Workshop Chiral Photonics 2017

4 September 2017 – 6 September 2017

Max Planck Institute for the Science of Light, Erlangen, Germany

MAX PLANCK INSTITUTE
for the science of light

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NATURWISSENSCHAFTLICHE
FAKULTÄT

Organizers

Andrea Aiello, MPL Erlangen

Florian Marquardt, MPL Erlangen

Workshop Location

Max Planck Institute for the Science of Light,

Staudtstrasse 2, 91058 Erlangen, Germany

Workshop rooms (see maps next pages for precise location)

Talks

4-6 September	MPL Bibliothek A.2.500, 2nd floor

Lunch

4-6 September	MPL Casino A.-1.206, UG/Basement

Dinner

4 September	MPL Main Hall, EG/Ground floor
5 September	Kitzmann BräuSchänke, Erlangen Zentrum

Poster Session

4 September	MPL Main Hall, EG/Ground floor

Contact

Mrs. Gesine Murphy, MPL Room: A.2.108, Tel.: +49 9131 7133 401,

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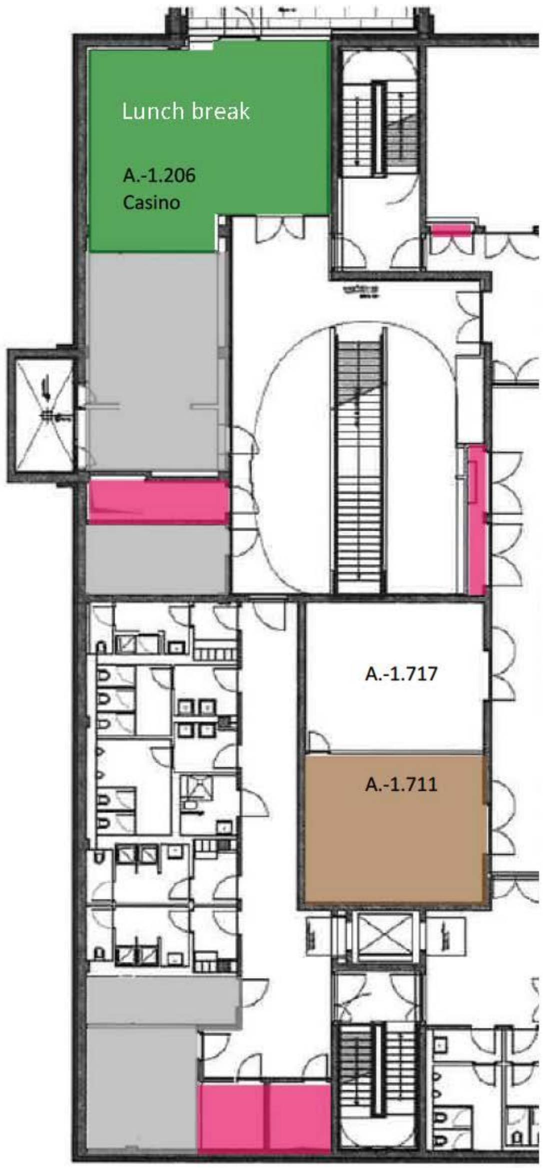
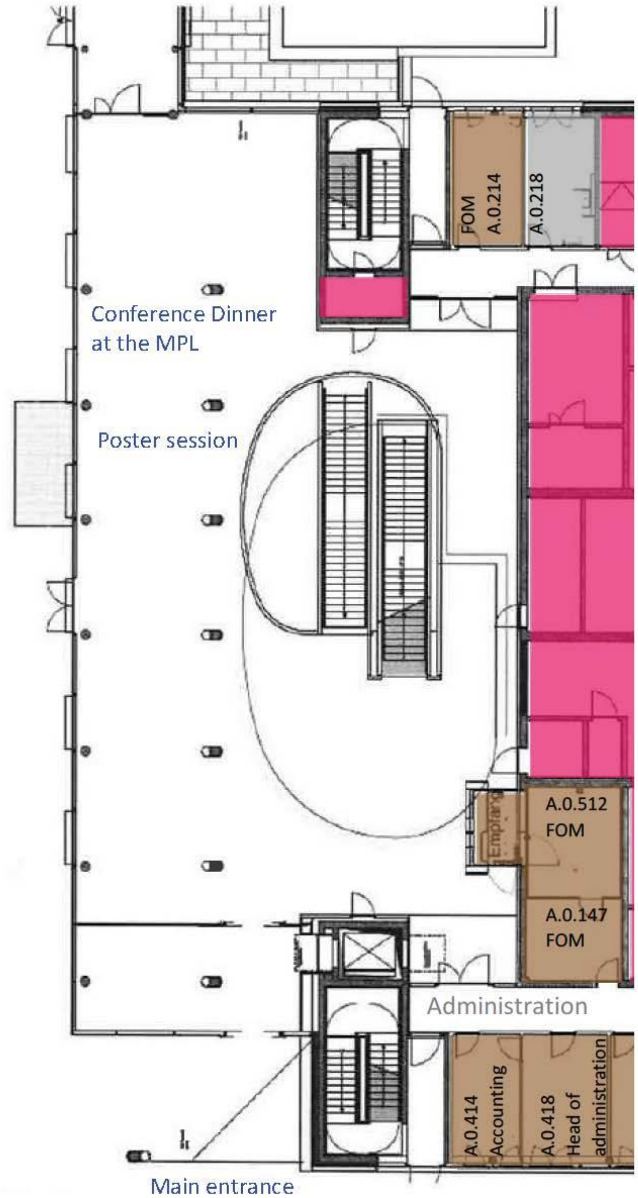
MPL UG/Basement



