Thursday, 11:20 – 12:00

“Structured Light in Classical and Quantum Optics”

Robert Fickler (Tampere University)

The study of light with non-trivial shapes in time, space, and/or polarization, is often termed structured light. Over the last decades, it has become a versatile approach to explore fundamental optics effects and develop novel applications in fields such as microscopy, imaging, optical communications, and quantum technologies, to name a few. In this talk, I will introduce the field and discuss some of the recent advances including our latest result on quantum frequency conversion controlled by structured light.

Thursday, 12:00 – 12:20

“Spatial polarisation spectroscopy of hot atomic vapours with structured light fields”

Richard Aguiar Maduro (University of Glasgow)

Polarisation spectroscopy is based on generating macroscopic magnetisation in an atomic vapour through optical pumping and analysing the effect on the polarisation state of a homogeneously polarised probe beam as a function of frequency. We find that by using spatially structured vector fields with inhomogeneous polarisation structures we can reliably measure the anisotropy resulting from circular dichroism.

The atomic resonant frequencies of the alkali vapour can be detected via the light-shaping of the beam: a clear rotation pattern on the intensity of the beam emerges and is recorded on a CCD. In this paper we present our findings, alongside a theoretical model that can predict the interaction, promising advances in laser locking and magnetometry.

Thursday, 12:20 – 12:40

“Interaction of structured light with optically polarized atomic medium in external magnetic field”

Shreyas Ramakrishna (Helmholtz Institute Jena)

In my talk, I will discuss the physics underlying the interaction between a Poincaré beam and an optically polarized atomic medium in the presence of a constant magnetic field. Our investigation reveals that the absorption profile of the Poincaré beam exhibits axial asymmetry. This asymmetry depends sensitively on the relative orientation of the pump and probe light fields with respect to the quantization axis, as well as on the strength of the magnetic field. To illustrate these findings, we choose the incoming radiation drives an electric dipole transition, $5s\,^2S_{1/2}(F=1) \rightarrow 5p\,^2P_{3/2}(F=0)$ in rubidium atoms subjected to various magnetic field strengths.

Thursday, 13:40 – 14:20

“Ultrafast strucured laser pulses for nonlinear laser-matter interactions”

Sergio Martín Domene (Universidad de Salamanca)

The attosecond time scale enables us to explore ultrafast science at the nanoscale. These ultrashort laser pulses can be generated through high-order harmonic generation (HHG), an extreme nonlinear process in which an infrared driver interacts typically with a gas target, leading to the emission of harmonics in the UV and XUV region of the spectrum. Given the physical complexity of HHG, it is not trivial how to tailor the resulting ultrashort pulses in its different degrees of freedom such us time, space, polarization or angular momentum. In this talk we will review some key aspects and technics to achieve it, together with related research developed in our group such us HHG in solids or the possibility of isolate and structure the optical magnetic field of light for applications in chiral or magnetic materials.

Thursday, 14:20 – 14:40

“Creation of “Magnetic Light” and its interaction with atoms”

Riaan Schmidt (PTB)

Azimuthally polarized light beams exhibit zero electric and non-zero magnetic fields in their center. In the case of a single beam, this “isolated” magnetic field is oriented along the beam axis. On the other hand, the use of two azimuthally polarized beams makes it possible to generate a magnetic field with a distinct direction and phase, while keeping the electric field still zero [1]. This configuration opens up new opportunities for studies of laser-induced ultrafast magnetization dynamics in solid matter, where suppression of electric field effects is important [2]. In the present contribution we explore the interaction of a single atom with different superpositions of azimuthally polarized beams. We perform calculations in the framework of the density matrix theory. For illustration purposes, we apply our general approach to the $5s\,^2S_{1/2}(F=2) - -5p\,^2P_{3/2}(F=3)$ transition in ^{87}Rb. Based on the results of our calculations, we show how the interaction of matter with the magnetic field of two azimuthally polarized beams can be enhanced. It is also demonstrated that observation of atomic population dynamics can be used as a sensor for the relative orientation and phase of the light field components.

