COURSE SYLLABUS

1. Data about the program

1.1 Higher education institution	Babeş-Bolyai University
1.2 Faculty	Faculty of Physics
1.3 Doctoral school	Physics
1.4 Field of study	Physics
1.5 Study cycle	Doctorate
1.6 Study program / Qualification	Doctoral training / PhD in Physics

2. Course data

2.1 Name of discipline	Advanced methods in Atomic and Molecular Physics						
2.2 Teacher responsible for lectures	Prof. dr. David Leontin, Prof. dr. Damian Grigore, Prof. dr. habil. Baia Monica, Prof. dr. habil. Pinzaru Simona, Prof. dr. habil. Leopold Nicolae						
2.3 Teacher responsible for seminars	Prof. dr. David Leontin, Prof. dr. Damian Grigore, Prof. dr. habil. Baia Monica, Prof. dr. habil. Pinzaru Simona, Prof. dr. habil. Leopold Nicolae						
2.4 Year of study	1	2.5 Semester	1	2.6. Type of evaluation	E	2.7 Course framework	DO

3. Estimated total time of teaching activities (hours per semester)

3.1 Hours per week	3	Out of which: 3.2 Lectures	2	3.3 Seminars / Laboratory classes	1
3.4 Total hours in the curriculum	36	Out of which: 3.5 Lectures	24	3.6 Seminars / Laboratory classes	12

Allocation of study time:	
Study supported by textbooks, other course materials, recommended bibliography and personal student notes	62
Additional learning activities in the library, on specialized online platforms and in the field	24
Preparation of seminars / laboratory classes, topics, papers, portfolios and essays	22
Tutoring	10
Examinations	10
Other activities: -	

3.7 Individual study (total hours)	128
3.8 Total hours per semester	160
3.9 Number of credits	10

4. Preconditions (where applicable)

4.1 Curriculum	●
4.2 Competences	●

5. Conditions (where applicable)

5.1 Conducting lectures	● Course hall with blackboard, projector, internet access and software
5.2 Conducting seminars / laboratory classes	● Course hall with blackboard, projector, internet access and software

6. Specific competences acquired

Professional competences	• The ability to formulate hypothesis and evaluate experimental data specific to the advanced methods applied in atomic and molecular physics • Practical skills to operate high performance equipments • The capacity to obtain and evaluate experimental data in correlation with the state-of-the - art in the research field • The capacity to summarise the scientific results and to elaborate manuscripts based on the obtained results. • Planning and organising skills. Interdisciplinary mindset.
Transversal competences	• Fulfilling the professional tasks in an efficient and responsible way in accordance with the law and specific professional ethics • Respecting, in accordance with the law, of intellectual property rights (including the technological transfer), product certification methodology, principles, norms and values of professional ethics in the framework of the own rigurous, efficient and responsible strategy of work. • Effective work in multidisciplinary team on different hierarchical levels, fulfilling specific roles within a team, showing initiative and entrepreneurial leadership based on dialogue, cooperation positive attitudes, mutual respect, diversity and multiculturalism and continuous improvement of the own activities. • Effective use of information sources and communication resources and training assistance, both in English and Romanian language.

7. Course objectives (based on the acquired competencies grid)

7.1 The general objective of the course	• Acquiring advanced theoretical knowledge about advanced methods applied in atomic and molecular physics • Acquiring advanced experimental and theoretical methodologies for characterizing atomic and molecular systems
7.2 Specific objectives	• Increasing the PhD student ability to identify new methods applied for the atom and molecule study • Knowledge of the advanced research methods and techniques available within the Doctoral School to better organise and develop the research topic. • Knowledge of metal – molecule charge transfer processes and of the electronic mechanism of surface-enhanced Raman scattering (SERS) • Knowledge of the modern magnetic resonance methods (ESR and NMR) and the magneto-structural analysis of the coupled paramagnetic systems. • Advanced concepts of the techniques and methods of electron paramagnetic resonance (EPR) • Knowledge of the optical spectroscopy theory and practical use of analytical tools for different interdisciplinary applications (physics-chemistry-pharmacy-medicine-biology)

8. Content

8.1 Lectures	Teaching methods	Comments
Molecular magnetism	Presentation, discussion, case studies, exercises	3h
Magnetic resonance methods (ESR and NMR)		2h
The influence of the ionising radiation and oxidizing agents effect on the biopharmaceutical and food compounds		3h

The use of spin traps and spin markers in the study of biological systems and antioxidative processes.		2h
Surface-enhanced Raman spectroscopy- a versatile tool for various applications- theoretical considerations		3h
Applications of SERS in various fields: pharmaceutical, medical, environmental, etc.		2h
Electron transfer at metal-molecule interfaces		3h
Study of halide ion adsorption to metal nanoparticles		2h
The study of the structure and vibrational properties of some molecules of biologic, medical and environmental interest		3h
Developing multidisciplinary applications of detection, monitoring and/or biosensing based on optical spectroscopy techniques (Raman, IR, UV-VIS, SERS, resonant Raman, SERRS)		2h

