



Univerza v Mariboru

Fakulteta za naravoslovje
in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Uvod v kvantno teorijo polja in fiziko delcev
Course title:	Introduction to quantum theory and particle physics

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
FIZIKA		1. ali 2.	1., 2. ali 3.
PHYSICS		1. or 2.	1., 2. or 3.

Vrsta predmeta / Course type

Izbirni za modula Biofizika 3 in Fizika 1, 2, 3

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Lab. vaje Laboratory work	Terenske vaje	Samost. delo Individ. work	ECTS
10					290	10

Nosilec predmeta / Lecturer:

Mirjam Cvetič

Jeziki /

Languages:

Predavanja / slovenski/Slovenian

Lectures:

Vaje / Tutorial:

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Ni posebnih zahtev.

Prerequisites:

No special prerequisites.

Vsebina:

- Klein-Gordonova enačba, simetrije pripadajočega Lagrangiana in druga kvantizacija delcev spina-0.
- Diracova enačba, njene simetrije in druga kvantizacija delcev s spinom $\frac{1}{2}$.

Content (Syllabus outline):

- Klein-Gordon equation, symmetries of the Lagrangian and second quantization of the spin-0 particles.
- Dirac equation, its symmetries and second quantization of

<ul style="list-style-type: none"> - Maxwellova enačba, umeritvena simetrija, druga kvantizacija delcev s spinom 1. - Tipi interakcij: skalarna, Yukawa-ina, umeritveno invariantne interakcije. - Uvod v perturbativne izračune v kvantni teoriji polja, demonstrirano na delcih s spinom 0: <ul style="list-style-type: none"> a) Izpeljava tri-nivojskega Feynmanovega diagrama za S-matriko, b) reakcijski presek in izračun razpadov. - Perturbativni pristopi v kvantni elektrodinamiki: <ul style="list-style-type: none"> a) izpeljava Feynmanovih pravil s fermioni in polji spinov 1, b) izračuni za tipične primere sipalnih procesov in razpadov. - Vpeljava radiativnih popravkov in renormalizacija: <ul style="list-style-type: none"> a) vertex popravek, b) vakuumska polarizacija. - Aplikacije v sipalnih procesih v pospeševalnikih in sistemih fizike kondenzirane materije. 	<ul style="list-style-type: none"> spin $\frac{1}{2}$ particles. - Maxwellova equation, gauge symmetry, second quantization of spin 1 particles. - Types of interaction: scalar, Yukawa, gauge invariant interactions. - Interaction to the perturbative calculations in quantum field theory, demonstrated for spin 0 particles: <ul style="list-style-type: none"> a) Derivation of the three-level Feynman diagram for S-matrix, b) reakcijski presek in izračun razpadov. - Perturbative approaches in quantum electrodynamics: <ul style="list-style-type: none"> a) derivation of Feynman rules for fermions and fields for spin 1, b) calculations for typical examples of scattering processes and decays. - Introduction of radiative corrections and renormalization: <ul style="list-style-type: none"> a) vertex correction,, b) vacuum polarization. - Applications in scattering processes in accelerators and condensed matter systems.
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Temeljni literatura in viri / Readings:

- 1) Steven Weinberg: The Quantum Theory of Fields, Volume 1: Foundations, Cambridge University Press, 2005 (ISBN-13: 978-0521670531)
- 2) Mark Srednicki: Quantum Field Theory, Cambridge University Press, 2007 (ISBN-13: 978-0521864497)
- 3) Pierre Ramond: Field Theory : A Modern Primer (Frontiers in Physics Series, Vol 74) Westview Press, 2001 (ISBN-13: 978-0201304503)
- 4) Paul Langacker: The Standard Model and Beyond (Series in High Energy Physics, Cosmology and Gravitation), Taylor and Francis, 2009 (ISBN-13: 978-1420079067)
- 5) Mirjam Cvetič and Paul Langacker: Testing the Standard Model: Proceedings of the 1990 Theoretical Advanced Study Institute in Elementary Particle Physics, World Scientific Publishing Co Pte Ltd, 1991 (ISBN-13: 978-9810203146)

Cilji in kompetence:

Objectives and competences:

- Razumeti principe, metode in rezultate kvantne teorije polja
- Znati uporabljati metode
- Pridobiti si sposobnost nadaljnega samostojnega študija fizike visokih energij

Predvideni študijski rezultati:

- Understanding of principles, methods and results of the quantum field theory
- Gaining skills to use the methods
- Gaining the ability of individual independent further study of the high energy physics

Intended learning outcomes:

Znanje in razumevanje:

- Znanje principov, metod in rezultatov kvantne teorije polja
- Razumevanje rezultatov in njihove uporabe

Prenesljive/ključne spretnosti in drugi atributi:

- Sposobnost samostojnega dela in študija
- Uporaba znanj na drugih področjih

Knowledge and understanding:

- Understanding of principles, methods and results of the quantum field theory
- Understanding of the results and their applications

Transferable/Key Skills and other attributes:

- Ability to perform individual work and study
- Ability to apply the knowledge in other fields

Metode poučevanja in učenja:

Predavanja, seminar

Learning and teaching methods:

Lectures, seminar

Delež (v %) /

Načini ocenjevanja:

Weight (in %)

Assessment:

Način (pisni izpit, ustno izpraševanje, naloge, projekt)

- Ustni izpit
- Projektne naloge

50%
50%

Type (examination, oral, coursework, project):

- Oral exam
- Projects

Reference nosilca / Lecturer's references:

1. CVETIČ, Mirjam, HALVERSON, James, PIRAGUA, Hernan. Stringy hidden valleys. *The journal of high energy physics*, ISSN 1029-8479, 2013, issue 2, art. 005, str. 1-42, doi: [10.1007/JHEP02\(2013\)005](https://doi.org/10.1007/JHEP02(2013)005). [COBISS.SI-ID 77566721]

2. CVETIČ, Mirjam, GUICA, Monica, SALEEM, Zain H. General black holes, untwisted. *The journal of high energy physics*, ISSN 1029-8479, 2013, issue 9, art. 017, str. 1-32, doi: [10.1007/JHEP09\(2013\)017](https://doi.org/10.1007/JHEP09(2013)017). [COBISS.SI-ID 77564417]

3. CVETIČ, Mirjam, LU, Hui, POPE, Christopher N. Entropy-product rules for charged rotating black holes. *Physical review. D, Particles, fields, gravitation, and cosmology*, ISSN 1550-2368. [Online ed.], 2013, vol. 88, issue 4, str. 044046-1-044046-11, ilustr., doi: [10.1103/PhysRevD.88.044046](https://doi.org/10.1103/PhysRevD.88.044046). [COBISS.SI-ID 77565697]

4. CVETIČ, Mirjam, GIBBONS, G. W. Graphene and the Zermelo optical metric of the BTZ

black hole. *Annals of physics*, ISSN 0003-4916, 2012, vol. 327, issue 11, pages 2617-2626.
<http://www.sciencedirect.com/science/article/pii/S0003491612000814>, doi:
10.1016/j.aop.2012.05.013. [COBISS.SI-ID 73420545]

5. CVETIČ, Mirjam, LARSEN, Finn. Conformal symmetry for black holes in four dimensions.
The Journal of high energy physics, ISSN 1126-6708, 2012, issue 9, art. no. 76, 21 str.
http://download.springer.com/static/pdf/237/art%253A10.1007%252FJHEP09%25282012%2529076.pdf?auth66=1363420725_c431af950abbcefd2b45d01468167550&ext=.pdf, doi:
10.1007/JHEP09(2012)076. [COBISS.SI-ID 73421057]