Direction des Sciences de la Matière
Département de Recherche sur l'Etat Condensé, les Atomes et les Molécules

Service des Photons, Atomes et les Molécules

To the attention of Professor Nobuhiro Kosugi
Director of UVSOR
Institute for Molecular Science
Myodaiji
Okazaki 444-8585

Saclay, 2005, the 15th of March

Dear Professor Kosugi,

UVSOR is a world-class research synchrotron radiation facility for VUV and soft X ray radiation. Regular up-grades on the machine and on the beamlines make it very competing, even now, in the new landscape of third generation synchrotron light sources such as ALS (Berkeley), ELETTRA (Trieste), BESSY-II (Berlin), MAX II (Lund), SLS (Villengen), and the newly coming Diamond (Oxford) and SOLEIL (Saclay). Besides, UVSOR hosts a storage ring Free Electron Laser (SRFEL) source. I had the chance to collaborate with FEL scientists during short time stays, and a longer three months stay this summer in Okazaki, after the shut down of the Super-ACO Free Electron Laser at the end of 2003, on which I have been working for 14 years.

Key advances for the FEL community were made on the UVSOR FEL since its first lasing in 1992. Since 1994 in UVSOR, very early systematic sophisticated experimental analysis of the FEL micropulse temporal and spectral distributions versus time with the use of a double sweep streak camera in the early days of storage ring FELs could provide a deeper insight on FEL dynamics, for different operating conditions especially versus detuning (i.e. synchronism between the electron stored in the ring and the optical pulses bouncing in the optical resonator). Detailed studies on FEL performances for different momentum compaction factors were carried out. A great progress was also made with the installation of the first helical to planar optical klystron for FEL operation, in 1996. UVSOR contributed also to the progress in short FEL wavelength operation, with FEL lasing at 238 nm in 1996. A longitudinal feedback system was developed to maintain the FEL pulse at perfect synchronism, leading to successful pump-probe two-colour experiments in gas phase using FEL light and synchrotron radiation for the first time. The production of monochromatic gamma-rays by Compton Back-Scattering with SRFELs was first demonstrated on the UVSOR FEL in 1996 and broadened the use of FELs into the field of nuclear physics. Professor Hiroyuki Hama was awarded the FEL Prize in 2004 jointly with V. Litvinenko for these pioneering works.

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Recent upgrade of UVSOR II with significantly lower emittance resulting from a chromatic optics provides a unique opportunity to investigate more deeply the interaction between the FEL and the electron beam, and to compare it to the well-established saturation process in the usual achromatic mode. Indeed, in the chromatic case, the saturation process in which the electron beam is heated by the light source (enhancement of energy spread) induces not only a lengthening of the electron bunch in the longitudinal plane but also in the transverse domain, leading to a significant increase of the Touschek lifetime induced by the FEL. Besides, a very high current can be stored, allowing the appearance of various types of instabilities, with which the FEL is competing, and under given circumstances, to the level of suppressing them. Such an understanding of the interplay between the FEL and the electron beam will be fruitful for the new slicing project to be conducted by Prof. Masahiro Katoh, with a high intense Titanium:Sapphire laser interacting with the electron beam in an undulator, for the production of femtosecond synchrotron radiation.

Apart from the increasing interest for Linac based FEL for short wavelength radiation (i.e. VUV and X ray range) and from the FEL user facilities operating in the infra-red, Storage Ring Based FELs appear to be quite valuable sources for the UV and VUV range. At present, after the closing of Super-ACO in France, four installations are operating. The European ELETTRA FEL (Trieste, Italy), installed on a third generation light source, detains the record of the shortest wavelength (172-182 nm) for FEL oscillators, and a program of harmonic generation is under development. On the NIJI-IV FEL (Tsukuba, Japan), different studies on the FEL sources are in progress. Besides, the DUKE FEL (DUKE University, USA), after various successful results (gamma-rays produced by Compton Back Scattering exploited by users, short wavelength operation in the oscillator and harmonic generation configuration…) is planning the installation of an multiple optical klystron (OK5) on a long straight section.

The FEL source quality of UVSOR II should be pointed out, and it offers a high stability level, very unique nowadays. This is of crucial importance for the quality of the data of the user experiments, and especially requested for pump-probe two-colour experiments. Pump-probe two-color experiments have been performed only on the SRFELs installed on UVSOR and Super-ACO so far, because of the very limited intensity fluctuations of these particular sources. Besides, the possibility of changing the polarisation of the UVSOR FEL, will be exploited soon at 250 nm for chirality studies in biological molecules.

The high FEL stability also permits to progress further in the FEL dynamics, which is understood in this case with the point of view of the conventional laser systems. Indeed, the study of pass to pass equations of the FEL electric field exhibits some phase singularities, which signature can be given by the presence of holes in the spectral distribution and temporal drifts in the temporal domain. These correlated phenomena were clearly observed on the UVSOR FEL. The nonlinear dynamics approach also allowed the pulsed regimes at the millisecond time scale to be controlled, thanks to the existence of an unstable cw state coexisting with the limit cycles regimes. The region of the detuning curve in which the FEL is cw can then be further extended, and offers a wider zone of operation for users applications.

Finally, it is quite relevant to stress the advantage of developing an FEL in the environment provided by the synchrotron radiation community of UVSOR, and the laser oriented laboratories of IMS. Such a double culture is key issue for the establishment and fruitful exchanges between sources builders and user scientists, for conventional lasers, high harmonics produced in gases and accelerator based light sources such as synchrotron radiation centres and fourth generation light sources based on Free Electron Laser devices. IMS can be considered as combined facility providing short and ultra-short light sources for a multi-disciplinary community. Gathering accelerator light sources and conventional lasers facilities at the same location provides an enhancement expertise and opens the way for new opportunities of scientific challenges. Besides, the interaction between scientists takes place in a very nice atmosphere, which makes the exchanges even more fruitful.

Yours sincerely,

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