| 4.2. competences | Knowledge about: Quantum mechanics, Electronics |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Lecture hall with multimedia equipment (computer, video projector, white board, internet connection) |
| 5.2. for tutorials/practicals | Access to a research laser facility (CETAL) with optical systems and ultrafast lasers, specialized software for numerical modeling. Safety equipment. |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

### 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Elements of wave optics in lasers physics and engineering. | Systematic exposition - lecture. Examples | 2 Hours |
| Optical materials and their properties. Nonlinear interaction of ultrashort laser pulses with optical materials. | Systematic exposition - lecture. Examples | 2 Hours |
| Generation of ultrashort pulses. Mode locking technique. Temporal and spectral properties of ultrashort laser pulses. | Systematic exposition - lecture. Examples | 2 Hours |
| Laser amplification of ultrashort laser pulses. Regenerative and multipass amplifiers. | Systematic exposition - lecture. Examples | 2 Hours |

| | | |
|---|---|---|
| Stretcher and compressors in CPA systems. OPCPA systems. | Systematic exposition - lecture. Examples | 2 Hours |
| Temporal characterization by the autocorrelation method (FROG and SPIDER techniques). Measurement and control of ultrashort laser pulses. The contrast factor. | Systematic exposition - lecture. Examples | 2 Hours |
| Optical systems for transporting high power laser beams. Alignment of ultraintense laser systems. | Systematic exposition - lecture. Examples | 2 Hours |
| Spatial distribution formation techniques. Wavefront control. | Systematic exposition - lecture. Examples | 2 Hours |
| Secondary sources: Generation of THz beams. | Systematic exposition - lecture. Examples | 2 Hours |
| Higher harmonics, X-rays and applications. | Systematic exposition - lecture. Examples | 2 Hours |
| Particle acceleration with PW-class laser beams and applications. | Systematic exposition - lecture. Examples | 2 Hours |
| Laser targets - toward high repetition rate ultra-intense lasers. | Systematic exposition - lecture. Examples | 2 Hours |
| The formation of pre-plasmas in the operation of petawatt beams. Plasma mirrors. High power fiber optic lasers. | Systematic exposition - lecture. Examples | 2 Hours |
| Safety rules for non-ionizing and ionizing radiation in laboratories with PW-Class lasers. | Systematic exposition - lecture. Examples | 2 Hours |

**References:**


1. F. Trager (ed), Handbook of Lasers and Optics, Springer 2007
2. R. Dabu, Lumina extrema. Lasere de mare putere, ED. Academiei Romane 2015
3. I. Ionita, Optica ondulatorie, online cours, FFB website
4. Extreme Light Infrastructure – Nuclear Physics (ELI-NP) White Book – https://www.eli-np.ro/whitebook.php - as Accessed in February 2023.
5. I. Ionita, Optical Spectroscopy and Group Theory: An Illustrated Introduction, Taylor and Francis, 2014.


| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| Presentation of laboratories with ultra-intense lasers. Safety rules. | | 2 Hours |
| Lasers with ultrashort pulses: construction, characteristics, operation. | | 2 Hours |
| Alignment of an optical system with a femtosecond laser with near-infrared emission. | | 2 Hours |
| Measurement and control of the spatial, spectral and temporal properties of laser beams with ultrashort pulses. Second order autocorrelators. | | 2 Hours |
| Temporal and spatial control of the laser beams. Adaptive optics | | 2 Hours |
| Generation and characterization of harmonics emitted by a target irradiated with a laser beam of ultrashort pulses. | | 2 Hours |
| Design of an experiment at CETAL laser facility from INFLPR: laser control, target manipulation, diagnosis set-up and data management. | | 2 Hours |

**References:**


1. Extreme Light Infrastructure – Nuclear Physics (ELI-NP) White Book – https://www.eli-np.ro/whitebook.php - as Accessed in February 2023.
2. R. Dabu, Lumina extrema. Lasere de mare putere, ED. Academiei Romane 2015
3. I. Ionita, Optical Spectroscopy and Group Theory: An Illustrated Introduction, Taylor and Francis, 2014
4. Ath. Trutia, F.Iova, I.Ionita, Caiet de aplicatii la Spectroscopia starilor condensate, Editura Universitatii Bucuresti (1997)


**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

| |
|---|
| In order to outline the contents, the choice of teaching/learning methods, given the particular importance of the discipline for applications in modern technology, the holders of the discipline consulted the content of similar disciplines taught at universities in the country and abroad. The content of the discipline is according to the employment requirements in research institutes in optics, lasers and in education (under the law). |

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of the methods/ physical models.<br>- The ability to give specific examples. | Written test | 80% |
| Practical | - Knowledge and use of experimental techniques.<br>- Processing of experimental data and interpretation of the results. | Hands-on laboratory assessment. | 20% |
| Minimal requirements for passing the exam | | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Marian ZAMFIRESCU | Raluca IVAN |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026

DO.110.2 Modern computational methods in spectroscopy and imaging

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Modern computational methods in spectroscopy and imaging | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | exam | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 3 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/1/0 |
| 3.4. Total hours per semester | 42 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/14/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 67 |
| Research in library, study of electronic resources, field research | | | | | 33 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 33 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 133 |
| 3.8. Total hours per semester | | | | | 175 |
| 3.9. ECTS | | | | | 7 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

## 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| |

## 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | | | |

| | | |
|---|---|---|
| Date, | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| 13.07.2025 | | |

| | |
|---|---|
| Date of approval | Head of department<br>name and signature |
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.111.1 Digital processing of images and optical fields

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Digital processing of images and optical fields | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 60 |
| Research in library, study of electronic resources, field research | | | | | 30 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 29 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 119 |
| 3.8. Total hours per semester | | | | | 175 |
| 3.9. ECTS | | | | | 7 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Optics |
| 4.2. competences | Use of software packages for data analysis and processing |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Computer room with multimedia equipment (video projector, etc.) |
| 5.2. for tutorials/practicals | Experimental setups in the Digital Image Processing Laboratory; Computers, Matlab/SciLab modeling software, Python, video projector |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | R1. The student/graduate understands and interprets the concepts, theories, principles, phenomena and fundamental laws of electromagnetism and of light-matter interaction<br>R3. The student/graduate establishes appropriate analysis methods for specific situations in the field of physics.<br>R4. The student/graduate deduces working formulas for calculations with physical quantities, correctly using fundamental principles and laws of physics, with emphasis on electromagnetism and light-matter interaction<br>R6. The student/graduate identifies optimal analysis alternatives for obtaining relevant information, making the connection with the fundamental principles of physics.<br>R10. The student/graduate identifies the appropriate mathematical models and algorithms for analyzing experimental data in electromagnetism and light-matter interaction |

| | |
|---|---|
| Skills | R1. The student/graduate uses the concepts and methods specific to the modeling of physical phenomena related to electromagnetism and light-matter interaction<br>R3. The student/graduate correlates statistical analysis methods with experimental data, integrating the results and critically interpreting the information obtained.<br>R4. The student/graduate critically evaluates a scientific communication or a specialized report with a low degree of difficulty, analyzing the arguments and conclusions presented.<br>R6. The student/graduate writes and presents a scientific or professional report, respecting ethical requirements and quality standards.<br>R10. The student/graduate uses the appropriate models and algorithms to make predictions on phenomena specific for electromagnetism and light-matter interaction |
| Responsibility and autonomy | R1. The student/graduate presents scientific or popularization papers and seminars on the fundamentals of electromagnetism and light-matter interaction, adapting the content<br>R3. The student/graduate takes responsibility for the personal professional development, planning and evaluating their own progress.<br>R4. The student/graduate responsibly performs independent work tasks and contributes to interdisciplinary approaches<br>R6. The student/graduate uses information sources autonomously<br>R10. The student/graduate identifies and uses appropriate mathematical tools in agreement with ethical and deontological principles |

**7. Contents**

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| INTRODUCTION Acquisition, processing, storage and digital transmission of optical field information. | Systematic exposition - lecture. Examples | 4 Hours |
| DIGITAL ACQUISITION OF OPTICAL FIELD INFORMATION. IMAGE COMPRESSION | Systematic exposition - lecture. Examples | 4 Hours |
| DIGITAL ANALYSIS OF THE COMPLEX AMPLITUDE OF OPTICAL FIELDS. RECONSTRUCTION OF PHASE DISTRIBUTION. | Systematic exposition - lecture. Examples | 4 Hours |
| REPRESENTATION OF discrete geometry images. Operations, transformations and multiscale presentations | Systematic exposition - lecture. Examples | 4 Hours |
| RANDOM FIELDS. PUNCTUAL/LOCAL OPERATIONS and PIXEL OPERATIONS | Systematic exposition - lecture. Examples | 4 Hours |
| GEOMETRIC TRANSFORMATIONS. OPERATIONS ON NEIGHBORHOODS. FILTRATION – linear and nonlinear filtration | Systematic exposition - lecture. Examples | 4 Hours |
| GEOMETRIC TRANSFORMATIONS. OPERATIONS ON NEIGHBORHOODS. FILTRATION – linear and nonlinear filtration | Systematic exposition - lecture. Examples | 4 Hours |

