



Univerza v Mariboru

Fakulteta za naravoslovje
in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Moderna optika
Course title:	Modern Optics

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

Vrsta predmeta / Course type izbirni / elective

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Teren. vaje Field work	Samost. delo Individ. work	ECTS
35		10			105	5

Nosilec predmeta / Lecturer: prof. dr. Nataša Vaupotič

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

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

predznanje iz predmetov nihanje in valovanje, elektromagnetizem, matematična fizika 1 in 2, moderna fizika

Prerequisites:

preknowledge of the Oscillations and Waves, Electromagnetism, Mathematical Physics 1 and 2 and Modern Physics

Vsebina:

Valovna in delčna narava svetlobe; časovna in prostorska koherenca; polarizacija svetlobe. Lom in odboj na ravni površini. Skalarna teorija uklona: Fraunhoferjev in Fresnelov uklon. Razširjanje svetlobe v snovi: Maxwellove enačbe v snovi, valovna enačba, kompleksni lomni količnik, razširjanje svetlobe v izotropnih dielektrikih, razširjanje svetlobe po prevodnikih, optično anizotropni materiali, razširjanje svetlobe v kristalih in tekočih kristalih, dvojni lom, elektrooptični in magnetooptični pojav, modulatorji, optični retarderji, konoskopija. Nelinearna optika: simetrija v kristalih, nelinearna susceptibilnost, generiranje druge harmonične frekvence, štirivalovno mešanje.

Content (Syllabus outline):

Wave and particle nature of light; spatial and temporal coherence; polarization. Diffraction and refraction on a plane surface. Scalar theory of diffraction: Fraunhofer and Fresnel diffraction. Light propagation in matter: Maxwell equations in matter, wave equation, complex index of refraction, light propagation in isotropic dielectrics, light propagation in conducting media, anisotropic optical materials, light propagation in crystals and liquid crystals, double refraction, electro-optic and magneto-optic effects, modulators, optical retarders, conoscopy. Nonlinear optics: symmetries in crystals, second-order nonlinear susceptibility, frequency doubling, four wave mixing.

Prostorninski in površinski plazmoni; prenos informacije po verigi nanodelcev.

Bulk and surface plasmons; propagation of information along a chain of nanoparticles.

Temeljni literatura in viri / Readings:

1. G. R. Fowles, Introduction to Modern Optics, 2nd. Ed. (Dover, New York, 1989).
2. R. D. Guenther, Modern Optics (Wiley, New York, 1990).
3. G. Brooker, Modern Classical Optics (Oxford Master Series in Atomic, Optical and Laser Physics) (Oxford University Press, Oxford, 2003).
4. M. Fox, Optical Properties of Solids (Oxford Master Series in Condensed Matter Physics), 2. izdaja (Oxford University Press, Oxford, 2010).
5. katerakoli učbenik s področja moderne optike, laserjev, optoelektronike ali fotonike in optičnih lastnosti materialov

Cilji in kompetence:

Študenti usvojijo napredna teoretična znanja s področja linearne in nelinearne optike, optičnih preiskav materialov in razširjanja svetlobe skozi materiale ter znanje uporabijo pri reševanju ustreznih problemov z rabo matematičnih orodij.

Objectives and competences:

Students obtain advanced knowledge from linear and nonlinear optics, optical studies of materials and propagation of light through different materials and are able to use the knowledge to tackle problems by the use of mathematical tools.

Predvideni študijski rezultati:

Znanje in razumevanje:

Po uspešno zaključeni učni enoti bodo študenti zmožni:

- uporabiti skalarno teorijo uklona za obravnavo uklona svetlobe v Fraunhoferjem in Fresnelovem režimu;
- Fraunhoferjev uklon na poljubno kompleksni odprtini obravnavati s Fourierovo transformacijo;
- uporabiti Maxwellove enačbe za obravnavo odboja in loma na meji med optično homogeno in nehomogeno snovjo (kovina, absorptivni dielektrik) in za analizo razširjanja svetlobe po kovinah ter optično enosnih in dvoosnih dielektrikih;
- obravnavati razširjanje površinskih plazmonov – polaritonov na meji med dielektrikom in kovino in analizirati prenos informacije po razvejani verigi nanodelcev;
- obravnavati razširjanje svetlobe skozi snov, ki se odziva nelinearno na električno polje.

Prenesljive/ključne spretnosti in drugi atributi:

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;

Intended learning outcomes:

Knowledge and Understanding:

On completion of this course students will be able to:

- use scalar theory of diffraction to study diffraction in the Fraunhofer and Fresnel regime;
- analyze the Fraunhofer diffraction on a complex aperture by applying the Fourier transformation;
- use Maxwell's equations to study refraction and reflection on a plane boundary between an optically homogeneous and non-homogeneous matter (metal, absorptive dielectric) and analyse propagation of light in metals and optically uniaxial and biaxial dielectrics;
- describe propagation of surface plasmon – polaritons on the metal-dielectric interface and analyse transfer of information along a branched chain of nanoparticles;
- predict properties of light propagation through a material, which responds nonlinearly to electric field.

