Closing remarks – Session 2

Ursula van Rienen
Scientific secretary: Mario S. Beck

22. September 2017
Session 2.1: Impedance theory and modeling (Chair: Ursula van Rienen, University of Rostock, DE)

- Wakefields/impedances for a bunch moving between two corrugated plates (20’)
  (Karl Bane, SLAC, US)

- Calculation of wakefields for plasma-wakefield accelerators (20’)
  (Gennady Stupakov, SLAC, US)

- Advanced methods of wakefield calculations – numerical methods, parallel computing (20’)
  (Erion Gjonaj, TU-Darmstadt, DE)

- Analytical impedance models for very short bunches (20’)
  (Igor Zagorodnov, DESY, DE)
Session 2.1: Impedance theory and modeling
(Chair: Ursula van Rienen, University of Rostock, DE)

- Analytical approaches for specific wakefield calculations
- Generic numerical approach for wakefield calculations
- Analytical approach for specific wakefield calculations
Wakefields/Impedances for a Bunch Moving Between Two Corrugated Plates

Karl Bane
SLAC National Accelerator Laboratory

ICFA mini-Workshop on Impedances and Beam Instabilities in Particle Accelerators
18–22 September 2017
Benevento, Italy
Concept of an adjustable corrugated dechirper for passive control of energy chirp; installed at LCLS – here used as fast kicker

Analytical surface impedance approach for the wake in case of one/two corrugated plate(s); numerical and experimental validation

(From right to left) the beam passes through: the vertical dechirper module, a quad, and the horizontal module

Detail showing the corrugated plates and their supports
Calculation of wakefields for plasma-wakefield accelerators

G. Stupakov, SLAC

ICFA mini-Workshop on Impedances and Beam Instabilities in Particle Accelerators

18-22 September 2017
Here, wakefields in plasma w.r.t. to witness bunch itself (leading charges acting on trailing charges)

Analytical wake calculation in the blow-out regime from Maxwell's equations using correct plasma response

With that: BBU instability of witness bunch; projected emittance

I developed theory that calculates a jump in $E_z$ immediately behind the witness charge, $\Delta E_z(r, \xi)$. Remarkably, the theory predicts that this jump is proportional to the (dimensionless) witness charge $\gamma_w$ (the charge has not to be small). So we can introduce the longitudinal wake is $w_l = \Delta E_z(0, \xi)/\gamma_w$.  

One way to characterize BBU is to calculate the projected emittance:

$$
\epsilon^2_{proj}(s) = \langle (X - \bar{X})^2 \rangle \langle (X' - \bar{X}')^2 \rangle - \langle (X - \bar{X}) (X' - \bar{X}') \rangle
$$

where the averaging means

$$
\langle \ldots \rangle = \int dz (\ldots) f_W(z)
$$
Wakefield calculations with PBCI

Erion Gjonaj, Andranik Tsakanian
Institut für Theorie Elektromagnetischer Felder (TEMF),
Technische Universität Darmstadt, Germany

ICFA Mini-Workshop on Impedances and Beam Instabilities in Particle Accelerators
Benevento, 18–22 September, 2017
2-1-3 Erion Gjonaj

- Overview over wakefield simulation codes
- PBCI - especially parallelization, moving window, boundary confirming & dispersion-free approach, surface impedance model

**Dispersion-free**

- Exact propagation in the z-direction by splitting of FDTD updates

**Open structures**

- Single plate dechirper (Bane, Stupakov)
Analytical Impedance Models for Very Short Bunches

Igor Zagorodnov

ICFA Workshop on Impedances and Beam Instabilities

Benevento, Italy
19. September 2017
2-1-4 Igor Zagorodnov

- Asymptotic analytical methods for relatively small RMS bunch length for various cases of wakefield formation length - optical, diffraction, surface impedance models; limits; combining with numerical methods
- Formulas for typical structures, each for wakefields and impedances
- Impedance database

### Diffraction Model

**Periodic array of irises (G.Stupakov)**

\[ Z_1(k) = i \frac{Z_0}{\pi ka^2} \left[ 1 + (1+i) \frac{1}{a} \sqrt{\frac{g\pi}{k}} \alpha + i \frac{1}{ka} \right]^{-1} \]

**Periodic array of cavities (my guess)**

\[ Z_1(k) = i \frac{Z_0}{\pi ka^2} \left[ 1 + (1+i) \frac{p}{a} \sqrt{\frac{\pi}{kg}} \alpha \left( \frac{g}{p} \right) + i \frac{p}{a kg} \right]^{-1} \]

\[ \eta = \left[ \frac{1-i}{2} \alpha \left( \frac{g}{p} \right) p \sqrt{\frac{k\pi}{g}} + \frac{1}{2} \frac{p}{g} \right]^{-1} \]