**References:**

Geometrical Optics, Mircea Bulinski , Editura Universitatii Bucuresti (2014)•Milan Sonka, Vaclav Hlavac, Roger Boyle, Image Processing, Analysis and Machine Vision, Brooks-Cole Publishing Comp. 1999; •Bernard Jahne, Digital image Processing, Springer 2001; •P Verma, P Verma, A Dumka, A Ashok, •Advanced Digital Image Processing and Its Applications in Big Data, CRC Press 2020; R C. Gonzalez, R E. Woods, S L. Eddins, Digital Image Processing Using MATLAB, Gatesmark Publishing 2020

| 7.3 Practicals | Teaching techniques | Observations |
|---|---|---|
| | Directed practical activity | 4 Hours |
| DIGITAL IMAGE ACQUISITION. Digital image processing: Matlab/Scilab Image Processing Toolbox, specific functions and methods. | Directed practical activity | 4 Hours |
| NOISE AND IMAGE RESTORATION. Filtering through time mediation. Filters for getting out of the noise. | Directed practical activity | 4 Hours |

| | | |
|---|---|---|
| IMAGE PROCESSING. Convolution and deconvolution filters. Image enhancement | Directed practical activity | 4 Hours |
| THE APPLICATIONS OF THE FOURIER TRANSFORM WHEN RECOGNIZING THE SHAPES. OCR by manipulating the spectrum of space frequencies. | Directed practical activity | 4 Hours |
| MEASURING THE CHARACTERISTICS of IMAGES. Granulometry, identification of the shape of objects, measurement of regions | Directed practical activity | 4 Hours |
| 3D VISUALIZATION – VIRTUAL REALITY. Voxels, surfaces and meshes. Illumination and visualization of volumes. | Directed practical activity | 4 Hours |

**References:**
Digital Signal and Image Processing Using MATLAB, Gérard Blanchet Maurice Charbit, ISTE Ltd, 2006 •Learning Modern 3D Graphics Programming, Jason L. McKesson, 2012 •Rohit M. Thanki, Ashish M. Kothari, Digital Image Processing using SCILAB, Springer International Publishing 2019; •P. K. Thiruvikraman, Course on Digital Image Processing with MATLAB, IOP Publishing 2020

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | Clarity, coherence and brevity of exposure; •Proper use of models, formulas, computational relationships and routines; •The ability to exemplify | Written test/oral examination | 30% |
| Practical | Apply specific resolution methods to the given problem | Homeworks / continuous assessment | 70% |
| Minimal requirements for passing the exam | | | |

| | | |
|---|---|---|
| Date,<br><br>13.07.2025 | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| Date of approval<br><br>15.07.2025 | | Head of department<br>name and signature<br>Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.111.2 Photonics and optically anisotropic media

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Photonics and optically anisotropic media |
| 2.2. Teacher | |
| 2.3. Tutorials/Practicals instructor(s) | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 60 |
| Research in library, study of electronic resources, field research | 30 |
| Preparation for practicals/tutorials/projects/reports/homework | 29 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 119 |
| 3.8. Total hours per semester | 175 |
| 3.9. ECTS | 7 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

### 7. Contents

### 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| |

### 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
| --- | --- | --- |
| 13.07.2025 | | |

| Date of approval | Head of department name and signature |
| --- | --- |
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.203.1 Plasma spectroscopy

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Plasma spectroscopy | | | | | | |
| 2.2. Teacher | Lector dr. Bazavan Marian Cornel | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | Lector dr. Bazavan Marian Cornel | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one’s own course notes, manuals, lecture notes, bibliography | | | | | 72 |
| Research in library, study of electronic resources, field research | | | | | 36 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 36 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 144 |
| 3.8. Total hours per semester | | | | | 200 |
| 3.9. ECTS | | | | | 8 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Optică, Spectroscopie si laseri, Fizica atomului si moleculei, Fizica plasmei si aplicatii |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | R4. The student/graduate deduces working formulas for calculations with physical quantities, correctly using fundamental principles and laws of physics, with emphasis on electromagnetism and light-matter interaction<br>R5. The student/graduate correctly describes physical systems, using specific theories and tools to characterize them.<br>R6. The student/graduate identifies optimal analysis alternatives for obtaining relevant information, making the connection with the fundamental principles of physics.<br>R7. The student/graduate explains the operating principle of a measuring device or a physical method, highlighting the algorithm used.<br>R8. The student/graduate identifies and specifies relevant scientific information and legislative regulations specific to the field of physics, with an emphasis on electromagnetism and light-matter interaction |

| | |
|---|---|
| Skills | R4. The student/graduate critically evaluates a scientific communication or a specialized report with a low degree of difficulty, analyzing the arguments and conclusions presented.<br>R5. The student/graduate collects and interprets data resulting from the application of appropriate scientific methods, integrating the results obtained into an analytical framework.<br>R6. The student/graduate writes and presents a scientific or professional report, respecting ethical requirements and quality standards.<br>R7. The student/graduate prepares scientific reports and presentations, building logical and coherent arguments on general physics topics.<br>R8. The student/graduate compares theoretical results from the specialized literature with experimental ones, integrating the data into a professional report or project. |
| Responsibility and autonomy | R4. The student/graduate responsibly performs independent work tasks and contributes to interdisciplinary approaches<br>R5. The student/graduate efficiently organizes his/her schedule and resources, respecting deadlines and safety regulations.<br>R6. The student/graduate uses information sources autonomously<br>R7. The student/graduate carries out research internships in specialized units, writing reports on the activity and results obtained.<br>R8. The student/graduate critically analyzes a specialized paper or a scientific communication with a medium degree of difficulty, assuming the conclusions and recommendations. |

**7. Contents**

| **7.1 Lecture [chapters]** | **Teaching techniques** | **Observations** |
|---|---|---|
| Introductory notions. Elementary processes in plasma: elementary processes of the case I; elementary processes of the second case; laws and rules of preservation in elementary processes; rates of elementary processes. | Systematic exposition - lecture. Examples | 4 Hours |
| Radiative model of plasma: complete thermodinamic equilibrium (ET) model; local thermodinamic equilibrium (ETL) model; corona (MC) model; time-dependent corona model; collision-radiative model (MCR). | Systematic exposition - lecture. Examples | 6 Hours |
| Interaction of electromagnetic radiation with plasma. The radiative transfer equation. The optical thickness of a plasma. | Systematic exposition - lecture. Examples | 2 Hours |
| Profile and widening of spectral lines. Natural profile of spectral lines. Doppler widening of spectral lines in plasma. Widening of spectral lines due to pressure. Stark widening of spectral lines in plasma. | Systematic exposition - lecture. Examples | 6 Hours |
| Spectral diagnosis of plasmas. Determination of electronic temperature, rotation and vibration. Determination of particle concentrations. Simulation of plasma spectra in atomic and molecular gases. | Systematic exposition - lecture. Examples | 6 Hours |
| Sources of plasma radiation. Applications. | Systematic exposition - lecture. Examples | 4 Hours |

**References:**

: I.Iova , I.I.Popescu, E.I. Toader, ”Bazele spectroscopiei plasmei”, Editura Stiintifica si Enciclopedica, Bucuresti, 1987; H. R. Griem. ”Principles of Plasma Spectroscopy”,Cambridge University Press, 1997; H. R. Griem, ”Plasma Spectroscopy”, McGraw-Hill, New York, 1964; V.N. Ochkin, ”Spectroscopy of Low Temperature Plasma”, Wiley-VCH Verlag GmbH and Co. KGaA, Weinheim 2009; R. Huddlestone, S.L. Leonard, ”Plasma diagnostic techniques”, Academic Press, New York, 1965; W. Lochte-Holtgreven, ”Plasma diagnostics”, Amsterdam, North-Holland, 1968.

| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| Calibration of a spectral chain. Correction of heterochromaticity. | Directed practical activity | 4 Hours |
| Determination of electronic temperature in an ETL-type plasma | Directed practical activity | 4 Hours |
| Determination of electronic temperature in a non-ETL plasma. | Directed practical activity | 4 Hours |
| Collisional radiative modelfor an argon plasma. | Directed practical activity | 4 Hours |

| | | |
|---|---|---|
| Simulation of the spectrum of a plasma in diatomic molecular gases. Applications to N2 (FPS- first positive system, SPS-second positive system), N2+ (FNS- the first negative system), OH, CN, C2. | Directed practical activity | 4 Hours |
| Detemination of the rotating temperature in a plasma in molecular gases | Directed practical activity | 4 Hours |
| Determination of the vibration temperature in a molecular nitrogen plasma. | Directed practical activity | 4 Hours |

**References:**
I.Iova, F.Iova, M.Bulinski, M.Bazavan, C.Biloiu, I.Gruia, I.Winkler, ”Spectroscopie si Laseri. Aplicatii”, Editura Universitatii Bucuresti, 2001; V.N. Ochkin, ”Spectroscopy of Low Temperature Plasma”, Wiley-VCH Verlag GmbH and Co. KGaA, Weinheim 2009; R. Huddlestone, S.L. Leonard, ”Plasma diagnostic techniques”, Academic Press, New York, 1965; W. Lochte-Holtgreven, ”Plasma diagnostics”, Amsterdam, North-Holland, 1968.

