



Univerza v Mariboru

Fakulteta za naravoslovje
in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Uvod v fotoniko
Course title:	Introduction to Photonics

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Enovit magistrski študijski program druge stopnje Predmetni učitelj		4	8
Five-year master's degree program Subject Teacher			

Vrsta predmeta / Course type

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Lab. vaje Laboratory work	Terenske vaje Field work	Samost. delo Individ. work	ECTS
45		15			90	5

Nosilec predmeta / Lecturer:

Jeziki / Predavanja / Lectures:
Languages: Vaje / Tutorial:

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

Prerequisites:

Vsebina:

Content (Syllabus outline):

Interferenca: Fabry – Perotov interferometer, odbojnost in prepustnost večplastnih nanosov, dielektrična zrcala.

Koherenca: časovna in prostorska, avtokorelacijska funkcija. Oblika in širina spektralnih črt: naravna širina, homogena in nehomogena širitev; povezava med koherenco in širino spektralnih črt.

Laserji: optični resonatorji, stimulirana emisija, optično črpanje, ojačanje, prag delovanja, Gaussovi snopi, preslikave Gaussovih snopov z lečami, vrste laserjev, primerjava laserjev in nekoherentnih svetil, tehnološka uporaba laserjev

Optična vlakna: valovni vodnik, eno in večrodovno vlakno, izgube, disperzija, žarkovna analiza, valovna slika

Optično anizotropne snovi: razširjanje svetlobe v optično enosnih kristalih, modulacija svetlobe, optični retarderji, optična aktivnost, Faradayev in Kerrov pojav.

Spatial and temporal coherence, autocorrelation function. Shape and width of spectral lines: natural width, homogeneous and nonhomogeneous broadening; correlation between the spectral width and coherence length.

Lasers: optical resonators, stimulated emission, optical pumping, gain, threshold, Gaussian beams, transformation of Gaussian beams with lenses, types of lasers, comparison of lasers and incoherent light sources, lasers in technology.

Optical fibres: guided waves, single mode and multimode fibres, losses, dispersion, ray analysis, wave picture.

Optically anisotropic materials: light propagation in optically uniaxial crystals, modulation of light, retarder plates, optical activity, Faraday and Kerr effect.

Temeljni literatura in viri / Readings:

1. F. G. Smith, T. A King, Optics and Photonics, An introduction (Wiley, Chichester, 2000).
2. D. Meschede, Optics, Light and Lasers (Wiley-VCH, Weinheim, 2004).
3. G. Brooker, Modern Classical Optics (Oxford University Press, New York, 2002)
4. D. Donlagić, M. Završnik, D. Donlagić, Fotonika: uvodna poglavja (Fakulteta za elektrotehniko, računalništvo in informatiko, Maribor, 1997).
5. katerakoli knjiga s področja moderne optike, laserjev, optoelektronike ali fotonike / any book from the field of modern optics, lasers, optoelectronics and photonics

Cilji in kompetence:

Študenti usvojijo teoretična znanja s področja valovne optike, načinov izsevanja svetlobe, delovanja in uporabe laserjev, razširjanja svetlobe skozi anizotropne snovi ter prenosa informacije po optičnih vlaknih in jih znajo uporabiti pri reševanju ustreznih problemov z rabo matematičnih orodij.

Objectives and competences:

Students obtain an advanced knowledge from the field of wave optics, light emission, the use and work of lasers, propagation of light through anisotropic materials and transfer of information with the use of optical fibres. They are capable of using the knowledge for solving problems with the use of mathematical methods.

Predvideni študijski rezultati:

Znanje in razumevanje

Po uspešno zaključeni učni enoti bodo študenti zmožni:

Intended learning outcomes:

Knowledge and understanding

On completion of this course students will be able to:

- opredeliti, v katerih primerih lahko svetlobo obravnavajo kot žarke, kdaj kot elektromagnetno valovanje in kdaj kot tok fotonov;
- uporabiti Maxwellove enačbe za obravnavo odboja in loma svetlobe na meji dveh neprevodnih snovi, na zaporedju poljubnega števila tankih plasti, ter za opis razširjanja svetlobe skozi izotropne in anizotropne dielektrike;
- napovedati učinek določenih optičnih elementov na lastnosti izhodne svetlobe glede na lastnosti vpadne svetlobe v odvisnosti od fizikalnih parametrov optičnih elementov;
- povezati obliko in širino spektralnih črt z longitudinalno koherenco svetlobe ter velikost izvora s transversalno koherenco;
- opredeliti ključne lastnosti laserjev in analizirati razširjanje laserske svetlobe skozi različne optične elemente ter optična vlakna.

Prenosljiva znanja

Po uspešno zaključeni učni enoti bodo študenti zmožni:

- uporabiti matematične metode linearne algebre, realne in kompleksne analize v eni in več dimenzijah in analizo nelinearnih diferencialnih enačb za reševanje realnih problemov;
- zreducirati različne kompleksne optične pojave na osnovne optične zakonitosti;
- uporabljati sodobno računalniško programsko opremo kot pomoč pri kvantitativni obravnavi zahtevnih fizikalnih problemov.

- define cases in which light can be considered as rays, electromagnetic wave or a stream of photons;
- use Maxwell's equations to study reflection and refraction of light on a plane boundary of two non-absorptive dielectrics, on a thin film and multiple stacks of thin layers, and to describe light propagation through isotropic and anisotropic dielectrics;
- predict the effect of some optical elements on the properties of the transmitted light as a function of properties of the incident light and physical parameters of optical elements;
- connect the shape and width of spectral lines with the longitudinal coherence of light and the size of a source with the transverse coherence;
- define crucial properties of lasers and analyse propagation of laser light through variable optical elements and optical fibres.