[1] Sergio Martín-Domene et al., Appl. Phys. Lett. 124, 211101 (2024)

[2] Luis Sánchez-Tejerina et al., High Power Laser Science and Engineering, (2023), Vol. 11, e82, 8

Thursday, 14:40 – 15:00

“Strongly nonlinear superconducting dynamics and high harmonic generation with structured light”

Björn Niedzielski (Martin-Luther-Universität Halle-Wittenberg)

The presented work shows how a pulse of structured light interacts with a mesoscopic superconductor, leading to the emission of high-harmonic light up to the seventh order. Of specific interest are optical vortex pulses carrying angular momentum and their potential for inducing time-dependent supercurrents in the target material. It is demonstrated how changing the beam parameters allows for precise control of high-harmonic generation and which beams and configurations are best suited for optimal light-matter interaction. The presented results are based on the time-dependent Ginzburg-Landau equations, which are solved using the finite element method.

Thursday, 15:00 – 15:20

“On-Chip Generation of a HG-like Mode for excitation of the forbidden E3 Clock Transition in Yb^+”

Guochun Du (PTB)

The ultra-narrow E3 transition of ytterbium ions (Yb^+) at 467 nm has been used in precision optical clocks and tests of fundamental physics. In this talk, we present the generation of a Hermite-Gaussian-like mode tailored for the excitation of this transition while only weakly perturbing the atomic levels. We share results from the optical characterization of the beam-shape and mode quality and estimate its value for clock spectroscopy.

Thursday, 16:00 – 16:40

“Imprinting of skyrmionic patterns onto topological materials using vector beams”

Marco Ornigotti (Tampere University)

Topological physics has attracted a lot of attention in the last decade, due to the peculiar way the properties of physical systems can be controlled by simply shaping their underlying geometrical structure. Although most of these concepts have been studies in condensed matter physics first (topological insulators, Skyrmions, etc.), recently they have bled into Photonics, creating new possibilities for light transport and light-based quantum information protocols. Now that topological physics has reached maturity in both fields, it is time to look at the interplay and interactions between light and matter topologies. In this talk, after briefly reviewing the core concepts behind optical skyrmions and topological insulators, I will discuss how Skyrmion beams (i.e., optical beams with nonuniform polarisation patterns) can be used to locally control the topology of electrons in topological insulators.

Thursday, 16:40 – 17:00

“Optical simulations for space interferometry. Tool: IfoCAD”

Gudrun Wanner (Leibniz Universität Hannover)

I will present where and how we use Laguerre-Gaussian modes for simulations in the context of space-interferometry missions, such as LISA and GRACE-FO.

Thursday, 17:00 – 17:20

“Structured Light Microscopy for Optical and Topological Characterization”

Denis Ukolov (TU Braunschweig)

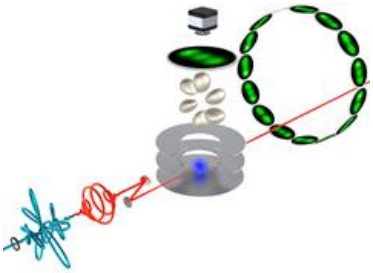
Structured light beams with orbital angular momentum (OAM) are applied to study topological properties of thin films and metasurfaces. Using a laser confocal microscope with integrated interferometry, we investigate phase distributions and topological features of chiral structures.

Friday, 9:00 – 9:40

“Control of electron vortices from femtosecond multiphoton ionization”

Matthias Wollenhaupt (Universität Oldenburg)

We review recent advances in controlling three-dimensional photoelectron momentum distributions (3D PMDs) via multiphoton ionization (MPI) of atoms using polarization-shaped femtosecond laser pulses. The talk begins with an overview of the basic coherent control mechanisms underlying MPI, followed by a description of the experimental methodology. Supercontinuum polarization pulse shaping enables the generation of temporally structured, polarization-tailored laser pulses. 3D PMDs are reconstructed using velocity map imaging (VMI)-based photoelectron tomography. We showcase recent experimental results on the generation and manipulation of free-electron vortices with single-color and bichromatic polarization-shaped pulses. In particular, we highlight the formation of shaped electron vortices (SEVs) through perturbative and non-perturbative MPI with oppositely chirped, counter-rotating circularly polarized (OC-CRCP) pulses, and explore absorption delays in (1+2) resonance-enhanced MPI using transform-limited CRCP pulse sequences.



Friday, 9:40 – 10:20

“Photonic to electronic OAM conversion at the atomic scale”

Jamal Berakdar (Martin-Luther-Universität Halle-Wittenberg)

A brief overview is given on attempts to transfer orbital angular momentum to quantum particles via structured optical fields. The prospect for use in testing for electronic correlation and entangled electrons is discussed.