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

In order to sketch the contents, to choose the teaching/learning methods, given the special importance of the discipline for applications in modern technology, the holders of the discipline consulted the content of similar subjects taught at universities in the country and abroad. The content of the discipline is in accordance with the requirements of employment in research institutes in optics, plasma and laser physics and in education (under the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of the methods/ physical models<br>- The ability to give specific examples | Written test | 50% |
| Practical | - Knowledge and use of experimental techniques;<br>- Interpretation of the results; | Laboratory colloquium | 50% |
| Minimal requirements for passing the exam | | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Lector dr. Bazavan Marian Cornel | Lector dr. Bazavan Marian Cornel |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.203.2 Advanced plasma physics

**1. Study program**

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

**2. Course unit**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Advanced plasma physics | | | | | | | | |
| 2.2. Teacher | Lector dr. Bazavan Marian Cornel | | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | Lector dr. Bazavan Marian Cornel | | | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | | | |

**3. Total estimated time**

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 72 |
| Research in library, study of electronic resources, field research | | | | | 36 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 36 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 144 |
| 3.8. Total hours per semester | | | | | 200 |
| 3.9. ECTS | | | | | 8 |

**4. Prerequisites (if necessary)**

| | |
|---|---|
| 4.1. curriculum | Optics, Spectroscopy and Lasers, Atom and Molecule Physics, Statistical Physics, Plasma Physics |
| 4.2. competences | |

**5. Conditions/Infrastructure (if necessary)**

| | |
|---|---|
| 5.1. for lecture | Video projector |
| 5.2. for tutorials/practicals | Experimental set-ups in the laboratory |

**6. Learning outcomes**

| | |
|---|---|
| Knowledge | R4. The student/graduate deduces working formulas for calculations with physical quantities, correctly using fundamental principles and laws of physics, with emphasis on electromagnetism and light-matter interaction<br>R5. The student/graduate correctly describes physical systems, using specific theories and tools to characterize them.<br>R7. The student/graduate explains the operating principle of a measuring device or a physical method, highlighting the algorithm used.<br>R9. The student/graduate identifies methods, techniques, and laboratory instruments necessary for designing and conducting physical experiments. |

| | |
|---|---|
| Skills | R4. The student/graduate critically evaluates a scientific communication or a specialized report with a low degree of difficulty, analyzing the arguments and conclusions presented.<br>R5. The student/graduate collects and interprets data resulting from the application of appropriate scientific methods, integrating the results obtained into an analytical framework.<br>R7. The student/graduate prepares scientific reports and presentations, building logical and coherent arguments on general physics topics.<br>R9. The student/graduate correctly interprets the data and deduces working formulas for calculations with physical quantities, appropriately applying specific fundamental principles and laws. |
| Responsibility and autonomy | R4. The student/graduate responsibly performs independent work tasks and contributes to interdisciplinary approaches<br>R5. The student/graduate efficiently organizes his/her schedule and resources, respecting deadlines and safety regulations.<br>R7. The student/graduate carries out research internships in specialized units, writing reports on the activity and results obtained.<br>R9. The student/graduate demonstrates autonomy in operating and maintaining laboratory equipment, respecting safety and quality standards. |

**7. Contents**

| **7.1 Lecture [chapters]** | **Teaching techniques** | **Observations** |
|---|---|---|
| Introduction – short reminder to the main characteristics of plasma. | Systematic exposition - lecture. Examples | 2 Hours |
| Models of plasmas. The MHD model. The uniparticule model. The kinetic model. Vlasov equation. The moments of the Boltzmann equation. The PIC algorithm (particle in the cell) of simulation in plasma. | Systematic exposition - lecture. Examples | 6 Hours |
| The formation of the spatial load layer. Bohm criterion. The Child-Langmuir equation. OML theory, ABR. Plasma diagnosis by probe method- Druyvesteyn method, Malter Johnson.si method. | Systematic exposition - lecture. Examples | 6 Hours |
| Waves in magnetized and unmagnetized plasmas. Electromagnetic waves. Ion-acoustic waves. The general dispersion relationship. Brillouin diagram. | Systematic exposition - lecture. Examples | 4 Hours |
| Optical methods of plasma diagnosis (microwave interferometry and lasers) | Systematic exposition - lecture. Examples | 2 Hours |
| Types of plasma: ECR discharge (Electron cyclotron resonance). Helicon Discharge. Plasma jets at atmospheric pressure. Dusty plasmas. | Systematic exposition - lecture. Examples | 2 Hours |
| Applications; Thermonuclear fusion plasma. The Lawson criterion. Present and perspectives. Plasma propulsion. | Systematic exposition - lecture. Examples | 4 Hours |
| | | 2 Hours |

**References:**

Gh. Popa, ”Fizica plasmei” www.phys.uaic.ro; M.A Lieberman, A.J. Lichetenberg, ”Principles of plasma discharges and materials processing”, John Wiley, New York, 1994; Y.P. Raizer, ”Gas discharges physics”, Springer-Verlag Berlin, 1991; P. Bellan, ”Fundamentals of plasma physics”, Cambridge University Press, 2006; A. Piel, ”Plasma physics”, Springer-Verlag Berlin Heidelberg, 2010; R. Huddlestone, S.L. Leonard, ”Plasma diagnostic techniques”, Academic Press, New York, 1965; W. Lochte-Holtgreven, ”Plasma diagnostics”, Amsterdam, North-Holland, 1968.

| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| Electrical breakdown of gases in the presence of a magnetic field. | Directed practical activity | 4 Hours |
| Determination of the electronic temperature by the Johnson and Malter method | Directed practical activity | 4 Hours |
| Determination of the spatial distribution of the electron concentration in the plasma | Directed practical activity | 4 Hours |

| | | |
|---|---|---|
| Determination of the energy distribution function of electrons in the plasma by the Druyvesteyn method | Directed practical activity | 4 Hours |
| Diagnostics of plasmas by spectral optical methods | Directed practical activity | 4 Hours |
| Plasma jets at atmospheric pressure. Applications | Directed practical activity | 4 Hours |
| The reflex plasma reactor. | Directed practical activity | 4 Hours |

**References:**
: V.Covlea, H. Andrei, ”Diagnosticarea plasmei – Lucrari de laborator”, Editura Universitatii din Bucuresti, 2001; D. Ciobotaru, V. Covlea, C. Biloiu, ”Gaze ionizate – Lucrari de laborator”, Editura Universităţii din Bucureşti, Bucureşti, 1992; C. Negrea, V. Manea, C. Vancea, A. Tudorica, V. Covlea – Ingineria plasmei, Editura Universitatii din Bucuresti, Bucuresti, 2011.

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

In order to plan the contents, to choose the teaching/learning methods, given the special importance of the discipline for applications in modern technology, the holders of the discipline consulted the content of similar subjects taught at universities in the country and abroad. The content of the discipline is according to the requirements of employment in research institutes in optics, plasma and laser physics and in education (under the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of the methods/ physical models<br>- The ability to give specific examples | Written test | 50% |
| Minimal requirements for passing the exam | Requirements for mark 5 (10 points scale)<br>Getting the average 5.<br>Completion of all laboratory works and grade 5 in the colloquium – for the laboratory<br>The correct exposure of the indicated subjects to obtain a score of 5 in the final exam. | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Lector dr. Bazavan Marian Cornel | Lector dr. Bazavan Marian Cornel |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.204.2 Thin films optics

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Thin films optics | | | | | | |
| 2.2. Teacher | Associate Professor Ovidiu Theodor Toma/ Associate Professor Doiniţa Bejan | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | Associate Professor Ovidiu Theodor Toma / Associate Professor Doiniţa Bejan | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 3 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/1/0 |
| 3.4. Total hours per semester | 42 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/14/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 67 |
| Research in library, study of electronic resources, field research | | | | | 33 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 33 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 133 |
| 3.8. Total hours per semester | | | | | 175 |
| 3.9. ECTS | | | | | 7 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Taking courses: Optics, Electricity and Magnetism, Fundamentals of Atomic Physics |
| 4.2. competences | Use of software packages for data analysis and processing |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Multimedia equipped class (videoprojector) |
| 5.2. for tutorials/practicals | Spectroscopy laboratory |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

### 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Preparation of thin films by pulsed laser deposition (PLD). Experimental considerations. Physics of the processes involved. | Systematic exposition - lecture. Examples | 4 Hours |
| Optical ellipsometry. Fundamental ellipsometric equations. Single-wave ellipsometry (SWE). Null ellipsometry (NE). Imaging ellipsometry (IE). Applications to refractive index measurement of thin films. | Systematic exposition - lecture. Examples | 6 Hours |
| Instrumentation, types of ellipsometers (SWE, NE, IE). | Systematic exposition - lecture. Examples | 4 Hours |

| | | |
|---|---|---|
| Maxwell equations. Optical admittance. Fresnel formulas for dielectrics. Tilted optical admittance. Absorbing media. | Systematic exposition - lecture. Examples | 2 Hours |
| Reflectance of a thin film. Characteristic matrix of the thin film. Reflectance of an assembly of thin films. Transmittance, absorptance and potential transmittance. | Systematic exposition - lecture. Examples | 4 Hours |
| Quarter and half wave optical thickness. Anti-reflection coatings on high index substrates: single, double and multilayer coatings. Anti-reflection coatings on low index substrates: single, double and multilayer coatings | Systematic exposition - lecture. Examples | 4 Hours |
| High reflectance mirror coatings. Beam splitters with metallic and dielectric layers. Optical filters. | Systematic exposition - lecture. Examples | 4 Hours |

