Description of the PhD-project

Thesis: "Investigations of Impedance and Multi-bunch Effects on the Emission of coherent THz radiation"

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Introduction

The ANKA synchrotron light source situated at the Karlsruhe Institute of Technology (KIT) is a multipurpose facility for investigation of matter using synchrotron radiation. The electrons are accumulated at 500 MeV during the injection procedure. After that the beam energy can be ramped up to a nominal beam energy of 2.5 GeV. Using dedicated low-α_c-optics at ANKA we can reduce the bunch length and generate Coherent Synchrotron Radiation (CSR) in the THz range. In recent years research activity on CSR at ANKA [1] has steadily increased. Studies of the coherent emission in the time domain and spectral measurements in the THz range allow us to gain insight into the longitudinal bunch dynamics. [2]

Importance and aims of research

In regular user operation, the radiated power at long wavelengths (THz and microwave range) of the incoherent synchrotron radiation is very low and cannot be used for experiments. To overcome this limitation a dedicated low-α_c-optics was developed for the ANKA storage ring [3]. In this mode the momentum compaction factor and thus the bunch length is significantly reduced. As the bunch length gets shorter the radiated power for wavelengths that are longer than the bunch length increases drastically (CSR). The advantage of coherent compared to incoherent emission is, that the radiation power scales with the square of the particle number contributing to the coherent effect instead of linear scaling law. Hence significant amplification factor of $10^6 - 10^9$ can be achieved. The main challenge is the characterization of longitudinal dynamics of these ultra compressed bunches and understanding of corresponding collective effects. For example, the electrons in the front of a high density bunch can be influenced by a strong CSR self-field. This can initiate a process of microbunching. As CSR power depends strongly on the bunch length and shape, the microbunching leads to high amplitude, time dependent bursts of THz power. [4] The bursting behavior is not yet fully understood. Furthermore it was shown that there are many of interesting CSR phenomena based on influence of the geometric impedance and of different structures of the filling pattern of the storage ring.

Status and outlook

For time domain studies of bursting CSR, an external sampling method was employed that allows detailed systematic studies of longitudinal instability spectra. With the achieved high resolution over a wide frequency range, intriguing structures at very low bursting frequencies could be revealed. It has been shown using a scraper that there is a gain of CSR due to the change of geometric impedance. A Martin-Puplett Interferometer was commissioned for the frequency domain diagnostics of CSR at the ANKA storage ring. Commissioning of first version of a dedicated FPGA data acquisition board at ANKA in collaboration with the Institute for Data Processing and Electronics (IPE) at KIT was successfully done. Using this system it will be possible to record a THz signal simultaneously for all electron buckets for investigation of bunch-bunch interactions [2] and thus to study the CSR dynamics of a single bunch in a multi-bunch environment.

References

[1] A.-S. Müller et al., Exp. Aspects of CSR in the ANKA Storage Ring, B.-D. Newsletter No. 57, 2012

[2] V. Judin et al., Spectral and temporal observations of CSR at ANKA, IPAC 2012

[3] A.-S. Müller et al., Far Infrared Coherent Synchrotron Edge Radiation at ANKA, PAC 2005

[4] V. Judin et al., Observation of bursting behavior using multiturn measurements at ANKA, IPAC 2010