UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Tekoči kristali
Course title:	Liquid Crystals

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika 2. st.		1,2	2,3
Physics 2nd degree		1,2	2,3

Vrsta predmeta / Course type	izbirni/ optional
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
45	15	0	0	0	90	5

Nosilec predmeta / Lecturer:	Samo Kralj, Nataša Vaupotič

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski/Slovenian in/and angleški/English
	Vaje / Tutorial:	slovenski/Slovenian in/and angleški/English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Predznanje klasične in moderne fizike, modelske fizike, fizike materialov in fizike mehke snovi	Preknowledge of classical and modern physics, physics of material and soft matter physics

Vsebina:	**Content (Syllabus outline):**
• Predstavitev poglavitnih tekočekristalnih (TK) faz. • Modelni opisi TK faz: molekularni (Maier-Saupe model) in kontinuumski pristop (Frankov in Landau-de Gennesov model). • Fazni prehodi: primerjava s faznimi prehodi para-voda-led, paramagnetna-ferromagnetna faza, dogodki med Velikim pokom. • Defekti v tekočih kristalih: i) primerjava sil med defekti v TK in silami med električnimi naboji in med kvarki, ii) dinamika defektnih mrež TK v hitrem faznem prehodu in analogija s širjenjem vesolja, iii) struktura jeder defektov, analogija s hipotetičnim magnetnim monopolom in kozmološkimi vzmetmi, iv) primerjava zvite dislokacije v smetični A fazi in defekti v supraprevodniku. • Ograjeni tekoči kristali: vpliv pojava končnih dimenzij, površine in nereda na fazno obnašanje tekočega kristala. • Smektični tekoči kristali (akiralni, feroelektrični, antiferoelektrični), zlom zrcalne simetrije, strukturna kiralnost. • Uporaba tekočih kristalov. • Tekoči kristali in živa bitja (biološke celice, diferenciacija celic, transport informacij).	• Presentation of main liquid crystal (LC) phases. • Modelling of LC phases: molecular (Maier-Saupe model) and continuum (Frank and Landau-de Gennes model) type approaches. • Phase transitions: comparison with vapour-liquid-crystal, paramagnetic-ferromagnetic phase transition and evolution of the Universe after the Big Bang. • Defects in liquid crystals: i) comparison of forces among defects and forces among electric charges and quarks, ii) coarsening dynamics of defect pattern and the evolution of the Universe after the Big Bang, iii) structure of cores of defects, magnetic monopoles and cosmic strings, iv) comparison between dislocations in smectic phases and superconductors and superfluids. • Confined liquid crystals: finite size effects, influence of surface interactions and disorder. • Smectic liquid crystals (achiral, ferroelectric, antiferroelectric), chiral symmetry breaking, structural chirality. • LCs applications. • LCs and life (biological cells, differentiation of cells, transport of information).

Temeljni literatura in viri / Readings:

1. P.G. de Gennes and J. Prost, The Physics of Liquid Crystals (Clarendon press, Oxford, 1998).
2. I. Muševič, R. Blinc, B. Žekš, The physics of ferroelectric and antiferroelectric liquid crystals, (World Scientific, Singapore, 2000).
3. V. Popa-Nita, Phase transitions, applications to liquid crystals, organic electronic and optoelectronic fields (Research Signpost, Kerala, 2006)
4. http://plc.cwru.edu/tutorial/enhanced/files/hindex.html
5. Članki v Science, Nature, Scientific American.
6. Članki na: http://www.pfmb.uni-mb.si/complex/

Cilji in kompetence:	**Objectives and competences:**
Študenti usvojijo znanje s področja univerzalnosti tekočih kristalov.	Students acquire knowledge on universal properties of liquid crystals.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Razumevanje procesov v tekočih kristalih. Razumejo analogije med tekočekristalnimi fazami in drugimi sistemi in spoznajo, da se navidez različni sistemi matematično enako obravnavajo. Prenesljive/ključne spretnosti in drugi atributi: Poznavanje tehniške uporabe tekočih kristalov. Razumevanje procesov v tekočih kristalih omogoča razumevanje in kvantitativni opis pojavov v drugih sistemih, npr. v biofiziki, astronomiji, fiziki delcev.	Knowledge and Understanding: Understanding of processes in liquid crystals. They understand the analogy between the liquid crystal systems and other physical systems and know that the same mathematical description is possible in analog systems. Transferable/Key Skills and other attributes: Liquid crystals applications. Understanding of processes in liquid crystals enables the understanding and modeling of other physical systems, e.g. in biophysics, astronomy, particle physics.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja seminarji	Lectures seminars