**References:**


1. Zdenek Knittl, Optics of thin films, John Wiley and Sons, 1976
2. H. Angus Macleod, Thin films optical filters, Taylor and Francis Group, 2010.
3. Doina Bejan, Note de curs, 2024.
4. A. Piegari, F. Flory, Optical thin films and coating (From materials to applications), Woodhead Publishing, 2013.
5. H.G. Tompkins, Handbook of ellipsometry, Springer, 2005.
6. R.M.A. Azzam, N.M. Bashara, Ellipsometry and polarized light, North-Holland, 1999.
7. H. Fujiwara, Spectroscopic ellipsometry: principles and applications, Wiley, 2007.
8. M. Losurdo and K. Hingerl, Ellipsometry at the Nanoscale, Springer,2013.


| **7.2 Tutorials** | **Teaching techniques** | **Observations** |
|---|---|---|
| Calculation of the transfer matrix for various layers. Reflectance of a single layer coating in s- and p-polarization. | | 2 Hours |
| Reflectance of two, three and four layers coating. | | 4 Hours |
| Protection of metal thin films. Neutral beam splitters. | | 1 Hour |

**References:**


1. Zdenek Knittl, Optics of thin films, John Wiley and Sons, 1976
2. H. Angus Macleod, Thin films optical filters, Taylor and Francis Group, 2010.
3. Doina Bejan, Note de curs, 2024.
4. A. Piegari, F. Flory, Optical thin films and coating (From materials to applications), Woodhead Publishing, 2013


| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| Asymmetrical reflectors. | Guided practical activity | 1 Hour |
| Study of an ellipsometer in monochromatic light (He-Ne laser). Alignment, calibration, refractive index and thickness measurements for thin films. | Guided practical activity | 2 Hours |
| Study of an ellipsometer in polychromatic light (Xe lamp). Alignment, calibration, recording of ellipsometric spectra. | Guided practical activity | 2 Hours |
| Modeling of ellipsometric spectra. Optical models. | Guided practical activity | 2 Hours |

**References:**


1. A. Piegari, F. Flory, Optical thin films and coating (From materials to applications), Woodhead Publishing, 2013.
2. H.G. Tompkins, Handbook of ellipsometry, Springer, 2005.
3. R.M.A. Azzam, N.M. Bashara, Ellipsometry and polarized light, North-Holland, 1999.
4. H. Fujiwara, Spectroscopic ellipsometry: principles and applications, Wiley, 2007.
5. M. Losurdo and K. Hingerl, Ellipsometry at the Nanoscale, Springer,2013.


**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

| |
|---|
| In order to outline the contents, the choice of teaching/learning methods, the subject holders consulted the contents of similar subjects taught at universities abroad (Comenius University, Bratislava). The content of the subject is in accordance with the requirements for employment in research institutes in physics and materials science and in teaching (according to the law). |

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity, coherence and brevity of exposition;<br>- Correct use of models, formulae and calculation relationships;<br>- Ability to exemplify; | Written test | 60% |
| Tutorial | - Application of specific solution methods for the given problem; | continuous evaluation | 20% |
| Practical | - Interpretation of results; | Laboratory colloquium | 20% |
| Minimal requirements for passing the exam | Mandatory attendance: 50% of classes, seminars and 80% of laboratory work.The correct presentation of the subjects indicated for obtaining a score of 5 in the final exam in the two part of the course. Failure to obtain score 5 in one of these subjects means that the student has not passed the exam. The final score will be the average of the grades obtained in the two subjects if the student obtained a score greater than or equal to 5 in each of the two subjects. | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Associate Professor Ovidiu Theodor Toma<br><br>Associate Professor Doiniţa Bejan | Associate Professor Ovidiu Theodor Toma<br><br>Associate Professor Doiniţa Bejan |

Date of approval

15.07.2025

Head of department
name and signature
Lect. dr. Rozana ZUS

# Syllabus

Academic year 2025/2026
DO.204.2 Design of optical systems

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Design of optical systems |
| 2.2. Teacher | |
| 2.3. Tutorials/Practicals instructor(s) | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 2 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 3 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/1/0 |
| 3.4. Total hours per semester | 42 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/14/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 67 |
| Research in library, study of electronic resources, field research | 33 |
| Preparation for practicals/tutorials/projects/reports/homework | 33 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 133 |
| 3.8. Total hours per semester | 175 |
| 3.9. ECTS | 7 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | R4. The student/graduate deduces working formulas for calculations with physical quantities, correctly using fundamental principles and laws of physics, with emphasis on electromagnetism and light-matter interaction<br>R7. The student/graduate explains the operating principle of a measuring device or a physical method, highlighting the algorithm used.<br>R10. The student/graduate identifies the appropriate mathematical models and algorithms for analyzing experimental data in electromagnetism and light-matter interaction |
| Skills | R4. The student/graduate critically evaluates a scientific communication or a specialized report with a low degree of difficulty, analyzing the arguments and conclusions presented.<br>R7. The student/graduate prepares scientific reports and presentations, building logical and coherent arguments on general physics topics.<br>R10. The student/graduate uses the appropriate models and algorithms to make predictions on phenomena specific for electromagnetism and light-matter interaction |

| | |
|---|---|
| Responsibility and autonomy | R4. The student/graduate responsibly performs independent work tasks and contributes to interdisciplinary approaches<br>R7. The student/graduate carries out research internships in specialized units, writing reports on the activity and results obtained.<br>R10. The student/graduate identifies and uses appropriate mathematical tools in agreement with ethical and deontological principles |

## 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| The equation of the eikonal. Lagrange invariant. Fermat's principle. Ray equation | Systematic exposition - lecture. Examples | 4 Hours |
| Sisteme liniare. Point Spread Function, Optical Transfer Function | Systematic exposition - lecture. Examples | 4 Hours |
| Diffraction, aberrations and image quality. Specific geometric aberrations | Systematic exposition - lecture. Examples | 4 Hours |
| Matrix formulation of geometric optics. Thick lens. Complex diopter system. | Systematic exposition - lecture. Examples | 4 Hours |
| Imagery with Gaussian beam. Thin optical films. Modeling and analysis of optical sensor systems. | Systematic exposition - lecture. Examples | 4 Hours |
| CAD. Specific software packages (WinLens3D BasicCAD OPTIC, OSLO, VOB, ZEMAX, etc.) | Systematic exposition - lecture. Examples | 4 Hours |
| Optical design process. Evaluation of the performance of the simulation. Considerations on the manufacture of optical systems. | Systematic exposition - lecture. Examples | 4 Hours |

**References:**
Bibliography: •Geometrical Optics, Mircea Bulinski , Editura Universitatii Bucuresti (2014); •Max Born and Emil Wolf, Principles of Optics, Cambridge University Press 1999 •L Hazra, Foundations of Optical System Analysis and Design, CRC Press 2021; I S Amiri, M Ghasemi, Design and Development of Optical Dispersion Characterization Systems, Springer International Publishing 2019

| 7.3 Practicals | Teaching techniques | Observations |
|---|---|---|
| Metode matriceale în optică paraxială. Matricea de transfer. Punctele cardinale ale unui sistem optic. | Problem solving | 2 Hours |
| Funcţia de transfer de modulare şi contrast. Exemple in calitatea si transformarea imaginii. | Problem solving | 2 Hours |
| Metoda de propagare a fasciculului în paşi de divizare. Propagarea fasciculului în medii neliniare | Problem solving | 2 Hours |
| Cristale uniaxiale; Birefringenţa.Plăcile semiunda, Indicele elipsoidului. | Problem solving | 2 Hours |
| Efect acousto-optic. Modularea intensităţii unui fascicul laser. | Problem solving | 2 Hours |
| CAD. Utilizare pachete software specifice (CAD OPTIC, OSLO, VOB, ZEMAX, etc.) | Problem solving | 2 Hours |
| Studii de caz pentru optimizarea proiectării lentilelor | Problem solving | 2 Hours |

**References:**
Bibliography: •Geometrical Optics, Mircea Bulinski , Editura Universitatii Bucuresti (2014) •Scott W. Teare, Optics Using MATLAB, SPIE PRESS BOOK 2017 •Le Nguyen Binh, Scott W. Teare, Optical Fiber Communication Systems with MATLAB® and Simulink® Models, , CRC Press 2014 •L Hazra, Foundations of Optical System Analysis and Design, CRC Press 2021

## 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| The choice of teaching/learning methods and the drawing of the guidelines of the content were corroborated with the content of similar subjects taught at universities in the country and abroad (Imperial College London; Wyant College of Optical Sciences - University of Arizona; University of Colorado Boulder; Indian Institute of Space Science and Technology). The content of the discipline is according to the requirements of employment in research institutes in optics, plasma and lasers and in education (under the law). |

