TUT 1: Careers in science (joint session AKjDPG/TUT)

Time: Sunday 16:00–17:15 Location: HSZ 02

Tutorial TUT 1.1 Sun 16:00 HSZ 02

Careers in science: "To boldly go where no one has gone before" — •Manfred Fiebig — Department of Materials, ETH Zurich, 8093 Zurich, Switzerland

What does it take to do a career in science and become a university professor? An obvious answer is: you have to do outstanding research. But just doing great science plays a surprisingly small part — and what defines ones scientific work as excellent anyway? Then, you also need to communicate your findings well. The best result is worth little if you present it in an awful talk or manuscript. You also need to be "good with people", may these be your students or your colleagues. Even luck can play an important role in asuccessful scientific career, but is very important to distinguish luck from "luck". I will refer to all these points and analyze what "being lucky" has actually to do with luck. I will present a list of points that I consider essential for a prosperous start into a scientific career. Some of these points are surprisingly unnoticed, so following them may put you ahead of the crowd.

Questions and discussion

TUT 2: Stochastic Processes from Financial Risk to Dynamics in Biology and Physics (joint session SOE/DY/TUT)

Stochastic Processes are an essential ingredient of models in biology, physics and chemistry, as well as in socio-economic systems where agents are often modeled by a simple set of rules. The tutorials first lay foundations, then introduce advanced concepts and finally demonstrate their application in turbulence, critical phenomena in socio-technical networks, and the dynamics of epidemic spreading. (Session organised by Jens Christian Claussen.)

Time: Sunday 16:00–18:30 Location: HSZ 03

Tutorial TUT 2.1 Sun 16:00 HSZ 03

Stochastic models for particles in turbulence — •Bernhard Mehlig — Department of Physics, University of Gothenburg, Sweden

The subject of this tutorial is the dynamics of heavy particles in turbulence, such as water droplets in the turbulent air of a cumulus cloud, dust grains in the turbulent gas around a growing star, or motile microorganisms in the turbulent ocean. The analysis of such highly nonlinear and multi-scale problems poses formidable challenges, because any description of the dynamics must refer to the turbulent fluctuations that the particles experience as they move through the fluid. Experiments resolving the particle dynamics have only recently become possible, and direct numerical simulations of such systems are still immensely difficult.

In this tutorial I explain how to understand the fundamental mechanisms determining the dynamics of particles in turbulence in terms of statistical models that account for the symmetries and statistics of the turbulent flow. Using simple examples I illustrate how to solve such models with diffusion approximations, highlighting an analogy with Kramers' escape problem. I discuss the limitations of the approach, and summarise recent progress. I conclude by discussing open questions, arguing that the approach outlined provides a unique opportunity to make significant progress regarding this challenging and important problem.

Tutorial TUT 2.2 Sun 16:50 HSZ 03

From Percolation and Explosive Percolation to a unifying principle — •Jan Nagler — Frankfurt School of F&M, Frankfurt, Germany

The emergence of large-scale connectivity crucially underlies the structure, proper functioning, and failure of many complex socio-technical networks. For many decades, percolation was studied predominately as a second-order phase transition where at the critical threshold, the order parameter increases in a rapid but continuous way. In 2009, an explosive, i.e. extremely rapid, transition was found for a network growth process where links compete for addition. This observation of "explosive percolation" started an enormous surge of analyzing explosive phenomena and their consequences. Many models are now shown to yield discontinuous explosive percolation transitions, and some models exhibit a hybrid transition with a combination of second- and first- order features. Important mechanisms that achieve the required delay for explosive transitions include history dependence, non-self-averaging, and strong correlations. In this tutorial we will start to review standard percolation and end with "explosive phenomena" in networked systems. Examples include social systems, globalization, and the emergence of molecular life [D'Souza, Gomez-Gardenes, Nagler, Arenas, Explosive phenomena in complex networks, Advances in Physics 68(3):123, 2019]. We will close with some recent publication that provides a unifying framework for continuous, discontinuous and even hybrid phase transitions [Fan, Meng, Liu, Saberi, Kurths, Nagler, Universal gap scaling in percolation, Nature Physics, in press].

Tutorial TUT 2.3 Sun 17:40 HSZ 03

Spreading dynamics on networks: from social interactions to epidemics and pandemics — •Fakhteh Ghanbarnejad — Sharif University of Technology, Tehran, Iran

Spreading of gossips, news, infectious diseases, computer viruses, new products, etc. are some examples of epidemic dynamics. In this tutorial, firstly we review the basic models for modelling such phenomena including deterministic and stochastic approaches. Also we address how social contacts and the underlying topology of interactions can affect the dynamics. Finally we discuss when and how a spreading dynamics may end to a widespread endemic or pandemic and if and how social interactions play a role.