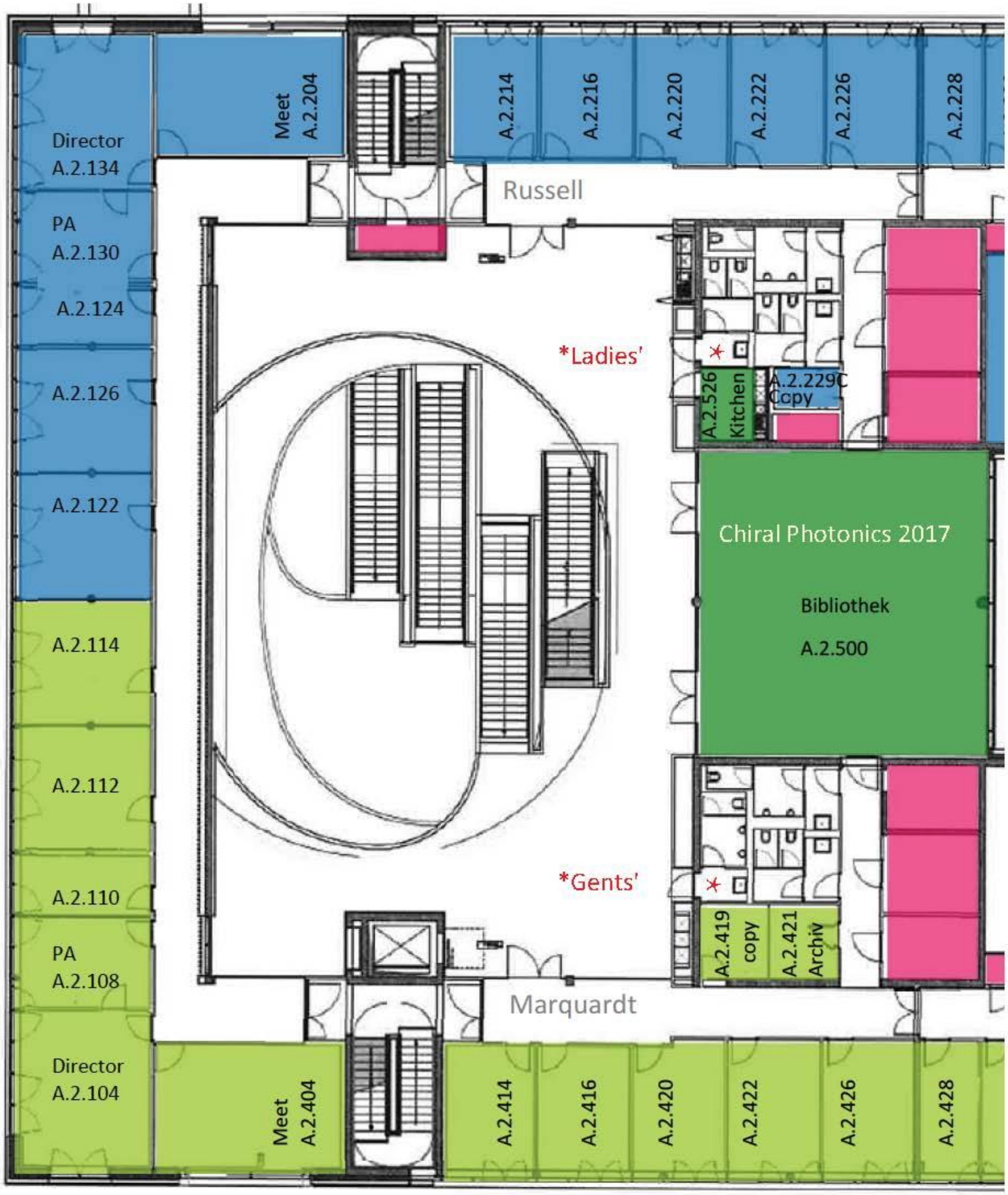
UG / basement

MPL EG/Ground floor



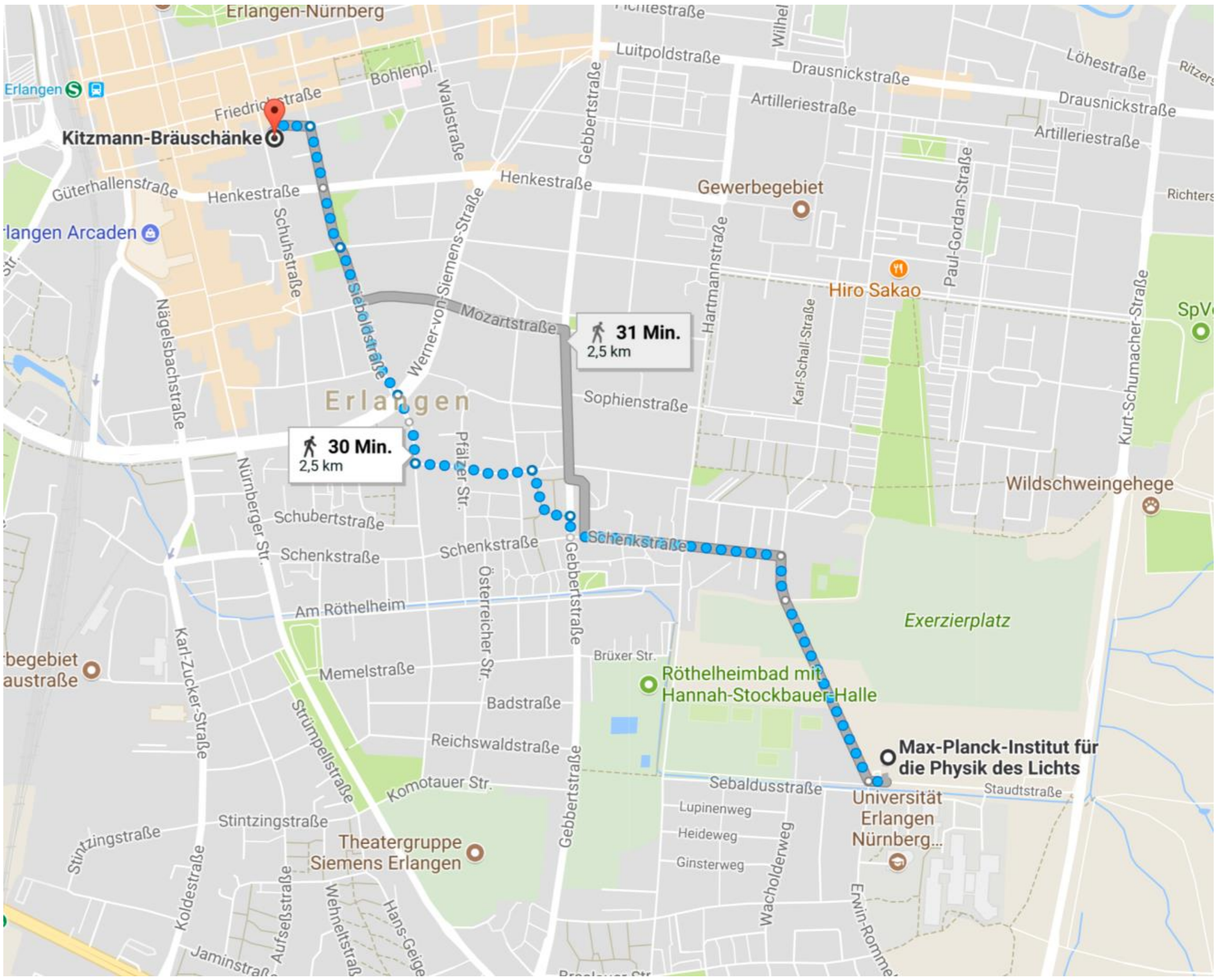
EG / ground floor

MPL 2nd floor



2. OG / 2nd floor

Walking route to Kitzmann BräuSchänke, Südliche Stadtmauerstraße 25, 91054 Erlangen



