Summer school *Computational Photonics*
21. – 25. September 2020
CRC 1173 – KIT

General Information

Welcome to our summer school, we are happy that we can organize this event partly on site. But your health is our top priority at our summer school. In order to manage the event due to the Corona crisis we will provide you with information on imminent measures at KIT and during our event.

You will receive by registration an envelope with general information, a face mask, name tags, seating plan for the lecture halls and information concerning internet access.

Corona Crisis and Hygiene Prevention

Please pay attention to:

- Keeping the required minimum distance of 1.5 meters is one of the most effective measures to prevent transmission of the infection.
- Wearing a face mask is mandatory for the registration, entering the lecture hall, for picking up coffee, beverages and food in the catering room and at the grill station.
- Washing hands and using hand disinfecting liquid should be obviously.
- Cough and sneeze in disposable handkerchiefs, which you can dispose of quickly, or in the crook of your arm if necessary.
- Following always the instructions of the organizational team: Christian Knieling, Laurette Lauffer, Sonja Becker, Katrin Römer.

Please note: At KIT, the maximum possible number of persons in a lecture hall is restricted by the limited availability of space. Due to the hygiene regulations and the requirement to keep distance, far fewer people therefore with the introduction of the safeguard measures are allowed to stay in the rooms. Speakers and the organizational team excluded.

Before entering the lecture hall please follow the signs for entrance and for outgoing. Your name will be registered at the entrance so we are always aware you took place at the lecture. Please wear your name tag you have received with the envelope by registering in order that we can identify you as part of the summer school and you are allowed to participate.

On the last page of this information you will find a form with which you confirm us that you don't have any symptoms of Corona, that you haven't been tested positive on Corona in the last 14 days, that you are not under quarantine legally and you didn't have any contact to a corona infected person in the last 14 days. Please sign the form and bring it with you

by registering on the first day of the summer school. If you cannot sign the form you cannot take part in the summer school. More about Corona restrictions in Germany and at KIT you will find on the following links:

http://www.kit.edu/kit/english/25911.php#tabpanel-25993

https://www.integrationsbeauftragte.de/ib-de/amt-und-person/informationen-zum-coronavirus

Of course, you will be informed immediately if we have/had a Corona case during our summer school.

Locations

The summer school site is located on KIT South Campus (KIT Campus Süd) in Karlsruhe. The campus is situated in central Karlsruhe, to the east of the palace (Karlsruher Schloss), and can be reached conveniently by many tram lines. Nearby tram stops are Kronenplatz, Kronenplatz/Fritz-Erler-Straße or Durlacher-Tor/KIT Campus-Süd (all located near the bottom on the map below).
The summer school activities take place in or in front of the Mathematical Science Building (20.30), in the Johann-Gottfried Tulla Auditorium (in building 11.40) and (probably) in the NTI lecture hall of building 30.10.

