Observation of THz radiation from THz Coherent Undulator Radiation Source

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To investigate the performance of THz Coherent Undulator Radiation (CUR) Source at Kyoto University for generating intense quasi-monochromatic radiations, the THz CUR intensity and power spectrum have been measured. The experimental setup and results are reported and discussed.

Key words: Quasi-monochromatic, Coherent Undulator Radiation (CUR), THz intensity

Introduction

Our THz Coherent Undulator Radiation (THz CUR) source has been developed since 2013. The total length is approximately 5 meters. The system starts from the 1.6-cell S-band BNL-type photocathode RF-gun driven by a UV laser of 266-nm wavelength which provided from a photocathode drive laser system [1]. Then, the electron bunch is focused by a solenoid magnet. The electron bunch length is shortened by a magnetic chicane consisting of four dipole magnets. The electron beam is also matched to the undulator [2] by the triplet quadrupole magnets. The doublet quadrupole and bending magnets have also been installed to dump the electron beam. In August 2016, this system has successfully started generating the quasi-monochromatic THz CUR. This paper presents the measurement result of the power spectrum of the THz CUR and relationship between the bunch charges and the CUR intensity to study the effect of the electron space charge on the bunch form factor.

THz Coherent Undulator Radiation measurement and results

The schematic diagram of CUR spectrum measurement setup is shown in Fig. 1. The CUR generated in the undulator was reflected by a titanium foil inside in the vacuum chamber. Then, it travels through a fused silica window and directly goes to the Michelson interferometer setup. This setup consists of parabolic mirrors, a fixed mirror, a moving mirror, a beam splitter, and a pyroelectric detector as shown in Fig. 1. The measured signal intensity as a function of the path difference (so called interferogram) was measured then it is converted to power spectrum by using Fast Fourier Transform (FFT).

The CUR power spectrum with different undulator gaps are presented in Fig 2a under the condition of bunch charge of 60 pC. As a result, our source can generate THz CUR in the frequency range from 0.16 to 0.65 THz. Figure 2b shows the dependence of CUR spectral peak intensity at the resonance frequency on the bunch charge. For the undulator gap of 40 mm and 50 mm, the spectral peak intensity slightly reduces if the bunch charge is higher than 110 pC and 90 pC, respectively. But it still keeps increasing up for undulator gap of 30 mm although the bunch charge is higher than 160 pC. The result as explained above is caused by the degradation of bunch form factor or the bunch lengthening due to space charge effect. The bunch form factor depends on the bunch length and it also relates to the radiation intensity versus bunch charge square [3]. Currently, the bunch length has not been measured but we can estimate the bunch length by using General Particle Tracer (GPT) code [4]. It is about 1 ps after optimizing the beam optics from RF gun until the end of undulator. The bunch form factor calculated from this bunch length decreases almost zero at the frequency of 0.65 THz. This result is in good agreement with the measured result of radiation intensity at the undulator gap of 60 mm.

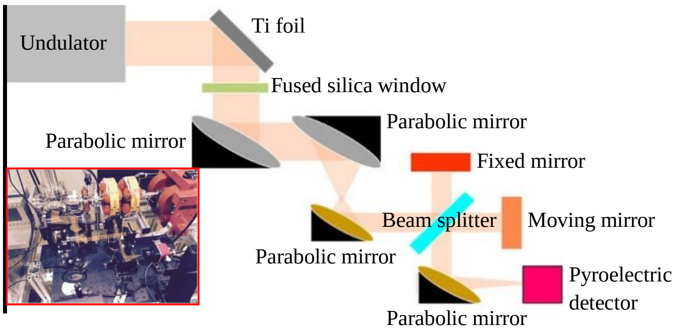

Figure 1 Experimental layout of Michelson interferometer.

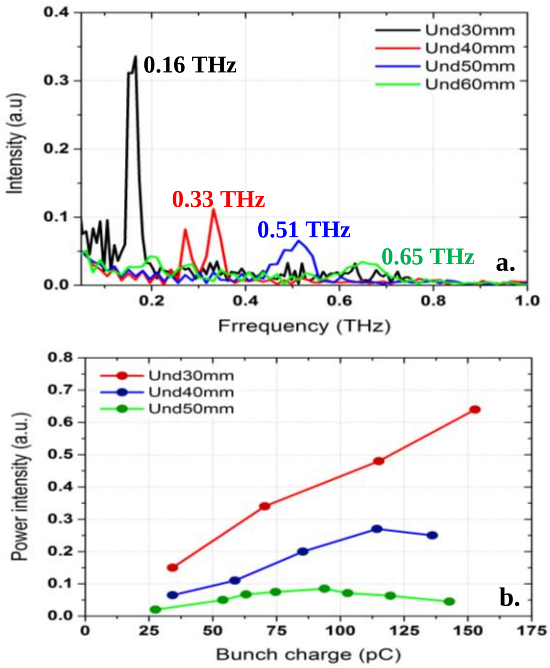

Figure 2 (a) Power spectrum with the bunch charge of 60 pC.
(b) Power intensity as a function bunch charge.

Summary

The THz CUR can be generated in the frequency range from 0.16 – 0.65 THz if the bunch charge is lower than 60 pC. At the frequencies above 0.51 THz with high bunch charge, the radiation intensity is extremely low because there is high space charge effect and degradation of bunch form factor.

References

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