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | Clarity, coherence and brevity of exposure; •Proper use of models, formulas, computational relationships and routines; •The ability to exemplify; | Written test/oral examination | 50% |
| Practical | Knowledge and use of design and verification techniques; •Interpretation of results; | Homeworks | 50% |
| Minimal requirements for passing the exam | | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | | |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.211.1 Modeling methods in plasma physics

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Modeling methods in plasma physics | | | | | | |
| 2.2. Teacher | Prof. Virgil Baran | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | Prof. Virgil Baran | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 2 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 3 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/1/0 |
| 3.4. Total hours per semester | 30 | 3.5. Lectures | 20 | 3.6. Tutorials/Practicals/Projects | 0/10/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 48 |
| Research in library, study of electronic resources, field research | 24 |
| Preparation for practicals/tutorials/projects/reports/homework | 23 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 95 |
| 3.8. Total hours per semester | 125 |
| 3.9. ECTS | 5 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Programming languages, Linear Algebra, Analytical Mechanics, Electrodynamics. Quantum Mechanics, Thermodynamics and Statistical Physics |
| 4.2. competences | Working with software packages which do not require a license for data analysis and data processing |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Videoprojector |
| 5.2. for tutorials/practicals | Scientific computing laboratory |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | R4. The student/graduate deduces working formulas for calculations with physical quantities, correctly using fundamental principles and laws of physics, with emphasis on electromagnetism and light-matter interaction |
| Skills | R4. The student/graduate critically evaluates a scientific communication or a specialized report with a low degree of difficulty, analyzing the arguments and conclusions presented. |
| Responsibility and autonomy | R4. The student/graduate responsibly performs independent work tasks and contributes to interdisciplinary approaches |

### 7. Contents

| **7.1 Lecture [chapters]** | **Teaching techniques** | **Observations** |
|---|---|---|
| Fundamentals of plasma physics. Debye length, Landau length, collective oscillations and plasma frequency, Larmour frequency and plasma magnetization. | Systematic exposition - lecture. Examples | 2 Hours |

| | | |
|---|---|---|
| Derivation of fluid equations in plasmas (Vlasov-type equations, two-component fluid equations, magnetohydrodynamic equations). | Systematic exposition - lecture. Examples | 2 Hours |
| Wave propagation in plasmas. Where Alfvén. Dispersion relations. Dynamic instabilities. | Systematic exposition - lecture. Examples | 2 Hours |
| Boltzmann-Vlasov and Boltzmann-Maxwell type transport equation. | Systematic exposition - lecture. Examples | 2 Hours |
| Test particle method. Derivation of particle-in-cell equations. Study on shape functions. | Systematic exposition - lecture. Examples | 4 Hours |
| Self-consistent solution of field equations and those describing particle dynamics. The Boris particle time propagation algorithm. Courant stability condition. | Systematic exposition - lecture. Examples | 4 Hours |
| Symplectic and near-symplectic methods for the numerical solution of equations describing particle dynamics. Symplecticity. Conservation of energy and volume in phase space. | Systematic exposition - lecture. Examples | 2 Hours |
| Comparative presentation of the main particle-in-cell codes (in particular, EPOCH, VSim, PIConGPU, OSIRIS) | Systematic exposition - lecture. Examples | 2 Hours |

**References:**

1. P.M. Bellan, Fundamentals of plasma physics, Cambridge University Press, 2008.
2. A. Piel, Plasma physics. An introduction to laboratory, space, and fusion plasmas, Springer, 2010.
3. P. Mulser şi D. Bauer, High power laser-matter interaction, Springer, 2010.
4. C.K. Birdsall şi A.B. Langdon, Plasma physics via computer simulation, Taylor and Francis, 2004
5. B. Leimkuhler şi S. Reich, Simulating Hamiltonian dynamics, Cambridge University Press, 2004.

| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| Analytical solutions of Maxwell equations | Exposition; problem solving | 1 Hour |
| Analytical solutions of Boltzman equations | Exposition; problem solving | 1 Hour |
| Analytical solutions of Vlasov equations | Exposition; problem solving | 2 Hours |
| Numerical solution of differential equations with Hamiltonian structure by symplectic and almost symplectic methods. Writing own code in Octave/python/C | Supervized Practical Activity | 2 Hours |
| Numerical solution of particle-in-cell equations. Observation of laser-plasma interaction. Use EPOCH program | Supervized Practical Activity | 2 Hours |
| Comparative numerical study on EPOCH, VSim, PIConGPU, OSIRIS. Interaction of a variable intensity laser pulse with gaseous and solid targets in two- and three-dimensional setups. | Supervized Practical Activity | 2 Hours |

**References:**

1. P. Mulser şi D. Bauer, High power laser-matter interaction, Springer, 2010.
2. C.K. Birdsall şi A.B. Langdon, Plasma physics via computer simulation, Taylor and Francis, 2004

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

In order to sketch the contents, to choose the teaching/learning methods, the coordinator of the course consulted the content of similar disciplines taught at Romanian universities and abroad. The content of the discipline is according to the requirements of employment in research institutes in physics, as well as in education (according to the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of the methods/ physical models<br>- The ability to give specific examples | Written test/oral examination | 60% |
| Practical | - Ability to use specific problem-solving methods<br>- Analysis of the results | Homework | 30% |

| | |
|---|---|
| Minimal requirements for passing the exam | At least 50% of exam score and of homeworks. |

| | | |
|---|---|---|
| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
| 13.07.2025 | Prof. Virgil Baran | Prof. Virgil Baran |

| | |
|---|---|
| Date of approval | Head of department name and signature |
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DO.211.2 Homogeneous and inhomogeneous waveguides. Applications

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Homogeneous and inhomogeneous waveguides. Applications |
| 2.2. Teacher | Prof. dr Daniela DRAGOMAN |
| 2.3. Tutorials/Practicals instructor(s) | Prof. dr Daniela DRAGOMAN |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 2 | 2.5. Semester | 2 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 3 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/1/0 |
| 3.4. Total hours per semester | 30 | 3.5. Lectures | 20 | 3.6. Tutorials/Practicals/Projects | 0/10/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 48 |
| Research in library, study of electronic resources, field research | 24 |
| Preparation for practicals/tutorials/projects/reports/homework | 23 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 95 |
| 3.8. Total hours per semester | 125 |
| 3.9. ECTS | 5 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Electricity and magnetism, Optics, Equations of mathematical physics |
| 4.2. competences | Knowledge of scientific calculus |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Video projector |
| 5.2. for tutorials/practicals | Computer room |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | R1. The student/graduate understands and interprets the concepts, theories, principles, phenomena and fundamental laws of electromagnetism and of light-matter interaction<br>R4. The student/graduate deduces working formulas for calculations with physical quantities, correctly using fundamental principles and laws of physics, with emphasis on electromagnetism and light-matter interaction<br>R6. The student/graduate identifies optimal analysis alternatives for obtaining relevant information, making the connection with the fundamental principles of physics. |
| Skills | R1. The student/graduate uses the concepts and methods specific to the modeling of physical phenomena related to electromagnetism and light-matter interaction<br>R4. The student/graduate critically evaluates a scientific communication or a specialized report with a low degree of difficulty, analyzing the arguments and conclusions presented.<br>R6. The student/graduate writes and presents a scientific or professional report, respecting ethical requirements and quality standards. |

| | |
|---|---|
| Responsibility and autonomy | R1. The student/graduate presents scientific or popularization papers and seminars on the fundamentals of electromagnetism and light-matter interaction, adapting the content<br>R4. The student/graduate responsibly performs independent work tasks and contributes to interdisciplinary approaches<br>R6. The student/graduate uses information sources autonomously |

**7. Contents**

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Introductory notions: homogeneous waveguides. Types. Relevant parameters. | Systematic exposition - lecture. Examples | 2 Hours |
| Modes in planar waveguides. Modes in optical fibers. Dispersion relations. Pulse propagation in waveguides | Systematic exposition - lecture. Examples | 4 Hours |
| Power transfer between homogeneous waveguides. Coupled mode method. Applications in optical integrated circuits and laser resonators | Systematic exposition - lecture. Examples | 4 Hours |
| Inhomogeneous waveguides: diffraction gratings in waveguides. Coupled mode theory in passive and active periodic structures. Applications in integrated laser configurations | Systematic exposition - lecture. Examples | 4 Hours |
| Coupling of light sources to waveguides. Coupling efficiency. Coupling methods | Systematic exposition - lecture. Examples | 2 Hours |
| Waveguide sensors. Detection principles. Types. Performances | Systematic exposition - lecture. Examples | 4 Hours |

**References:**
1. A.W. Snyder, J.D. Love, Optical Waveguide Theory, Chapman and Hall, 1983
2. B.E.A. Saleh, M.C. Teich, Fundamental of Photonics, 2nd edition, Wiley, 2007, Chapter 21: Nonlinear Optics
3. Număr special al revistei Sensors, vol. 18, octombrie 2018, cu acces liber: https://www.mdpi.com/journal/sensors/special_issues/Waveguide_Sensors
4. D. Dragoman, Optoelectronica integrata, Editura Univ. Bucuresti, 2003
5. D. Dragoman, Lecture notes

| 7.3 Practicals | Teaching techniques | Observations |
|---|---|---|
| Light propagation in planar curved waveguides. Power loss. Applications | Guided practical activity | 3 Hours |
| Power transfer in various many-waveguide configurations | Guided practical activity | 3 Hours |
| Applications of coupled mode theory. Designing an optical switch | Guided practical activity | 4 Hours |

**References:**
1. D. Dragoman, Optoelectronica integrata, Editura Univ. Bucuresti, 2003
2. A. Yariv, Optical Electronics, CBS College Publishing, 3rd edition, 1985
3. A.W. Snyder, J.D. Love, Optical Waveguide Theory, Chapman and Hall, 1983

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

The contents of the discipline is similar to that of other lectures taught at universities in Romania (Univ. Alexandru Ioan Cuza, Iaşi) and abroad (Boston University, USA, Tokyo Institute of Technology), allowing the student to develop competences and abilities to model the propagation of electromagnetic fields in passive and active waveguides, and to design experimental configurations to observe the specific phenomena, themes of interest for research institutes and companies with activities in the area of Optics, Laser Physics and/or Materials Physics, especially Nanotechnologies, as well as in teaching.

