Study programmes: BACHELOR STUDIES – Astronomy and Astrophysics
Course name: Physics of Atoms and Molecules
Lecturers: Vladimir Milosavljević and other lecturers
Status: Optional
ECTS: 10
Attendance prerequisites: General Physic (Mechanics, Thermodynamics, Electromagnetism & Optics).
Course aims: The course is aimed to emphasis advantages of Modern Physics over a classical physics. The student/s should be able to employ knowledge of Atomic and Molecular Physics to explain the structure of matter. The course gives an overview of atom and molecular structures, e.g. energy levels and lifetimes. It provides a comprehensive link between atomic and molecular physics, and quantum mechanics, with emphasis on the importance of an electron energy in the modification of an atomic and molecular structure. This course presents main application of atomic and molecular physics: a process of optical amplification based on the stimulated emission of electromagnetic radiation (Laser), electron microscope, CCD, TV and PC.
Course outcome: 1. Explain the importance of modern Physics in understanding matter and light. 2. Understand the general principles of atomic and molecular physics 3. Carry out experimental and theoretical studies on atoms and molecules, with focus on the structure and dynamics of atoms and molecules 4. Account for theoretical models, terminology and working methods used in atomic and molecular physics 5. Handle relevant experimental equipment and evaluate the experimental results obtained 6. Develop graduate attributes appropriate to their programme of study by participating effectively in group work, problem solving and peer teaching through participation in class activities, workshop practical sessions and in online environments. 7. Apply advanced numerical and data manipulation skills, appropriate to their programme of study with theoretical concepts.
Course content: Motion of a charged particle in an electrical and magnetic fields. The Millikan's experiment. A black body radiation and the Planck hypothesis. The photoelectric effect. The photocells and photomultipliers. The radiation pressure. The Compton Effect. The J.J. Thomson's atomic model. The Rutherford's experiment and atomic model. The Bohr's atomic model. Hydrogen spectral series and Balmer formula. The Franck-Hertz experiment. An elliptical trajectories for the one-electron system. Space quantization. The Bohr magneton. The Stern–Gerlach experiment. X (Röntgen)-rays, spectral analysis. X-rays, energy levels (Auger electrons). X-rays, Max von Laue experiment. X-rays, penetration depth. Spectral lines intensity and shape. Spectra of alkali atoms. Electron spin. Electron shells population – the Pauli Exclusion Principle. The periodic table of elements. Spectra of Many-Electron Systems. Spectrum of helium. The fine structure of Balmer Hα line. The Lamb-Retherford experiment. The normal Zeeman Effect. The anomalous Zeeman Effect. Stimulated emission of radiation – Laser effect (Einstein coefficients). Stimulated emission of radiation – Laser effect (atomic model with two and three energy levels). Helium-Neon laser. DeBroglie hypothesis: Wave–particle duality. The Davisson–Germer experiment. The Heisenberg uncertainty principle. Molecules – electronegativity. Molecules – formation of ions. Molecules – covalent bonding. Molecules – quantum numbers. Molecules – valence. Nitrogen molecule. Oxygen molecule. Molecular symmetry – the additional selection rules. The Shapes of Molecules: LiH & BeH2. The Shapes of Molecules: BH3. The Shapes of Molecules: sp3 hybridization. The Shapes of Molecules: CH4 , NH3 & H2O. Molecular

mirror symmetry. Molecular structure – role of C, N & O atoms. The delocalized molecular orbitals. The ring molecular orbitals. Metallic bonding. Molecular Spectra - Rotational spectroscopy. Molecular Spectra – Vibrational spectroscopy. Molecular Spectra – Rotational–vibrational spectroscopy. Molecular Spectra – vibrational-rotational-electronic spectroscopy. Molecular dissociation - The Franck–Condon principle. Molecular Spectra – Raman spectroscopy. Intermolecular interactions – Van der Waals interaction. Intermolecular interactions – Dipole-Dipole interactions. Intermolecular interactions – hydrogen bonding.
Literature: 1. S.Djeniže Osnovi atomske kvantne i molekulske fizike, Nauka, Beograd,1995 2. D. Belić, Molekulska fizika, Beograd 2001 3. E. Špoljskij Atomska fizika I, Naučna knjiga, Beograd, 1964 4. J. Purić i S. Djeniže Zbirka rešenih zadataka iz atomske fizike, Naučna knjiga, Beograd, 1978 5. D. Filipović i S. Kalezić Praktikum atomske fizike, Fizički fakultet Univerziteta u Beogradu, 2007

Number of hours: 8	**Lectures**: 4	**Tutorials**: 2	**Laboratory**: 2	**Research**: -

Teaching and learning methods: In-class problem solving. Laboratory sections: Millikan's experiment; Determining Specific Charge of Electron; Experimental determination of Rydberg's constant; Photoelectric effect - Planck constant; Absorption spectroscopy; The Franck-Hertz Experiment; The Ramsauer–Townsend effect; Emission Spectroscopy

Assessment (maximal 100 points)

Course assignments	points	Final exam	points
Lectures	10	Written exam	20
Exercises / Tutorials	15	Oral exam	30
Colloquia	-	Written-oral exam	-
Essay / Project	15+10		