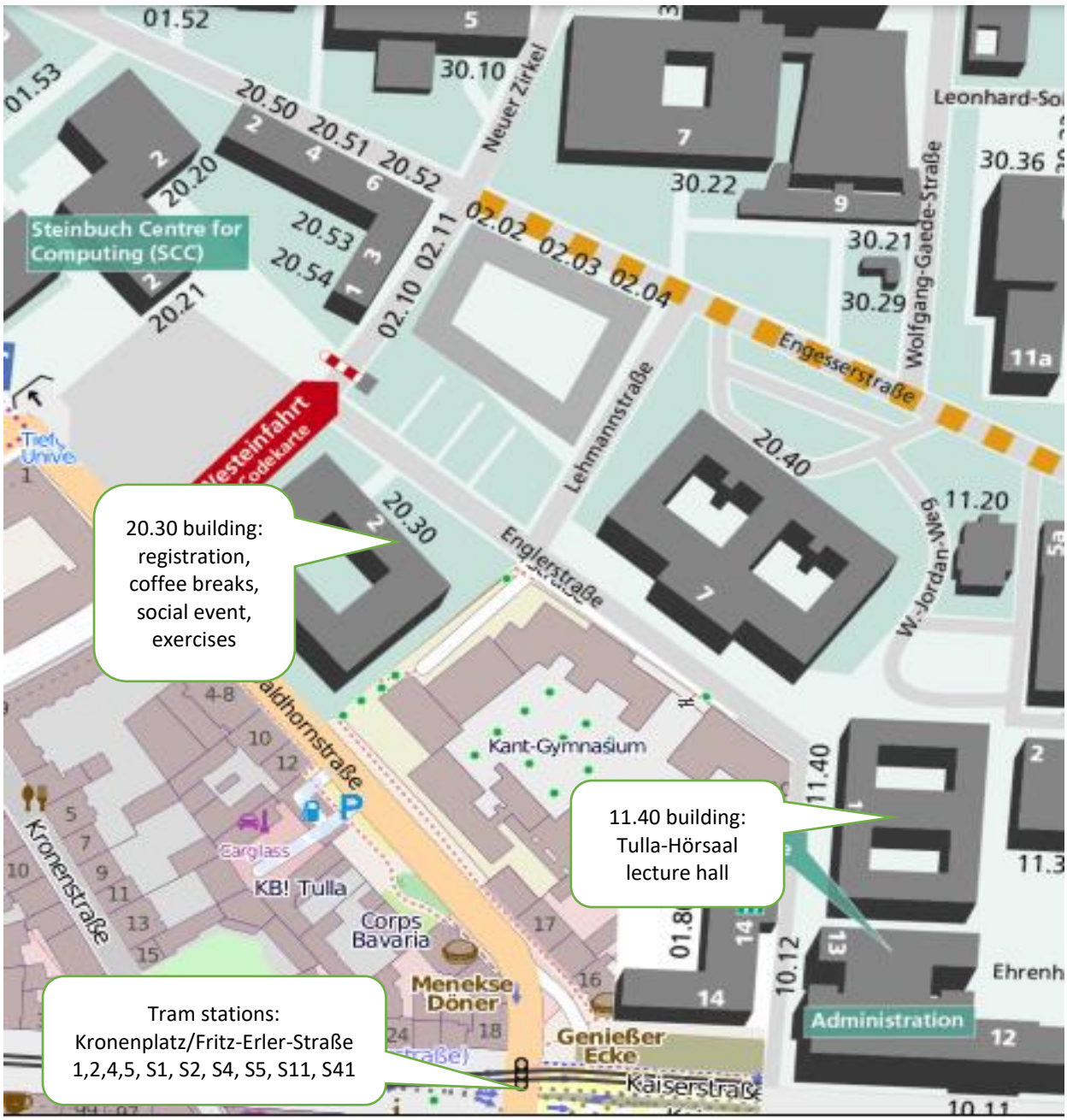
Registration

Kollegiengebäude Mathematik 20.30: Registration takes place in room 0.001 of the mathematical sciences building and will start on Monday, 21th September at 9:00 am. Please follow the signs and watch the distance. The registration desk will be stayed every day during coffee breaks to help you with any queries regarding the summer school or any related issues. You can also approach one of the members of the local organizing committee.

Lectures and exercises

All lectures are held in the **Johann-Gottfried Tulla Auditorium in building 11.40**:
Enter through the main entrance on the west side. The entry to the auditorium is on the first floor. Please use the left entrance of the hall for registration on basis of your name tag and watch to keep always distance to your colleagues. Please sit down at your assigned seat.

All lectures will be streamed and all registered participants abroad can enter the online lecture rooms. Participants online can also take part in the exercises and ask questions as well. Researchers of the KIT will support the exercises in answering questions online or forward them to the lecturers.


