RTG approved Courses

Summer Semester 2021

TRR 306
QuCoLiMa
Quantum Cooperativity of Light and Matter

FAU Erlangen-Nürnberg

Title	Course leader	Date
1. Modern Optics 2: Nonlinear Optics, Lecture	Maria Chekhova / Birgit Stiller	Tue 13.30-15
2. Quantum Magnetism, Spin Waves, and Light	Silvia Viola-Kusminskiy	Wed 14-16 Wed 16-17
3. Quantum Physics of Light-Matter Interactions	Claudiu Genes	Fri 10-12 Tue 11-12

JGU Mainz

Title	Course leader	Date
4. Photonics	Mustapha Laatiaoui / Arne Wickenbrock	Mon 12-14 & Wed 8-10
5. Quantum cooperativity of light and matter, Seminar	Ferdinand Schmidt-Kaler	Tue 14
6. Physical Chemistry IV: Modern Methods of Physical Chemistry	Thomas Basché	Thu 10-12 & Fri 8-10

UdS, Saarbrücken

Title	Course leader	Date
7. Control of quantum systems for the development of quantum technologies, Seminar	Jürgen Eschner, Giovanna Morigi, Christoph Becher	Wed 9-10 (approx. every 2 weeks runs the whole year)
8. Fluorescence Spectroscopy, Lecture	Gregor Jung	Fri 10-12

Please register for courses you are interested in via email. You can find the contact information and short abstracts on the following pages. All courses will take place via an online video solution like zoom or MS Teams and can be attended from any location. For successful attendance active participation is required. Details will be defined by the lecturer at the beginning of the course.

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1. Modern Optics 2: Nonlinear Optics, Lecture by Maria Chekhova and Birgit Stiller

Abstract:

- Linear properties of materials.
- Origin of the nonlinear susceptibility.
- Importance of phase-matching.
- Second harmonic generation, derivation of the set of coupled equations.
- Importance of the initial phase and case of seeding second harmonic generation. Use of birefringence to achieve phase-matching.
- Electro-optic effects.
- Nonlinear process in relation to third order nonlinearity.
- Modulation instability, soliton formation, perturbations of soliton, and supercontinuum generation.
- Application: nonlinear optics in photonic crystal fibers.

Tuesday 13.30-15

Registration:
Please send an email to: maria.chekhova@mpl.mpg.de (cc: larissa.lehmann@fau.de)
FAU-Members: Please sign in via StudOn, but also send an email to larissa.lehmann@fau.de

2. Quantum Magnetism, Spin Waves, and Light by Silvia Viola-Kusminskiy

Abstract:
Both magnetic materials and light have always played a predominant role in the storage, processing, and communication of information, and continue to do so as we move into the realm of quantum technologies. In this course we review the basics of magnetism before embarking in more advanced subjects, which will give us the basic tools to go over a selection of topics of current research. Magnetism is intrinsically quantum mechanical in nature, and magnetic ordering can only be explained by use of quantum theory. We will go over the interactions and the resulting Hamiltonian that governs magnetic phenomena, and discuss its elementary excitations, denominated magnons. After that we will study magneto-optical effects and derive the classical Faraday effect. This will allow us to understand a topic of current research denominated Cavity Optomagnonics. If the time allows, we will study another modern topic which deals with the design of photonic and magnonic crystals at the nanoscale. Basic knowledge of quantum mechanics, electromagnetism, and solid state at the bachelor level will be assumed.

Lecture: Wednesday 14-16 Exercise: Wednesday: 16-17

Registration:
Please send an email to: silvia.viola-kusminskiy@mpl.mpg.de (cc: larissa.lehmann@fau.de)
FAU-Members: Please sign in via StudOn, but also send an email to larissa.lehmann@fau.de

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3. Quantum Physics of Light-Matter Interactions
by Claudiu Genes

Abstract:
This course aims at covering a few special topics in the interactions between quantum matter (atoms, molecules) and quantum light. The first part of the course will present fundamental aspects such as light field quantization, spontaneous emission, stimulated emission and absorption, cavity quantum electrodynamics. The second part of the course makes use of the introduced concepts to allow the understanding of laser theory, laser cooling, cavity cooling and cavity optomechanics. The mathematical tools involved are quantum master equations and quantum Langevin equations.