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition;<br>- Correct use of the methods/<br>physical models;<br>- The ability to give specific examples; | Written exam | 67% |
| Practical | - Ability to use specific problem solving methods | Written exam | 33% |
| Minimal requirements for passing the exam | Correct solving of subjects indicated as required for obtaining mark 5 at both written exams | | |

Date, 13.07.2025

Teacher's name and signature, Prof. dr Daniela DRAGOMAN

Practicals/Tutorials/Project instructor(s), name and signature Prof. dr Daniela DRAGOMAN

Date of approval 15.07.2025

Head of department name and signature Lect. dr. Rozana ZUS

# Syllabus

Academic year 2025/2026
DFC.107 Volunteering

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Volunteering | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 1 | 2.6. Type of evaluation | verificare | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 0 | 3.2. Lectures | 0 | 3.3. Tutorials/Practicals/Projects | 0/0/0 |
| 3.4. Total hours per semester | 0 | 3.5. Lectures | 0 | 3.6. Tutorials/Practicals/Projects | 0/0/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 13 |
| Research in library, study of electronic resources, field research | | | | | 6 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 6 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 25 |
| 3.8. Total hours per semester | | | | | 25 |
| 3.9. ECTS | | | | | 1 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

## 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| |

## 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | | | |

| | | |
|---|---|---|
| Date,<br><br>13.07.2025 | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| Date of approval<br><br>15.07.2025 | | Head of department<br>name and signature<br>Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DFC.112 Fundamental processes in ionized gases

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | |
|---|---|
| 2.1. Course unit title | Fundamental processes in ionized gases |
| 2.2. Teacher | Conf.dr. Iulian Ionita; Lect.dr. Marian Bazavan |
| 2.3. Tutorials/Practicals instructor(s) | Conf.dr. Iulian Ionita; Lect.dr. Marian Bazavan |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | oral | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 10 |
| Research in library, study of electronic resources, field research | 5 |
| Preparation for practicals/tutorials/projects/reports/homework | 4 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 19 |
| 3.8. Total hours per semester | 75 |
| 3.9. ECTS | 3 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Fundamentals of Atomic Physics, Quantum mechanics, Thermodinamics and Statistical Physics, Plasma Physics |
| 4.2. competences | Knowledge about: Mathematical analysis |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Video projector |
| 5.2. for tutorials/practicals | Plasma Physics Laboratory |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Plasma in Nature. Plasma types. | Systematic exposition - lecture. Examples | 2 Hours |
| Production of plasmas | Systematic exposition - lecture. Examples | 6 Hours |
| Plasma diagnosis (electric and spectral techniques) | Systematic exposition - lecture. Examples | 6 Hours |
| Space Plasma<br>Sun, stars. White dwarfs | Systematic exposition - lecture. Examples | 2 Hours |

| | | |
|---|---|---|
| Solar wind | Systematic exposition - lecture. Examples | 4 Hours |
| The ionosphere | Systematic exposition - lecture. Examples | 2 Hours |
| Magnetosphere | Systematic exposition - lecture. Examples | 2 Hours |
| Auroras (boreal and austral) | Systematic exposition - lecture. Examples | 1 Hour |
| The lightning. The lightning rod. Plasmoids, ball lightning | Systematic exposition - lecture. Examples | 1 Hour |
| Shock wave plasma. Entry of space vehicles into the atmosphere | Systematic exposition - lecture. Examples | 2 Hours |

**References:**

1. L. Tonks, I. Langmuir, Phys. Rev. 34, 876, 1929; L. Tonks, Am. J. Phys. 35, 857, 1967
2. J.L. Delcroix, A. Bers, Physique des Plasmas vol.1, InterEditions et CNRS Editions, Paris, 1994
3. Y.P. Raizer, Electric discharges through gases, Springer-Verlag, Berlin Heidelberg New York, 1997
4. R.W. Schunk, A.F. Nogy, Ionospheres: Physics, Plasma Physics and Chemistry, Cambridge University Press, 1999

| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| Presentation of the laboratory, activities and work regulations in the laboratory (safety work rules). | Directed practical activity | 4 Hours |
| The comparative study of plasmas. | Directed practical activity | 8 Hours |
| Gases breakdown at low and medium pressures. | Directed practical activity | 8 Hours |
| Methods of experimental study of ionospheres | Directed practical activity | 4 Hours |
| Plasmoids | Directed practical activity | 4 Hours |

**References:**

1. D. Ciobotaru, V. Covlea, C. Biloiu, Gaze ionizate - lucrari de laborator, Editura Universitatii din Bucuresti, 1992

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

In order to outline the contents, the choice of teaching/learning methods, given the special importance of the discipline for applications in modern technology, the holders of the discipline consulted the content of similar disciplines taught at universities in the country and abroad (Princeton University, Berkeley University, A. I University Cuza from Iasi). The content of the discipline is in accordance with the employment requirements in research institutes with topics in plasma, lasers, atmospheric physics and in education (under the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition<br>- Correct use of the methods/ physical models<br>- The ability to give specific examples | Colloquium | 80% |
| Practical | - Knowledge and use of experimental techniques;<br>- Interpretation of the results | Laboratory colloquium | 20% |
| Minimal requirements for passing the exam | Requirements for mark 5 (10 points scale)<br>Getting the average 5.<br>Completion of all laboratory works and grade 5 in the colloquium – for the laboratory<br>The correct exposure of the indicated subjects to obtain a score of 5 in the final exam. | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Conf.dr. Iulian Ionita; Lect.dr. Marian Bazavan | Conf.dr. Iulian Ionita; Lect.dr. Marian Bazavan |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DFC.113 Elemenets of Complexity theory

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | | | Elemenets of Complexity theory | | | | | |
| 2.2. Teacher | | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | oral | 2.7.Classification | | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 2/0/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 28/0/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 10 |
| Research in library, study of electronic resources, field research | | | | | 5 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 4 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 19 |
| 3.8. Total hours per semester | | | | | 75 |
| 3.9. ECTS | | | | | 3 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | R1. The student/graduate understands and interprets the concepts, theories, principles, phenomena and fundamental laws of electromagnetism and of light-matter interaction<br>R5. The student/graduate correctly describes physical systems, using specific theories and tools to characterize them.<br>R6. The student/graduate identifies optimal analysis alternatives for obtaining relevant information, making the connection with the fundamental principles of physics.<br>R7. The student/graduate explains the operating principle of a measuring device or a physical method, highlighting the algorithm used.<br>R9. The student/graduate identifies methods, techniques, and laboratory instruments necessary for designing and conducting physical experiments. |

| | |
|---|---|
| Skills | R1. The student/graduate uses the concepts and methods specific to the modeling of physical phenomena related to electromagnetism and light-matter interaction<br>R5. The student/graduate collects and interprets data resulting from the application of appropriate scientific methods, integrating the results obtained into an analytical framework.<br>R6. The student/graduate writes and presents a scientific or professional report, respecting ethical requirements and quality standards.<br>R7. The student/graduate prepares scientific reports and presentations, building logical and coherent arguments on general physics topics.<br>R9. The student/graduate correctly interprets the data and deduces working formulas for calculations with physical quantities, appropriately applying specific fundamental principles and laws. |

| | |
|---|---|
| Responsibility and autonomy | R1. The student/graduate presents scientific or popularization papers and seminars on the fundamentals of electromagnetism and light-matter interaction, adapting the content<br>R5. The student/graduate efficiently organizes his/her schedule and resources, respecting deadlines and safety regulations.<br>R6. The student/graduate uses information sources autonomously<br>R7. The student/graduate carries out research internships in specialized units, writing reports on the activity and results obtained.<br>R9. The student/graduate demonstrates autonomy in operating and maintaining laboratory equipment, respecting safety and quality standards. |

