Structured Light and its Applications
TU Braunschweig, June 1st 2023

Talks

- **Fei Ding (Leibniz University Hannover)**

  "Semiconductor quantum dots as an emerging platform for generating twisted single photons"

  Twisted single photons carrying orbital angular momentum (OAM) are interesting for quantum information applications. Recently, solid-state sources for single photons with OAM have been realised by using semiconductor quantum dots and as well as nitrogen-vacancy in nanodiamonds. In this talk I will introduce our works on high quality single photon sources based on GaAs/AlGaAs quantum dots, and then discuss their possible applications in generating twisted single photons.

- **Kayn A. Forbes (University East Anglia)** ***online***

  "Novel routes in chiral light-matter interactions and optical activity using structured light"

  For nearly 200 years optical chirality has been associated with circular polarisation, where the electromagnetic fields propagate in a helical fashion, twisting to the left or right. Advances in technology allow us to now readily structure the amplitude, phase, and polarization of laser light in both space and time, producing new types of structured chiral light. In this talk I will survey the past, present, and future of the rapidly emerging field of structured chiral light.

- **Sonja Franke-Arnold (University of Glasgow)** ***online***

  "Structured light for polarimetry and magnetometry"

  Structured vector light is correlated in its polarisation and spatial degree of freedom. This offers perspectives to covert temporal detection mechanisms into the spatial domain, offering one-shot image-based analysis. I will illustrate this concept with our experimental demonstrations of white light polarimetry and an "atomic compass".

- **Wolfgang Löffler (University Leiden)**

  "Twisted and entangled photons"

  High-gain spontaneous parametric downconversion operates in a fascinating regime - entanglement lasing. We show how insight on the production process can be obtained by detecting 4 photons in the orbital angular momentum basis, but that the theoretical description based on text-book quantum optics results in very complex quantum states. We then discuss the derivation of a simple theory - to be able to compare to experimental data.

- **Ekkehard Peik (PTB)**

  "Excitation of an electric octupole transition by twisted light"

  We study the laser excitation of the S-F electric octupole transition by twisted light modes with a single trapped Yb^+ ion in the dark center of a vortex beam. For the operation as an optical clock, this results in a fivefold reduced light shift in comparison to excitation by plane wave radiation for the same Rabi frequency. We compare the experimental results with theoretical predictions and find good qualitative agreement.

Posters

- Richard Lange, **Nils Huntemann,** Anton A. Peshkov, Andrey Surzhykov, Ekkehard Peik, **(PTB and TU Braunschweig)**

  "Excitation of an electric octupole transition of a single trapped ion"

  We study the coherent excitation of the $^2S_{1/2}$-$^2F_{7/2}$ electric octupole (E3) transition by twisted light modes with a single $^{171}Yb^+$ ion in the dark center of a vortex beam. The intensity distribution of the beam is mapped as a function of the ion's position by measuring the light shift on an auxiliary electric quadrupole transition. In the center of the vortex beam, we observe excitation of the E3 transition with a fivefold reduced light shift in comparison to excitation by plane wave radiation for the same Rabi frequency. In the future, we are interested in experimentally investigating the scaling of the Rabi frequency with the beam diameter of vortex beams for the E3 excitation in $^{171}Yb^+$ and in $^{173}Yb^+$, for which hyperfine interaction causes a significant modification of coupling between ground and excited state.

- **Jörg Götte (University of Glasgow)**

  "Quantum phases of bosonic chiral molecules in helicity lattices"

  We reveal the existence of polarizing phases for the enantiomers of cold, interacting chiral molecules in a helicity lattice. These recently proposed lattices have sites with alternatinghelicity which exert a discriminatory force on chiral molecules. We find that a strong dipolar repulsion between molecules results in the separation of left and right enantiomers.

- **Silvia Müllner (TU Braunschweig)**

  "Chiral and Helical Contributions to Topological Raman scattering using Twisted Light"

  Light with orbital and spin angular momentum is used to probe chiral fluctuations in chiral liquid crystals. We find helical and chiral contributions to low energy Raman scattering, depending on the scattering vector and topological number of the incident photon field. The anomalous observed dispersion is attributed to quasiparticle scattering, in which the orbital angular momentum is transfered to rotonlike quasiparticles.

- **Shreyas Ramakrishna (Helmholtz institute Jena and FSU Jena)**

  "Detecting the oscillating magnetic field using the vector light-atom interaction"

  Detection of the (oscillating) magnetic field can be useful in the study of life sciences, in magnetic resonance imaging (MRI), in detecting dark matter, and in many more areas. In this poster, I explain a new method to detect the strength and frequency of the oscillating magnetic field. That is, we study photoexcitation of Rb atoms by vector Bessel beams, and by analyzing the population of the excited state we can infer the details of the oscillating magnetic field. In addition, we believe that our results can enhance the quantum metrology experiments based on twisted light atom interaction.

- **Riaan P. Schmidt (PTB)**

  "Probing Properties of Twisted Light by the Hanle Effect"

  The so-called twisted light can be generated using different techniques in order to employ them in experiments. However, experimental equipment might not produce perfectly pure twisted light as recent investigations have shown [1]. We propose using the Hanle effect as a new method to study the admixture of twisted light and plane wave radiation. We develop our approach within the framework of the density matrix theory based on the Liouville–von Neumann equation which can be applied to any atomic system and various compositions of the incident radiation.
  [1] R. Lange, N. Huntemann, A. A. Peshkov, A. Surzhykov, and E. Peik, Phys. Rev. Lett. 129, 253901 (2022)