The experimental progress for the strong field Terahertz radiation at SXFEL

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Introduction

Strong field Terahertz (THz) light source has been increasingly important for many scientific frontiers, while it is still a challenge to obtain THz radiation with high pulse energy at wide-tunable frequency. In this paper, we introduce an accelerator-based strong filed THz light source to obtain coherent THz radiation with high pulse energy and tunable frequency and X-ray pulse at the same time, which adopts a frequency beating laser pulse modulated electron beam. Here, we present the experimental progress for the strong filed THz radiation at shanghai soft X-ray free-electron laser (SXFEL) facility and show its simulated radiation performance.

Working Principle

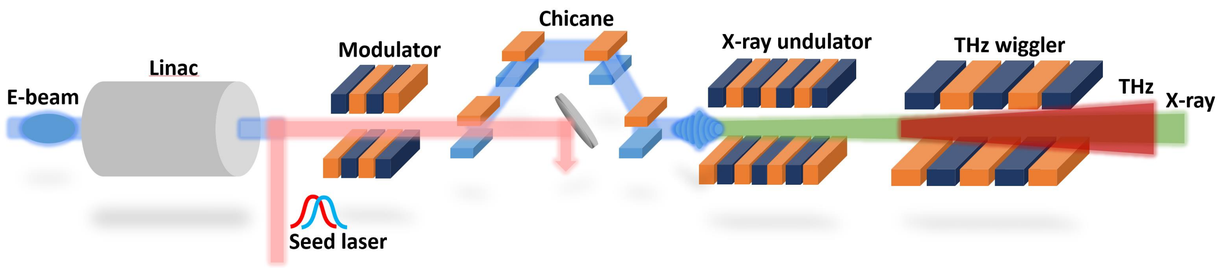
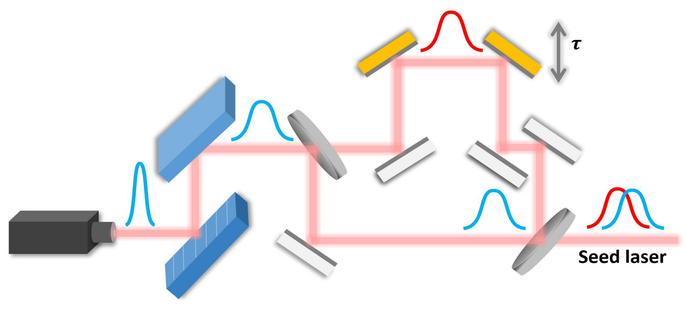


Figure 1: The layout of a strong field THz radiation based on laser modulated electron beam.



$$f = \frac{\tau}{\pi\sigma\sigma_n} \cong \frac{\mu\tau}{2\pi}$$

Figure 2: The layout of the frequency beating laser pulse.

Frequency beating Laser

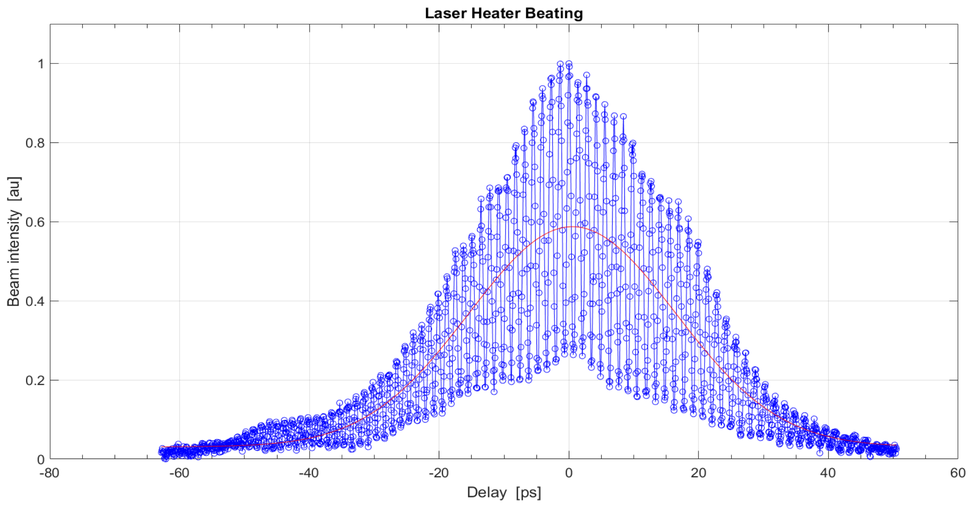


Figure 3: The frequency beating optical path and the measured longitudinal profile after optical path.

Based on the layout of Figure 2, an actual beating frequency optical path has been built together with the laser heater optical path, which has been shown in Figure 3 (a). To verify the performance of the optical path, the longitudinal profile at the exit of the optical path has been measured by using the driven laser, and the results are also shown in the Figure 3 (b). One can find a frequency beating structure at THz frequency exists along the longitudinal profile.

