University of Gdańsk

Subject card

Subject name and code	, PG_00165900		
Field of study	Medical Physics		
Date of commencement of studies	October 2024	Academic year of realisation of subject	2024/2025
Education level	postgraduate studies	Subject group	Obligatory subject group 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 English possible upon students request.
Semester of study	1	ECTS credits	6.0
Learning profile	academic	Assessment form	
Conducting unit	Zakład Biomateriałów i Fizyki Medycznej -> Instytut Fizyki Doświadczalnej -> Faculty of Mathematics, Physics and Informatics -> Rektor		
Name and surname of lecturer (lecturers)	Subject supervisor	prof. dr hab. Piotr Bojarski	
	Teachers	dr hab. Illia Serdiuk prof. dr hab. Piotr Bojarski	

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	30.0	0.0	0.0	0.0	60
	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	60	0.0	0.0	60

Subject objectives	Presentation and understanding of basic laws, phenomena and processes connected to modern photophysics of molecular excited states in the condensed phase with particular emphasis on biologically active molecules, macromolecules and ensembles. Description of luminescent characteristics, their proper determination, sources of typical experimental errors, data analysis and fundamental experimental methods upon steady-state and pulsed excitation.

Learning outcomes	<table><tr><th>Course outcome</th><th>Subject outcome</th><th>Method of verification</th></tr><tr><td>[FIZMEDMU2_W06] has knowledge of current directions in the development of physics, in particular within the chosen specialization</td><td>Understands the idea of non-radiative energy transfer as a spectroscopic ruler in the nanoscale, as a tool delivering valuable information on macromolecular conformations and as an indicator of the proximity of biological macromolecules.</td><td>[SW4] test/exam - oral or written [SW1] oral statement/ conversation/discussion</td></tr><tr><td>[FIZMEDMU2_U05] has the ability to synthesize methods and ideas from various areas of physics and other natural sciences; is able to notice that distant phenomena are sometimes described by similar models</td><td>Understands the importance and limitations of theoretical models describing luminescent effects in solutions and selected systems of biophysical importance. Is aware of alternative methods for describing complex systems, e.g. the Monte-Carlo method.</td><td>[SU1] oral statement/conversation/ discussion [SU4] test/exam - oral or written</td></tr><tr><td>[FIZMEDMU2_U06] is able to adapt the knowledge and methodology of physics as well as the experimental and theoretical methods used to related scientific disciplines</td><td>Knows and understands the basic experimental and theoretical methods of absorption and luminescence spectroscopy; Is able to assess the correct/ incorrect result of a typical spectroscopic measurement and identify the sources of typical errors; is able to determine typical excitation and observation conditions and analyze measurement data in relation to amino acids, polypeptides labeled with fluorophores, proteins and other biologically active entities.Knows and understands the key effects and models of phenomena in molecular biospectroscopy, such as solvatochromism, transfer of electronic excitation energy and rotational depolarization of fluorescence.</td><td>[SU1] oral statement/conversation/ discussion [SU4] test/exam - oral or written</td></tr></table>
Subject contents	1)Effects of interaction of UV-Vis radiation and molecules. Necessary and sufficient conditions for absorption. 2)Jablonski diagram for an isolated molecule. 3)Basic laws, rules and types of luminescence. Examples and limitations.Absorption and luminescence of amino acids. 4)Measurement of absorption spectra. Typical measurement limitations. Schematic diagram. Single- and double-beam spectrophotometer. 5)Measurement of excitation emission spectra, fluorescence and phosphorescence spectra. Schematic diagram of the apparatus. Typical measurement errors. Example. Why do we measure emission? 6)Phenomena and artifacts influencing the intensity and position of emission spectra. 7)Definition and methods of determining emission quantum yield. Sources of errors in efficiency assessment. Factors influencing emission quantum yield.Examples with biophysical basis. Aggregation in the ground and excited states. Dimers and excimers. Kasha's excitone model of a dimer. Analysis of absorption spectra of concentrated solutions. Example application in molecular biophysics (FMN aggregation). 8)Photoselection phenomenon. Degree of polarization and emission anisotropy. Measurement method and sources of error. 9)Factors depolarizing fluorescence: rotational and concentration depolarization of fluorescence, torsional vibrations. Radiative energy transfer and secondary effects. 10)Emission intensity decay and mean emission lifetime. Time-correlated single photon counting method. Analysis of emission intensity decay. Example in the biophysical context. 11)Emission anisotropy decay and its analysis. Examples in the biophysical context. 12)Solvatochromism and thermochromism. Dipole moments in the ground and excited states. Example of a solvatochromically sensitive probe in the biophysical context (biological membranes). 13) Static and dynamic fluorescence quenching. Host-guest systems as a drug delivery system. 14) Radiative and non-radiative excitation energy transfer. Physical mechanisms of non-radiative energy transfer. 15) Migration and trapping of excitation energy. Energy transfer as a spectroscopic measure at the nanoscale, an indicator of the proximity of biological macromolecules and a tool for assessing the conformational freedom of polypeptides and proteins.
Prerequisites and co-requisites	Completing the basics of physics. Knowledge of the basics of atomic physics and quantum mechanics.
Assessment methods and criteria	<table><tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr><tr><td>oral exam</td><td>60.0%</td><td>100.0%</td></tr></table>
Recommended reading	<table><tr><td>Basic literature</td><td>1) A.Kawski, Fotoluminescencja roztworów, PWN, 1992 2) J.R. Lakowicz, Principles of Fluorescence Spectroscopy, Plenum Press, 2006 3) Z.Gryczynski and I. Gryczynski, Practical Fluorescence Spectroscopy, CRC Press, 2020.</td></tr></table>