Lecture: Friday 10-12 Exercise: Tuesday 11-12

Registration:
Please send an email to: claudiu.genes@mpl.mpg.de (cc: larissa.lehmann@fau.de)
FAU-Members: Please sign in via StudOn, but also send an email to larissa.lehmann@fau.de

4. Photonics
by Mustapha Laatiaoui and Arne Wickenbrock

Abstract:
In this lecture you will get an insight into state-of-the-art methods in atomic physics. A special focus will be set on the investigation and manipulation of atoms and molecules with laser light.

At the beginning, basics of different spectroscopy and manipulation techniques, e.g., Doppler-free spectroscopy, particle traps, control of quantum states of matter etc., will be introduced together with technical tools such as optical modulators and non-linear optics (frequency doubling, non-linear frequency mixing).

Subsequently, basics of laser beam characterization will be discussed and an in-depth introduction to Gaussian optics and optical resonators will be given.

The lecture will teach many fundamentals that are of great importance far beyond the field of quantum and atomic physics.

Monday 12-14 & Wednesday 8-10

Registration:
Please send an email to: wickenbr@uni-mainz.de (cc: larissa.lehmann@fau.de)

5. Quantum cooperativity of light and matter, Seminar
by Ferdinand Schmidt-Kaler

Abstract:
We are fascinated by the various aspects of quantum cooperativity. We will address this topic in an overarching manner, joining experimental and theoretical physics, bridging between atomic and quantum optical model systems and condensed matter systems.

The quantum cooperativity may result in collective light emission, featuring spectacular non-classical behavior. Or, alternatively, atoms and ions and even solid-state systems show quantum cooperativity. Here, the systems may undergo transition to entangled states, which is mediated by collective degrees of freedom. The Spin-Boson model is the prominent example and serves for understanding genuine collective effects.

As all talks will contribute to the same common theme, there is a large additional benefit for students, as they understand on top of the individual topic the entire field, theory, model systems and applications.

Tuesday 14

Registration:
Please send an email to: fsk@uni-mainz.de (cc: larissa.lehmann@fau.de)

6. Physical Chemistry IV: Modern Methods of Physical Chemistry
by Thomas Basché (and other lecturers)

Abstract:
The lecture deals with microscopic methods with different spatial resolution: optical microscopy, scanning probe microscopy, electron microscopy. In the field of optical microscopy, the following topics are discussed: super-high-resolution microscopy, fluorescence correlation spectroscopy and single molecule spectroscopy.

The lecture is designed for students of the Master's Chemistry Program with prior knowledge.

Thursday 10-12 & Friday 8-10

Registration:
Please send an email to: basche@uni-mainz.de (cc: larissa.lehmann@fau.de)

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7. Control of quantum systems for the development of quantum technologies, Seminar
by Jürgen Eschner, Giovanna Morigi, Christoph Becher

Abstract:
The Ctrl-Q Seminar is a regular activity of the topical PhD Program "Control of quantum systems for the development of quantum technologies" at the UdS. Seminar speakers, who may be either guests or regular participants, present recent papers from the field of quantum science and quantum technologies.

The Ctrl-Q Seminar is organized through Teams and is held digitally, about bi-weekly, on Wednesdays at 9:00 am. You have to sign up to attend. You find all further information on Wiki pages in the Team, including papers that are suggested for presentation. Suggested papers shall be approved by the coordinating professors, Prof. Morigi, Prof. Becher, Prof. Eschner, or Prof. Wilhelm-Mauch.

Everybody in QuCoLiMa is welcome to attend the Ctrl-Q Seminar as regular or occasional listener. In order to pass it as an RTG course, you will have to participate for one semester (i.e., for 6 months that can begin any time) and to present one paper in a seminar talk.

Wednesday 9-10 (bi-weekly, during and outside lecture time)

Registration:
Please send an email to: saran.shaju@physik.uni-saarland.de (cc: larissa.lehmann@fau.de)

8. Fluorescence Spectroscopy, Lecture
by Gregor Jung

Abstract:
The lecture series covers the topics from quantum chemical consideration of selected fluorophores via experimental techniques to applications in bioanalysis, with special focus on photophysical properties.

Fri 10-12

Registration:
Please send an email to: g.jung@mx.uni-saarland.de (cc: larissa.lehmann@fau.de)