UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Klasični in kvantni kaos
Course title:	Classical and Quantum Chaos

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, 3. stopnja		1	1
Nanosciences and Nanotechnologies, 3rd cycle		1	1

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: NANO3-807

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike Others	Samost. delo Individ. work	ECTS
15	**15**			**15**	**105**	**5**

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transfered to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Marko Robnik

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina, angleščina / Slovenian, English
	Vaje / Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Zaključena druga stopnja bolonjskega študija ali diploma univerzitetnega študijskega programa s področja naravoslovja ali tehnologije. Potrebna so tudi osnovna znanja matematike in (po možnosti teoretične) fizike.	Completed Bologna second cycle study program or an equivalent pre-Bologna university study program the field of natural sciences or technology. Basic knowledge of mathematics and (possibly theoretical) physics is also required.

Vsebina:	**Content (Syllabus outline):**
– Uvod v klasični kaos: integrabilnost, nelinearnost, neintegrabilnost, KAM teorija, ergodičnost, statistične lastnosti klasičnega gibanja, simbolična dinamika – Uvod v semiklasične metode, WKB metoda, Gutzwillerjeva teorija (periodičnih orbit) – Teorija naključnih matrik in aplikacija v različnih sistemih – Uvod v kvantni kaos: statistične lastnosti energijskih spektrov, lastnih funkcij, Wignerjevih funkcij ter matričnih elementov – Dinamični kvantni kaos in dinamična	– Introduction to classical chaos: integrability, nonlinearity, nonintegrability, KAM theory, ergodicity, statistical properties of classical motion, symbolic dynamics – Introduction to semiclassical methods, WKB method, Gutzwiller theory (of periodic orbits) – Random matrix theory and its application in various systems – Introduction to quantum chaos: statistical properties of energy spectra, eigenfunction, Wigner functions, and matrix elements – Dynamical quantum chaos and dynamic

lokalizacija – Aplikacije: biljardni sistemi, vodikov atom v močnem magnetnem polju, valovni kaos	localization – Applications: billiard systems, hydrogen atom in a strong magnetic field, wave chaos

Temeljna literatura in viri / Readings:

Izbrana poglavja iz naslednjih knjig: / Selected chapters from the following books:
I. C. Percival and D. Richards, Introduction to Dynamics, Cambridge University Press, 1982
E. Ott, Chaos in Dynamical Systems, Cmabridge University Press, 2002
M.C. Gutzwiller, Chaos in Classical and Quantum Mechanics, Springer, 1990
F. Haake, Quantum Signatures of Chaos, Springer, 2010
H.-J. Stöckmann, Quantum Chaos - an introduction, Cambridge University Press, 1999
R. Blümel and W.P. Reinhardt, Chaos in Atomic Physics, Cambridge University Press, 1997

Cilji in kompetence:	**Objectives and competences:**
Seznaniti študente z osnovnimi pojmi in teorijami klasičnega in kvantnega (valovnega) kaosa, ki imajo pomembne in ključne aplikacije v mikroskopskih pojavih in strukturah, kot so atomski ter molekulski sistemi ter nanostrukture, kot so npr. kvantne pike. Kompetence študenta z uspešno zaključenim predmetom bodo vključevale razumevanje osnovnih pojmov z obeh področij, poznavanje sodobnih metod in znanje o primerih uporabe le-teh na področju tehnologije mezoskopskih in nano sistemov.	The aim is to acquaint the students with the basic concepts and theories of classical and quantum (wave) chaos, which have important and crucial applications in microscopic phenomena and structures such as atomic and molecular systems and nanostructures such as quantum dots.The competencies of the students completing this course successfully would include understanding of basic concepts from both areas, familiarity with state-of-the art methods, and knowledge of examples of applications in the field of technology of mesoscopic and nano systems.

Predvideni študijski rezultati:	**Intended learning outcomes:**
<u>Znanje in razumevanje:</u> Razumevanje klasičnega in kvantnega kaosa v najširšem kontekstu. Predmet pripravlja študente za uporabo znanja s področja klasičnega in kvantnega kaosa, seznani jih z osnovnimi in glavnimi motivacijami, metodami in rezultati na tem področju, kakor tudi z osnovno literaturo, s pomočjo česar lahko uspešno aplicirajo znanje v konkretnih tehnoloških primerih.	Knowledge and understanding: Understanding classical and quantum chaos in its broadest context. The course prepares the students for the application of the knowledge in the field of classical and quantum chaos, acquaints them with the basic motivations, methods and results in this field, as well as with the basic literature, by means of which they can successfully apply the knowledge in concrete technological cases.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, konzultacije ter seminarska naloga	Lectures, consultancy and seminar work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminarska naloga	50 %	Seminar work
Ustni zagovor seminarske naloge	50 %	Oral defense of seminar work

Reference nosilca / Lecturer's references:

LOZEJ, Črt, ROBNIK, Marko. Aspects of diffusion in the stadium billiard. *Physical review. E.*, ISSN 2470-0053, 12. jan. 2018, str. 012206-1-012206-10, graf. prikazi, tabele. https://journals.aps.org/pre/pdf/10.1103/PhysRevE.97.012206, doi: 10.1103/PhysRevE.97.012206

ROBNIK, Marko. Recent results on time-dependent Hamiltonian oscillators. *The European physical journal, Special topics*, ISSN 1951-6355, sep. 2016, vol. 225, iss. 6/7, str. 1087-1101

ROBNIK, Marko. Fundamental concepts of quantum chaos. *The European physical journal, Special topics*, ISSN 1951-6355, sep. 2016, vol. 225, iss. 6/7, str. 959-976, doi: 10.1140/epjst/e2016-02649-0

MANOS, Thanos, ROBNIK, Marko. Statistical properties of the localization measure in a finite-dimensional model of the quantum kicked rotator. *Physical review. E, Statistical, nonlinear and soft matter physics*, ISSN 1550-2376. [Online ed.], 2015, vol. 91, iss. 4, str. 042904-1 - 042904-11, graf. prikazi, doi: 10.1103/PhysRevE.91.042904

MANOS, Thanos, ROBNIK, Marko. Survey on the role of accelerator modes for anomalous diffusion : the case of the standard map. *Physical review. E, Statistical, nonlinear and soft matter physics*, ISSN 1550-2376. [Online ed.], 2014, vol. 89, iss. 2, str. 022905-1 - 022905-12, graf. prikazi, doi: 10.1103/PhysRevE.89.022905.