Schedule Monday 4 September 2017

09:30 – 09:45	**Registration**
09:45 – 10:00	**Welcome and Opening Remarks**
10:00 – 10:50	**Chirality, optical activity, helicity, angular momentum and all that jazz** Gabriel Molina-Terriza, Macquarie University (Australia)
10:50 – 11:25	**The plurality of chirality** David Andrews, University of East Anglia (UK)
11:25 – 11:55	Coffee break
11:55 – 12:30	**Optical momentum, spin, and angular momentum in dispersive and inhomogeneous media** Konstantin Bliokh, RIKEN Center for Emergent Matter Science (Japan)
12:30 – 13:05	**Chiral strong coupling of valley excitons in a transition metal dichalcogenide monolayer** Stefano Azzini, Université de Strasbourg (France)
13:05 – 14:05	Lunch

Schedule Monday 4 September 2017

14:05 – 14:55	**Reversal of orbital angular momentum arising from an extreme Doppler shift** Miles Padgett, University of Glasgow (UK)
14:55 – 15:30	**Measuring transverse electric and magnetic spin densities of light at the nanoscale** Peter Banzer, Max Planck Institute for the Science of Light (Germany)
15:30 – 16:00	**Coffee break**
16:00 – 16:35	**Nonreciprocal quantum optical devices based on chiral interaction of confined light with spin-polarized atoms** Arno Rauschenbeutel, Vienna University of Technology (Austria)
16:35 – 17:10	**Polarization twists in non-collinear paraxial-beam crossings** Kiko Galvez, Colgate University (USA)
17:10 – 17:45	**Photonic spin Hall effects in plasmonics and metamaterials** Anatoly Zayats, King's College London (UK)
17:45 – 18:30	**Pause**
18:30 – 19:30	**Buffet dinner at MPL**
19:30 – 21:00	**Poster session**

Schedule Tuesday 5 September 2017

09:00 – 09:50	**Lab tour** InMik (Peter Banzer) and Russell's labs
10:00 – 10:50	**Stable and unstable Airy-related caustics and beams** Michael Berry, University of Bristol (UK)
10:50 – 11:25	**Swings and roundabouts: operators and rays for structured Gaussian beams** Mark Dennis, University of Bristol (UK)
11:25 – 11:55	Coffee break
11:55 – 12:30	**The effect of orbital angular momentum on ultrashort optical pulses** Marco Ornigotti, University of Rostock (Germany)
12:30 – 13:05	**Pseudo-quantum-gravity: Planck scale physics by classical and quantum nonlinear optics** Claudio Conti, University of Rome "La Sapienza" (Italy)
13:05 – 14:05	Lunch

Schedule Tuesday 5 September 2017

14:05 – 14:55	**Light twists at the nanoscale** Kobus Kuipers, TU Delft (The Netherlands)
14:55 – 15:30	**Chiral photonic crystal fibre** Philip Russell, Max Planck Institute for the Science of Light (Germany)
15:30 – 16:00	**Coffee break**
16:00 – 16:35	**Revealing magnetic structure of materials with twisted electrons** Ebrahim Karimi, University of Ottawa (Canada)
16:35 – 17:10	**Phase transitions in the diffusion of light** Aristide Dogariu, CREOL, University of Central Florida (USA)
17:10 – 17:45	**Quantum dot cavity-QED: single photon interference & chirality** Wolfgang Löffler, Leiden University (The Netherlands)
17:45 – 18:30	**Pause**
18:30 –	**Dinner at Kitzmann BräuSchänke, Erlangen Zentrum**

Schedule Wednesday 6 September 2017

09:00 – 09:50	**Lab tour** Sandoghdar's labs
10:00 – 10:50	**Controlling light-matter interactions on the nanometer scale** Lukas Novotny, ETH Zürich (Switzerland)
10:50 – 11:25	**Majorana towers in structured light beams** Fabrizio Tamburini, ZKM Karlsruhe (Germany)
11:25 – 11:55	**Coffee break**
11:55 – 12:30	**Multi-axis orbital momentum** Michael Mazilu, University of St Andrews (UK)
12:30 – 13:05	**Manipulating higher-order Poincaré sphere beams for classical and quantum applications** Andrew Forbes, University of the Witwatersrand (South Africa)
13:05 – 14:05	**Lunch**
14:05 –	**Closing/Discussions/Departures**