THz undulator

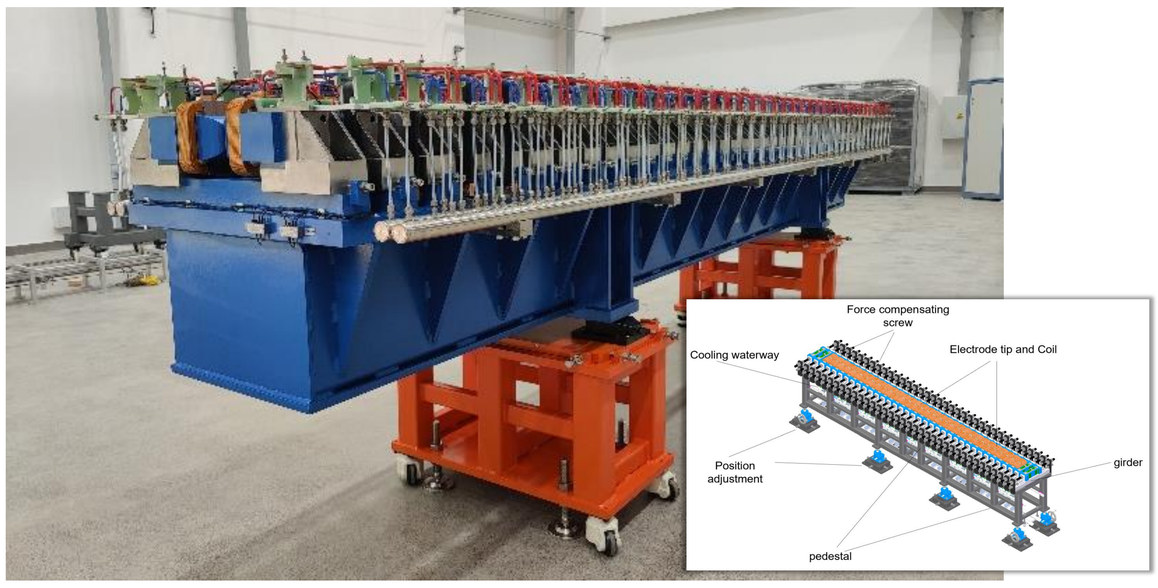


Figure 4 The THz undulator for SXFEL.

Table : The basic parameters of THz undulator.

Parameter	Value	Unit
Type	Electromagnetic	-
Period	280/560	mm
Total length	5	m
Efficient peak magnetic field	0.8-1.78	T
ΔK/K	1.4e-4	-
Phase error	<5	degree

The THz undulator is shown in Figure 4, and the THz undulator parameters are also presented. The undulator adopts an electromagnetic undulator with a changeable undulator magnetic period of 280 or 560 mm. The total length of the undulator is about 5m with about 18 magnetic of 280 mm. The THz undulator will be installed before the dump and after the X-ray undulator.

THz beam line

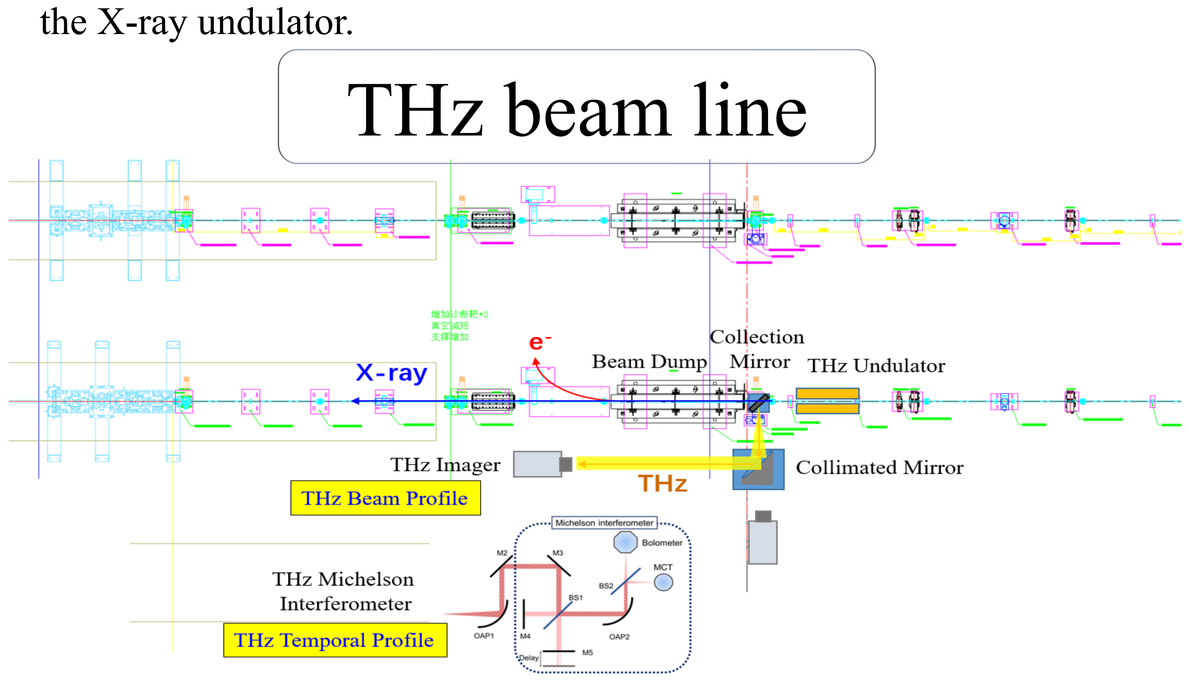


Figure 5 the layout of THz undulator and THz diagnostic line.

After the THz undulator, there will a THz mirror with a 3 mm hole to reflect the THz radiation to the downstream THz diagnostic line and transfer the X-ray to beam line. In the THz diagnostic line, a michelson interferometer will be installed to detect the radiation pulse energy, THz image and THz temporal profile will also be installed to measure the transverse and temporal image. Figure 5 show the detail information about the basic layout of THz diagnostic line at SXFEL.

Conclusion

In conclusion, we have introduced the strong field THz radiation technique, which can generate THz radiation with high pulse energy and tunable wavelength by using a frequency beating laser pulse modulated electron beam. The basic working principle and the experimental progress including frequency beating laser, THz undulator and THz diagnostic line are presented. The simulations of the technique are also presented, and the results show that the THz undulator with a total length of 5 m can produce THz radiation with a peak power 0.58 GW and a pulse energy below 1 mJ. The experiment will be carried out at SXFEL in the following years.