



Univerza v Mariboru

Fakulteta za naravoslovje
in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Teorija trdne snovi
Course title:	Theoretical Solid State 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	Teren. vaje Field work	Samost. delo Individ. work	ECTS
7	3				290	10

Nosilec predmeta / Lecturer:

Dean Korošak

Jeziki /

Languages:

Predavanja / slovenski/Slovenian

Lectures:

Vaje / Tutorial:

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

Ni.

Prerequisites:

None.

Vsebina:

- Uvod: simetrije v kristalih
- Druga kvantizacija: fermioni, bozoni, operatorji v drugi kvantizaciji
- Greenove funkcije: definicije, lastnosti, Dysonova enačba, kvazidelci, enačbe

Content (Syllabus outline):

- Introduction: crystal symmetries
- Second quantization: fermions, bosons, operators in second quantization
- Green functions: definitions, properties, Dyson equation, quasiparticles, equations of motion

<p>gibanja</p> <ul style="list-style-type: none"> - Linearni odziv: korelacijske in odzivne funkcije, Kubova formula, elektronski plin: odzivna funkcija, coulumska interakcija, plazmoni - Elektron v periodičnem potencialu: skoraj prosti elektroni, močno vezani elektroni, metode računanja elektronske strukture trdnin - Interagirajoči elektroni: Hartree-Fockov približek in približek naključnih faz, samousklajeni dielektrični odziv, Fermijeve tekočine - Izolatorji: dielektrična funkcija, optične lastnosti, ekscitoni, prehod kovina-izolator - Magnetizem: Hubbardov model, tenzor magnetne susceptibilnosti, magnetne ureditve, feromagnetni in antiferomagnetni spinski valovi - Fononi: harmonična nihanja kristalne mreže, sklopitev elektron-fonon, polaroni - Superprevodnost: Cooperjevi pari, BCS osnovno stanje, elektrodinamika superprevodnega stanja, visokotemperaturna superprevodnost 	<ul style="list-style-type: none"> - Linear response: correlation and response functions, Kubo formula, electron gas: response function, coulumb interaction, plasmons - Electron in periodic potential: nearly free electron approximation, tight binding approximation, computations of energy band structure in solids - Interacting electrons: Hartree-Fock approximation, random phase approximation, selfconsistent dielectric response, Fermi liquids - Insulators: dielectric function, optical properties, excitons, metal-insulator transition - Magnetism: Hubbard model, tensor of magnetic susceptibility, magnetic ordering, ferromagnetic and antiferromagnetic spin waves - Phonons: harmonic oscillations in crystal lattice, electron-phonon coupling, polarons - Superconductivity: Cooper pairs, BCS ground state, electrodynamics of superconducting state, hightemperature superconductivity
---	---

Temeljni literatura in viri / Readings:

<ol style="list-style-type: none"> 1) W. Jones, N. H. March, Theoretical Solid State Physics vols. I,II, Wiley-Interscience, 1973. 2) O. Madelung, Introduction to Solid-State Theory, Springer, 1978. 3) C. Kittel, Introduction to Solid State Physics 8th ed., Wiley, 2004. 4) N. W. Ashcroft, N. D. Mermin, Solid State Physics (inter. ed.), Saunders College, 1976. 5) C. Kittel, Quantum Theory of Solids, Wiley, 1963.

Cilji in kompetence:

Uvajanje in razumevanje modernih teoretičnih in računskih metod teorije trdne snovi kot osnove za samostojno raziskovalno delo in kot podlaga razumevanja principov novih tehnologij in materialov.

Objectives and competences:

Introduction and understanding of modern theoretical and computational methods in solid state physics as a basis for individual research work and understanding of principles of new technologies and materials.

Predvideni študijski rezultati:

Intended learning outcomes:

<p>Znanje in razumevanje:</p> <p>Pregled in razumevanje mikroskopskega opisa pojavov v trdni snovi in uporaba teoretičnih metod v problemih fizike trdne snovi.</p> <p>Prenesljive/ključne spretnosti in drugi atributi:</p> <p>Sposobnost izbire in uporabe ustreznih teoretičnih ter računskih metod pri problemih fizike trdne snovi.</p>	<p>Knowledge and understanding:</p> <p>Overview and understanding of microscopic description of solid-state phenomena, and application of theoretical methods in solid-state physics problems.</p> <p>Transferable/Key Skills and other attributes:</p> <p>Skills to choose and implement proper theoretical and computational methods in solid state physics problems</p>
--	--

Metode poučevanja in učenja:

predavanja, seminar, seminarske naloge, reševanje odprtih nalog/problemov

Learning and teaching methods:

lectures and seminars, student's seminar work, solving of open problems/tasks

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Način (pisni izpit, ustno izpraševanje, naloge, projekt)		Type (examination, oral, coursework, project):
Odprte naloge/problemi	20%	Open tasks/problems
seminarji	20%	seminars
ustni izpit	30%	oral exam
pisni izpit	30%	written exam

Reference nosilca / Lecturer's references:

1. YAKUBO, Kousuke, SAIJO, Y., KOROŠAK, Dean. Superlinear and sublinear urban scaling in geographical networks modeling cities. *Physical review. E, Statistical, nonlinear, and soft matter physics*, ISSN 1539-3755, 2014, vol. E90, issue 2, str. 1-10, ilustr. <http://journals.aps.org/pre/pdf/10.1103/PhysRevE.90.022803>. [COBISS.SI-ID 18003222]
2. STOŽER, Andraž, GOSAK, Marko, DOLENŠEK, Jurij, PERC, Matjaž, MARHL, Marko, RUPNIK, Marjan, KOROŠAK, Dean. Functional connectivity in islets of Langerhans from mouse pancreas tissue slices. *PLoS computational biology*, ISSN 1553-734X, Feb. 2013, vol. 9, iss. 2, str. e100292312-1-e1002923-12, doi: [10.1371/journal.pcbi.1002923](https://doi.org/10.1371/journal.pcbi.1002923). [COBISS.SI-ID 512264760]
3. GOSAK, Marko, KOROŠAK, Dean, MARHL, Marko. Topologically determined optimal stochastic resonance responses of spatially embedded networks. *New journal of physics*, ISSN 1367-2630. [Online ed.], Jan. 2011, vol. 13, issue 1, str. 013012-1-013012-15, ilustr. <http://dx.doi.org/10.1088/1367-2630/13/1/013012>. [COBISS.SI-ID 18087432]
4. YAKUBO, K., KOROŠAK, Dean. Scale-free networks embedded in fractal space. *Physical review. E, Statistical, nonlinear, and soft matter physics*, ISSN 1539-3755, 2011, vol. 83, iss. 6, 066111-1-066111-12, doi: [10.1103/PhysRevE.83.066111](https://doi.org/10.1103/PhysRevE.83.066111). [COBISS.SI-ID 15114518]
5. KOROŠAK, Dean, MANDŽUKA, Goran, SAMEC, Marko, CHEN, Wen. Slow kinetics in clay-water and hydrating cement gel porous systems. *International journal of nonlinear sciences and*

numerical simulation, ISSN 1565-1339. [Print ed.], 2010, vol. 11, no. 1, str. 43-47, doi:
[10.1515/IJNSNS.2010.11.1.43](https://doi.org/10.1515/IJNSNS.2010.11.1.43). [COBISS.SI-ID 14042390]