TUT 3: SKM-relevante Aspekte der Umweltphysik (joint session UP/TUT)

Time: Sunday 16:00–18:00 Location: HSZ 04

Tutorial TUT 3.1 Sun 16:00 HSZ 04

Spektroskopische Messungen atmosphärischer Spurenstoffe — •Christian von Savigny — Institute of Physics, University of Greifswald, Greifswald, Germany

Die Messung atmosphärischer Spurenstoffe ist eine wichtige Teildisziplin der physikalischen Umweltforschung. Mit spektroskopischen Verfahren im Optischen, Infrarot und im Mikrowellen-Bereich lassen sich eine Vielzahl atmosphärischer Spurenstoffe experimentell bestimmen. Dabei spielen beispielsweise die Messung von Treibhausgasen, Stickoxiden und anderen Luftschadstoffen, oder von Ozon in der Stratosphäre eine besondere Rolle. Die Messungen werden als in-situ oder Fernerkundungsmessungen durchgeführt und können vom Boden, von Flugzeugen, Forschungsballons oder auch an Bord von Satelliten durchgeführt werden. Dieses Tutorial gibt einen Überblick über die zugrundeliegenden physikalischen Messprinzipien, die erforderlichen numerischen Methoden zur Ableitung von Spurenstoffmengen und veranschaulicht anhand zahlreicher Beispiele die aktuellen technischen und experimentellen Möglichkeiten und den Beitrag dieser Messungen zur aktuellen Atmosphären- und Klimaforschung.

Tutorial TUT 3.2 Sun 17:00 HSZ 04

Die "Dieselproblematik": Warum erst jetzt "saubere" PKW-Diesel und sind sie "sauber"? — •Ulrich Platt — Institut für Umweltphysik, Universität Heidelberg

Verharmlosend als "Dieselproblematik" bezeichnet wird der vermutlich größte Industrie-skandal der letzten Jahrzehnte. Worum geht es dabei? Bekanntlich stoßen Verbrennungs-motoren Schadstoffe aus die die menschliche Gesundheit bedrohen, im Zentrum des Inter-esses stehen Stickoxide (NO und NO2), Kohlenmonoxid (CO), Kohlenwasserstoffe und Feinstaub (Partikel mit Radien unter 1/100 mm). Zum Schutz der Bewohner, insbesondere von Ballungsgebieten, werden verbindliche Grenzwerte für die o.g. Spezies festgelegt, in der EU sind des aktuell nach der EU Richtlinie 2007/46/EG die Euro 6 Grenzwerte, die z.B. für Diesel PKW eine Emission von max. 80 mg NOX (Summe aus NO und NO2) vorschreibt. Problematisch ist bei Dieselabgasen (im Gegensatz zu Abgasen von Benzinmotoren) insbesondere die Entfernung von NOX aus dem Abgas, eine Lösung ist die selective kata-lytische Reduktion (SCR) bei der eine in den Abgas-Strom eingespritzte Harnstoff-Lösung NOX zu N2 reduziert. Seit etwa 10 Jahren zeigen Messungen auf der Straße jedoch bei Diesel PKW keine Abnahme der NOX-Emission im realen Verkehr, obwohl in diesem Zeitraum die Grenzwerte in 3 Stufen um nahezu eine Größenordnung abgesenkt wurden. Dies scheint auch die PKW aller Hersteller zu betreffen. Im Tutorial werden die Grundlagen der Schadstoffbildung im Abgas und die Verfahren zur Abgasreinigung vorgestellt und erklärt. Konsequenzen fehlender Luftreinhaltung werden diskutiert, Methoden zur Emissionsmessung, vor allem auch die Messungen im tatsächlichen Verkehr (Real Driving Emissions, RDE und Plume Chasing), werden beschrieben. Zum Schluss wird ein Ausblick auf die Zukunft der Luftreinhaltung gegeben.

TUT 4: Nanofabrication and 3D Printing with Submicron Resolution (joint session CPP/TUT)

3D printing or additive manufacturing witnessed one of the most revolutionizing progresses in the last decade. Traditionally used for macro-scale prototyping, 3D printing currently finds applications in large-scale industrial manufacturing, medical technology, education and scientific research. More astonishingly, the resolution of lithography-free 3D printing technologies has reached to microns, pushing the borders of nanoscale and pioneering the miniaturisation of diverse tools to smallest-ever dimensions. This tutorial will present an overview on submicron 3D printing technologies and nanofabrication tools, their novel applications, and recent scientific progress in the area. Organised by: Regine v. Klitzing (TU Darmstadt) and Cagri Üzüm (Grace GmbH, Worms).

