



# **VUV and X-ray Free-Electron Lasers**

## **Introduction**

Dinh C. Nguyen,<sup>1</sup> Petr Anisimov,<sup>2</sup> Nicole Neveu<sup>1</sup>

<sup>1</sup> SLAC National Accelerator Laboratory

<sup>2</sup> Los Alamos National Laboratory

Yuanshen Li (grader)

University of Chicago



# Course Overview 1

## FEL Materials Lectures

There will be six morning sessions for the FEL course materials, Monday-Tuesday of the first week, and Monday-Thursday of the second week.

Morning (10:00 – Noon Central)

Lecturer: Dinh Nguyen

- FEL\_1 (Jan 25) Introduction, Undulator Motions, Undulator Radiation & How an FEL Works
- FEL\_2 (Jan 26) SASE, 1D Theory of High-gain FEL & 3D Parameterization
- FEL\_3 (Feb 1) SASE Self-Seeding, RAFEL, XFEL & Low-gain FELs
- FEL\_4 (Feb 2) Non-linear Harmonic Generation, HHG & EEHG
- FEL\_5 (Feb 3) Photoinjectors, Emittance, Photoinjector Designs & Optimization
- FEL\_6 (Feb 4) Bunch Compression, CSR, Microbunching Instabilities & Laser Heater

# Course Overview 2

## FEL Simulations Lectures & Projects

There will be three morning sessions for the FEL simulations, Wed-Fri of the first week.

Morning (10:00 – Noon Central)

Lecturer: Petr Anisimov

- SIM\_1 (Jan 27) Introduction to FEL Simulations
- SIM\_2 (Jan 28) Time-independent 3D FEL Simulations
- SIM\_3 (Jan 29) Time-dependent FEL Simulations

There will be no lectures on Friday Feb 5. The morning of Friday Feb 5 will be reserved for students to present their FEL simulation projects.

# Course Overview 3

## FEL Simulations Lab

Afternoon Labs (2:00 PM – 3:00 PM Central)

Laboratory Assistants: Nicole Neveu and Petr Anisimov

- LAB\_1 (Jan 25) Computer & software install; Genesis 2.0 install; Running LUME-Genesis
- LAB\_2 (Jan 26) 1D FEL exercise
- LAB\_3 (Jan 27) 1D FEL with seed, SASE, detuning
- LAB\_4 (Jan 28) Time-independent 3D Genesis simulations
- LAB\_5 (Jan 29) Time-dependent Genesis exercise; Simulation Project begins
- LAB\_6 (Feb 1) Simulation Project
- LAB\_7 (Feb 2) Simulation Project
- LAB\_8 (Feb 3) Simulation Project

# Course Overview 4

## Homework & Final Exam

Homework assignments will be handed out at noon on the following days:

- Monday (Jan 25) Homework assignment 1 (due at 10 AM Wed Jan 27)
- Wednesday (Jan 27) Homework assignment 2 (due at 10 AM Fri Jan 29)
- Friday (Jan 29) Homework assignment 3 (due at 10 AM Mon Feb 1)
- Monday (Feb 1) Homework assignment 4 (due at 10 AM Wed Feb 3)
- Thursday (Feb 4) No assignments; Take-home final exam is handed out.  
The final exam is due at 10 AM Friday Feb 5.

Homework assignments and final exam are to be submitted to the student's private Sirepo folder. Homework help sessions are scheduled for 4-5 PM the evenings before the due dates.

# Schedule at a Glance (First Week)

	Jan 25 Monday	Jan 26 Tuesday	Jan 27 Wednesday	Jan 28 Thursday	Jan 29 Friday	
<b>Time (Central)</b>						
10:00 - 10:30 AM	FEL_1 Lecture	FEL_2 Lecture	Homework 1 due 10 AM	SIM_2 Lecture	Homework 2 due 10 AM	
10:30 - 11:00 AM			SIM_1 Lecture		SIM_3 Lecture	
11:00 - 11:30 AM			Homework 1 handed out		Homework 2 handed out	Homework 3 handed out
11:30 AM - Noon			Lunch Break		Lunch Break	Lunch Break
2:00 - 2:30 PM	LAB_1 Laboratory	LAB_2 Laboratory	LAB_3 Laboratory	LAB_4 Laboratory	LAB_5 Laboratory	
2:30 - 3:00 PM						
4:00 - 5:00 PM		Homework 1 help session		Homework 2 help session		