**7. Contents**

| **7.1 Lecture [chapters]** | **Teaching techniques** | **Observations** |
|---|---|---|
| COMPLEX SYSTEMS IN NATURE AND SOCIETY - definitions and paradigms. Stochastic and deterministic models. Determinism and predictability | Systematic exposition - lecture. Examples | 4 Hours |
| COMPLEXITY THEORY. Measures and definitions of complexity. ALGORITHMIC (COMPUTATIONAL) MEASUREMENT OF COMPLEXITY. THE THEORY OF MODELING AND SIMULATION. Modeling, simulation and prediction of complex systems | Systematic exposition - lecture. Examples | 4 Hours |
| CONSTITUENT ELEMENTS OF SYSTEMS MODELING: Hierarchy of system specification; Systems analysis; The morphisms of the system specification. Structure of modeling and simulation of systems | Systematic exposition - lecture. Examples | 4 Hours |
| SIMULATION BY DISCRETE EVENTS; Model Simulation Verification; Statistical analysis of simulated data; Statistical validation techniques. | Systematic exposition - lecture. Examples | 4 Hours |
| MODELING AND SIMULATION OF DISCRETE DETERMINISTIC SYSTEMS. Cellular automata; Self-organization; Artificial neural networks | Systematic exposition - lecture. Examples | 4 Hours |
| COMPLEX SYSTEMS AND DYNAMICAL SYSTEMS – Phase space, maps and flows, autonomous and non-autonomous systems; chaotic deterministic systems | Systematic exposition - lecture. Examples | 4 Hours |
| ANALYSIS OF TIME SERIES – linear prediction: stationary analysis; tendency, probabilities; Fourier analysis; autocorrelation analysis; R/S analysis of the rescalare domain; sonification. | Systematic exposition - lecture. Examples | 4 Hours |

**References:**

Bibliography: •M. Bulinski, ”Econofizica si Complexitate”, Ed Universitatii Bucuresti 2007 •Ed. M. Bulinski, ”Econofizica si Complexitate, – Lecturi”: Scoala de Vara: 2005, 2006, 2007, Ed Universitatii Bucuresti. •”Theory of Modeling and Simulation”, Bernard P. Zeigler, Herbert Praehofer, Tag Gon Kim, Academic Press (2000) •Stephen Wolfram, A New Kind of Science •M Sotomayor, D Perez-Castrillo, F Castiglione, Complex Social and Behavioral Systems: Game Theory and Agent-Based Models. Encyclopedia of Complexity and Systems Science Series, 2020

| 7.2 Tutorials | Teaching techniques | Observations |
|---|---|---|
| SIMULATION THROUGH DISCRETE EVENTS. Construction, simulation and analysis of a model. | Problem solving | 4 Hours |
| AUTOMATIC CELLULAR SELF-ORGANIZATION; Artificial neural networks (networks of coupled grids) | Problem solving | 4 Hours |
| ANALYSIS OF TIME SERIES. Linear and nonlinear prediction. Analysis of the degree of determinism. | Problem solving | 4 Hours |
| DNAMICS DETERMINIST CHAOTIC Controlul chaos. Obtaining order by injecting disorder. | Problem solving | 4 Hours |
| COMPLEX SYSTEMS AND DYNAMIC SYSTEMS Phase space, autonomous and non-autonomous systems | Problem solving | 4 Hours |
| ARCH PROCESSES AND GARCH statistical properties and determination of parameters | Problem solving | 4 Hours |
| MODELE STOHASTICE ALE DINAMICII PREŢURILOR | Problem solving | 4 Hours |

**References:**

Bibliography: :•M. Bulinski, "Econofizica si Complexitate", Ed Universitatii Bucuresti 2007 •"Chaos and Time-Series Analysis", Julien Clinton Sprott, Oxford University Press (2004) •"A First Course in Probability", Sheldon M. Ross, Prentice Hall (2002) •"Nonlinear Time Series Analysis", Holger Kantz, Thomas Schreiber, Cambridge University Press (2004) •"Simulation", Sheldon M. Ross, Academic Press (2002)

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

In order to draw the guidelines of the contents, the choice of teaching/learning methods, given the special importance of the discipline for modnal science, the holders of the discipline consulted the content of similar disciplines taught at universities in the country and abroad (Massachusetts Institute of Technology; Stanford University; Max Planck Insitute for Software Systems; University of Bergen). The content of the discipline is according to the requirements of employment in research institutes in optics, plasma and lasers and in education (under the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | •Clarity, coherence and brevity of exposure; •Proper use of models, formulas, computational relationships and routines; •The ability to exemplify; | Written test/oral examination | 50% |
| Tutorial | Knowledge and use of simulation and experimental techniques •Interpretation of results; | Homeworks | 50% |
| Minimal requirements for passing the exam | | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | | |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DFC.114 Volunteering

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Volunteering | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 1 | 2.5. Semester | 2 | 2.6. Type of evaluation | verificare | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 0 | 3.2. Lectures | 0 | 3.3. Tutorials/Practicals/Projects | 0/0/0 |
| 3.4. Total hours per semester | 0 | 3.5. Lectures | 0 | 3.6. Tutorials/Practicals/Projects | 0/0/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 13 |
| Research in library, study of electronic resources, field research | 6 |
| Preparation for practicals/tutorials/projects/reports/homework | 6 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 25 |
| 3.8. Total hours per semester | 25 |
| 3.9. ECTS | 1 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

## 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| |

## 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | | | |

| | | |
|---|---|---|
| Date,<br><br>13.07.2025 | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| Date of approval<br><br>15.07.2025 | | Head of department<br>name and signature<br>Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DFC.205 Volunteering

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Volunteering | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 1 | 2.6. Type of evaluation | verificare | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 0 | 3.2. Lectures | 0 | 3.3. Tutorials/Practicals/Projects | 0/0/0 |
| 3.4. Total hours per semester | 0 | 3.5. Lectures | 0 | 3.6. Tutorials/Practicals/Projects | 0/0/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 13 |
| Research in library, study of electronic resources, field research | | | | | 6 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 6 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 25 |
| 3.8. Total hours per semester | | | | | 25 |
| 3.9. ECTS | | | | | 1 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

## 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| |

## 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | | | |

| | | |
|---|---|---|
| Date,<br><br>13.07.2025 | Teacher's<br>name and signature, | Practicals/Tutorials/Project instructor(s),<br>name and signature |
| Date of approval<br><br>15.07.2025 | | Head of department<br>name and signature<br>Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DFC.206 Applied optics

### 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

### 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Applied optics | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

### 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 0/2/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 0/28/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 10 |
| Research in library, study of electronic resources, field research | | | | | 5 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 4 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 19 |
| 3.8. Total hours per semester | | | | | 75 |
| 3.9. ECTS | | | | | 3 |

### 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

### 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

### 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

### 7. Contents

| 7.1 Lecture [chapters] | Teaching techniques | Observations |
|---|---|---|
| Metrology of optical systems and optical metrology of surfaces | Systematic exposition - lecture. Examples | 4 Hours |
| Propagation of optical fields and special interferometric techniques | Systematic exposition - lecture. Examples | 4 Hours |
| Nonlinerar Optics - magneto-optical effects | Systematic exposition - lecture. Examples | 4 Hours |
| Optical Litography. 3d techniques: fast prototyping. | Systematic exposition - lecture. Examples | 4 Hours |
| Adaptive and active optics | Systematic exposition - lecture. Examples | 4 Hours |

| | | |
|---|---|---|
| Fotometry and radiometry, colorimetry, spectroscopy applications in chemistry, biology, medicine, typographic technique, displays, etc.. | Systematic exposition - lecture. Examples | 4 Hours |
| Lsits, fiber optics and waveguide guides. new trends in applied optics | Systematic exposition - lecture. Examples | 4 Hours |

**References:**
Bibliography: :•"Optica", St. Levai, M. Bulinski, O. Toma, Ed. Univ. Buc. (2005); •Spectroscopie şi laseri. Aplicaţii", I. Iova, M. Bulinski, F. Iova, M. Băzăvanm, C. Biloiu, I. Gruia, Gh. Ilie, I. Winkler, Ed. Univ. Buc. (2001); •International Trends in Applied Optics, De Arthur Henry Guenther, Spie Press 2002; • "Optical Measurement Techniques and Applications", editor Pramod K. Rastogi, Artech House, Inc. London(1997) •William L. Wolfe, Rays, Waves and Photons: A compendium of foundations and emerging technologies of pure and applied optics, IOP Series in Emerging Technologies in Optics and Photonics (2020)

| **7.3 Practicals** | **Teaching techniques** | **Observations** |
|---|---|---|
| DESIGN OF OPTICAL SYSTEMS Use of specialized CAD's for the design of optical systems. | Directed practical activity | 4 Hours |
| MICRO-TOPOGRAPHY OF SURFACES. 3D-convolution method in optical microscopy. | Directed practical activity | 4 Hours |
| DIGITAL INTERFERENTIAL HOLOGRAPHY | Directed practical activity | 4 Hours |
| SPECKLE METHODS – photography and speckle inteferometry | Directed practical activity | 4 Hours |
| DIGITAL PHOTOGRAMMETRY – analysis of volumes and distances. | Directed practical activity | 4 Hours |
| COLORIMETRY – determination of color indices, calibration of a color display | Directed practical activity | 4 Hours |
| ANALYSIS OF MAGNETO-OPTICAL ELECTS – Polarimetry, Faraday effect, moke measurement principle | Directed practical activity | 4 Hours |

**References:**
Bibliography: •"Optica", Ioan-Iovit Popescu si Emil Toader, Ed. Stiintifica si Enciclopedica, Bucuresti (1989); •Young M., "Optics and Lasers", in Springer Series in Optical Science Vol. 5, Springer Verlag N.Y.(1977) •"Engineering Optics with MATLAB", Ting-Chung Poon, Taegeun Kim, (World Scientific Publishing Company 2006);

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

Thechoice of teaching/learning methods and the drawing of the guidelines of the content were corroborated with the content of similar subjects taught at universities in the country and abroad (Imperial College London; Georgia Institute of Technology; Duke University). The content of the discipline is according to the requirements of employment in research institutes in optics, plasma and lasers and in education (under the law).

