Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Izbrana poglavja iz kvantne mehanike
Course title:	Selected topics from Quantum Mechanics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Fizika 2. st.		**1,2**	**1,2,3,4**
Physics 2nd degree		**1,2**	**1,2,3,4**

Vrsta predmeta / Course type	izbirni/optional
Univerzitetna koda predmeta / University course code:	

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
30	**0**	**15**	**0**	**0**	**105**	**5**

Nosilec predmeta / Lecturer:	Robert Hauko

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski/Slovenian
	Vaje / Tutorial:	slovenski/Slovenian

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Formalno ali neformalno znanje iz moderne fizike, osnov algebre in analize, uvoda v kvantno mehaniko.	Formal or informal knowledge of the Modern Physics, basic Algebra and Calculus, Introduction to Quantum Mechanics.

Vsebina:	**Content (Syllabus outline):**

Skalarni, vektorski in tenzorski operatorji. Rotacije v kvantni mehaniki, vrtilna količina, seštevanje vrtilnih količin, sklopitev spin-tir. Sistem več delcev: sistem ločljivih in neločljivih delcev, Paulijevo izključitveno načelo. Približne metode za stacionarna stanja: časovno neodvisna teorija motenj, variacijska metoda. Časovno odvisna teorija motenj: verjetnost za prehod v konstantnem in v periodičnem potencialu, adiabatska aproksimacija, interakcija atomov z EM valovanjem, izbirna pravila za električni dipolni prehod. Teorija sipanja: sipalni presek, sipalna amplituda, Bornova aproksimacija.	Scalar, vector and tensor operators. Rotations in quantum mechanics, angular momentum, addition of angular momenta, coupling of orbital and spin angular momenta. Many-particle systems: systems of distinguishable and identical particles. Pauli exclusion principle. Approximation methods for stationary states: time independent perturbation theory, the variational method. Time dependent perturbation theory: transition probability for a constant and for a harmonic perturbation, adiabatic approximation, interaction of atoms with radiation, the electric dipole selection rules. Scattering theory: scattering cross section, scattering amplitude, the Born approximation.

Temeljni literatura in viri / Readings:

1. N. Zettili, Quantum Mechanics – Concepts and Applications (Wiley, Chichester, 2003).
2. A. Ramšak, Kvantna mehanika (Založba Univerze v Ljubljani, Ljubljana, 2021).
3. M. C. Rogalski, S. B. Palmer, Quantum Physics (Gordon and Breach, Amsterdam, 1999).
4. D. J. Griffits, Introduction to Quantum Mechanics (Prentice Hall, Upper Saddle River, 1994).

Dodatna literatura / Additional Readings

Y. Peleg, R. Pnini, E. Zaarur, Schaum's outlines – Quantum Mechanics (McGraw Hill, New York, 1998).

Cilji in kompetence:	**Objectives and competences:**
Študenti nadgradijo osnovno znanje iz kvantne mehanike z vsebinami, ki so osnova za razumevanje in obravnavo pojavov v fiziki trde in mehke snovi ter v biofiziki. Usvojeno znanje in matematična orodja znajo uporabiti za obravnavo nekaterih osnovnih kvantnomehanskih procesov.	Students enrich the basic knowledge in quantum mechanics with topics, which are elemental for understanding and studying the phenomena in solid state physics, in soft mater physics and in biophysics. They can use the acquired knowledge and mathematical tools to tackle some basic quantum-mechanical processes.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Po uspešno zaključeni učni enoti bodo študenti zmožni: - seštevati vrtilne količine (posebni primer: sklopitev spin-tir)	**Knowledge and understanding:** On completion of this course students will be able to: - perform addition of angular momenta (special case: spin–orbit coupling)

