OVERVIEW OF RESEARCH OPPORTUNITIES AND PERSPECTIVES USING SYNCHROTRON AND FREE ELECTRON LASER RADIATION

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Large scale synchrotron and free electron laser (FEL) facilities are the cradle of multidisciplinary research, spanning over physics, chemistry, material science and engineering to environment, biology, medicine, archaeology, cultural heritage etc. The complementary capabilities of the versatile experimental stations operated at the beamlines provide access to a great variety of techniques based on the photon interactions with matter such as (i) photon-in/electron-out spectroscopies (PES, ARPES and XAS), including spectro-microscopy and chemical or magnetic imaging; (ii) photon-in/photon-out spectroscopies (XAS, XRF, IUVS, Raman and IR), including microscopy, and ptychography; (iii) X-ray diffraction and scattering (XRD, XRR, SAXS-GISAXS-WAXS, XPCS, CDI).

The use of photon-based methods has opened unique opportunities to explore the properties of a broad range of complex static and dynamic systems as a function of their size, morphology, composition and functional conditions, paving the road to further scientific advancements. Along with tunable wavelength and polarization the key parameters that determine energy, spatial and time resolution of the experiments are photon brightness, degree of transverse coherence and electron bunch (pulse) length. The ongoing upgrades of the synchrotron storage rings and the growing number of FELs are opening exciting prospects for “watching” how matter behaves at ultra-short ps-fs time scales down to the level of nano-units, atoms and molecules.

Using selected exemplary systems the talk will address the most recent achievements in basic and applied research in various fields of material and life sciences. The emphasis will be on the potentials of modern x-ray microscopes based on detecting and filtering emitted electrons, transmitted, emitted or scattered photons and on-going efforts for expanding in-operando potentials of the experimental set-ups. The unprecedented opportunity for exploiting ultrafast dynamics with chemical sensitivity will be illustrated by selected recent results obtained using single and multicolor FEL light.