Transferable/Key Skills and other attributes:

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 nonlinear differential equations to tackle problems in physics;

- reševati kompleksne probleme, ki jih je treba razstaviti na večje število problemov z različnih področij fizike;
- uporabljati sodobno računalniško programsko opremo kot pomoč pri kvantitativni obravnavi zahtevnih fizikalnih problemov;
- uporabiti znanje za obravnavo dejanskih tehnoloških problemov v fotoniki, plazmoniki, preiskavah v medicini, preiskavah materialov...

- solve complex problems, which have to be disassembled into larger number of problems from different fields of physics;
- use modern computer software for quantitative study of advanced physical problems;
- use the knowledge to tackle actual technological problems in photonics, plasmonics, medicine, material studies etc...

Metode poučevanja in učenja:

predavanja z demonstracijskimi eksperimenti
teoretične vaje
vodeno samostojno delo
razlaga
razgovor
demonstracija
delo s tekstom
metoda pisnih in grafičnih del
uporaba simulacij
uporaba simulacijskih okolij

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

Learning and teaching methods:

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

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

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
izračun teoretičnih nalog in njihov zagovor	60%	solved of theoretical problems and their defense
pisni izpit (nadomesti se lahko s pisnimi kolokvijii)	40%	written exam (it can be replaced by written tests)
Za uspešno zaključeno učno enoto mora vsak del posebej biti pozitiven; vse teoretične naloge morajo biti izračunane in zagovorjene.		For a successfully finished course, both oral and written exams have to be positive. All the problems have to be solved and defended.

Reference nosilca / Lecturer's references:

1. POCIECHA, Damian, VAUPOTIČ, Nataša, MAJEWSKA, Magdalena, CRUICKSHANK, Ewan, WALKER, Rebecca, STOREY, John M. D., IMRIE, Corrie T., WANG, Cheng, GÓRECKA, Ewa. Photonic bandgap in achiral liquid crystals - a twist on a twist. *Advanced materials*. [Online ed.]. 2021, vol. 33, no. 39, str. 2103288-1-2103288-7. ISSN 1521-4095. DOI: [10.1002/adma.202103288](https://doi.org/10.1002/adma.202103288). [COBISS.SI-ID [80061955](#)]
2. GRABOVAC, Timon, GÓRECKA, Ewa, POCIECHA, Damian, VAUPOTIČ, Nataša. Modeling of the resonant X-ray response of a chiral cubic phase. *Crystals*. 2021, vol. 11, no. 2, str. 214-1-214-12. ISSN 2073-4352. DOI: [10.3390/cryst11020214](https://doi.org/10.3390/cryst11020214). [COBISS.SI-ID [55156483](#)]
3. LEWANDOWSKI, Wiktor, VAUPOTIČ, Nataša, POCIECHA, Damian, GÓRECKA, Ewa, LIZ-MARZÁN, Luis M. Chirality of liquid crystals formed from achiral molecules revealed by resonant X-ray scattering. *Advanced materials*. 2020, , str. 1905591-1-1905591-17. ISSN 0935-9648. DOI: [10.1002/adma.201905591](https://doi.org/10.1002/adma.201905591). [COBISS.SI-ID [20099843](#)]
4. CAO, Yu, ALAASAR, Mohamed, NALLAPANENI, Asritha, SALAMONCZYK, Mirosław, MARINKO, Peter, GÓRECKA, Ewa, TSCHIERKE, Carsten, LIU, Feng, VAUPOTIČ, Nataša, ZHU, Chenhui. Molecular packing in double gyroid cubic phases revealed via resonant soft X-ray scattering. *Physical review letters*. [Print ed.]. 2020, vol. 125, no. 2, str. 027801-1-027801-6. ISSN 0031-9007. DOI: [10.1103/PhysRevLett.125.027801](https://doi.org/10.1103/PhysRevLett.125.027801). [COBISS.SI-ID [22068227](#)]

5. ALI, M. Yusuf, GÓRECKA, Ewa, POCIECHA, Damian, VAUPOTIČ, Nataša. Structure and grating efficiency of thin cells filled by a twist-bend nematic liquid crystal. *Physical review. E*. 2020, vol. 102, no. 3, str. 032704-1-032704-10. ISSN 2470-0045. DOI: [10.1103/PhysRevE.102.032704](https://doi.org/10.1103/PhysRevE.102.032704). [COBISS.SI-ID [30975235](#)]

6. 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](#)].