

Course Outline Accelerator Physics

Meeting Times: 9:00-12:00, 14:00-17:00

Text: H. Wiedemann, *Particle Accelerator Physics*, 3rd Edition, Springer

Supplementary Texts: K. Wille, *The Physics of Particle Accelerators*, A. W. Chao and M. Tigner, *Handbook of Accelerator Physics and Engineering*, J. D. Jackson, *Classical Electrodynamics*

Grading: Homework Problems 35%; Mid-term Examination 25%; Final Examination 40%

Course Content

Introduction to Accelerators and Short Historical Overview

Basic Units and Definitions

Lorentz Force

Linear Accelerators

Circular Accelerators

- Particle Motion in EM Fields

- Linear Beam Dynamics

- Periodic Systems

- Magnetic Multipoles

- Nonlinear Perturbations

- Coupled Motion

- Synchrotron Radiation

- Radiation Power and Distribution

- Insertion Devices

- X-ray Sources

- Free Electron Lasers

- Technical Components

- Particle Acceleration Cavities and RF Systems

- Spin and Spin Manipulation

- Collective Effects

- Particle Distributions

- Vlasov Equation

- Self-consistent Fields

- Landau Damping

- Beam-Beam Effects

- Relaxation Phenomena

- Radiation Damping

- Toushek effect/IBS

- Beam Cooling

1. INTRODUCTION TO RECIRCULATED LINEAR ACCELERATORS

1.1. Properties of Storage Rings, Linear Accelerators, and Recirculated Linear

Accelerators

1.2. Beam Recirculation: Opportunities and Challenges

1.3. Superconducting RF (SRF)

1.4. Microtrons, Racetrack Microtrons, and Polytrons

1.5. Independent Orbit Recirculators:

1.6. Energy Recovered Linacs (ERLs)

2. INTRODUCTION TO LINEAR OPTICS

2.1. Particle Motion in the Linear Approximation (both Trans and Long.)

2.2. Ellipses in Beam Optics and the Area Theorem

2.3. Unimodular Matrices and their Twiss Parameters

2.4. Hill's Equation and its Solution

2.5. Dispersion Tracking and Longitudinal Stability

2.6. Beam Matching and Rms Emittance

3. SINGLE PARTICLE DYNAMICS

3.1. Longitudinal Dynamics

3.1.1. Longitudinal gymnastics

3.1.2. Longitudinal tune choices

3.1.3. Correcting RF curvature (T566 or sextupoles)

3.1.4. Energy spread estimates

3.2. Transverse Dynamics

3.2.1. Basic considerations

3.2.2. Betatron Motion Damping and Antidamping

3.2.3. RF Focussing

3.2.4. Energy ratio limits

3.2.5. Beam Loss

4. RF ISSUES AND BEAM LOADING

4.1. Cavity Equations

4.2. Optimization of loaded Q

4.3. Energy Recovery

4.4. Fundamental Mode Cooling

4.5. Multiplication Factor and System Efficiency

4.6. RF Instruments

5. COLLECTIVE EFFECTS

5.1. Multibunch

5.1.1. Transverse Instability

5.1.1.1. Cumulative

5.1.1.2. Multipass

5.1.1.2.1. Theory

5.1.1.2.2. Computational Tools

5.1.2. Longitudinal Instability

5.1.3. Ions Effects

5.2. Single Bunch

5.2.1. CSR

5.2.2. Transverse BBU

5.2.3. Longitudinal wakes

5.3. RF Instability

5.4. HOM Cooling

6. PHOTONINJECTORS

6.1. Laser-driven photocathode guns

6.1.1. DC guns

6.1.2. RF guns

6.2. Polarized electron sources

6.3. Examples of high brightness electron sources

7. RADIATION AND BEAM TRANSPORT IN RECIRCULATING LINACS

7.1. Radiation from relativistic electrons

7.2. Quantum fluctuations and particle diffusion

7.3. Aberrations and higher-order transfer maps

7.4. Practical beam optics designs

8. PERFORMANCE OF PRESENT RECIRCULATING LINACS

8.1. Electron beam diagnostics devices

8.2. Feedback systems

8.3. Transverse beam stability

8.4. Energy stability

8.5. Longitudinal beam stability

8.6. Beam polarization

9. FUTURE APPLICATIONS

9.1. CEBAF physics upgrades

9.2. FELs

9.3. Synchrotron Light Sources (ERL,PERL,MARS)

9.4. Electron-Ion Collider (EIC)

