Electric Field Detection of Terahertz Coherent Synchrotron Radiation and Its Application

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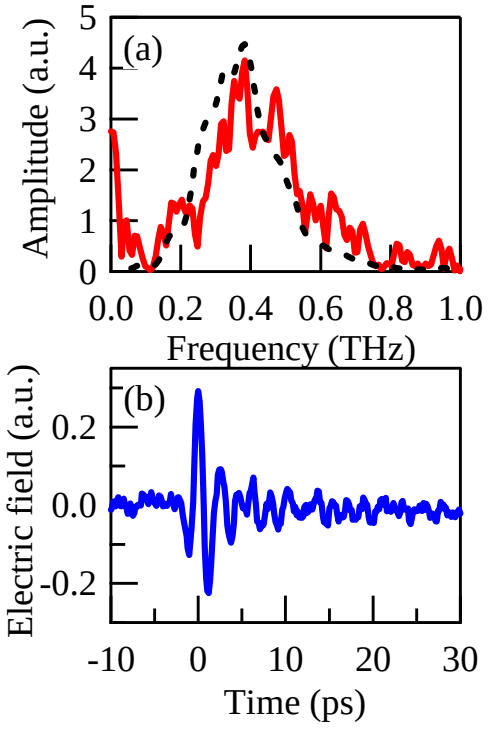
The electric field detection of the coherent synchrotron radiation (CSR) from the UVSOR-II Electron Storage Ring generated with a laser bunch slicing technique has been demonstrated in terahertz region. The electro-optic sampling method with a 24-m-long.photonic crystal fiber for the delivery of the probe laser was used for the field resolved detection. The observed wave form of the electric field was stable.

Synchrotron radiation has been widely used for broadband spectroscopy ranging from far-infrared to X-ray region due to its high brilliance. However, most of the spectral components are basically incoherent and cannot be used for time-domain spectroscopy (TDS). On the other hand, it is well known that the CSR is generated in the microwave frequency range due to the longitudinal density profile of the electron bunch whose duration is typically 100 ps in a storage ring. In order to demonstrate the high potential of the CSR as an intense light source for coherent spectroscopy, the laser bunch slicing technique was successfully used for the expansion of the CSR frequency up to terahertz range [1,2]. Since the power of CSR scales quadratically with the number of electrons in the bunch, this light source can be a promising candidate for nonlinear and coherent terahertz spectroscopy. In the present work, we demonstrate that the electric field of the CSR produced by the laser bunch slicing can be observed with the electro-optic sampling method and show that the waveform is very stable if the current flow in the storage ring is kept constant.

In this experiment, we used an undulator to couple the electric field of a regenerative amplifier laser with the electron bunch to produce the energy modulation. The energy-modulated electron bunch passes through the bending magnets and a picoseconds dip is induced due to the different path length of the electrons with different energy in the magnet. The dip generates the CSR in the terahertz frequency region, which is detected with the probe pulses. The probe is sent through a 24-m-long fiber from the oscillator placed at the laser booth. The electric field was detected with electro-optic sampling method using a ZnTe crystal. The observed spectrum and electric field is shown in Figs. (a) and (b), respectively. The spectrum corresponds well to that observed with an FT-FIR spectrometer with an InSb bolometer as shown by the dashed line. The result indicates that most of the spectral radiation in the terahertz range is coherent and stable, and the CSR can be applied to the THz-TDS.



This work was done by a collaboration of I. Katayama of Yokohama National University, H. Shimosato, M. Bito, and K. Furusawa of Osaka University, M. Shimada of High Energy Accelerator Research Organization, N. Yamamoto and M. Hosaka of Nagoya University, and M. Adachi, H. Zen, S. Kimura, and Masahiro Katoh of UVSOR, Institute of Molecular Science.

[1] M. Shimada et al., Phys. Rev. Lett. **103** (2009) 144802.
[2] S. Bielauski et al., Nat. Phys. **4** (2008) 390.