A COURSE SYLLABUS – DOCTORAL SCHOOL

REGARDING THE QUALIFICATION CYCLE FROM 2021 TO 2025

GENERAL INFORMATION ABOUT COURSE	
Course title	**PhD seminar**
Name of the unit running the course	Doctoral School at University of Rzeszów
Type of course *(obligatory, optional)*	obligatory
Year and semester of studies	2021 – 2025 (sem. I – VIII)
Discipline	Physical Sciences
Language of Course	Polish
Name of Course coordinator	Dr hab. Rafał Hakalla, prof. UR
Name of Course lecturer	Dr hab. Rafał Hakalla, prof. UR
Prerequisites	A range of knowledge stemming from the Master's programme in Physics. Knowledge of English to the extent enabling the use of foreign language sources of scientific information, preparation of publications and presentation of scientific achievements at specialist conferences.

BRIEF DESCRIPTION OF COURSE
(100-200 words)

The doctoral seminar focuses on supporting the consecutive stages of the research procedure, the realisation of which is crucial for the preparation of the doctoral dissertation. The content of the course focuses on the preparation of spectral sources of a selected diatomic molecule, obtaining high quality spectra of this molecule by modern high-resolution spectroscopy methods, performing extended spectral analysis of the strongly and extensively perturbed rovibronic states of this particle in order to work out its physical and chemical properties that can be applied to space, astrophysical and astronomical programmes. The topics pursued will be linked to:

- the acquisition of knowledge and skills related to the planning, execution and refinement of scientific investigations of high resolution precision spectroscopy,
- using knowledge from different scientific fields to creatively identify and innovatively solve complex spectroscopic, research and analytical problems,
- to critically analyse and evaluate research results,
- developing the ability to present research results through active participation in the international scientific community

COURSE LEARNING OUTCOMES AND METHODS OF EVALUATING LEARNING OUTCOMES

Learning outcome	The description of the learning outcome defined for the course	Relation to the degree programme outcomes (symbol)	Learning Format (Lectures, classes,...)	Method of assessment of learning outcomes (e.g. test, oral exam, written exam, project,...)
Knowledge (no.)	**The PhD student knows and understands:**			
1	To the extent that he/she is able to revise existing paradigms, he/she is familiar with the worldwide body of work, including theoretical foundations and general and selected specific issues, specific to high-resolution molecular spectroscopy.	P8S-WG/1	Lab	PhD project
2	The main trends in the development of the discipline of physical science, in particular related to the subject of spectroscopy.	P8S-WG/2	-||-	-||-
3	Research methodology applied in the discipline of physical sciences.	P8S-WG/3	-||-	-||-
4	The principles of dissemination of the results of scientific activity, including in open access mode.	P8S-WG/4	-||-	-||-

5	Knowledge of the principles of knowledge transfer to the economic and social spheres and the principles of commercialisation of the results of scientific activity and of know-how related to these results.	P8S-WK/3	-||-	-||-
Skills (no.)	**The PhD student can:**			
1	Use knowledge from various fields of science to creatively identify and innovatively solve complex spectroscopic problems or perform tasks of a research nature, in particular: be able to define the purpose and object of spectroscopic research, formulate a research hypothesis, develop methods, techniques tools for spectroscopic research and creatively apply them, make inferences on the basis of spectroscopic scientific research and obtained research results.	P8S-UW/1	-||-	-||-
2	Critically analyse and evaluate the results of scientific research, expert activity and other works of creative nature and their contribution to the development of spectroscopy.	P8S-UW/2	-||-	-||-
3	Transfer the results of scientific activity to the economic and social sphere.	P8S-UW/3	-||-	-||-
4	Communicate on specialised topics in the physical sciences, especially in the field of molecular spectroscopy to the extent that can actively participate in the international scientific community.	P8S-UK/1	-||-	-||-
5	Disseminate the results of scientific activity, including in popular science forms.	P8S-UK/2	-||-	-||-
6	Initiate and lead scientific debate and professional debate.	P8S-UK/3	-||-	-||-
7	Take an active part in scientific discourse on specialised topics.	P8S-UK/4	-||-	-||-
8	Plan and carry out individual and team research projects in the field of high resolution molecular spectroscopy taking on various roles, also in an international environment.	P8S-UO	-||-	-||-
9	To plan and act independently for their own broader development and to inspire and organise the development of others.	P8S-UU/1	-||-	-||-
Social competence (no.)	**The PhD is ready to:**			
1	Critically evaluate the scientific output of within high resolution molecular spectroscopy.	P8S-KK/1	-||-	-||-