- sestaviti valovno funkcijo sistema delcev s pravilno simetrijo (ločljivi, neločljivi delci, ferminoni, bozoni)
- uporabiti približne metode za izračun stacionarnih stanj: perturbativno, variacijsko in WKB (posebni primer: popravek fine strukture in Zeemanov učinek)
- izračunati verjetnosti za prehod pri konstantni in pri periodični motnji z uporabo časovno odvisne perturbacijske metode
- uporabiti adiabatski približek in približek nenadnega prehoda
- izračunati verjetnost prehoda v dipolnem približku interakcije atoma z elektromagnetnim valovanjem, uporabiti izbirna pravila
- izračunati sipalni presek v Bornovi aproksimaciji

Prenesljive/ključne spretnosti in drugi atributi:
Po uspešno zaključeni učni enoti bodo študenti zmožni:
- uporabljati usvojene matematične in fizikalne metode pri problemih s področij trdne in mehke snovi ter biofizike
- uporabljati računalniška orodja za analitično in za numerično računanje
- brati strokovne tekste s področja moderne fizike

- construct wavefunction with adequate symmetry for a system of particles (identical, distinguishable, fermions, bosons)
- use approximation methods for computation of stationary states: perturbation, variational and WKB (special cases: fine structure, Zeeman effect)
- calculate transition probability for a constant and for a harmonic perturbation with time-dependent perturbation method
- use adiabatic and sudden approximations
- calculate transition rates within the dipole approximation for interaction of atoms with radiation, use electric dipole selection rules
- calculate scattering cross section within Born approximation

Transferable/Key Skills and other attributes:
On completion of this course students will be able to:
- use the adopted mathematical and physical methods for related problems in solid state physics, in soft mater physics and in biophysics
- use computer tools for analytical and numerical computation
- read scientific literature in the field of modern physics

Metode poučevanja in učenja:

Predavanja
teoretične vaje
razlaga
razgovor
delo s tekstom
metoda pisnih in grafičnih del
uporaba simulacij
uporaba simulacijskih okolij

Learning and teaching methods:

Lectures
Theoretical excercises
Explanation
Discussion
Work with text
Work with graphic elements
Use of simulations
Use of simulation software

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
pisni izpit (lahko se nadomesti z 2 pisnima kolokvijema) ustni izpit (zagovor teoretičnih nalog) Za uspešno zaključeno učno enoto mora vsak del posebej biti pozitiven; vse teoretične naloge morajo biti izračunane in zagovorjene.	50% 50%	Written exam (can be replaced by 2 written tests) Oral exam (defence of theoretical exercises) For a successful completion, both written and oral exams must be positive; all theoretical problems must be solved and defended.

Reference nosilca / Lecturer's references:

1. HAUKO, Robert, DAJNKO, Matic, GAČEVIĆ, Dino, MARINKO, Peter, POTRČ, Melani, REPNIK, Robert. From speed of sound to vapour pressure : an undergraduate school experiment as an example of systematic error research. *European journal of physics*. 2022, vol. 43, no. 4, str. 1-14. ISSN 0143-0807. DOI: 10.1088/1361-6404/ac6cb9. [COBISS.SI-ID 117802755]
2.HAUKO, Robert, PADEŽNIK GOMILŠEK, Jana, KODRE, Alojz, ARČON, Iztok. X-ray absorption spectroscopy set-up for unstable gases : a study of 5p hydrides. *Radiation physics and chemistry*. 2020, vol. 171, str. 1-4, ISSN 0969-806X. DOI: 10.1016/j.radphyschem.2020.108743. [COBISS.SI-ID 5564411].
3. HAUKO, Robert, PADEŽNIK GOMILŠEK, Jana, KODRE, Alojz, ARČON, Iztok, AQUILANTI, Giuliana. Effects of the molecular potential on coexcitations of valence electrons in the K-shell photoeffect of 3p and 4p elements. *Physical review. A*. 2019, vol. 99, no. 6, str. 062501-1-062501-10. ISSN 2469-9926. Repozitorij Univerze v Novi Gorici - RUNG, DOI: 10.1103/PhysRevA.99.062501. [COBISS.SI-ID 22395158]