P.N. Ostroumov
September 1, 2023

List of project topics for PHY862 course

1. **Fundamental beam dynamics**

(Reference: "Accelerator Physics" by S.Y. Lee, or "Particle accelerator physics" by H. Wiedemann)

1.1 Stable condition of repeating cells
1.2 Space charge and tune shift
1.3 Nonlinear beam resonances
1.4 Courant Snyder phase space invariant and relation to rms emittance
1.5 Solenoid focusing
1.6 Focusing with electrostatic devices

2. **Accelerator components**

2.1 Betatron oscillations in betatron. (First 5 sections in MIT "Betatrons" report http://web.mit.edu/course/22/22.09/ClassHandouts/Charged%20Particle%20Accel/CHAP11.PDF)
2.2 Optimization of cavity design (The material will be provided later)

References: 1. https://www.classe.cornell.edu/public/SRF/2006/SRF060424-03/SRF060424-03.pdf**; 2.** https://indico.frib.msu.edu/event/38/attachments/159/1141/SRF2021_Tutorial_-_RF_Basics_TM_cavity_design_and_fabrication-_BELOMESTNYKH.pdf**; 3.** https://www.sciencedirect.com/science/article/pii/S0168900218300019 **(see references in this paper); 4.** https://accelconf.web.cern.ch/ipac2018/papers/thpal035.pdf

2.3 SRF topics: Multi-cell field flatness tuning (***H. Padamsee et al. "RF Superconductivity for Accelerators", John Wiley and Sons.***)
2.4 SRF topics: SC cavity testing (***H. Padamsee et al. "RF Superconductivity for Accelerators", John Wiley and Sons.***)
2.5 Diagnostic instruments of hadron accelerators (Techniques for measurement of beam emittance, P. Strehl, "Beam Instrumentation and Diagnostics", Springer; Electromagnetic reciprocity relations, G. Lambertson, "Dynamic Devices -Pickups and Kickers", AIP Conference Proceedings153, 1413, 2016, doi:http://dx.doi.org/10.1063/1.36380)
2.6 Basic design and engineering of normal-conducting, iron-dominated electromagnets (***Proceedings of CERN Particle Accelerator School, http://cds.cern.ch/record/1158462/files/cern-2010-004.pdf?version=1***)
2.7 Eddy currents in accelerator magnets (***Proceedings of CERN Particle Accelerator School, http://cds.cern.ch/record/1158462/files/cern-2010-004.pdf?version=1***)
2.8 Thermionic and Photo-emission Electron Guns (https://uspas.fnal.gov/materials/08UCSC/Lecture2_EmissionStatisticsCathodeEmittance.pdf)

2.9 Proton and Heavy Ion sources (The Physics and Technology of Ion Source, I. G. Brown, New York)

2.10 Design of Cryogenics sub-systems (***See 6 problems on cryogenic topics and select 2 problems***)
Radio Frequency Quadrupoles (RFQ) (Chapter 8 in RF Linear Accelerators. 2nd edition. Thomas P. Wangler, Copyright 2008 Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim ISBN: 978-3-527-40680-7)

2.11 Heavy Ion Storage Rings. Literature: A. "Heavy-ion storage rings and their use in precision experiments with highly charged"
www.sciencedirect.com/science/article/pii/S0146641020300582
B. TSR: A storage and cooling ring for HIE-ISOLDE,
https://www.sciencedirect.com/science/article/pii/S0168583X15012501?via%3Dihub
C. THE RARE-RI RING AT RIKEN RI BEAM FACTORY
https://accelconf.web.cern.ch/HIAT2015/papers/tum1c03.pdf
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.128.152701

3. Applications

3.1 Lattice optimization for synchrotron light source (USPAS lecture note: https://casa.jlab.org/publications/viewgraphs/USPAS2018/Lectures/L_8_Low_Emitt_Latt_DBA.pdf)

3.2 Fundamentals of free electron laser (USPAS lecture note: https://uspas.fnal.gov/materials/14UNM/1_Introduction.pdf)

3.3 Hadron/Lepton/Electron-Ion colliders; Luminosity considerations. (CERN Particle Accelerator School: http://cas.web.cern.ch/sites/cas.web.cern.ch/files/lectures/zurich-2018/luminosity.pdf)

4. Special topics

4.1 Beam cooling methods (M. Blaskiewicz, "Cooling of High-Energy Hadron Beams", https://www.annualreviews.org/doi/pdf/10.1146/annurev-nucl-102313-025427)

4.2 Beam lifetime considerations (USPAS lecture note: https://casa.jlab.org/publications/viewgraphs/USPAS2011/USPAS2011Lect18.pdf)

4.3 Advanced concepts of beam accelerations (***S. Hooker, Lecture "Advanced Concepts for Laser-Driven Acceleration" at CERN Accelerator School http://cas.web.cern.ch/sites/cas.web.cern.ch/files/lectures/egham-2017/laser-drivenaccelerators.pdf***)

4.4 Self-consistent beam simulation methods with Particle In Cell codes. https://uspas.fnal.gov/materials/09UNM/ComputationalMethods.pdf

Assignments