Friday, 11:00 – 11:40

“Generation and Detection of Neutron Orbital Angular Momentum”

Niels Geerits (Technische Universität Wien)

Over the last decade a targeted effort was dedicated towards generating twisted neutron beams, in the hope of unlocking their unique scattering properties, advantageous for materials science, and the additional quantum mechanical degree of freedom offered by orbital angular momentum (OAM). The latter would prove useful for testing the foundations of quantum mechanics, quantum information and contextuality. After providing an introduction to neutron optics, orbital angular momentum and a history of twisted neutrons, I will go over two novel techniques: the Sagnac effect, a coupling between OAM and rotation, for definitive OAM detection and the Schwinger effect, which describes a relativistic effect where neutron spin and OAM can exchange in the presence of an electric field, enabling generation of twisted neutron waves. Finally, I will show that this effect may have generated the first twisted neutrons almost three decades ago, in an experiment involving neutron diffraction from perfect quartz, a crystal known for its strong interplanar electric fields.

Friday, 11:40 – 12:00

“Electron vortex beams in crystals: Beam splitting and local vortex center formation”

Christian Bick (PTB)

Electron vortex beams have been of interest in scanning transmission electron microscopy due to their channeling properties and potential applications such as electron magnetic circular dichroism and nanoparticle manipulation. They have attracted new attention with the recent development of an orbital angular momentum sorter, theoretical developments in analysis of momentum transfer and as a possible quantum logic gate.
When propagating through a crystal, the vortex electron beam interacts with the asymmetric crystal potential, causing the wave to split into intensity centers around atomic columns. This behavior known as channeling gives rise to a total orbital angular momentum that can no longer be described by an integer vortex quantum number. In this presentation we show the behavior of

electron beams inside crystalline material. We present a simulation-based analysis of the wave phase propagating through the crystal for different materials, focusing on beam splitting into intensity centers with individual orbital angular momentum.

Friday, 12:00 – 12:20

"Inelastic vortex electron scattering by atomic targets"

Sophia Strnat (PTB)

Since their prediction in 2007 and first realization in 2010, vortex electron beams have been widely studied, especially in electron microscopy for probing magnetic and chiral properties of materials. While elastic scattering has been the subject of numerous studies, inelastic processes that excite target atoms have received much less attention. To address this, we develop a distorted-wave approach that accounts for Coulomb interactions, which are known to be important in elastic scattering. Our calculations for 20–100 eV vortex electrons scattering from hydrogen show that Coulomb distortion significantly affects both wave functions and differential cross sections.

Friday, 13:20 – 14:00

"Potential of vortex light and matter for the study of nuclei"

Adriana Palffy (University of Würzburg)

Low-lying nuclear excited states can be accessed by x-ray photons or coupling to the atomic shell. The talk will discuss how electron and photon vortex beams can be used to drive nuclear transitions on the examples of two metastable nuclear states, First, we will discuss results for nuclear excitation by electron capture employing electron vortex beams [1]. On the example of $93m$-Mo, we show theoretically that the use of tailored electron vortex beams increases the depletion of the isomer by 4 orders of magnitude compared to its spontaneous nuclear decay. Second, we will present results on photoexcitation of the 229-Th nuclear clock transition using Bessel and Laguerre-Gauss photon vortex beams. While the total excitation is not more efficient than the case of plane waves, we will discuss the specific features of vortex beam excitation for two possible nuclear clock setups [2].

[1] Y. Wu et al., Phys. Rev. Lett. 126, 162501 (2022).
[2] T. Kirschbaum et al., Phys. Rev. C 110, 064326 (2024)

Friday, 14:00 – 14:20

“Coherent vortex beam pulse propagation in ^{229}Th:CaF_2”

Alexander Franz (University of Würzburg)

A formalism for the coherent propagation of Bessel beams through an ensemble of nuclei is presented. Our approach is based on the iterative wave equation. The formalism is applied to an ensemble of two-level thorium nuclei doped in a CaF_2 crystal. We calculate the scattering profile which is determined by the interaction between the nuclear ensemble and the Bessel beam.

Friday, 14:20 – 14:40

“PNC studies with vector light beams”

Jan Richter (PTB)

In this presentation, we will discuss the potential of vector light beams for studying parity non-conservation phenomena in atomic systems. In particular, we aim to revisit the well-known case of 2s-2p parity-violating mixing and to show how it can be measured with the help of azimuthally and radially polarized beams.