



Univerza v Mariboru

Fakulteta za naravoslovje  
in matematiko

### UČNI NAČRT PREDMETA / COURSE SYLLABUS

**Predmet:** Fizika kompleksnih sistemov  
**Course title:** Physics of complex systems

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

**Vrsta predmeta / Course type**

obvezni/compulsory

**Univerzitetna koda predmeta / University course code:**

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
30		30			150	7

**Nosilec predmeta / Lecturer:**

Samo Kralj

**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:**

Pogojev ni.

Priporočljiva znanja so: predznanje iz mehanike, elektromagnetizma, matematične fizike, moderne fizike in iz kompleksnih sistemov

**Prerequisites:**

None.

Recommended: preknowledge of mechanics, electromagnetism, mathematical physics, modern physics, complex systems.

**Vsebina:**

**Content (Syllabus outline):**

- Zlom simetrije in vzročnost
- Naključje in nered
- **Fraktali:** fraktalna geometrija, metode določanja fraktalnih dimenzij, modeli rasti fraktalnih vzorcev
- **Samo-organizirana kritičnost:** modelni sistemi, primeri iz narave
- **Fizika mrež:** neprilagodljive in prilagodljive mreže, strukturni prehodi, dinamična rast, primeri mrež v živih in neživih sistemih
- **Fizika vzorcev:** modelni sistemi, analogije med mehanskimi sistemi in živimi organizmi
- **Evolucijska dinamika:** modelni sistemi, teorija iger, univerzalnosti in robustne rešitve, izbrani primeri

- Symmetry breaking and causality
- Uncertainty and disorder
- **Fractals:** fractal geometry, determination of fractal dimensions, models of fractal growth
- **Selforganized criticality:** model systems, examples from the nature
- **Physics of networks:** nonadaptive and adaptive networks, structural transitions, examples
- **Physics of patterns:** model systems, analogies between mechanical and biological systems
- **Evolution dynamics:** model systems, game theory, universalities and robust solutions, examples

#### Temeljni literatura in viri / Readings:

1. B. Mandelbrot, The Fractal Geometry of Nature, Freeman, San Francisco, 1982.
2. P. Bak, How Nature Works: The Science of Self-Organized Criticality, Springer Verlag, 1996.
3. T. Vicsek, Fractal Growth Phenomena, World Scientific, Singapore, 1992.
4. J.F.F. Mendes and N.S. Dorogovtsev, Evolution of Networks: From Biological Nets to the Internet and WWW, Oxford University Press, Oxford, 2003
5. J. M. Smith, Evolution and the Theory of Games, Cambridge Univ. Press, Cambridge, 1982.
6. <http://www.nd.edu/~networks/>

Članki v Science, Nature, Scientific American

#### Cilji in kompetence:

Študenti poglobijo znanje s področja fizike kompleksnih sistemov.

#### Objectives and competences:

Students acquire advanced knowledge on physics of complex systems.

#### Predvideni študijski rezultati:

Znanje in razumevanje:  
Razumevanje in matematično modeliranje ključnih mehanizmov, ki narekujejo obnašanje kompleksnih sistemov.

Prenosljive/ključne spretnosti in drugi atributi:  
Rešitev problemov z matematičnimi orodji in celosten pristop k reševanju problemov.

#### Intended learning outcomes:

Knowledge and Understanding:  
Understanding and mathematical modelling of key mechanisms that dominate behavior of complex systems.

Transferable/Key Skills and other attributes:  
Solving of problems with mathematical tools and gained global approach on solving a problem.

**Metode poučevanja in učenja:**

Metodika obsega: teoretičen uvod v problematiko in numerično reševanje posameznih problemov.

**Learning and teaching methods:**

They are based on: theoretical introduction and numerical solving of specific problems.

**Načini ocenjevanja:**

Delež (v %) /

Weight (in %)

**Assessment:**

Pisni izpit.

50

Written exam.

Ustni izpit.

50

Oral exam.

**Reference nosilca / Lecturer's references:**

- 1) 1. HÖLBL, Arbresha, MESAREC, Luka, POLANŠEK, Juš, IGLIČ, Aleš, KRALJ, Samo. Stable assemblies of topological defects in nematic orientational order. ACS omega. 2023, vol. 8, iss. 1, str. 169-179, ilustr. ISSN 2470-1343. DOI: 10.1021/acsomega.2c07174. [COBISS.SI-ID 137430275]
- 2) financer: ARRS, Programi, P1-0099, SI, Fizika mehkih snovi, površin in nanostruktur; ARRS, Projekti, J1-2457, SI, Fazni prehodi proti koordinaciji v večplastnih omrežjih
- 3) 2. DOBOVIŠEK, Andrej, AMBROŽIČ, Milan, KUTNJAK, Zdravko, KRALJ, Samo. Liquid crystal based active electrocaloric regenerator. Heliyon. Mar. 2023, vol 9, iss. 3, [article no.] e14035, str. 1-12, ilustr. ISSN 2405-8440.  
<https://www.sciencedirect.com/science/article/pii/S2405844023012422?via%3Dihub>, DOI: 10.1016/j.heliyon.2023.e14035. [COBISS.SI-ID 143422211]
3. PAL, Kaushik, ASTHANA, Nidhi, ALJABALI, Alaa AA, BHARDWAJ, Sheetal K., KRALJ, Samo, PENKOVA, Anastasia, THOMAS, Sabu, ZAHEER, Tean, SOUZA, Fernando Gomes de. A critical review on multifunctional smart materials "nanographene" emerging avenue : nano-imaging and biosensor applications. Critical reviews in solid state and materials sciences. 2022, vol. 47, no. 5, str. 691-707, ilustr. ISSN 1040-8436. DOI: 10.1080/10408436.2021.1935717. [COBISS.SI-ID 68095491]