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, 3. stopnja		1. ali 2.	**1., 2. ali 4.**
PHYSICS, 3rd cycle		1. or 2.	**1., 2. or 4.**

Vrsta predmeta / Course type: Izbirni za vse module

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Lab. vaje Laboratory work	Terenske vaje	Samost. delo Individ. work	ECTS
15					**165**	**6**

Nosilec predmeta / Lecturer: **Mirjam Cvetič**

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski/Slovenian in/and angleški s slovenskim prevodom/English with translation in Slovenian
	Vaje / Tutorial:	

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

Ni posebnih zahtev.

Prerequisits:

No special prerequisites.

Vsebina:

- Klein-Gordonova enačba, simetrije pripadajočega Lagrangiana in druga kvantizacija delcev spina-O.
- Diracova enačba, njene simetrije in druga kvantizacija delcev s spinom ½.
- Maxwellova enačba, umeritvena simetrija, druga kvantizacija delcev s spinom 1.
- Tipi interakcij: skalarna, Yukaw-ina, umeritveno invariantne interakcije.

Content (Syllabus outline):

- Klein-Gordon equation, symmetries of the Lagrangian and second quantization of the spin-O particles.
- Dirac equation, its symmetries and second quantization of spin ½ particles.
- Maxwellova equation, gauge symmetry, second quantization of spin 1 particles.

- Uvod v perturbativne izračune v kvantni teoriji polja, demonstrirano na delcih s spinom 0:
  a) Izpeljava tri-nivojskega Feynmanovega diagrama za S-matriko,
  b) reakcijski presek in izračun razpadov.
- Perturbativni pristopi v kvantni elektrodinamiki:
  a) izpeljava Feynmanovih pravil s fermioni in polji spinov 1,
  b) izračuni za tipične primere sipalnih procesov in razpadov.
- Vpeljava radiativnih popravkov in renormalizacija:
  a) vertex popravek,
  b) vakuumska polarizacija.
- Aplikacije v sipalnih procesih v pospeševalnikih in sistemih fizike kondenzirane materije.

- Types of interaction: scalar, Yukawa, gauge invariant interactions.
- Interaction to the perturbative calculations in quantum field theory, demonstrated for spin 0 particles:
  a) Derivation of the three-level Feynman diagram for S-matrix,
  b) reakcijski presek in izračun razpadov.
- Perturbative approaches in quantum electrodynamics:
  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:
  a) vertex correction,,
  b) vacuum polariztion.
- Applictions in scattering processes in accelerators and condensed matter systems.

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 Cvetic 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:

- Razumeti principe, metode in rezultate kvantne teorije polja
- Znati uporabljati metode

Objectives and competences:

- Understanding of principles, methods and results of the quantum field theory
- Gaining skills to use the methods

• Pridobiti si sposobnost nadaljnjega samostojnega študija fizike visokih energij	• Gaining the ability of individual independent frther study of the high energy physics

Predvideni študijski rezultati:	**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:	**Learning and teaching methods:**
Predavanja, seminar	Lectures, seminar

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt)		Type (examination, oral, coursework, project):
• Ustni izpit	**50%**	• Oral exam
• Projektne naloge	**50%**	• Projects

Reference nosilca / Lecturer's references:

1. CVETIČ, Mirjam, HALVERSON, James, LANGACKER, Paul. String consistency, heavy exotics, and the 750 GeV diphoton excess at the LHC. *Fortschritte der Physik*, ISSN 1521-3978, okt. 2016, vol. 64, issue 10, str. 748-782, doi: 10.1002/prop.201600080. [COBISS.SI-ID 90839809],

2. CVETIČ, Mirjam, GIBBONS, G. W., POPE, Christopher N. Compactifications of deformed conifolds, branes and the geometry of qubits. *The journal of high energy physics*, ISSN 1029-8479, jan. 2016, issue 1, str. 1-26, doi: 10.1007/JHEP01(2016)135. [COBISS.SI-ID 90841857],

3. CVETIČ, Mirjam, et al. Origin of Abelian gauge symmetries in heterotic/F-theory duality. *The journal of high energy physics*, ISSN 1029-8479, apr. 2016, issue 4, art. 041, doi: 10.1007/JHEP04(2016)041. [COBISS.SI-ID 90840321],

4. CVETIČ, Mirjam, PAPADIMITRIOU, Ioannis. AdS(2) holographic dictionary. *The journal of high energy physics*, ISSN 1029-8479, dec. 2016, issue 12, art. 008, doi: 10.1007/JHEP12(2016)008. [COBISS.SI-ID 90837249],

5. CVETIČ, Mirjam, GIBBONS, G. W., POPE, Christopher N. Photon spheres and sonic horizons in black holes from supergravity and other theories. *Physical review. D.*, ISSN 2470-0029, nov. 2016, vol. 94, issue 10, art. 106005, doi: 10.1103/PhysRevD.94.106005. [COBISS.SI-ID 90837505],

6. CVETIČ, Mirjam, GIBBONS, G. W., SALEEM, Zain H., SATZ, Alejandro. Vacuum polarization of STU black holes and their subtracted geometry limit. *The journal of high energy physics*, ISSN 1029-8479, jan. 2015, issue 1, art. 130, doi: 10.1007/JHEP01(2015)130. [COBISS.SI-ID 86136833],