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Synchrotron radiation in physical and biomedical sciences - 10 lecture hours

Outline program of the lecture (Thursdays, 14:15, room D)

1. **Intro to the lectures**. (organizacja wykładów, prezentacja wykładowcy, reguły)
   What is SR – definition, SR sources, history, synchrotrons and FELs over the world.
   Properties of SR, comparison with other sources. Examples
   Main fields of utilization. Examples
2. **Types of SR machines:** Storage rings and FELs. General principles of operation.
   Basic SR sources: Bending magnets, Undulators and Wigglers – Principle of operation, output radiation spectrum, power, polarity. Main ranges of operation. Tunability.
   FELs vs. Optical lasers.
3. **X-ray range of EM radiation**. Interaction of X-rays with matter: Photelectric effect, Pair creation, Compton scattering, Rayleigh scattering, Bremsstrahlung.
   Optical properties of X-rays, complex optical constants,
   X-ray optics. Beam shaping, optical lenses and diffractive (Fresnel) optics.
   Diffraction limit and beyond. Resolution limits of imaging techniques.
   Introduction to experimental methods: Elastic and inelastic scattering techniques. Spectroscopy and Diffraction.
4. **SR in Biology and Medicine. Damage** (in solids and in biology)
   EM spectrum – applications to biology. Four ranges of radiation: Hard X-rays, Soft X-rays NUV-Vis-NIR, FIR-THz. "biological windows" in SXR and IR for spectroscopy of biomolecules.
5. **X-Ray diffraction (Classical)**: Why we need a large crystal to determine the elementary cell structure. An outline of the structure determination. Bragg's law, Bragg diffraction, Laue diffraction, form factor, structure factor, fundamental limitations. Phase problem in X-ray crystallography: Patterson function. MX crystallography. Rietveld method, powder diffraction.
   Imaging with SR – part I: the X-ray range.
   Some of 2D techniques: Radiography, X-ray microscopy, Scanning microscopy, Phase contrast imaging, 3D imaging intro (tomography and microtomography)
   Bioimaging and medical imaging with SR.
6. **X-Ray diffraction** (New) – Neutze postulate, Intense coherent X-ray beams from FELs, Why the demand of large crystal is no more necessary - Serial crystallography. Diffraction vs. imaging., Possibility of a single macromolecule crystallography.
   Coherent X-ray Diffraction Imaging (CXDI) with intense beams
   Radiotherapy with SR: Microbeam Radiation Therapy (MRT), Photon Activated Therapy (PAT),
7. **Miscellanea and inelastic techniques**
   X-ray reflectometry, SAXS (Small Angle X-Ray Scattering);
   Absorption spectroscopies**.** Raman spectroscopy, XANES, EXAFS, XPS, …
8. **Experimental tips and tricks,** Error sources and treatment, Algorithms and software for data processing and analysis.
9. **Synchrotron Radiation THz + FIR in Biology and Physics**
   Non-ionizing SR, Properties of THz and FIR radiation, THz-TDS (time Domain Spectroscopy), THz Imaging, Tissue ablation for surgery, SNOM, spectroscopic signatures of molecules. Some examples from physics and life sciences.
10. **Users at SR facilities.** Safety rules for people, machines and samples. Specificity of work. Regulations, procedures, SR user duties. References, **Closing Remarks**