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Origine : Fiez (VD) – Suisse

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Titre et résumé de la thèse – Title and abstract of the thesis

SwissFEL: X-ray Electron Free Laser

Light is without doubt one of the most important means to explore and understand our surrounding world. This is particularly true for our daily life but also for the scientific approach to investigate and to study nature. The dual character of light, as an electromagnetic wave or energy quanta, allowed novel experiments, which paved the way of modern science over the last century. X-ray Free-Electron Lasers (XFELs) are a new generation of light sources offering novel experimental capabilities in diverse areas of science by providing very intense and ultra-short focused beams of X-rays.

This habilitation highlights the main advantages of the XFEL compared to others existing photon sources. The XFEL opens new perspectives to study ultra-fast phenomena with an atomic resolution and with unprecedented detail. The available time scale is in the order of femtosecond resolution (10^{-15} sec or 0.000'000'000'000'001 sec) which corresponds typically to the electron transfer time between atoms in a chemical reaction. The shortest wavelength of the photon, in the range of Ångstrom (10^{-10} m or 0.000'000'000'1 m), is essential to determine the positions of atoms in a molecule or crystal. This represents a perfect tool to record time-resolved “movies” in photochemistry and photobiology and ultra-fast dynamics in condensed matter.

After a short history on the X-ray and an introduction to XFEL radiation, this habilitation presents the SwissFEL, the new XFEL facility in Switzerland. A general description of the whole SwissFEL is given, whereby the accelerator, beamline, end-stations, laser and common systems contribute to the overall picture of the facility. SwissFEL is designed to cover soft and hard X-ray energies (from 250 eV to 12.4 KeV) offering new scientific opportunities over a large range of research including: ultrafast dynamics in photochemistry, photobiology, serial femtosecond crystallography, non-linear X-ray science condensed matter physics, material science, and magnetization on the nanoscale. Scientific opportunities of SwissFEL are then presented to illustrate the type of experiments, which can be performed at the SwissFEL facility in the field of ultra-fast chemistry and dynamics in condensed matter. Finally, pioneering works using time- and momentum-resolved Resonant Inelastic X-ray Scattering (RIXS) and Resonant Elastic X-ray Scattering (REXS) at XFEL are presented.

Titre et résumé de la leçon d'essai – Title and abstract of the inaugural lecture

Du chaos à la cohérence

Le soleil joue un rôle fondamental pour la vie. Cependant, tout comme la lumière émise par une ampoule à incandescence, il s'agit d'une source de lumière non monochromatique, dispersive et incohérente. Avec la physique moderne, d'autres sources de lumières ont été développées, qui, elles, possèdent un caractère monochromatique, directionnel et cohérent comme par exemple les lasers.

Nous entamerons cette leçon d'essai en introduisant les propriétés fondamentales caractérisant la qualité de rayonnement d'une source de lumière comprenant le flux, la luminosité et la cohérence. Ensuite, nous présenterons différentes sources de lumière telles que le tube à rayon X, la source de lumière synchrotrique et le Laser à électron libre.

Finalement, nous étendrons la leçon en donnant quelques exemples régissant la physique moderne, utilisant des sources de lumière aux propriétés de cohérence exceptionnelles, tels que le synchrotron et le Laser à électrons libres.