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Sub-cycle Terahertz Diagnostics

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The terahertz frequency range is located between the realms of electronics and optics in the electromagnetic spectrum. Light-matter interaction in this sub-mm wavelength range can therefore happen via both continuous and quantized processes, strongly dependent on material properties. The THz electric field can accelerate quasi-free carriers, but also excite rotational and low-lying vibrational degress of freedom as well as spin dynamics and other collective low-energy modes.

The detection methods for terahertz radiation are therefore comparably diverse. There is the class of incoherent detectors which basically measure the (electronic) heat of the absorbed THz light. These are Golay cells, pyroelectric detectors and bolometers, as well as Schottky diodes. Due to the comparably low oscillation frequency of the THz waves - 1 ps per cycle at 1 THz - coherent detection is technically feasible using short, i.e. fs, optical probe pulses. Sampling techniques, such as electro-optic sampling (EOS) or the use of photoconductive antennas enable the precise measurement of amplitude and phase of the actual THz field transients. In my presentation I will give an overview of the above mentioned THz detection methods and provide some detailed insight into our work on ultrafast THz-based diagnostics of accelerator-based light sources. At the TELBE THz facility at HZDR we employ single shot EOS to measure and adjust the timing jitter between accelerator-based THz and optical laser systems. This scheme can be extended to monitor the phase of a CEP-unstable free-electron laser, enabling phase-resolved experiments to be performed after the application of a sorting algorithm. A proof-of-principle experiment was recently carried out at the FELBE free-electron laser at HZDR. Furthermore, converting XUV pulses into THz radiation yields a powerful diagnostic tool for accurately measuring the timing and intensity of XUV sources, such as XFELs.

Summary

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