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 2nd degree		1	1

Vrsta predmeta / Course type obvezni/compulsory

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
30	0	30	0	0	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:

Predznanje iz mehanike, elektromagnetizma, matematične fizike, moderne fizike in iz kompleksnih sistemov

Prerequisits:

Preknowledge of mechanics, electromagnetism, mathematical physics, modern physics, complex systems.

Vsebina:

- 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

Content (Syllabus outline):

- 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, anlogies between mechanical and biological systems
- **Evolution dynamics**: model systems, game theory, universalities and roboust 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/
7. Članki v Science, Nature, Scientific American.

Cilji in kompetence:	Objectives and competences:
Študenti poglobijo znanje s področja fizike kompleksnih sistemov.	Students acquire advanced knowledge on physics of complex systems.

Predvideni študijski rezultati:	Intended learning outcomes:
Znanje in razumevanje: Razumevanje procesov v kompleksnih sistemih. Prenesljive/ključne spretnosti in drugi atributi: Rešitev problemov z matematičnimi orodji in celosten pristop k reševanju problemov.	Knowledge and Understanding: Understanding of processes in 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:	Learning and teaching methods:
Metodika obsega: teoretičen uvod v problematiko in numerično reševanje posameznih problemov.	They are based on: theoretical introduction and numerical solving of specific problems.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
2 pisna kolokvija ali pisni izpit ustni izpit	50 50	2 written tests or written or exam oral exam

Reference nosilca / Lecturer's references:

Marko Marhl:

BODENSTEIN, Christian, KNOKE, Beate, MARHL, Marko, PERC, Matjaž, SCHUSTER, Stefan. Using Jensen's inequality to explain the role of regular calcium oscillations in protein activation. *Physical biology*, 2010, vol. 7, no. 3, str. 036009-1-036009-12, doi: 10.1088/1478-3975/7/3/036009. [COBISS.SI-ID 14376470]

GOSAK, Marko, KOROŠAK, Dean, MARHL, Marko. Optimal network configuration for maximal coherence resonance in excitable systems. *Phys. rev., E Stat. nonlinear soft matter phys. (Print)*, 2010, vol. 81, iss. 5, str. 056104-1-056104-7, ilustr., doi: 10.1103/PhysRevE.81.056104. [COBISS.SI-ID 17626120]

KNOKE, Beate, BODENSTEIN, Christian, MARHL, Marko, PERC, Matjaž, SCHUSTER, Stefan. Jensen's inequality as a tool for explaining the effect of oscillations on the average cytosolic calcium concentration.*Theory biosci.*, Jun. 2010, vol. 129, no. 1, str. 25-38, doi: 10.1007/s12064-010-0080-1. [COBISS.SI-ID 14376726]

GOSAK, Marko, KOROŠAK, Dean, MARHL, Marko. Topologically determined optimal stochastic resonance responses of spatially embedded networks. *New journal of physics*. [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]

GOSAK, Marko, MARKOVIČ, Rene, MARHL, Marko. The role of neural architecture and the speed of signal propagation in the process of synchronization of bursting neurons. *Physica, A*. [Print ed.], 2012, vol. 391, no. 8, str. 2764-2770, ilustr., doi: 10.1016/j.physa.2011.12.027. [COBISS.SI-ID 18948872]

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