| UČNI NAČRT PREDMETA / COURSE SYLLABUS | |
|---|---|
| **Predmet:** | Magnetna relaksacija in resonanca nanomaterialov |
| **Course title:** | Magnetic Relaxation and Resonance of Nanomaterials |

| Študijski program in stopnja<br>Study programme and level | Študijska smer<br>Study field | Letnik<br>Academic year | Semester<br>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:** | NANO3-809 |

| Predavanja<br>Lectures | Seminar<br>Seminar | Vaje<br>Tutorial | Klinične vaje<br>work | Druge oblike študija | Samost. delo<br>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. Tomaž Apih |

| | | |
|---|---|---|
| **Jeziki / Languages:** | **Predavanja / Lectures:** | Slovenščina, angleščina / Slovenian, English |
| | **Vaje / Tutorial:** | Slovenščina, angleščina / Slovenian, English |

| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | **Prerequisits:** |
|---|---|
| Zaključen dodiplomski študijski program druge stopnje s področja tehnike ali naravoslovja. | Completed second level study program from the fields of technical disciplines or natural sciences. |

| **Vsebina:** | **Content (Syllabus outline):** |
|---|---|
| Uvod v jedrsko magnetno resonance (NMR)<br>NMR tekočin in trdnih snovi<br>Študij molekularne dinamike in ekscitacij v trdni snovi z NMR relaksacijo<br>Magnetnoresonančno slikanje kondenzirane materije<br>Spektri neurejenih sistemov, stekel, relaksorjev in kvazikristalov<br>Spektri molekularnih nanomagnetov in fuleridov<br>Spektri biomolekul<br>Detekcija magnetne resonance z magnetometrijo dušikovih vrzeli v diamantih | Introduction to nuclear magnetic resonance (NMR)<br>NMR of liquids and solid state<br>Study of molecular dynamics and excitations in solid state by NMR relaxation<br>Magnetic resonance imaging of condensed matter<br>Spectra of disordered systems, glasses, relaxors and quasicrystals<br>Spectra of nanomagnets and fullerides<br>Biomolecule spectra<br>Detection of magnetic resonance by nitrogen vacancy defects in diamond |

**Temeljni literatura in viri / Readings:**

Temeljni študijski vir so znanstveni članki, objavljeni v zadnjih letih, predvsem v revijah Science, Nature in Physical Review Letters

- Magnetometry with nitrogen-vacancy defects in diamond, Rondin, L. et all, Rep. Prog. Phys. 77 056503 (2014)
- Diamond-based single-molecule magnetic resonance spectroscopy, Jianming Cai et al 2013 New J. Phys. 15 013020

Uvodna predavanja pa se opirajo na:

- A. Abragam: The principles of nuclear magnetism, Oxford University Press (1960)
- G. A. Webb (Ed.), Modern Magnetic Resonance, 2nd edition, 2018, Springer International Publishing

**Cilji in kompetence:**

Študenti se usposobijo za raziskovalno delo na področju magnetne resonance in relaksacije nanomaterialov.

Splošne kompetence:

- obvladanje raziskovalnih metod, postopkov in procesov, razvoj kritične in samokritične presoje,
- sposobnost uporabe znanja v praksi,
- razvoj komunikacijskih sposobnosti in spretnosti, posebej komunikacije v mednarodnem okolju,
- kooperativnost, delo v skupini (in v mednarodnem okolju).

Predmetnospecifične kompetence:

Predmet pripravlja študente za uporabo znanja s področja magnetne resonance in relaksacije nanomaterialov.

**Objectives and competences:**

Students are trained for research work in the field of magnetic resonance and relaxation of nanomaterials.

General Competences:

- *The student will master research methods, procedures and processes*
- *The student will develop critical thinking*
- *The student will develop communications skills to present research achievement in the international environment*
- *Work in team (in international environment)*

Course Specific Competences:

*This course prepares students to apply knowledge from magnetic relaxation and resonance of nanomaterials.*

**Predvideni študijski rezultati:**

Znanje in razumevanje:

- Razumevanje magnetne resonance in relaksacije nanomaterialov

Vrednotenje in sinteza:

- Sposobnost uporabe znanja s področja magnetne resonance in relaksacije nanomaterialov pri novih raziskovalnih problemih
- Sposobnost komunikacije v angleškem jeziku na področju magnetne resonance in relaksacije

**Intended learning outcomes:**

Knowledge and Understanding

- *The student will understand magnetic relaxation and resonance of nanomaterials*

Evaluation and synthesis:

- *Ability to apply knowledge from magnetic relaxation and resonance of nanomaterials for novel research problems*
- *Ability to communicate in English in the field of magnetic relaxation and resonance*

**Metode poučevanja in učenja:**

- Predavanja
- Seminarji
- Laboratorijsko delo

**Learning and teaching methods:**

- Lectures
- Seminar work
- Laboratory work

| Načini ocenjevanja: | Delež (v %) / Weight (in %) | Assessment: |
|---|---|---|
| • Seminar | 50 % | • Seminar |
| • Ustni izpit | 50 % | • Oral Exam |

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

- WENCKA, Magdalena, APIH, Tomaž, CERC KOROŠEC, Romana, JENCZYK, Jacek, JAREK, Marcin, SZUTKOWSKI, Kosma, JURGA, Stefan, DOLINŠEK, Janez. Molecular dynamics of 1-ethyl-3-methylimidazolium triflate ionic liquid studied by $^{1}$H and $^{19}$F nuclear magnetic resonances. PCCP. Physical chemistry chemical physics 2017, vol. 19, no. 23, str. 15368-15376,
- IMANI, Roghayeh, DILLERT, Ralph, BAHNEMANN, Detlef W., PAZOKI, Meysam, APIH, Tomaž, KONONENKO, Veno, REPAR, Neža, KRALJ-IGLIČ, Veronika, BOSCHLOO, Gerrit, DROBNE, Damjana, EDVINSSON, Tomas, IGLIČ, Aleš. Multifunctional gadolinium-doped mesoporous TiO2 nanobeads ephotoluminescence, enhanced spin relaxation, and reactive oxygen species photogeneration, beneficial for cancer diagnosis and treatment. Small, 2017, vol. 13, iss. 20, str. 1-11
- APIH, Tomaž, GREGOROVIČ, Alan, ŽAGAR, Veselko, SELIGER, Janez. Nuclear quadrupole resonance study of proton and deuteron migration in short strong hydrogen bonds formed in molecular complex 3,5-dinitrobenzoic acid-nicotinic acid and in deuterated 3,5-pyridinedicarboxylic A. The journal of physical chemistry. C, Nanomaterials and interfaces, 2016, vol. 120, issue 18, str. 9992-10000
- APIH, Tomaž, ŽAGAR, Veselko, SELIGER, Janez. NMR and NQR study of above-room-temperature molecular ferroelectrics diisopropylammonium chloride and diisopropylammonium perchlorate. The journal of physical chemistry. C, Nanomaterials and interfaces, 2016, vol. 120, no. 11, str. 6180-6189
- GREGOROVIČ, Alan, APIH, Tomaž. WURST-QCPMG sequence and ˝spin-lock˝ in 14N nuclear quadrupole resonance. *Journal of magnetic resonance*, ISSN 1090-7807, 2013, vol. 233, p. 96-102