# Schedule at a Glance (Second Week)

	Feb 1	Feb 2	Feb 3	Feb 4	Feb 5
Time (Central)	Monday	Tuesday	Wednesday	Thursday	Friday
10:00 - 10:30 AM	Homework 3 due 10 AM		Homework 4 due 10 AM	Lab Project due 10 AM	Final Exam due 10 AM
10:30 - 11:00 AM	FEL_3 Lecture	FEL_4 Lecture	FEL_5 Lecture	FEL_6 Lecture	FEL Simulations Projects (Student Presentations)
11:00 - 11:30 AM					
11:30 AM - Noon	Homework 4 handed out			Final Exam handed out	Class is over!
	Lunch Break	Lunch Break	Lunch Break	Lunch Break	
2:00 - 2:30 PM	LAB_6 Project	LAB_7 Project	LAB_8 Project	No Lab	
2:30 - 3:00 PM					
4:00 - 5:00 PM	Lab Project help session	Homework 4 help session	Lab Project help session		

# Textbook and Useful Links

“Free-Electron Lasers in the UV and X-ray Regime”

P. Schmüser, M. Dohlus, J. Rössbach and C. Behrens

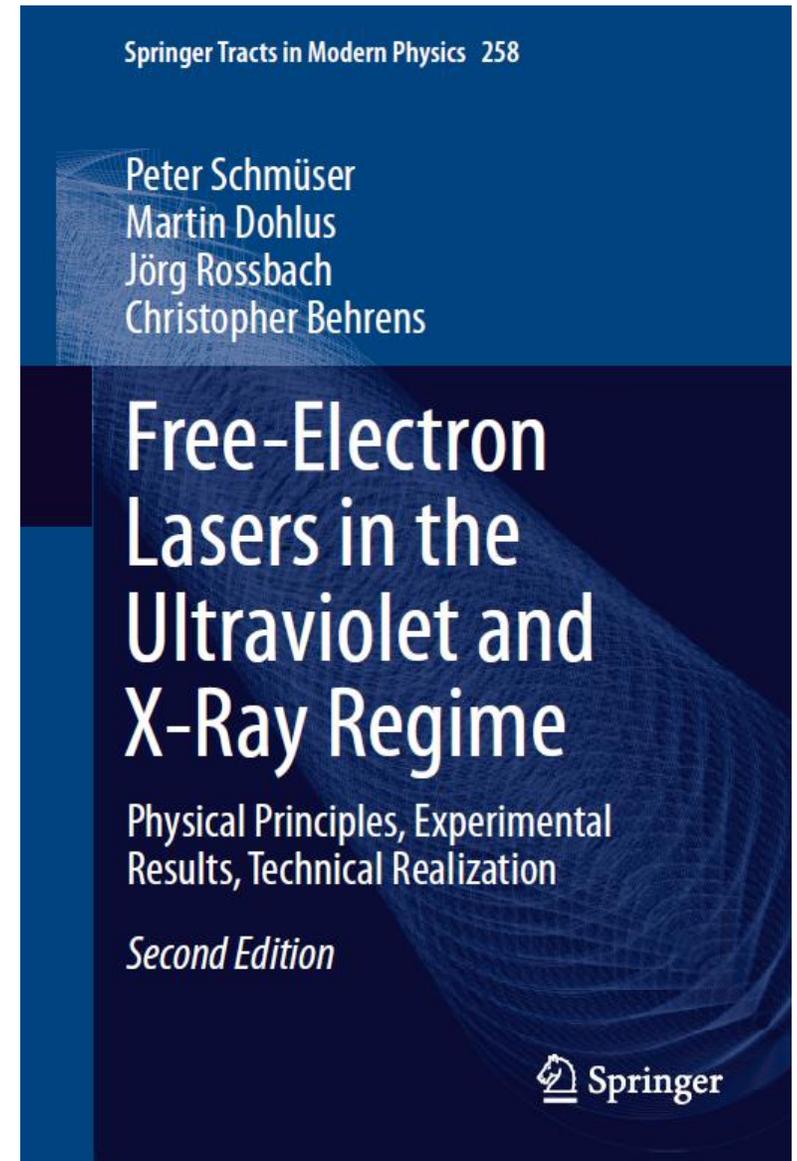
Second Edition

Springer Tracts in Modern Physics V. 258

Sirepo: <https://www.sirepo.com/>

SRW <https://www.sirepo.com/srw#/simulations>

Genesis: <http://genesis.web.psi.ch/download.html>



# Class Materials Repositories & Links

The lecture notes and recorded videos of the Zoom lectures will be posted on the USPAS website which can be accessed via the following link:

<https://uspas.fnal.gov/materials/materials-table.shtml>

The python scripts for FEL Simulations can be found at the following repository:

<https://github.com/uspas/FEL2021> (You need to sign in to your github account before clicking on this)

A Slack channel has been set up for the USPAS FEL Q&A and help sessions:

Slack channel: SLAC #uspas-fel

# Grades and Attendance Rules

1. The morning lectures are mandatory; attendance will be monitored.
2. Participation in the Lab work is also mandatory (40% of the course grade)
3. Homework assignments are required and constitute 40% of the grade.
4. The take-home final exam constitutes 20% of the course grade