20.30 building: registration, coffee breaks, social event, exercises
11.40 building: Tulla-Hörsaal lecture hall
Tram stations: Kronenplatz/Fritz-Erler-Straße 1,2,4,5, S1, S2, S4, S5, S11, S41
Steinbuch Centre for Computing (SCC)
Kant-Gymnasium
KB! Tulla
Corps Bavaria
Menekse Döner
Genießer Ecke
Administration
Kronenstraße
Kaiserstraße
Engesserstraße
Lehmannstraße
Englerstraße
Wolfgang-Gaede-Straße
Neuer Zirkel

Detailed schedule of the school on ***Computational Photonics***
21. September 2020 – 25. September 2020, Karlsruhe, Germany
Final information can be found on the webpage https://www.waves.kit.edu/summer.php.

Monday, 21. September

Time	Subject	Speaker	Institution
09:30	**Registration & Coffee**		
11:00	Opening Ceremony	W. Dörfler, R. Griesmaier, C. Rockstuhl	Karlsruhe Institute of Technology
11:30	Finite element method based simulations Abstract: In this lecture, we will give a short introduction to finite element methods (FEM) for solving Maxwell's equations. Also, recent developments regarding contour integral methods will be discussed. Further, usage and specific features of the FEM solver JCMsuite will be introduced.	S. Burger	JCMwave and Zuse Institute Berlin
13:00	**Lunch**		
14:00	Optimization of photonic devices Abstract: The parameter optimization of photonic devices can be computationally very demanding. The objective functions are often multi-modal due to optical resonance or interference effects and their computation generally requires to solve the Maxwell's equations, which can take minutes to hours. Hence, a grid search for the best paramter values is already for more than two parameters often too costly. Instead, local or global optimization methods have to be employed. In this lecture, several commonly used optimization methods are introduced and compared. A special emphazise is put to Bayesian optimization because it turns out to be the most efficient method for the parameter optimization of photonic devices. The method is based on a Gaussian process regression (GPR) of the objective function, which will also be a topic of the lecture. GPR uses all previous computations of the objective function in order to determine the most probable function value and its uncertainty for any parameter value. It is therefore a valuable tool not only for optimization but also as a general-purpose surrogate model for expensive function evaluations that require the solution of Maxwell's equations. ==========	S. Burger, P. Schneider	JCMwave and Zuse Institute Berlin

	The slide-show of the lecture including Python code examples is based on a Jupyter notebook. The attached zip file contains the Jupyter notebook, some additional python code and a README.txt with information on how to run the notebook. It would be great if you could provide the zip file as a download such that the students get the chance to play around with the code examples.		
15:30	**Coffee break**		
16:00-17.30	The Fourier Modal Method Abstract: An effective computational approach to simulate diffraction gratings is the Fourier Modal Method (FMM) or Rigorous Coupled Wave Analysis (RCWA). It exploits the periodicity of the structures and works in reciprocal / Fourier space. In this lecture, we look at the theoretical description of one- and twodimensional nanostructures in a layered system. We talk in detail about the Fourier transforms at the center of this method and derive the eigenvalue equation that solves the electromagnetic wave equation for regular structures. We will briefly talk about the scattering matrix method to use the properties of the nanostructure within a multilayer.	C. David	Friedrich-Schille University Jena
18:00	**Poster Session**		
20:00	**End of day I**		

Tuesday, 22. September

Time	Subject	Speaker	Institution
09:00	Nonlocality in Nanophotonics Abstract: Nanoscale features in a large-scale device have intriguing applications as they enhance a number of local optical phenomena. When reducing the size, we need to take into account quantum effects, in particular, quantum particle interaction. In this lecture, we take a step beyond classical electrodynamic, while trying to maintain the rapid and reliable methods known from computational photonics. Possible quantum confinement effects and experimental observations are discussed. We introduce the hydrodynamic model for the electron gas in detail deriving the major equations. Finally, we look at modifications to the FMM to address nonlocal interaction effects.	C. David	Friedrich-Schiller-University Jena
10:30	**Coffee break**		

