UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Detektorski sistemi in metode za meritve rentgenskih fotonov z visoko energijsko ločljivostjo
Course title:	Detector Systems and Methods for High Energy Resolution X-Ray Measurements

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Senzorske tehnologije, 3. stopnja	/	1	1
Sensor technologies, 3rd cycle	/	1	1

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: ST-536

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	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: Doc. dr. Matjaž Kavčič

Jeziki / Languages:	**Predavanja / Lectures:**	Slovenski ali angleški / Slovene or English
	Vaje / Tutorial:	Slovenski ali angleški / Slovene or English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Zaključen študij druge stopnje ustrezne (naravoslovne ali tehniške) smeri ali zaključen študij drugih smeri z dokazanim poznavanjem osnov področja predmeta (pisna dokazila, pogovor).	Completed second cycle studies in natural sciences or engineering or completed second cycle studies in other fields with proven knowledge of fundamentals in the field of this course (certificates, interview).

Vsebina:	**Content (Syllabus outline):**
Predmet obravnava detektorske sisteme, ki omogočajo meritve fluorescenčnih ali sipanih rentgenskih fotonov z energijsko ločljivostjo na nivoju razširitve zaradi življenjskega časa vrzeli v notranjih lupinah. • Braggovi kristalni analizatorji v različnih fokusirajočih geometrijah (Johann, Johansson, VonHamos). • Rentgenske spektroskopske tehnike foton noter/foton ven (resonančno neelastično sipanje rtg. žarkov, rentgensko ramansko sipanje).	The course deals with detector systems for measurements of fluorescent or scattered x-ray photons with energy resolution on the level of core-hole lifetime broadening. • Bragg crystal analyzers in different focusing geometries (Johann, Johansson, VonHamos) • Photon-in/photon-out x–ray spectroscopic techniques (resonant inelastic x-ray scattering, x-ray Raman scattering). • Application of these spectroscopic methods to analyze the electronic structure of bulk materials using synchrotron radiation.

• Aplikacija obravnavanih spektroskopskih metod pri analizi elektronske strukture materialov s sinhrotronsko svetlobo. • Izbrani primeri s področja analize (nano)materialov, kemijskih raziskav in katalize, ki jih omogočata visoka ločljivost in kompatibilnost trdih rentgenskih žarkov s pogoji in-situ.	• Case analytical studies from the field of new (nano)materials, chemical research, and catalysis, which are driven by the high experimental resolution and compatibility of hard x-rays with in-situ conditions.

Temeljni literatura in viri / Readings:

- J. Als-Nielsen, D. McMorrow, Elements of Modern X-ray Physics, John Wiley and Sons, 2011.
- J.A. van Bokhoven, C. Lamberti, X-Ray Absorption and X-Ray Emission Spectroscopy, Theory and Applications,Wiley, 2016.
- S. Mobilio, F. Boscherini, C. Meneghini, Synchrotron Radiation, Basics, Methods and Applications, Springer 2015.
- F. de Groot, A. Kotani, Core Level Spectroscopy of Solids, Taylor and Francis, 2008.
- Izbrani članki iz znanstvenih revij /Selected papers from scientific journals (Review of Scientific Instruments, X-Ray Spectrometry, Journal of Synchrotron Radiation).

Cilji in kompetence:	**Objectives and competences:**
Spoznati tipe in osvojiti principe delovanja analizatorjev in detektorskih sklopov, ki omogočajo analizo rentgenskih žarkov z visoko energijsko ločljivostjo. Osvojiti teoretične fizikalne in metodološke koncepte rentgenskih spektroskopskih metod foton noter/foton ven. Uporaba detektorskih sistemov ter aplikacija ustreznih spektroskopskih metod na konkretnih primerih karakterizacije elektronske strukture materialov.	Familiarize with different types and principles of operation of analyzers and detector systems for high energy resolution x-ray spectroscopy. Learn theoretical and methodological concepts of photon-in/photon-out x-ray spectroscopic methods. Utilize the high resolution x-ray detection systems and apply the spectroscopy to characterize the electronic structure of particular material.
Predvideni študijski rezultati:	**Intended learning outcomes:**
Poznavanje karakterističnih lastnosti detektorjev za analizo rentgenskih žarkov z visoko energijsko ločljivostjo in sposobnost njihove uporabe pri spektroskopskih tehnikah foton noter/foton ven. Primerjava posameznih spektroskopskih metod, njihove prednosti in omejitve ter izbira optimalne metode pri analizi specifičnih materialov.	Knowledge and understanding of characteristic properties of high energy resolution x-ray detection systems and ability for their application for photon-in/photon-out x-ray spectroscopic techniques. Comparison of separate techniques, advantages and limitations of each method, and selection of appropriate method for the analysis of specific materials.
Metode poučevanja in učenja:	**Learning and teaching methods:**
Interaktivno individualno delo s študentom, ki temelji na reševanju realnih problemov (case-study). Izvedba praktičnih eksperimentov in demonstracij v laboratoriju.	Interactive individual work with a student based on solving real case-study problems . Practical experiments and demonstrations in the lab.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Seminarska naloga, projekt.	50 %	Seminar, coursework project.
Ustni izpit, zagovor projekta.	50 %	Oral exam, defense of the project.

Reference nosilca / Lecturer's references:

- M. Kavčič, M. Budnar, A. Mühleisen, F. Gasser, M. Žitnik, K. Bučar, R. Bohinc, *Design and performance of a versatile curved-crystal spectrometer for high-resolution spectroscopy in the tender x-ray range,* Rev. Sci. Instrum. **83**, 033113 (2012).
- M. Kavčič, M. Žitnik, K. Bučar, A. Mihelič, B. Marolt, J. Szlachetko, P. Glatzel, K. Kvashnina, *Hard x-ray absorption spectroscopy for pulsed sources,* Phys. Rev. B **87**, 075106 (2013).
- M. Petric, R. Bohinc, K. Bučar, M. Žitnik, J. Szlachetko and M. Kavčič, *Chemical State Analysis of Phosphorus Performed by X-ray Emission Spectroscopy*, Anal. Chem. 87 (11), 5632–5639 (2015).
- M. Petric, M. Kavčič, *Chemical speciation via X-ray emission spectroscopy in the tender X-ray range*, J. Anal. At. Spectrom. **31**, 450–457 (2016).
- M. Kavčič, K. Bučar, M. Petric, M. Žitnik, I. Arčon, R. Dominko, A. Vižintin, *Operando resonant inelastic X-ray scattering : an appropriate tool to characterize sulfur in Li-S batteries*, J. Phys. Chem. C **120**(43), 24568–24576 (2016).