Transferable knowledge

On completion of this course students will be able to:

- use mathematical methods of linear algebra, real and complex analysis in one and more dimensions and analysis of nonlinear differential equations to solve real problems;
- reduce different complex optical phenomena to basic laws of optics;
- use modern ICT software to quantitatively study complex physical problems.

Metode poučevanja in učenja:

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

Learning and teaching methods:

lectures
theoretical exercises
tutorial work
explanation
discussion
demonstration
work with text
work with graphic elements
use of simulations
use of simulation software

Poučevanje in učenje potekata z didaktično uporabo informacijsko-komunikacijske tehnologije.

Teaching and learning are done through the didactic use of ICT.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
ustni kolokviji (seminarske vaje)	40%	oral tests (theoretical exercises)
ustni kolokviji (predavanja)	30%	oral tests (lectures)
pisni kolokviji	30%	Written tests
Za pozitivno končno oceno morajo biti opravljene vse seminarske vaje in ocena iz vsakega posameznega načina ocenjevanja mora biti pozitivna.		For passing the course, all the theoretical exercises must be solved and the grade in every type of assessment must be positive.

Reference nosilca / Lecturer's references:

1. SALAMONCZYK, Mirosław, VAUPOTIČ, Nataša, POCIECHA, Damian, WALKER, Rebecca, STOREY, John M. D., IMRIE, Corrie T., WANG, Cheng, ZHU, Chenhui, GÓRECKA, Ewa. Multi-level chirality in liquid crystals formed by achiral molecules. *Nature communications*, ISSN 2041-1723, 2019, vol. 8, str. 1922-1-1922-8, doi: [10.1038/s41467-019-09862-y](https://doi.org/10.1038/s41467-019-09862-y). [COBISS.SI-ID [32322855](https://www.cobiss.si/id/32322855)].
2. VAUPOTIČ, Nataša, ALI, Muhammad, MAJEWSKI, P., GÓRECKA, Ewa, POCIECHA, Damian. Polarization gratings spontaneously formed from a helical twist-bend nematic phase. *ChemPhysChem : a European journal of chemical physics and physical chemistry*, ISSN 1439-4235. [Print ed.], [in press] 2018, 15 str., doi: [10.1002/cphc.201800360](https://doi.org/10.1002/cphc.201800360). [COBISS.SI-ID [31667751](https://www.cobiss.si/id/31667751)].
3. POCIECHA, Damian, CRAWFORD, Catriona A., PATERSON, Daniel A., STOREY, John M. D., IMRIE, Corrie T., VAUPOTIČ, Nataša, GÓRECKA, Ewa. Critical behavior of the optical birefringence at the nematic to twist-bend nematic phase transition. *Physical review. E*, ISSN 2470-0045, 2018, vol. 98, no. 5, str. 052706-1-052706-5, doi: [10.1103/PhysRevE.98.052706](https://doi.org/10.1103/PhysRevE.98.052706). [COBISS.SI-ID [31948071](https://www.cobiss.si/id/31948071)].
4. SALAMONCZYK, Mirosław, VAUPOTIČ, Nataša, POCIECHA, Damian, WANG, Cheng, ZHU, Chenhui, GÓRECKA, Ewa. Structure of nanoscale-pitch helical phases : blue phase and twist-bend nematic phase resolved by resonant soft X-ray scattering. *Soft matter*, ISSN 1744-683X, 2017, vol. 13, no. 38, str. 6694-6699, doi: [10.1039/c7sm00967d](https://doi.org/10.1039/c7sm00967d). [COBISS.SI-ID [30804519](https://www.cobiss.si/id/30804519)].
5. MATRASZEK, Joanna, TOPNANI, Neha, VAUPOTIČ, Nataša, TAKEZOE, Hideo, MIECZKOWSKI, Jozef, POCIECHA, Damian, GÓRECKA, Ewa. Monolayer filaments versus multilayer stacking of bent-core molecules. *Angewandte Chemie*, ISSN 1433-7851. [Print ed.], 2016, vol. 55, iss. 10, str. 3468-3472, doi: [10.1002/anie.201510123](https://doi.org/10.1002/anie.201510123). [COBISS.SI-ID [29302055](https://www.cobiss.si/id/29302055)].
6. SZCZYTKO, Jacek, VAUPOTIČ, Nataša, MADRAK, Karolina, SZNAJDER, Paweł, GÓRECKA, Ewa. Magnetic moment of a single metal nanoparticle determined from the Faraday effect. *Physical review. E, Statistical, nonlinear, and soft matter physics*, ISSN 1539-3755, 2013, vol. 87, no. 3, 033201-1-033201-6, doi: [10.1103/PhysRevE.87.033201](https://doi.org/10.1103/PhysRevE.87.033201). [COBISS.SI-ID [26612519](https://www.cobiss.si/id/26612519)].

7. SZCZYTKO, Jacek, VAUPOTIČ, Nataša, OSIPOV, Mihail A., MADRAK, Karolina, GÓRECKA, Ewa. Effect of dimerization on the field-induced birefringence in ferrofluids. *Physical review. E, Statistical, nonlinear, and soft matter physics*, ISSN 1539-3755, 2013, vol. 87, no. 6, str. 062322-1-062322-6, doi: [10.1103/PhysRevE.87.062322](https://doi.org/10.1103/PhysRevE.87.062322). [COBISS.SI-ID [26839079](https://www.cobiss.si/id/26839079)].