11:00	The Finite-Difference Time-Domain method I Abstract: In my lecture, I am going to explain main features of the finite-difference time-domain (FDTD) method. To exemplify the FDTD method and observe its peculiarities we will reduce Maxwell's equations to the one-dimensional form and express discrete time evolution scheme for electromagnetic waves propagation in the format suitable for writing a script, which will be the topic of the exercise. The lecture contains analysis of numerical dispersion, criteria for stability of the numerical scheme, types of sources and boundary conditions, including efficient perfectly matched layers for open domains and other knowledge required to implement and run the simplest one-dimensional FDTD simulations in class. Possible extensions of the FDTD method on problems with nonlinear and lasing media conclude the presentation.	A. Laurynenka	Technical University of Denmark
12:30	**Lunch**		
14:00	The Finite-Difference Time-Domain method II Abstract: See above	A. Laurynenka	Technical University of Denmark
15:30	**Coffee break**		
16:00	Exercise: Finite element method	P. Schneider	JCMwave and Zuse Institute Berlin
17:30	**End of day II**		

Wednesday, 23. September

Time	Subject	Speaker	Institution
09:00	Maxwell's equations in unbounded domains I Abstract: The propagation of acoustic, electromagnetic or elastic waves is often described by wave equations in unbounded domains. Since standard finite element methods are restricted to bounded domains, they cannot be used directly for a numerical simulation of such problems. One remedy is to combine standard finite element methods for a bounded subdomain with specialized methods for a most simple but unbounded so called exterior domain. These methods for the exterior domain can be interpreted as transparent	L. Nannen	Technical University Vienna

	boundary conditions for the artificial interface between the bounded and the unbounded domain. In this lecture, we first introduce radiation conditions, which control the behavior of waves if the local coordinate increases to infinity. These conditions take the role of a boundary condition at infinity. They should guarantee unique solvability of the problems as well as that a solution is of physical relevance. The basic radiation condition enforces a positive energy flux towards infinity. We will replace this radiation condition by somehow equivalent ones, which are better suited for a numerical discretization. We introduce the method of complex scaling, which is more popular under the name perfectly matched layer. We indicate the challenges when using this method and give some insights to a convergence analysis. Moreover, we introduce the so called Hardy space infinite element method, which is to some extent equivalent to a complex scaling method. The lecture covers Helmholtz and time-harmonic Maxwell scattering and resonance problems. In the end we show how the methods can be extended to scalar wave equations.		
10:30	**Coffee break**		
11:00	(Numerical) Homogenization of Maxwell's equations I Abstract: The presentation considers various variants of Maxwell's equations in heterogeneous media. This means that the material parameters (permittivity, permeability etc.) and hence the coefficients of the PDEs are not constant, but depend on the spatial variable. In particular, we study situations where these coefficients vary rapidly on small spatial scales, leading to so-called multiscale problems. Roughly speaking, homogenization is concerned with the questions (i) whether there exists a macroscopic function approximating the exact, rapidly varying solution and (ii) whether this macroscopic function solves a certain PDE. In the first part of this lecture, we will present some answers for these questions using analytical tools. More precisely, we look at periodic material parameters oscillating with a periodicity length δ and we study the limit $\delta\to 0$. In the second part of the lecture, we look at numerical methods which try to approximate the solution of our multiscale problems without resolving the finescale features of the material everywhere. In particular, numerical methods do not	B. Verfürth	Karlsruhe Institute of Technology

	necessarily require the material parameters to be periodic. In both parts of the lecture, we will first introduce and illustrate the ideas at the example of elliptic diffusion problems and then show corresponding results for various variants of Maxwell's equations. Finally, numerical experiments will illustrate the convergence of the methods and also highlight certain unusual features of Maxwell's equations in heterogeneous media.		
12:30	**Lunch**		
14:00	(Numerical) Homogenization of Maxwell's equations II Abstract: See above	B. Verfürth	Karlsruhe Institute of Technology
15:30	**Coffee break**		
16:00	Scattering Theory: Inverse Design Abstract:	O. Miller	Yale University
17:30	**End of day III**		

