PHYS 659: Special Problem in Physics Source of Bright Electron Beams (2 cr)

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CATALOGUE DESCRIPTION

Course Summary: During this course, the students will explore the Physics of bright electron-beam generation. Specifically the student will develop an understanding of key effects impacting the brightness of electron beams by analyzing published work, using lecture note from previous courses, and via numerical simulation. The student will also be able to apply the concepts by modeling an existing electron source.

Prerequisites: N/A.

CONTACT

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CLASS MEETINGS

Once a week (Monday or Tuesday) for two hours (one 1-hr oneline group meeting, and one 1-hr one-to-one meeting online or in person)

COURSE DESCRIPTION

Bright electron beams have a large number of widespread applications. The can be used as a direct probe to investigate material in, e.g., electron microscope, or accelerated to TeV energies for exploring elementary particle Physics. Likewise, the electron source can be used to produce a copious amount of coherent electromagnetic radiation from the microwave to gamma-ray photon energies using the so-called free-electron laser principle.

The class will be a mix of paper reading, discussion, and hands-on work using a simple beam-dynamics program. The goal will be to understand the principle of bright-electron-bunch generation including the physics of photocathodes and associated laser systems. A lot of the material will follow D. Dowell's class; see the USPAS webpage

1. Bright electron sources overview & application [reading BES report on electron source]

2. What is a beam? Refresh on classical mechanics and electrodynamics. Beam phase space and connection to macroscopic quantities (e.g. emittances).

3. The physics of electron emission [reading Electron emission & Cathode emittance]

4. Modeling electron beam emission and transport: Introduction to ASTRA [program available at from DESY at A Space Charge Tracking Algorithm and WARP-X [program available from Berkeley at WarpX documentation].

5. Acceleration to relativist energies: DC versus radiofrequency acceleration [introduction to SUPERFISH & POISSON from Los Alamos, reading rf-induced beam dynamics in rf guns and accelerating cavities]

6. Low-energy electron transport: solenoidal lenses [reading Understanding the focusing of charged particle beams in a solenoid magnetic field, modeling with the POISSON solver (available from Los Alamos)]

7. Collective effects: space-charge effects, image charge and emission limitation [reading to be provided]

8. Project (will be started in parallel to the class sometime at the end of September) on the modeling of an electron source with Astra, Poisson, and Superfish (will result in the final report). The facility to be modeled will tentatively be the ACT facility at ANL [see Argonne Cathode Test-stand (ACT)]. A visit of the facility will be organized if possible (i.e. if ANL has lifted its COVID-19 access-related restriction)

ASSESSMENT & GRADING

The students are expected to attend a weekly group meeting and discuss their reading with some homework based on the reading will be given (e.g. rederiving some equation, checking results from paper via numerical simulations). Besides, the student will have to write reports summarizing the outcome of a small project (in the present case modeling of an electron source). The final report will count for 40% of the final grade, the homework for 30%, and attendance/participation in weekly meetings and discussion for 30%.

The numeric grade (100 points maximum) will be computed given a letter grade will be assigned following the table below.

Letter grade	Percentage points.
A	≥ 85
A-	≥ 80
B+	≥ 75
B	≥ 70
B-	≥ 65
C+	≥ 60
C	≥ 55
D	≥ 50
F	< 50

Further information on NIU grading system can be found at:
http://www.niu.edu/regrec/grading/gradingfaqs.shtml

STUDENT RESPONSIBILITIES

The students are expected to be engaged researchers carrying their work safely and with the highest integrity.

ACCESSIBILITY

If you need an accommodation for this class, please contact the Disability Resource Center (RDC) as soon as possible. The DRC coordinates accommodations for students with disabilities. It is located on the 4th floor of the Health Services Building, and can be reached at 815-753-1303 (V) or drc@niu.edu. Also, please contact me privately as soon as possible so we can discuss your accommodations. The sooner you let us know your needs, the sooner we can assist you in achieving your learning goals in this course.