Time: Sunday 16:00–18:15 Location: HSZ 304

Tutorial TUT 4.1 Sun 16:00 HSZ 304

3D laser nanoprinting — •Martin Wegener — Institute of Applied Physics and Institute of Nanotechnology, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany

This tutorial follows a recently published review and perspectives article on 3D laser nanoprinting (V. Hahn et al., Opt. Photon. News 30(10), 28-35 (2019)).

I will review the underlying physical principles, describe the state-of-the art in the context of many other alternative 3D additive manufacturing approaches, and emphasize two challenges: (i) Substantially faster and scalable 3D printing with sub-micrometer voxel sizes, and (ii) multi-material 3D nanoprinting.

(i) I will present (unpublished) results on rapid multi-focus 3D laser nanoprinting leading to printing rates around 10^7 voxels/s at sub-micrometer voxels sizes. For example, this has led to 3D mechanical metamaterials with more than 100 thousand unit cells and more than 300 billion voxels total. Furthermore, I will sketch our ideas to go well beyond this by introducing light-sheet 3D laser nanoprinting.

(ii) I will discuss three different approaches towards multi-material architectures: (a) integrated microfluidic chamber, (b) stimuli-assisted 3D laser nanoprinting, and (c) meta-inks.

This work has been supported by the Excellence Cluster "3D Matter Made to Order".

Tutorial TUT 4.2 Sun 16:45 HSZ 304

3D printed microoptics: State of the art and future challenges — •Harald Giessen — 4. Physikalisches Institut, Universität Stuttgart

3D printing using femtosecond lasers gives submicron resolution when polymerizing plastics by two-photon absorption. The small voxel size well below the diffraction limit and the combination with high-speed scanners and high-precision piezo stages allows for the creation of millimeter-sized 3D optics with unprecedented design freedom. We will demonstrate that such complex optics with aspherical and freeform surfaces without rotational symmetry can lead to novel miniature optics with wavefront aberrations as small as lambda/10. Multiple materials can be combined with different refractive indices and dispersions, thus allowing for Fraunhofer-type achromats. Diffractive optics can be 3D printed as well, and stacking several Fresnel-type surfaces leads to aplanatic imaging systems. Hybrids that combine diffractive and refractive surfaces as well as transparent and opaque materials enhance the imaging capabilities even further. When combined with imaging fibers or CMOS imaging sensors, an entire new class of miniature optical devices can be created which will revolutionize augmented and virtual reality as well as self-driving cars. Fiber-based optical trapping, side-looking OCT endoscopes, the smallest imaging endoscope in the world, as well as applications in quantum technology pave the way towards future functionalities and applications [1-2].

[1] T. Gissibl et al., Nature Communications 7, 11763 (2016). [2] T. Gissibl et al., Nature Photonics 10, 554 (2016).

Tutorial TUT 4.3 Sun 17:30 HSZ 304

Nanofabrication and 3D printing with submicron resolution — •Michael Huth — Goethe University, Frankfurt am Main, Germany

Focused electron beam induced deposition (FEBID) is a direct-write method for the fabrication of nanostructures whose lateral resolution rivals that of advanced electron beam lithography but is in addition capable of creating complex three-dimensional (3D) nano-architectures. Over the last decade several new developments in FEBID and focused electron beam induced processing (FEBIP) in general have led to a growing number of scientific contributions in solid state physics and materials science based on FEBID-specific materials and particular shapes and arrangements of the employed nanostructures. In this tutorial talk I will give an introduction to the most relevant aspects of FEBID with a particular focus on the creation of 3D functional structures. I will discuss simulation-assisted approaches to FEBID based on effective models for the reliable growth of complex 3D shapes and will briefly allude to microscopic modeling attempts that aim to go beyond growth rate and shape prediction. During the talk I will show different examples of 3D FEBID materials used in nano-magnetism, superconductivity, single-electronics and scanning probe microscopy.

TUT 5: Frontiers of Semiconductor Lasers (joint session HL/TUT)

The development of semiconductor lasers has been an unprecedented success story and enabled multiple applications which influence many aspects of our modern society. Most important is world-wide optical data communication which relies crucially on semiconductor lasers. Additionally, medical diagnostics and many optical sensing applications are enabled by such optoelectronic devices. In this tutorial, we will highlight the state-of-the-art of semiconductor laser in high-speed data communication and terrestrial and extraterrestrial gas sensing applications. Moreover, we will present recent progress towards the realization and in-depth understanding of thresholdless nanolasers and topological nanolasers as well as cavity-enhanced lasers based on novel quantum materials as active medium.

