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TUTORIAL TALK ON SASE-FEL AND X-FEL PROJECT AT SPring-8

T. Shintake
RIKEN / SPring-8 Kouto 1-1-1, Mikazuki-Cho, Sayo-Gun, Hyogo, 679-5148, Japan MIKAZUKI-CHO SAYO-GUN, HYOGO 679-5148 JAPAN

Operation mechanism of SASE-FEL and special characteristics of X-ray beam available from it will be firstly described. The talk will also cover Japanese activity in this field, especially on the new soft-X-ray SASE-FEL project at SPring-8. This project was named SCSS: SPring-8 Compact SASE Source, which has been funded in 2001, aims to generate first light in 2004 at VUV and soft-X-ray regions. The following key technologies makes total machine size compact, less than 100 m long. (1) The short pitch undulator with 15 mm period using the in-vacuum undulator technology, which has been developed at SPring-8. (2) C-band (5712MHz) RF acceleration system with very high-gradient acceleration field (35 MV/m), which has been developed at KEK for the e^+e^- Linear Collider project. (3) Low emittance electron gun with 500 kV pulsed acceleration, using single crystal CeB6 cathode, which will generate 1 nC charge with 1 mm-mrad emittance. This is totally new design, will be developed at RIKEN/SPring-8 in few years.

Keywords: FEE ELECTRON LASER, SASE, FEL

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ENERGY RECOVERY LINAC (ERL) SYNCHROTRON RADIATION SOURCES

S.M. Gruner
CHESS & Physics Dept., Cornell University USA

A tutorial on Energy Recovery Linacs (ERLs) is given. ERLs and Free Electron Lasers (FELs) are two different linac-based x-ray sources now being intensively developed by the synchrotron radiation (SR) community. In an ERL, a laser-driven photoinjector produces electron bunches that are accelerated to high energy by a superconducting linac and then are passed through insertion devices to produce SR. The bunches are then passed through the linac again in such a manner as to recover the bunch energy into the linac electromagnetic field for use in accelerating new bunches. The energy-depleted bunches are then discarded. As opposed to storage rings, the SR brilliance is limited by the photoinjector, rather than the ring lattice. Since very brilliant photoinjectors are possible, this allows the production of SR beams of exceptional brilliance and flux. Very short x-ray bursts (c.a.100 femtosecond) are also possible. ERLs differ from FELs in that the SR bunches are produced continuously at very high rates, making practical use of the machine very similar to storage rings.

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NON-LINEAR PHENOMENA IN MOLECULES AND CLUSTERS INDUCED BY INTENSE VUV RADIATION FROM A FEL

T. Moeller[1] H. Wabnitz[1] J. Schulz[1] T. Laarmann[1] P. Guertler[1.] A. Swiderski[1] W. Laasch[1]
[1]HASYLAB at DESY, Hamburg, Notkestr. 85, 22603 Germany

The TTF- Free Electron Laser (FEL)1 at DESY has recently obtained so called saturation and provides unprecedented high peak power at short wavelength around 100 nm. This offers new experimental opportunities for the investigation of multi-photon ionization and optical non-linear processes since all studies in this field were so far restricted to rather small photon energies.2,3 First experiments were performed on rare gas atoms and clusters. By focusing FEL radiation on a pulsed beam multi-photon ionization could be achieved. The power density was varied between 1011 and 1014 Wcm^{-2}. Time-of-flight methods were used in to detect electrons and ions. At the highest power density Coulomb explosion was observed in Xenon and Argon clusters. Atomic ions with a charge state up to 6 (Ar) and 8 (Xe) are detected. While the kinetic energy of ions ranges between 10 eV and a few keV the energy of electrons is rather small (most electrons have energies less than 5 eV). The results demonstrate that the high intensity light from FELs allows for the study of multiphoton process at short wavelengths.

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FEMTOSECOND X-RAY DIFFRACTION APPLICATIONS TO BIOLOGY AND SOLID-STATE PHYSICS

D. Boschetto[1] C. Rischel[2] S. Fourmaux[1] I. Uschmann[2] O. Albert[1] J. Etchepare[1] A. Rousse[1]
Laboratoire D'Optique Appliquée Ecole Polytechnique-ENSTA-CNRS Chemin De La Huniere PALAISEAU 91761 FRANCE [2]Niels Bohr Institute, Blegdamsvej 17, DK-2100 Copenhagen, Denmark [3]X-ray Optics Group, Institute of Optics and Quantum Electronics, Friedrich Schiller University Jena, Max-Wien-Platz 1, 07743 Jena, Germany

Crystallography temporally resolved on the femtosecond time scale is a powerful instrument for studying ultrafast processes in matter. Femtosecond crystallography is today possible due to the development of ultra-short X-ray source. The laser-plasma source for producing femtosecond X-ray flash [1] has given rise to the first applications of this technique to follow a dynamical process on the sub-picosecond time scale: the non-thermal melting laser-induced on InSb single crystal [2]. These results were consistent with a time resolution of only 100 femtosecond.

Up to now femtosecond X-ray experiment were performed in a standard Bragg-like geometry. We studied a different geometry compatible with the features of the laser-plasma produced X-ray source (monochromatic and divergent) in order to detect several Bragg peaks at the same time. This study provides to extend this source to investigate complex system such as biological sample. Latest results on the application of this geometry to protein crystal investigation are also shown. Note that the interest on this geometry is amplified by the fact that new generation source of ultra-fast X-ray pulse like the X-FEL is strongly monochromatic, and therefore divergence is needed to detect many diffraction peaks at the same time.

Furthermore, we show our progress in coherent optical phonon detection by rocking curve perturbation for application to solid state physics. In conclusion, we show the latest improvement of the femtosecond X-ray laser-plasma source toward sub-picosecond time-resolved crystallography.

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