Thursday, 24. September

Time	Subject	Speaker	Institution
09:00	Exercise: Finite-difference time-domain method	A. Laurynenka	Technical University of Denmark
10:30	**Coffee break**		
11:00	Exercise:	Ch. David	Friedrich-Schiller-University Jena
12:30	**Lunch**		
14:00	Topology Optimization I Abstract: Popularity of topology optimization of photonic structures has increased tremendously during the last few years. The idea behind, i.e. optimizing the point or element-wise distribution of material in a design domain, was originally conceived for stiffness optimization in mechanical engineering. Since then, the concept has spread to multiple other applications areas including photonics and now goes under many different names covering the same basic concept such as	O. Sigmund	Technical University of Denmark

	"inverse design", "generative design", "evolutionary design", "objective first", etc. The lectures will give an indepth introduction and overview of the background, theory, numerical methods and extensions of topology optimization methods applied to design problems in photonics. Old and new applications within waveguide design, band gab engineering, plasmonics, cavity design as well as photonic insulator design will be covered as well. Interested students may download tutorial codes in Matlab and Comsol from the web-site https://www.topopt.mek.dtu.dk/Apps-and-software/Matlab-codes-electromagnetic-topology-optimization. The Comsol tutorial codes are described in an Arxiv paper: https://arxiv.org/pdf/2008.11816.pdf.		
15:30	**Coffee break**		
16:00-17.30	Scattering Theory: Optimality Bounds Abstract:	O. Miller	Yale University
19:00	**School dinner**		
22:00	**End of day IV**		

Friday, 25. September

Time	Subject	Speaker	Institution
09:00	Maxwell's equations in unbounded domains II Abstract: see Wednesday	L. Nannen	Technical University Vienna
10:30	**Coffee break**		
11:00	Topology Optimization II Abstract: See above	O. Sigmund	Technical University of Denmark
12:30	**Closing Ceremony**		

Technical aspects and software

All on-site participants should bring their laptops and a strong battery. In the lecture hall and the exercise rooms there are only limited possibilities for charging devices. We strongly recommend to charge the devices before participating in the exercises. Please bring a headset that you can follow the online lecture without any problems and

disturbances. We are providing you with internet access via a guest account for WiFi or you can use the Eduroam WiFi network. Information concerning the guest account you will find in the information envelope. Please approach one of the organizational team if you need assistance.

If you are participating online we recommend you to install a zoom client on your computer/mobile device; you can download it here https://zoom.us/download. This is needed to participate in the lectures, exercises and the poster session in the best way.

The lecturers will use Python, Matlab, JCMsuite for their exercises which will run on Linux or Windows and partly on macOS laptops; this is due to the fact that JCMsuite is not available for macOS so far. We will provide you with links for this software and alternatives. We intend to provide a virtual machine for VirtualBox where all free available software will be installed. There might be some steps still left open for activating demo licenses.

All participants will receive by mail and in time a link for participating in the lectures and exercises online.

Poster session

Thank you to all participants who will bring a poster on-site or present it online. The posters on-site should be send to us as a high quality PDF file till September 16, 2020, at noon. We will print and present them on-site during the whole time in the auditorium of the mathematical science building.
During the poster session please follow the hygiene instructions above.

For online presentation we recommend to provide us with a PDF file containing four slides with your topics which we will make accessible for all participants. The poster session will be held online in breakout rooms via Zoom. The researchers can discuss their poster with participants on-site and by entering the online rooms with participants worldwide. The links for the rooms and posters you will receive by mail.

Lunches

We have not organized lunch as the city centre of Karlsruhe is very close to the conference venue with many nice restaurants. We provide a list of places to eat that we can recommend. Of course, there are many other places, especially on Kaiserstraße which may be as good. The list includes the address and approximate distance from building 20.30. For directions, we recommend to search for the addresses on Google Maps for example.

