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Synchrotron radiation in the study of biostructures and life processes: New achievements and challenges

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More than thirty years ago, a wide access to the 3rd generation synchrotron sources has opened up new exciting era in research of the biological structures and processes, leading to a substantial progress in the fields. The history repeats in the last decade, due to a rapid development of the 4th generation sources of synchrotron radiation, the short-wavelength (SASE) FEL lasers.

SASE-FELs can produce a fully tunable monochromatic radiation in ultrafast femtosecond pulses with a peak power up to several GW, in the wide range of wavelength, including hard X-rays. With the new methods emerging to fully exploit unique emission properties of the FELs, a new qualities in probing the secrets of life are expected.

Some of the key experimental techniques have already been implemented and their invaluable potential confirmed. Included are, among other, new techniques of structure determination without the need of conventional crystallization, applicable both to large biomolecules and molecular complexes, a possibility of obtaining the precise structural information collecting diffraction patterns of a large number of small nanocrystals (so-called serial nanocrystallography) and imaging of small objects with unprecedented atomic spatial resolution. Underway are also developments of new pump and probe techniques dedicated to ultrafast dynamic study of biochemical processes.

The aim of this presentation is to draw the current state of research in the field and to show the emerging new trends and challenges, basing on examples of particular applications. Opportunities of research with the new classes of SR sources for the Polish scientists will be also discussed.

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Review of the ongoing efforts dedicated to Polish free electron laser POLFEL

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The free electron laser POLFEL at National Centre of Nuclear Research, Świerk, has been proposed in continuation of efforts to establish in Poland modern facilities providing coherent radiation for science and technology, which will follow the soft x-ray synchrotron in Krakow. The initiative has been risen by the accelerator physicists involved in collaboration on the continues wave and long pulse operations of European XFEL. These new operation modes, which are the main innovative feature of POLFEL, have been recognized as a desired objective of the future European XFEL upgrade.

Ultimately POLFEL is planned as 1 GeV accelerator feeding undulator, which emits XUV ranged radiation to five experimental stations. In order to accommodate such a large enterprise to technological budgetary capabilities, the project has been split in two stages. Terahertz and infrared source will be built at first, which will provide the linear polarized radiation ranged over 6 – 1000 μm in wavelength and of 25 W in average power. In the second stage, the linac will be extended and an elliptical undulator will be installed to reach few Watts at 10 nm fundamental wavelength.

Design studies have been launched at NCBJ dedicated to key issues of planned facility: construction of fully superconducting electron injector, beam dynamics and design of the undulator. These will be discussed in our contribution.