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 4.**
PHYSICS		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	Teren. vaje Field work	Samost. delo Individ. work	ECTS
10	**5**				**165**	**6**

Nosilec predmeta / Lecturer: **Dean Korošak**

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.

Prerequisits:

None.

Vsebina:

- Uvod: simetrije v kristalih
- Druga kvantizacija: fermioni, bozoni, operatorji v drugi kvantizaciji
- Greenove funkcije: definicije, lastnosti, Dysonova enačba, kvazidelci, enačbe gibanja
- Linearni odziv: korelacijske in odzivne funkcije, Kubova formula, elektronski plin:

Content (Syllabus outline):

- Introduction: crystal symmetries
- Second quantization: fermions, bosons, operators in second quantization
- Green functions: definitions, properties, Dyson equation, quasiparticles, equations of motion
- Linear response: correlation and response functions, Kubo formula, electron gas: response function, coulumb interaction, plasmons

odzivna funkcija, coulumbska 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	- 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:

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:	**Objectives and competences:**
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.	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:**
Znanje in razumevanje: Pregled in razumevanje mikroskopskega opisa pojavov v trdni snovi in uporaba teoretičnih metod v problemih fizike trdne snovi.	Knowledge and understanding: Overview and understanding of microscopic description of solid-state phenomena, and

Prenesljive/ključne spretnosti in drugi atributi: Sposobnost izbire in uporabe ustreznih teoretičnih ter računskih metod pri problemih fizike trdne snovi.	application of theoretical methods in solid-state physics problems. Transferable/Key Skills and other attributes: Skills to choose and implement proper theoretical and computational methods in solid state physics problems

Metode poučevanja in učenja:	**Learning and teaching methods:**
predavanja, seminar, seminarske naloge, reševanje odprtih nalog/problemov	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. COSENZA, Philippe, KOROŠAK, Dean. Secondary consolidation of clay as an anomalous diffusion process. *International journal for numerical and analytical methods in geomechanics*, ISSN 0363-9061, 2014, vol. 38, str. 1231-1246. http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1096-9853/earlyview, doi: 10.1002/nag.2256. [COBISS.SI-ID 17698326],

2. 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],

3. SAMEC, Marko, SANTIAGO, A., CARDENAS, Juan Pablo, BENITO, Rosa Maria, TARQUIS, Ana Maria, MOONEY, Sacha Jon, KOROŠAK, Dean. Quantifying soil complexity using network models of soil porous structure. *Nonlinear processes in geophysics*, ISSN 1023-5809, 2013, vol. 20, iss. 1, str. 41-45, doi: 10.5194/npg-20-41-2013. [COBISS.SI-ID 16604438],

4. TRACY, Saoirse R., BLACK, Colin R., ROBERTS, Jeremy A., MCNEILL, Ann, DAVIDSON, Rob, TESTER, Mark, SAMEC, Marko, KOROŠAK, Dean, STURROCK, Craig, MOONEY, Sacha Jon. Quantifying the effect of soil compaction on three varieties of wheat (Triticum aestivum L.) using X-ray Micro Computed Tomography (CT). *Plant and soil*, ISSN 0032-079X. [Print ed.], Apr. 2012, vol. 353, iss. 1/2, str. 195-208, doi: 10.1007/s11104-011-1022-5. [COBISS.SI-ID 16604950],

5. KOROŠAK, Dean, MOONEY, Sacha Jon. Applications of complex network models to describe soil porous systems. V: LOGSDON, Sally (ur.), BERLI, Markus (ur.), HORN, Rainer (ur.). *Quantifying and modeling soil structure dynamics*, (Advances in agricultural systems modeling, Vol. 3). Madison:

Soil Science Society of America, cop. 2013, str. 75-92, doi: 10.2134/advagricsystmodel3.c4. [COBISS.SI-ID 16879894]