Organiser: Stephan Reitzenstein (TU Berlin)

Time: Sunday 16:00–18:40 Location: HSZ 403

Tutorial TUT 5.1 Sun 16:00 HSZ 403

Interbandkaskaden und weit abstimmbare Laser las Lichtquellen für Sensorik — •Johannes Koeth, Robert Weih, Nicolas Koslowski und Tim Koslowski — nanoplus GmbH, Gerbrunn, Germany

ICLs zeichnen sich unter anderem dadurch aus, dass die Emissionswellenlänge in einem weiten Bereich des mittleren Infrarot durch die Variation der Quantenfilmdicke weitestgehend unabhängig von der Bandlücke des Halbleiters eingestellt werden kann. Da eine Vielzahl von Gasen ihre stärksten Absorptionslinien im Wellenlängenbereich zwischen 3 und 6 μm zeigen, eignen sich ICL basierte DFB-Laser hervorragend für die hochsensitive Absorptionsspektroskopie. Infolge kontinuierlicher Optimierungen des Schichtaufbaus können mittlerweile selbst Laser mit einer Wellenlänge $\lambda > 5\,\mu m$ im Dauerstrichbetrieb bei Raumtemperatur betrieben werden. Sie benötigen dabei kaum mehr als $200\,mW$ Eingangsleistung und erreichen Ausgangsleistungen von bis zu $10\,mW$. DFB Laser sind sehr gut dazu geeignet Absorptionslinien in einem engen Spektralbereicheben auszumessen. Daneben können auch weit abstimmbare, nach dem Vernier-Prinzip betriebene, Laser für Spektroskopie im nahen und mittleren Infrarot verwendet werden.

Tutorial TUT 5.2 Sun 16:40 HSZ 403

Advanced semiconductor lasers for high-speed data communication — •Johann Peter Reithmaier — Institute for Nanostructure Technologies and Analytics (INA), CINSaT, University of Kassel, Germany

An overview will be given on advanced semiconductor lasers and related optoelectronic devices, which are mainly utilizing specific properties of low-dimensional electronic systems, such as quantum dots (QDs) or mixed multi-dimensional systems. The special focus will be on laser properties, which are of highly interest for high-speed optical data communication. In particular, examples will be discussed for high-speed direct modulation, ultra-narrow linewidth lasers for coherent communication and high-speed high-temperature operation of semiconductor optical amplifiers. The tutorial will also give some background for the understanding of the more recent obtained record values of QD lasers in temperature stability, nearly-zero linewidth-enhancement factors and emission linewidths below 30 kHz at room temperature.

Tutorial TUT 5.3 Sun 17:20 HSZ 403

Theory of Nanolasers — •Christopher Gies — Institut für Theoretische Physik, Universität Bremen, Otto-Hahn-Allee 1, 28334 Bremen

The tutorial will give an introduction to the colorful physics and the modeling of nanolasers. The origin of rate equation will be discussed, focussing on their merits and shortcomings when describing nanolasers. Especially in the high-β regime, spontaneous emission plays an important role even above the laser threshold, emphasizing the impact of fluctuations on the emission characteristics.

The lecture will cover the quantized light field, open-systems approaches for including dissipation, and photon statistics and its relation to photon-correlation fuctions. A strong emphasis will be on how to relate the theoretical approaches to modeling real experiments.

Tutorial TUT 5.4 Sun 18:00 HSZ 403

Lasers for emulating topological and spin systems — •Mercedeh Khajavikhan — University of Southern California, Los Angeles, United States of America

In recent years, there has been a growing interest in using micro- and nano-scale lasers for implementing topological and spin systems. Spin models arise in the microscopic description of magnetic materials, where the macroscopic characteristics are governed by exchange interactions among the constituent magnetic moments. On the other hand, topological features are characterized as properties that remain invariant during continuous deformations of the system. The additional degrees of freedom afforded by gain and loss in active elements provide excellent opportunities to emulate these systems in a versatile photonic platform. In this tutorial, we describe some of the activities by our group and others in utilizing nanolasers and microcavities for implementing topological and spin systems. These studies could pave the way towards a new scalable nanophotonic platform to study spin exchange interactions or topological insulators, that can in turn be potentially exploited to design high power laser arrays, investigate more large-scale networks, emulate some magnetic materials, or to address a variety of optimization problems.