University of Gdańsk

Subject card

Subject name and code	Methods of Experimental Physics, PG_00182320		
Field of study	Physics		
Date of commencement of studies	October 2026	Academic year of realisation of subject	2026/2027
Education level	Master's studies	Subject group	Obligatory subject group in the field of study Subject group related to scientific research in the field of study
Mode of study	full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	Polish
Semester of study	1	ECTS credits	4.0
Learning profile	academic	Assessment form	exam
Conducting unit	Division of Atomic and Molecular Physics -> Institute of Experimental Physics -> Faculty of Mathematics, Physics and Informatics -> Rector		
Name and surname of lecturer (lecturers)	Subject supervisor	dr Łukasz Sobolewski	
	Teachers	dr Łukasz Sobolewski	

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	45.0	0.0	0.0	0.0	0.0	45

E-learning hours included: 0.0

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	45	0.0	55.0	100

Subject objectives

A presentation of advanced experimental methods for determining the energy level structure of atoms and molecules and the interactions between atoms and molecules. These methods are used in physical processesboth static and dynamicoccurring in atomic and molecular systems. An important element of the lecture will be a discussion of methods used at the Institute of Experimental Physics, with particular emphasis on methods employed in the Department of Atomic and Molecular Physics: high-resolution laser spectroscopy and methods used in atomic and ion collisions at low and intermediate energies.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[FIZMU2_U05] can synthesize methods and ideas from various areas of physics and other exact and natural sciences; can notice that similar models describe even distant phenomena	The student is able to: – interpret atomic and molecular spectra, – select appropriate spectroscopic methods for analyzing the physical systems being studied, – describe the operating principles of basic spectroscopic instruments, – plan preparation for classes for themselves and their group.	[SU1] oral statement/conversation/ discussion [SU3] text preparation/written work
[FIZMU2_W04] knows to an in-depth degree the principle of operation of measuring systems and research equipment specific to the area of physics related to the chosen specialization or knows advanced methods of theoretical and mathematical physics	The student knows: – basic experimental methods of atomic and molecular spectroscopy, – basic applications of atomic and molecular spectroscopy in physics, biophysics, and medicine, – the most important issues addressed in contemporary atomic and molecular spectroscopy.	[SW1] oral statement/ conversation/discussion [SW3] text preparation/written work
[FIZMU2_U01] is able to apply the scientific method in solving physical problems, conducting experiments and reasoning	The student is able to: – interpret atomic and molecular spectra, – select appropriate spectroscopic methods for analyzing the physical systems being studied, – describe the operating principles of basic spectroscopic instruments, – plan preparation for classes for themselves and their group.	[SU1] oral statement/conversation/ discussion [SU3] text preparation/written work
[FIZMU2_U08] can work independently or in a team, and lead a team	The student is able to: – interpret atomic and molecular spectra, – select appropriate spectroscopic methods for analyzing the physical systems being studied, – describe the operating principles of basic spectroscopic instruments, – plan preparation for classes for themselves and their group.	[SU1] oral statement/conversation/ discussion [SU3] text preparation/written work [SU8] observation of student's independent or team work
[FIZMU2_K01] is ready to critically evaluate the knowledge and content received, to formulate questions precisely and to further educate themselves and others	The student understands the need to: – expand knowledge and skills; – formulate ideas precisely; – continue learning and encourage others to do the same; – popularize scientific achievements in society in a substantive manner.	[SK1] oral statement/conversation/ discussion [SK8] observation of student's independent or team work
[FIZMU2_W03] knows to an in-depth degree experimental, observational, and numerical techniques allowing to plan and execute a complex physical experiment or computer simulation	The student knows: – basic experimental methods of atomic and molecular spectroscopy, – basic applications of atomic and molecular spectroscopy in physics, biophysics, and medicine, – the most important issues addressed in contemporary atomic and molecular spectroscopy.	[SW1] oral statement/ conversation/discussion [SW3] text preparation/written work
[FIZMU2_W01] has in-depth knowledge of various areas of physics; knows the history of the development of physics and its importance for the progress of exact and natural sciences, knowledge of the world and social development; has in-depth knowledge of the current directions of physics development and the fundamental dilemmas of modern civilization	The student knows: – basic experimental methods of atomic and molecular spectroscopy, – basic applications of atomic and molecular spectroscopy in physics, biophysics, and medicine, – the most important issues addressed in contemporary atomic and molecular spectroscopy.	[SW1] oral statement/ conversation/discussion [SW3] text preparation/written work