### Impedance Database

**Wake potential for arbitrary bunch shape**

\[ W(s) = -\int_{-\infty}^{s} w^{(0)}(s-s') \lambda(s') ds' - \frac{1}{C} \int_{-\infty}^{s} \lambda(s') ds' - R \alpha \lambda(s) - \]

\[ -c^2 L \lambda''(s) - c \int_{-\infty}^{s} w^{(-1)}(s-s') \lambda'(s) ds' \]

derivative of the bunch shape
Multi-physics simulations of impedance effects in accelerators (20’)

(Carlo Zannini, ADAM, CH)

Impedance Issues in the Design, Measurements, and Beam Commissioning of a Narrow Gap Stripline Kicker For On-Axis Injection (20’)

(Stefano De Santis, Lawrence Berkeley National Laboratory, US)

Eigenmode Computations for Chains of Cavities (20’)

(Thomas Flisgen, Helmholtz-Zentrum Berlin für Materialien und Energie, DE)

Birth and the Childhood of Coupling Impedance and Stability Maps!

(Vittorio Giorgio Vaccaro, Università di Napoli Federico II, IT)
Multiphysics simulation flow for impedance computations

Challenges in impedance computation
In case of very small apertures

Efficient field computation for long and complex chains of components

★ Birth and the Childhood of Coupling Impedance and Stability Maps!
(Vittorio Giorgio Vaccaro, Università di Napoli Federico II, IT)
Multiphysics simulations of impedance effects in accelerators

C. Zannini
Workflow for multi-physics simulations – in general and specifically for impedance calculations

Importance of considering the impedance in the design phase of accelerator components

Multiphysics simulations

Multiphysics treats simulations that involve multiple physical models:
- Electromagnetic simulations
- Impedance
  - Effect on Beam
  - Induced effects

Multiphysics design loop for electromagnetic components

Commercial FEM simulation codes allow performing the multiphysics design loop

Example: CERN-SPS extraction kicker

Beam induced heating model


The impedance model of the SPS extraction kicker with and without serigraphy can explain the beam induced heating observed in the SPS machine.
Impedance Issues in the Design, Measurements, and Commissioning of a Narrow Gap Stripline Kicker For On-Axis Injection

S. De Santis
ICFA mini-Workshop On Impedances and Beam Instabilities in Particle Accelerators Benevento, September 19th, 2017
‘Swap-out’ injection at ALS-U; design of a corresponding kicker – smallest aperture kicker ever installed

Comparison of simulations to observations with beam

Pushing parameters to extremes changes their influence

Traditional off-axis injection

On-axis swap-out injection

(Initially proposed by M. Borland)

Existing ALS ring

New accumulator ring

New ALS-U ring

Longitudinal tapers to reduce beam coupling impedance at high frequency and improve the feedthrough-to-stripline 50 Ω matching

(’D Alesini F Marcellini)
Eigenmode Computations for Chains of Cavities

Johann Heller, Thomas Flisgen, Adolfo Vélez and Ursula van Rienen
SSC (State Space Concatenation) approach – domain decomposition + Model Order Reduction (MOR)

Efficient simulation of cavity chains including couplers & bellows

Example: HOMs in BESSY VSR
The Birth and the Childhood of the Coupling Impedance and the Stability Maps

Vittorio G. Vaccaro

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II and INFN- SEZ. DI NAPOLI

19/05/2017
History of accelerators and beam coupling impedance

The Collider Age

- With increasing energy, the energy available in the Inertial Frame (IF) with fixed targets is incomparably smaller than in the head-on collision (HC), as Wideroe thought some decades before. If we want the same energy in the IF, using fixed targets one should build gigantic accelerators. In the fixed target case, according to relativistic dynamics, an HC-equivalent beam should have the following energy:

$$E_{FT} = 2\gamma_{HC} E_{HC}$$

The colliders were very demanding in terms of intensity and collimation.

Beam-equipment e-m interaction and Dynamics: the Flow Chart (circular accelerators)
The concept of coupling impedance in the plasma wake field excitation as a new tool for describing the self-consistent interaction of the driving beam with the surrounding plasma

Renato Fedele

Dipartimento di Fisica, Università di Napoli “Federico II” and INFN Sezione di Napoli, Napoli, Italy

Not held!
Slides on Indico