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Ustni ali pisni izpit	70%	Oral or written exam
seminar	30%	seminar

Reference nosilca / Lecturer's references:

Samo Kralj:

KRALJ, Samo, ROSSO, Riccardo, VIRGA, Epifanio G. Curvature control of valence on nematic shells. *Soft matter*, 2011, vol. 7, issue 2, str. 670-683, ilustr., doi: 10.1039/C0SM00378F. [COBISS.SI-ID 17960200]

BRADAČ, Zlatko, KRALJ, Samo, ŽUMER, Slobodan. Early stage domain coarsening of the isotropic-nematic phase transition. *J. chem. phys.*, 2011, vol. 135, no. 2, str. 024506-1-024506-9, ilustr., doi:10.1063/1.3609102. [COBISS.SI-ID 18553864]

SCHOOT, Paul van der, POPA-NITA, Vlad Dumitru, KRALJ, Samo. Alignment of carbon nanotubes in nematic liquid crystals. *J. phys. chem., B Condens. mater. surf. interfaces biophys.*, 2008, 112, iss. 15, str. 4512-4518. http://dx.doi.org/10.1021/jp712173n, doi: 10.1021/jp712173n. [COBISS.SI-ID 15940616]

KRALJ, Samo, ROSSO, Riccardo, VIRGA, Epifanio G. Fingered core structure of nematic boojums. *Phys. rev., E Stat. nonlinear soft matter phys. (Print)*, 2008, vol. 78, no. 3, str. 031701-1-031701-4, ilustr.http://dx.doi.org/10.1103/PhysRevE.78.031701, doi: 10.1103/PhysRevE.78.031701. [COBISS.SI-ID16177416]

KRALJ, Samo, CORDOYIANNIS, George, JESENEK, Dalija, ZIDANŠEK, Aleksander, LAHAJNAR, Gojmir,

NOVAK, Nikola, AMENITSCH, Heinz, KUTNJAK, Zdravko. Dimensional crossover and scaling behavior of a smectic liquid crystal confined to controlled-pore glass matrices. *Soft matter*, 2012, vol. 8, issue 8, str. 2460-2470, doi: 10.1039/C1SM06884A. [COBISS.SI-ID 25534759]

Nataša Vaupotič:

VAUPOTIČ, Nataša, POCIECHA, Damian, GÓRECKA, Ewa. Polar and apolar columnar phases made of bent-core mesogens. *Top. curr. chem.*, 2012, vol. 318, str. 281-302, doi: 10.1007/128_2011_231. [COBISS.SI-ID 25535015], [JCR]

VAUPOTIČ, Nataša, POCIECHA, Damian, ČEPIČ, Mojca, GOMOLA, Kinga, MIECZKOWSKI, Jozef, GÓRECKA, Ewa. Evidence for general tilt columnar liquid crystalline phase. *Soft matter*, 2009, vol. 5, no. 11, str. 2281-2285. [COBISS.SI-ID 22867239], [JCR, WoS, št. citatov do 6. 11. 2011: 3, brez avtocitatov: 3, normirano št. citatov: 1]

VAUPOTIČ, Nataša, et al. Structure studies of the nematic phase formed by bent-core molecules. *Phys. rev., E Stat. nonlinear soft matter phys. (Print)*, 2009, vol. 80, no. 3, str. 030701-1-030701-4. [COBISS.SI-ID 22965287], [JCR, WoS, št. citatov do 6. 4. 2012: 22, brez avtocitatov: 22, normirano št. citatov: 15]

VAUPOTIČ, Nataša, ČOPIČ, Martin, GÓRECKA, Ewa, POCIECHA, Damian. Modulated structures in bent-core liquid crystals: two faces of one phase. *Phys. rev. lett.*, 2007, vol. 98, no. 24, str. 247802-1-247802-4. [COBISS.SI-ID 20912167], [JCR, WoS, št. citatov do 6. 10. 2011: 11, brez avtocitatov: 8, normirano št. citatov: 3]

GÓRECKA, Ewa, VAUPOTIČ, Nataša, POCIECHA, Damian. Electron density modulations in columnar banana phases. *Chem. mater.*. [Print ed.], 2007, vol. 19, no. 13, str. 3027-3031. [COBISS.SI-ID 20860199], [JCR, WoS, št. citatov do 6. 11. 2011: 11, brez avtocitatov: 8, normirano št. citatov: 5]