Subject contents	0. Historical Overview of the Development of Atomic Physics 1. Light Detectors 2. Light Sources 3. Light Dispersion Methods 4. Laser Physics 5. Basic Spectroscopic Systems Used at the Institute 6. Saturation Problems in the Interaction of Laser Light with Atomic Systems 7. Basic Methods Used in Measuring the Luminescence of Solutions 8. Vacuum Equipment: Vacuum Gauges, Vacuum Pumps 9. Plasma and Its Applications
Prerequisites and co-requisites	Basic knowledge of atomic and molecular physics

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
not applicable	51.0%	20.0%
not applicable	51.0%	80.0%

Recommended reading

Basic literature	1. Haken, H.C. Wolf, Atomy i kwanty, wprowadzenie do spektroskopii atomowej, PWN 1998 2. Z. Leś, Podstawy fizyki atomu, PWN SA 2015 3. W. Demtroder, Spektroskopia laserowa, PWN, Warszawa 1993 4. F. Kaczmarek, Wstęp do fizyki laserów, PWN 1978 5. H. Haken, H.C. Wolf, Fizyka molekularna z elementami chemii kwantowej, PWN, Warszawa 1998. 6. Z. Kęcki, Podstawy spektroskopii molekularnej, PWN, Warszawa 1998 7. A. Kawski, Fotoluminescencja roztworów, PWN, Warszawa 1992 8. Ziętek Podstawy fizyki laserów" IF UMK Toruń 9. Gordon W. F. Drake, Springer Handbook of Atomic, Molecular, and Optical Physics 2nd ed. 2023
Supplementary literature	1. J. Sadlej, Spektroskopia molekularna, WNT, Warszawa 2002 2. J. Najbar, A. Turek, Fotochemia i spektroskopia optyczna Ćwiczenia laboratoryjne, PWN, Warszawa 2009
eResources addresses	

Example issues/ example questions/ tasks being completed

1. A historical outline of the development of atomic physics.
2. Important parameters of light detectors. Thermal light detectors.
3. Photoemission light detectors.
4. Photomultipliers - construction and general characteristics.
5. The technique of counting single photons using photomultipliers.
6. Other light detectors: e.g., photoelectric image intensifiers, photoresistors, photodiodes, photovoltaic detectors, CCDs, CMOS sensors.
7. The influence of temperature and magnetic field on the operation of a photomultiplier, along with methods for correcting these influences.
8. The concept of a laser and its operating principle. General characteristics of lasers. Longitudinal laser modes.
9. Is it possible to obtain a two-level laser? Justify your answer.
10. Derive the lasing condition for a three-level laser (presented by the inventor of the ruby laser). 11. A necessary condition for achieving laser action, using the example of the He-Ne laser.
12. The structure and operating principle of tunable lasers (e.g., using the Coherent 699-21 laser as an example).
13. Ionization and deionization processes in plasma.
14. Prism - linear dispersion.
15. Prism - angular dispersion, resolving power.
16. Diffraction gratings, spectrographs - structure and important parameters.
17. Interferometers, using the example of the Michelson interferometer.
18. Fabry-Perot interferometer - characteristics and applications.
19. Interferometric measurement of the wavelength of laser light.
20. Characteristics and types of vacuum.
21. Description of collisions between atoms or molecules (methods for determining cross sections).
22. Methods of imaging ("seeing") individual atoms.
23. Mass spectrometry (Aston spectrometer) and its applications.
24. Methods of isotope separation.
25. Emission method for measuring atomic structure.
26. Methods of measuring atomic structure using laser absorption spectroscopy (optogalvanic spectroscopy, laser-induced fluorescence, fluorescence depletion spectroscopy).
27. Fluorescence - characteristics and observation methods. Phosphorescence - characteristics and observation methods.
28. Luminescence in nature.
29. Vacuum gauges - types and characteristics.
30. Vacuum pumps - types and characteristics.

Work placement	Not applicable

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