Computational Photonics

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SS 2019
Introduction
What problems are solved by Computational Photonics?

**Development**
- Design of structures with a certain functionality
- Performance evaluation prior to fabrication
- Tolerance management

**Research**
- Unveiling inaccessible properties (electromagnetic field distribution)
- Checking physical models / theories
Introduction

• What is Computational Photonics?
  – rather unspecific name
  – different levels of abstraction:
    • Ray Optics → “Optical System Design” (Prof. Groß)
    • Wave Optics → “Optical Modelling” (Prof. Wyrowski / Zeitner)
    • EM Optics → this course
    • Quantum Optics → Dr. Setzpfandt

This course takes an electromagnetic field-based approach on optics with a focus on numerical methods for partial differential equations. We will take a research-oriented approach.
Introduction

• For whom is this course?

<table>
<thead>
<tr>
<th>Intrinsic motivation</th>
<th>Extrinsic motivation</th>
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<tbody>
<tr>
<td>You follow a research-oriented career path</td>
<td>Modern topic in a CV</td>
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<tr>
<td>You want to gain deeper numerical insight into electromagnetic theory</td>
<td>“easy credit points” (true?)</td>
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<tr>
<td>You want to enhance your already existing coding skills</td>
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<tr>
<td>You think Maxwell’s equations are the coolest thing you’ve ever seen and want to learn how to deal with them in real world situations</td>
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• Alternatives to this course
  – Courses “Optical System Design” and “Waveoptical Modelling” take a much more industry-oriented approach and need less basic programming skills to succeed
• Prerequisites
  – Good basic knowledge in MATLAB or Python (this is not a basic programming course!)
  – Solid mathematical background in PDE
  – Knowledge about electromagnetic field theory (Bachelor level Electrodynamics or Master level Fundamentals of modern optics)
  – Knowledge about numerical basic techniques on a Bachelor level (see 1st seminar & additional material)
Organization
Organization

- People

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Python expert
MATLAB expert

LECTURE

SEMINAR
• **Lecture**  
  – every Friday (not next week Apr 19: public holiday!)  
    08:30-10:00 am, Auditorium ACP  

• **Seminars**  
  – biweekly Friday 10:15-11:45 am, Computer Pool ACP  
    (depending on # of participants, will be announced)  
  – you get 5 homework programming tasks which you have to hand in, but they are not graded  
  – they are discussed in the seminars (you get feedback)  

• **Grading**  
  – You write a final exam. The questions will derive ≈70% from the lecture and ≈30% from the seminar tasks. The seminars themselves are for learning (no seminar grades)
• **Resources**
  
  – Website: [www.iap.uni-jena.de/teaching.html](http://www.iap.uni-jena.de/teaching.html)
  
  – Moodle: [moodle.uni-jena.de](http://moodle.uni-jena.de)
    (under construction)
  
  – Pingo: [pingo.coactum.de/421066](http://pingo.coactum.de/421066)
    (Live Feedback session code)
  
  – e-Mail: [teaching-nanooptics@uni-jena.de](mailto:teaching-nanooptics@uni-jena.de)
    (all your seminar solutions go there as a zip archive! See seminars for details)
Topics
• Matrix Method for stratified media

• Mode solvers
Topics

- Finite Difference Time Domain (FDTD)
- Beam Propagation Method (BPM)
Topics

• Fourier Modal Method (FMM)

• Finite Element Method (FEM)
Recap: Maxwell’s equations

→ see blackboard discussion
What to do in the next 2 weeks?

... in case you are bored ;)

Homework

- Consider, if this lecture is right for you
- Check online resources for self-check
- Try out small programming example tasks we put online
- Recap FOMO, especially Maxwells equations, stratified media