Pub Food

- Kippe (beer garden) (1,1km, 13min)
  Gottesauer Str. 23
- Oktave (beer garden) (1km, 12min)
  Ludwig-Wilhelm-Str. 3
- Oxford Pub (450m, 5min)

Fasanenstr. 6
- Schiller Kaffeebar (450m, 6min)
  Kronenstr. 30
- Zwiebel (1.1km, 13min)
  Durlacher Allee 24

German (restaurant/pub/beer garden)
- Litfaß (beer garden) (450m, 6min)
  Kreuzstr. 10
- Multi-Kulti (beer garden) (500m, 5min)
  Schlossplatz
- Pfannestiel (beer garden) (450m, 5min)
  Am Künstlerhaus 53
- Vogelbräu (beer garden) (600m, 8min)
  Kapellenstr. 46
- Alte Bank (beer garden) (1km, 11min)
  Herrenstr. 30
- Schlosscafe (beer garden) (500m, 5min)
- Karlsruhe Palace (entry from gardens)
- Gold (1.2km, 14min)
  Ludwig-Wilhelm-Str. 12
- Marktlücke (550m, 7min)
  Zähringerstr. 96
- Zum kleinen Ketterer (550m, 6min)
  Adlerstr. 34

Bistro
- Café Pan (400 m, 5 min)
  Kaiserstr. 50
- Café Palaver (750 m, 9 min)
  Steinstr. 23
- Cilantro Bistro Del Arte (Chilean, small) (750m, 9min)
  Markgrafenstr. 31

Italian
- Cortina
  Kaiserstr. 101 (400m, 5min)
- Il Caminetto (230m, 3min)
  Kronenstr. 5
  Turkish
- Goldenes Horn (350m, 4min)
  Kaiserstr. 111
- Kani (240m, 3min)
  Berliner Platz
- Kaisergrill Imbiss (240m, 3min)
  Kaiserstr. 32

Spanish
- Besitos (550m, 7min)
  Karl-Friedrich-Str. 9

Moroccan/Lebanese
- Habibi (Snack-Bar) (250m, 3min)
  Kaiserstr. 65
- Marrakesch (Snack-Bar) (250m, 3min)
  Fritz-Erler-Str. 3

Asian
- Kim Fat Pho (550m, 7min)
  Zirkel 27A
- Chiang Mai (Thai) (1.1km, 13min)
  Durlacher Allee 11
- Continent (Indian) (400m, 5min)
  Kaiserstr. 109
- Thai Orchid (750m, 10 min)
  Adlerstr. 44

Annex to the Operating Directive for Academic Education Operations for "On-campus Courses with Limited Numbers of Participants" and "Public On-campus Events with Limited Numbers of Participants", Version of July 30, 2020

Declaration on the Absence of a Suspected Corona Virus Infection for Participation in an On-campus Course

Please complete this form for the protection of your co-participants and the supervisory staff. In case you cannot sign the form, because one of the conditions leading to the suspicion of potential infection by the Corona virus is fulfilled, do not attend the course.

First and family names

Email

Program

On-campus course

To the best of my knowledge and belief, I herewith confirm that

1. I do not feel any symptoms of an infection by the Corona virus (such as fever and dry cough, but also sniff, short breath, a sore throat, aching limbs, fatigue, and chill may indicate an infection) that cannot be explained in another way,
2. I was not tested positively for the Corona virus during the past 14 days,
3. I am not in quarantine ordered by the authority, and
4. I had no contact to a person proved to be infected by the Corona virus in the last 14 days.

This holds for the first date and all follow-up dates of the course.

I am aware of the fact that according to Article 7 of the Ordinance of the State Government on Infection Protection Measures against the Spread of the SARS-CoV-2 Virus (Corona Ordinance – CoronaVO), persons who had contact to infected persons in the last 14 days or show symptoms of an infection of the respiratory passages or fever are not permitted to enter the university. Any violation of this ban on access shall be an administrative offence according to Article 19, No. 5, CoronaVO that may be punished by a fine.

I am also aware of the fact that any violation of a quarantine ordered by authority will be punished by imprisonment for up to two years or a fine according to Article 75, par. 1, No. 1 and Article 30, par. 1 of the Infection Protection Act.

Place and date

Signature