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | Clarity, coherence and brevity of exposure; •Proper use of models, formulas, computational relationships and routines; •The ability to exemplify; | Written test/oral examination | 50% |
| Practical | Application of specific methods of solving for the given problem; | Homeworks | 50% |
| Minimal requirements for passing the exam | | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | | |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DFC.207 Plasmonics and metamaterials

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Plasmonics and metamaterials | | | | | | |
| 2.2. Teacher | Prof. dr. Daniela DRAGOMAN | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | Prof. dr. Daniela DRAGOMAN | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 1 | 2.6. Type of evaluation | exam | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 4 | 3.2. Lectures | 2 | 3.3. Tutorials/Practicals/Projects | 2/0/0 |
| 3.4. Total hours per semester | 56 | 3.5. Lectures | 28 | 3.6. Tutorials/Practicals/Projects | 28/0/0 |

| | |
|---|---|
| Distribution of estimated time for study | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | 10 |
| Research in library, study of electronic resources, field research | 5 |
| Preparation for practicals/tutorials/projects/reports/homework | 4 |
| Tutorat | 0 |
| Other activities | 0 |
| 3.7. Total hours of individual study | 19 |
| 3.8. Total hours per semester | 75 |
| 3.9. ECTS | 3 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | Electricity and magnetism, Optics, Equations of mathematical physics |
| 4.2. competences | Knowledge of scientific calculus |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | Video projector |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | R1. The student/graduate understands and interprets the concepts, theories, principles, phenomena and fundamental laws of electromagnetism and of light-matter interaction<br>R2. The student/graduate understands, explains and interprets concepts, theories, models and principles of physics, highlighting practical applications of electromagnetism and light-matter interaction<br>R7. The student/graduate explains the operating principle of a measuring device or a physical method, highlighting the algorithm used. |
| Skills | R1. The student/graduate uses the concepts and methods specific to the modeling of physical phenomena related to electromagnetism and light-matter interaction<br>R2. The student/graduate applies the principles and laws of physics in solving theoretical or practical problems in electromagnetism and light-matter interaction, including in partially unpredictable situations<br>R7. The student/graduate prepares scientific reports and presentations, building logical and coherent arguments on general physics topics. |

| | |
|---|---|
| Responsibility and autonomy | R1. The student/graduate presents scientific or popularization papers and seminars on the fundamentals of electromagnetism and light-matter interaction, adapting the content<br>R2. The student/graduate manages technical or professional activities or projects, making decisions, including in partially unforeseen situations<br>R7. The student/graduate carries out research internships in specialized units, writing reports on the activity and results obtained. |

**7. Contents**

| **7.1 Lecture [chapters]** | **Teaching techniques** | **Observations** |
|---|---|---|
| Surface plasmon polaritons. Definition. Dispersion relation. Excitation modes | Systematic exposition - lecture. Examples | 4 Hours |
| Plasmonic waveguides. Applications | Systematic exposition - lecture. Examples | 4 Hours |
| Localized plasmon at nanoparticle's surface. Applications | Systematic exposition - lecture. Examples | 4 Hours |
| Electric and magnetic metamaterials. Media with a negative refractive index | Systematic exposition - lecture. Examples | 6 Hours |
| Light propagation in media with a negative refractive index. Transformation optics | Systematic exposition - lecture. Examples | 6 Hours |
| Applications of metamaterials: planar lenses, invisibility shields | Systematic exposition - lecture. Examples | 4 Hours |

**References:**

1. S. A. Maier, Plasmonics: Fundamentals and Applications, Springer, 2007
2. M. Dragoman, D. Dragoman, Plasmonics: Applications to nanoscale terahertz and optical devices, Prog. Quantum Electron. 32, 1-41, 2008
3. N. Engheta, R.W. Ziolkowskii, Electromagnetic Metamaterials: Physics and Engineering Explorations, Wiley, 2006
4. J. B. Pendry, Negative refraction makes a perfect lens, Phys. Rev. Lett. 85, 3966-3969, 2000
5. Special number of the journal Materials, vol. 8, October 2015, open access: https://www.mdpi.com/journal/materials/special_issues/plasmonic-materials?view=compact and listby=date
6. 5. Special number of the journal Nanophotonics, vol. 7, June 2018, open access: https://www.degruyter.com/view/j/nanoph.2018.7.issue-6/issue-files/nanoph.2018.7.issue-6.xml
7. D. Dragoman, Lecture notes

| **7.2 Tutorials** | **Teaching techniques** | **Observations** |
|---|---|---|
| Finding the dispersion relation of surface plasmon polaritons in various systems | Problem solving | 6 Hours |
| Field enhancement at the metal-dielectric interface. Applications in SERS | Problem solving | 4 Hours |
| Transmission line analogy method for calculating the transmission in slab plasmonic waveguides. Examples | Problem solving | 4 Hours |
| Calculation of the electric permittivity and magnetic permeability in open metallic wires and rings | Problem solving | 6 Hours |
| Examples of transformation optics applications | Problem solving | 5 Hours |
| Metasurfaces. Manipulation of the wavefront | Problem solving | 3 Hours |

**References:**

1. S. A. Maier, Plasmonics: Fundamentals and Applications, Springer, 2007
2. W. Cai, V. Shalaev, Optical Metamaterials. Fundamentals and Applications, Springer, 2010

**8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program**

| |
|---|
| The contents of the discipline is similar to that of other lectures taught at universities abroad (Univ. of Illinois, Rice University, ETH Zürich, Nanyang Technological University), allowing the student to develop competences and abilities to model the light-matter interaction at microscopic scale and to design experimental configurations for investigating systems and materials, of interest for research institutes with themes in Optics, Laser Physics and/or Materials Physics, especially Nanotechnologies, as well as in teaching |

**9. Assessment**

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Lecture | - Clarity and coherence of exposition;<br>- Correct use of the methods/ physical models;<br>- The ability to give specific examples | Written exam | 50% |
| Tutorial | - Ability to use specific problem solving methods | Written exam | 50% |
| Minimal requirements for passing the exam | | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | Prof. dr. Daniela DRAGOMAN | Prof. dr. Daniela DRAGOMAN |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |

# Syllabus

Academic year 2025/2026
DFC.212 Volunteering

## 1. Study program

| | |
|---|---|
| 1.1. University | University of Bucharest |
| 1.2. Faculty | Faculty of Physics |
| 1.3. Department | Theoretical Physics, Mathematics, Optics, Plasma and Lasers |
| 1.4. Field of study | Fizică/Physics |
| 1.5. Course of study | Master |
| 1.6. Study program | Photonics, Plasma and Lasers |

## 2. Course unit

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1. Course unit title | Volunteering | | | | | | |
| 2.2. Teacher | | | | | | | |
| 2.3. Tutorials/Practicals instructor(s) | | | | | | | |
| 2.4 Year of study | 2 | 2.5. Semester | 2 | 2.6. Type of evaluation | verificare | 2.7.Classification | |

## 3. Total estimated time

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Hours per week | 0 | 3.2. Lectures | 0 | 3.3. Tutorials/Practicals/Projects | 0/0/0 |
| 3.4. Total hours per semester | 0 | 3.5. Lectures | 0 | 3.6. Tutorials/Practicals/Projects | 0/0/0 |
| Distribution of estimated time for study | | | | | |
| Learning by using one's own course notes, manuals, lecture notes, bibliography | | | | | 13 |
| Research in library, study of electronic resources, field research | | | | | 6 |
| Preparation for practicals/tutorials/projects/reports/homework | | | | | 6 |
| Tutorat | | | | | 0 |
| Other activities | | | | | 0 |
| 3.7. Total hours of individual study | | | | | 25 |
| 3.8. Total hours per semester | | | | | 25 |
| 3.9. ECTS | | | | | 1 |

## 4. Prerequisites (if necessary)

| | |
|---|---|
| 4.1. curriculum | |
| 4.2. competences | |

## 5. Conditions/Infrastructure (if necessary)

| | |
|---|---|
| 5.1. for lecture | |
| 5.2. for tutorials/practicals | |

## 6. Learning outcomes

| | |
|---|---|
| Knowledge | |
| Skills | |
| Responsibility and autonomy | |

## 7. Contents

## 8. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program

| |
|---|
| |

## 9. Assessment

| Activity type | Assessment criteria | Assessment methods | Weight în final mark |
|---|---|---|---|
| Minimal requirements for passing the exam | | | |

| Date, | Teacher's name and signature, | Practicals/Tutorials/Project instructor(s), name and signature |
|---|---|---|
| 13.07.2025 | | |

| Date of approval | Head of department name and signature |
|---|---|
| 15.07.2025 | Lect. dr. Rozana ZUS |