1.	**Field of study**	**Biophysics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2022/2023 (winter term), 2023/2024 (winter term), 2024/2025 (winter term)
4.	Level of qualifications/degree	second-cycle studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Disordered and Off-Equilibrium Systems

Module code: W4-2BF-MB-21-03

1. Number of the ECTS credits: 6

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
MB_03_1	Students will be able to understand and analyze scientific reports concerning experimental, theoretical, and computational studies concerning the physics of disordered and off-equilibrium systems	KBF_K02 KBF_U11 KBF_W01 KBF_W03 KBF_W07 KBF_W10	4 4 4 4 4 4

3. Module description

Description	1. From order to disorder Non-periodical long-range positional order: quasi-crystals Disorder in long-range positional atomic systems (cellular disorder): Substitutional disorder: interstitial and substitutional impurities, vacancies; Orientational disorder: plastic crystals (e.g. fullerene) Disorder in atomic systems without long-range positional order (topological disorder): Base elements in real crystals: Dislocations and Burger's vector, Interfacial defects. Liquid state and amorphous state: N-bodies distribution functions, particular case: pair distribution; static structure factor; Hard sphere atomic liquids: Percus-Yevick theory. Disorder in polymeric systems: Conformations of polymeric linear chain: analogy with a random walk. Chain rigidity: Kuhn's segment. Size distribution of the linear polymeric chain. Free energy of polymeric chain, entropic elasticity. The pair distribution function of polymeric chain: self-similarity 2. From equilibrium to out of equilibrium Supercooled metastable states and glass transition in liquids: Van Hove function and its momenta; Collective and microscopic dynamics: cage effect and vibrational properties, local and structural relaxation, relaxation time distribution, diffusion, visco-elasticity; Simple models of glass transition: Free volume, Configurational entropy.

	Elements of non-equilibrium thermodynamics: Zero Principle: fictive temperature in glasses, fluctuation-dissipation theorem violation; Second Principle: Jarzynski's equality and Crooks fluctuation theorem: experimental tests in nanosystems. Polymeric chain Dynamics: Short-chain: Rouse model; Long chain: entanglement effect; Edwards tube model; De Gennes reptation motion: scale arguments. Non-equilibrium states in the active matter: Molecular Motors; Bacteria, Swimmers, swarms: emergent collective motions and glass transition. 3. Experimental techniques: structure and dynamics of disordered systems Scattering from disordered systems: generalities: Scattering cross-sections, coherent and incoherent scattering; Static and dynamic structure factor, elastic and inelastic scattering; Spatial, temporal and spatio-temporal correlation function. Photon Scattering (X-rays and light): Sources of coherent radiation (synchrotron), spectrometers and detectors; Structure of disordered systems: X-ray diffraction at a wide and small angle; Dynamics in disordered systems: Brillouin and Raman scattering, inelastic X-ray scattering, photocorrelation spectroscopy. Neutron scattering: Neutron sources and detectors: typical experimental layout; Structure of disordered systems: neutron diffraction at a wide and small angle, comparison with X-ray; inelastic neutron scattering and spectroscopy: TAS, TOF, Backscattering, Spin-Echo.
Prerequisites	

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
MB_03_w_1	exam	oral exam	MB_03_1

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
MB_03_fs_1	lecture	Detailed discussion by the lecturer of the issues listed in the table "module description" using the table and/or multimedia presentations	48	Supplementary reading, working with the textbook	102	MB_03_w_1