8.2 Seminars / laboratory classes	Teaching methods	Comments
Magneto-structural investigation of some coupled paramagnetic systems	Presentation, discussion, exercises	2.5h
Identification of the physical-chemical characteristics of nitrons and their use in the study of the structure and dynamics of biomolecular systems by means of ionising radiations		2.5h
Vibrational analysis (Raman, IR, SERS) of some pharmaceutical compounds		2.5h
Specific adsorption to metal surface and SERS detection of anionic and cationic molecules		2.5h
SERS in biomedical and environmental research		2.5h

Bibliography:
1. E.C. Le Ru, P.G. Etchegoin, Principles of Surface-Enhanced Raman Spectroscopy and Related Plasmonic Effects, Elsevier, Amsterdam, Boston, 2009
2. S.A. Maier, Plasmonics: Fundamentals And Applications, Springer, 2007
5. M. Baia, S. Astilean, T. Iliescu, **Raman and SERS investigations of pharmaceuticals**, Springer-Verlag GmbH, Berlin/Heidelberg, Germany, pp 214, 2008.
6. Alula, M. T.; Mengesha, Z. T.; Mwenesongole, E., **Advances in surface-enhanced Raman spectroscopy for analysis of pharmaceuticals: A review.** *Vibrational Spectroscopy* **2018,** *98*, 50-63.
7. Traian Iliescu, Simona Pinzaru, **Spectroscopia Raman si SERS cu aplicatii in biologie si medicina,** Ed. Casa Cartii de Stiinta, Cluj-Napoca, 2011;
8. SC Pînzaru, A Fălămaş, CA Dehelean, **Raman Spectroscopy: A Key Analytical Tool for New Drugs Research and Development**- Studies in Natural Products Chemistry, 2018;
9. Toporski, Jan, Dieing, Thomas, Hollricher, Olaf, **Confocal Raman Microscopy**, Springer Series in Surface Sciences, 2018
10. Rita Kakkar, **Atomic and Molecular Spectroscopy; Basic Concepts and Applications,** Cambridge University Press, 2015.
11. G.Damian, V.Miclauş, Radicali Nitroxidici, Ed. EFES, Cluj-Napoca 2001
12. Spin Labeling. Theory and Applications, Academic Press, 1976, ed. L.J.Berliner
13. D.J. Schreirer, J.H.Freed, Spin Labelling theory and Applications, în Biological Magnetic Resonance, vol.8, L.J.Berliner, J.Ruben, eds. Plenum press, New York, 1989
14. Garry R. Buettner, Ronald P. Mason, Spin-Trapping Methods for Detecting Superoxide and Hydroxyl Free Radicals In Vitro and In Vivo, in Critical Reviews of Oxidative Stress and Aging: Advances in Basic Science, Diagnostics and Intervention. (2003) Ed Richard G. Cutler and Henry Rodriguez. World Scientific, Volume I. Chapter 2

15. SC Pînzaru, A Fălămaş, CA Dehelean, **Raman Spectroscopy: A Key Analytical Tool for New Drugs Research and Development**- Studies in Natural Products Chemistry, 2018;

9. Aligning the contents of the discipline with the expectations of the epistemic community representatives, professional associations and standard employers operating in the program field

- The content of the discipline is in accordance with the subjects which are studied in the same field in Romanian and foreign universities and with the specific demands of research institutes, economy and labour market.

10. Examination

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Weight in the final grade
10.4 Lectures	Assessment of knowledge	Written exam	
	Assessment of knowledge	Ongoing tests	50%
10.5 Seminars / laboratory classes	Activity during seminars	Discussions, answers to questions	50%
	Assessment of knowledge	Written exam	
10.6 Minimum performance standard			

- Identification of the advanced experimental methods for the atom and molecule study
- Identification of the specific information derived by using these methods

Date of issue   Signature of the teacher   Signature of the teacher
                                 responsible for lectures   responsible for seminars

                                 Prof.dr. Leontin David   Prof.dr. Leontin David

                                 Prof.dr. Grigore Damian   Prof.dr. Grigore Damian

                          Prof.dr. habil. Monica Baia   Prof.dr. habil. Monica Baia

                          Prof.dr. habil. Simona Pinzaru   Prof.dr. habil. Simona Pinzaru

                          Prof. dr. habil. Nicolae Leopold   Prof. dr. habil. Nicolae Leopold

Date of approval by the doctoral school council   Signature of the doctoral school director
08.10.2021