	Supplementary literature	H.Hacken, H. Ch.Wolf, Fizyka molekularna z elementami chemii kwantowej, PWN, 1998. Own materials and data.
	eResources addresses	Adresy na platformie eNauczanie:
Example issues/ example questions/ tasks being completed	List of exam topics: 1) Effects of UV-Vis radiation and molecules. Necessary and sufficient conditions for absorption. Discuss using the example of a selected amino acid. 2) Jablonski diagram for an isolated molecule. 3) Basic laws, rules and types of luminescence. Examples and limitations. 4) Measurement of absorption spectra. Typical measurement limitations. Schematic diagram. Why do we measure absorption? 5) Measurement of excitation emission spectra, fluorescence and phosphorescence spectra. Schematic diagram of the apparatus. Typical measurement errors. Example. Why do we measure emission? 6) Phenomena and artifacts affecting the intensity and position of emission spectra. 7) Definitions and methods of determining the quantum yield of emission. Sources of errors in the assessment of efficiency. Factors affecting the quantum yield of emission. Discuss using a selected example with a biophysical basis. 8) Photoselection phenomenon. Degree of polarization and anisotropy of emission. Measurement method and sources of error. 9) Factors depolarizing fluorescence. Discuss qualitatively using a selected example from a biophysical background. 10) Emission intensity decay and mean emission lifetime. Time-correlated photon counting method. Analysis of emission intensity decay. Example in a biophysical context. 11) Emission anisotropy decay and its analysis. Example in a biophysical context. 12) Solvatochromism and thermochromism. What is it, what are its applications. Example of a solvatochrome-sensitive probe in a biophysical context. 13) Static and dynamic fluorescence quenching. Discuss the mechanism. Example relevant to biophysics. 14) Intermolecular aggregation. Kasha's exciton model of a dimer. Analysis of absorption spectra of concentrated solutions. Example application from the field of molecular biophysics. 15) Radiative and nonradiative excitation energy transfer. Physical mechanisms and applications in biophysics/ biochemistry.	
Work placement	Not applicable	