2	Critically evaluate one's own contribution to the development of high–-resolution molecular spectroscopy.	P8S-KK/2	-||-	-||-
3	Recognise the importance of knowledge in solving scientific cognitive problems and practical problems.	P8S-KK/3	-||-	-||-
4	To uphold and develop the ethos of the research and creative communities, including: - conducting scientific activity in an independent manner, - respecting the principle of public ownership of the results of scientific activity, taking into account the principles of protection of intellectual property.	P8S-KR	-||-	-||-

LEARNING FORMAT – NUMBER OF HOURS

Semester (no.)	Lectures	Seminars	Lab classes	Internships	others	ECTS
I			30			
II			30			
III			30			
IV			30			
V			30			
VI			30			
VII			30			
VIII			30			
total:			**240 hrs.**			0

METHODS OF INSTRUCTION

LABORATORY WORK; DATA ANALYSIS WITH COMPUTER PROGRAMMES; PREPARATION OF PRESENTATIONS; SCIENTIFIC DISCUSSION AND DEBATE.

COURSE CONTENT

Stages of dissertation preparation throughout the study cycle:

Year 2021/2022; sem. I and II

1. To develop a bespoke methodology for the measurement and spectroscopic analysis of a selected molecule, taking into account appropriate research techniques.
2. Design and commission a source of spectra of a selected diatomic molecule.
3. Obtain a ro-vibronic spectrum of the molecule in the selected measurement range.
4. Identification of the spectrum associated with the first vibrational level of the key electronic state.
5. Selection of the analytical methods appropriate for high resolution spectroscopy.

Year 2022/2023; sem. III and IV

1 Perform deperturbation analysis for the first vibrational level of the key electronic state.
2. Obtain and present results and formulate conclusions and predictions.
3. Writing a scientific paper presenting the results obtained for the first vibrational level.
4. Identifying the spectrum associated with the next vibrational level of the key electronic state.
5. Perform deperturbation analysis for the next vibrational level of the key electronic state.
6. Obtain and present results and make conclusions and predictions.
7. Writing a scientific paper presenting the results obtained.

Year 2023/2024; sem. V and VI

1. Carrying out a deperturbation analysis for the following two vibrational levels of the key electronic state.
2. Obtaining and presenting results and formulating conclusions and predictions.
3. Writing two scientific papers presenting the results obtained.

Year 2024/2025; sem. VII and VIII

1 To carry out a global deperturbation analysis involving all analysed vibrational levels of the key electronic state.
2 Writing a scientific paper presenting the results obtained.
3. Writing a dissertation.

COURSE ASSESSMENT CRITERIA

Assessment: pass/fail, after each semester. Each odd-numbered semester shall be credited with promotion based on the degree of the doctoral student's commitment to the tasks specified in the 'PROGRAMME CONTENTS' section. In order to receive credit after semesters II, IV, VI and VIII, the following tasks must actually be completed:

- credits 1-5 from the 'PROGRAMME CONTENTS' section in 2021/2022; semesters I and II
- credits 1-7 from the 'PROGRAMME CONTENTS' section in the year 2022/2023; semesters III and IV
- 1 to 3 credits from the 'PROGRAMME CONTENTS' section in the year 2023/2024; sem. V and VI
- credits 1-3 from the 'PROGRAMME CONTENTS' section in the year 2024/2025; sem. VII and VIII.

TOTAL PhD STUDENT WORKLOAD REQUIRED TO ACHIEVE THE INTENDED LEARNING OUTCOMES – NUMBER OF HOURS AND ECTS CREDITS

Activity	Number of hours
Scheduled course contact hours	240 hrs. – 8 x 30 hrs.
Other contact hours involving the teacher (consultation hours, examinations)	100 hrs.
Non-contact hours – student`s own work (preparation for classes or examinations, project, etc.)	400 hrs.
Total number of hours	740 hrs.
Total number of ECTS credits	

INSTRUCTIONAL MATERIALS

Compulsory literature:	1. J. Sadlej 'Molecular spectroscopy', WNT, 2002 2. W. Kolos, J. Sadlej 'Atom and molecule', WNT, 1998 3. W. Kolos 'Quantum chemistry', PWN, 1978 4. P. W. Atkins 'Physical Chemistry', PWN, 2001 5. H. Haken, H. Ch. Wolf 'Molecular physics with elements of quantum chemistry', PWN, 1998. 6. H. Haken, H. Ch. Wolf 'Atoms and quanta', PWN, 2002 (2nd ed.). 7. P. Kowalczyk "Physics of particles. Energies and spectra", PWN, 1999. 8. A. Gołębiewski 'Elementy mechaniki i chemii kwantowej', PWN, 1982. 9. Z. Leś 'Introduction to atomic spectroscopy', PWN 2014.
Complementary literature:	1. G. Gauglitz, D.S.Moore, „Handbook of Spectroscopy", Wiley-VCH Verlag GmBH, 2014.

24.11.2021

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Date and signature of the Course lecturer

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Approved by the Head of the Department or an authorised person