



Univerza v Mariboru

Fakulteta za naravoslovje
in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet: Zlom simetrije
Course title: Symmetry breaking

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
FIZIKA, 3. stopnja		1. ali 2.	1., 2. ali 4.
PHYSICS, 3 rd cycle		1. or 2.	1., 2. or 4.

Vrsta predmeta / Course type

Izbirni za vse module/ Optional for all modules

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
15					165	6

Nosilec predmeta / Lecturer:

Samo Kralj

Jeziki /

Languages:

Predavanja / slovenski/Slovenian

Lectures:

Vaje / Tutorial:

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Pogojev ni.

Priporočljiva znanja so: predznanje iz klasične in moderne fizike in iz matematične fizike.

Prerequisites:

None.

Recommended is preknowledge of classical physics, modern physics, and mathematical methods in physics.

Vsebina:

Content (Syllabus outline):

- 1) Landau-ova teorija faznih prehodov
- 2) Značilne razdalje in časovne skale
- 3) Zlom zvezne simetrije in topološki defekti
- 4) Statika in dinamiko topoloških defektov
- 5) Opis narave s polji
- 6) Interakcija med nanodelci, koloidi in topološkimi defekti; samoorganizacija
- 7) Topološki defekti v bioloških membranah
Topološki defekti kot občutljivi detektorji

- 1) Landau theory of phase transitions
- 2) Characteristic length and time scales
- 3) Symmetry breaking and topological defects
- 4) Statics and dynamics of topological defects
- 5) Field presentation of nature.
- 6) Interaction between nanoparticles, colloids, topological defects; selforganisation
- 7) Topological defects in biological membranes
Topological defects as sensitive detectors

Temeljni literatura in viri / Readings:

- 1) M. Kleman, O.D. Lavrentovich, *Soft Matter Physics*, Springer-Verlag, New York, 2003.
- 2) P. M. Chaikin, T. C. Lubensky, *Principles of Condensed Matter Physics*, Cambridge University Press, Cambridge, 1995.
- 3) K.F. Riley, M.P. Hobson, S.J. Bence, *Mathematical Methods for Physics and Engineering*, 3rd edition, Cambridge University Press, Cambridge, 2006
- 4) A. Hobson, There are no particles, there are only fields, *Am. J. Phys.* **81** (3), 211-243 (2013).
- 5) J.C. Taylor, *Hidden Unity in Natural Laws*, Cambridge University Press, Cambridge, 2001.

Cilji in kompetence:

Študenti poglobijo znanje s področja zloma simetrije. Spoznajo možnost modeliranja narave s »polji«, kjer »osnovni delci« nastopajo kot topološko stabilizirana lokalizirana stanja polj.

Objectives and competences:

Students acquire advanced knowledge on symmetry breaking. A "field" perspective of nature is presented, where "fields" represent fundamental entity of nature. In this respect "fundamental particles" are emergent.

Predvideni študijski rezultati:

Znanje in razumevanje:

Poglobljeno razumevanje ključnih procesov v naravi, ki so povezani z zlomom simetrije. Spoznanje uporabnost zloma simetrije za številne aplikacije v nanotehnologiji.

Prenosljive/ključne spretnosti in drugi atributi:

Rešitev problemov z matematičnimi orodji, numeričnimi metodami, univerzalnosti v fiziki in celosten pristop k reševanju problemov.

Intended learning outcomes:

Knowledge and understanding:

Understanding of key processes in nature based on symmetry breaking. Usefulness of symmetry breaking in emergent nanotechnology is understood.

Transferable/Key Skills and other attributes:

Solving of problems with mathematical tools, numerical methods, universalities in physics and gained global approach on solving problems.

Metode poučevanja in učenja:

Predavanja in reševanje zastavljenih problemov.

Learning and teaching methods:

Lectures and solving of defined problems.

Načini ocenjevanja:

Seminar.
Ustni izpit.

Delež (v %) /

Weight (in %)

Assessment:

Seminar.
Oral exam.

Reference nosilca / Lecturer's references:

1. DUBTSOV, Alexander, PASECHNIK, Sergey V., SHMELIOVA, Dina V., KRALJ, Samo. Light and phospholipid driven structural transitions in nematic microdroplets. *Applied physics letters*, ISSN 0003-6951. [Print ed.], 2014, vol. 105, no. 15, str. 151606-1-151606-4, doi: [10.1063/1.4898335](https://doi.org/10.1063/1.4898335). [COBISS.SI-ID [20904200](https://www.cobiss.si/id/20904200)]
2. RANJKESH SIAHKAL, Amid, AMBROŽIČ, Milan, KRALJ, Samo, SLUCKIN, T. J. Computational studies of history dependence in nematic liquid crystals in random environments. *Physical review. E, Statistical, nonlinear, and soft matter physics*, ISSN 1539-3755, 2014, vol. 89, iss. 2, str. 022504-1-022504-14, doi: [10.1103/PhysRevE.89.022504](https://doi.org/10.1103/PhysRevE.89.022504). [COBISS.SI-ID [20347912](https://www.cobiss.si/id/20347912)]
3. TRČEK, Maja, CORDOYIANNIS, George, TZITZIOS, Vassilios, KRALJ, Samo, NOUNESIS, George, LELIDIS, Ioannis, KUTNJAK, Zdravko. Nanoparticle-induced twist-grain boundary phase. *Physical review. E, Statistical, nonlinear, and soft matter physics*, ISSN 1539-3755, 2014, vol. 90, issue 3, str. 032501 -1-032501 -8, doi: [10.1103/PhysRevE.90.032501](https://doi.org/10.1103/PhysRevE.90.032501). [COBISS.SI-ID [27908903](https://www.cobiss.si/id/27908903)]
4. RANJKESH SIAHKAL, Amid, AMBROŽIČ, Milan, CORDOYIANNIS, George, KUTNJAK, Zdravko, KRALJ, Samo. History-dependent patterns in randomly perturbed nematic liquid crystals. *Advances in condensed matter physics*, ISSN 1687-8108, 2013, vol. 2013, str. 505219-1-505219-10, doi: [10.1155/2013/505219](https://doi.org/10.1155/2013/505219). [COBISS.SI-ID [26806567](https://www.cobiss.si/id/26806567)]
5. POVŠE JESENEK, Dalija, PERUTKOVÁ, Šárka, GÓZDŹ, Wojciech, KRALJ-IGLIČ, Veronika, IGLIČ, Aleš, KRALJ, Samo. Vesiculation of biological membrane driven by curvature induced frustrations in membrane orientational ordering. *International journal of nanomedicine*, ISSN 1178-2013. [Online ed.], 2013, vol. 8, no. 1, str. 677-687, ilustr. http://www.dovepress.com/articles.php?article_id=12253. [COBISS.SI-ID [4516971](https://www.cobiss.si/id/4516971)]
6. REPNIK, Robert, RANJKESH SIAHKAL, Amid, ŠIMONKA, Vito, AMBROŽIČ, Milan, BRADAČ, Zlatko, KRALJ, Samo. Symmetry breaking in nematic liquid crystals: analogy with cosmology and magnetism. *Journal of physics, Condensed matter*, ISSN 0953-8984, 2013, vol. 25, no. 40, str. 404201-1-404201-10, doi: [10.1088/0953-8984/25/40/404201](https://doi.org/10.1088/0953-8984/25/40/404201). [COBISS.SI-ID [20050952](https://www.cobiss.si/id/20050952)]