Poster session Monday 4 September 2017, 19:30 – 21:00

Anomalous time delays and quantum weak measurements in micro-resonators

Presenter: **Konstantin Bliokh**, RIKEN Center for Emergent Matter Science (Japan)

Third Harmonic Light Control in Plasmonic Metasurfaces for Nonlinear Beam Shaping

Presenter: **Antonino Calà Lesina**, University of Ottawa (Canada)

Time Asymmetric Quantum Mechanics in Nonlinear Optics

Presenter: **Giulia Marcucci**, Institute for Complex Systems of the National Research Council (Italy)

Transverse Spin in Structured Light

Presenter: **Martin Neugebauer**, Max Planck Institute for the Science of Light – InMik (Germany)

On determination of orientation of the optically trapped nano-particles inside a deep parabolic mirror

Presenter: **Vsevolod Salakhutdinov**, Max Planck Institute for the Science of Light – 4PiPAC (Germany)

Knotted polarization hopfions in tight focused light

Presenter: **Danica Sugic**, University of Bristol (UK)

Studying chirality at the nanoscale

Presenter: **Pawel Wozniak,** Max Planck Institute for the Science of Light – InMik (Germany)

Abstracts

David L. Andrews

The plurality of chirality

It has been known since the pioneering researches of Louis Pasteur that it is possible for matter to exist in identifiably different forms of handedness, and that such a feature can produce striking optical rotation effects. Following Lord Kelvin's later introduction of the scientific term 'chirality', numerous other optical manifestations have been discovered, and the term has become ever more extensively applied. Developments in the field of optical vortices and other forms of structured light, in particular, have spurred many wider applications. Recently, however, a new range of phenomena has been described using the same term; the optical 'handedness' of materials, and in particular the 'left-handedness' of negative-index metamaterials. The absence of any obvious linkage between these kinds of optical chirality invites questions as to what specific principles apply to each form, and whether there are any fundamental principles in common. By focusing on the properties and nanoscale interactions of individual photons, starting from the basis of fundamental CPT symmetry, this talk aims to set out the broad principles of geometry and scale that apply to the various aspects of optical chirality.

T. Chervy, Stefano Azzini, E. Lorchat, S. Wang, Y. Gorodetski, J. A. Hutchison, S. Berciaud, T. W. Ebbesen, and C. Genet

Chiral strong coupling of valley excitons in a transition metal dichalcogenide monolayer

The ability to achieve the spatial routing of the photoluminescence flow according to the spin of the polarization of the emitter transition, known as chiral coupling, is of fundamental interest in the field of light-matter interactions. In this work, we propose a new chiral photonic platform consisting of the spin-polarized valleys of a transition metal dichalcogenide (TMD) monolayer and the optical spin-orbit (OSO) modes of a surface plasmon grating. We observe that, in such a structure, each spin-polarized valley exciton is strongly coupled with a single plasmon mode of specific momentum, to yield spin-momentum locked polariton states, that we name chiralitons. Thanks to the operation under strong light-matter coupling, our platform remarkably shows two striking features, unexpected at room temperature: (i) robust valley polarization of the chiralitons, given that no valley polarization was observed for the excitons of the bare monolayer, and (ii) robust chiralitons inter-valley coherences, resulting in the coherent superpositions of chiral polaritons flowing in opposite directions. We believe that our results show that the strong coupling of OSO modes with excitons in a TMD material represents an interesting way to realize coherent dynamics at room temperature.

Peter Banzer

Measuring transverse electric and magnetic spin densities of light at the nanoscale

The transverse angular momentum of light is a fascinating property of spatially confined fields. After it was first discussed by Aiello and others in 2009, numerous studies followed, making this area of optics research a very lively experimental and theoretical field of investigations. Various interesting applications of transverse angular momenta and related phenomena have been proposed and presented in the literature.

In the context of transverse angular momenta, particularly the so-called transverse spin density is often discussed, describing the local transverse spin component in an electromagnetic field and, hence, the field vector locally spinning around an axis orthogonal to the propagation direction.

In this presentation, we discuss novel techniques for experimentally investigating and measuring transverse spin density maps at the nanoscale. We also show, for the first time, how to measure the magnetic spin density of light, whose distribution studied at deep-subwavelength dimensions can differ substantially from that of its electric counterpart.

Michael Berry

Stable and unstable Airy-related caustics and beams

Accelerated beams (Airy and Airy-related) correspond to curved caustics of the underlying geometrical rays. The connections will be explained in detail, concentrating on beams associated with the stable caustics classified by catastrophe theory. Some such beams, including the simplest Airy beam in three-dimensional space, are unstable in the mathematical sense: under a symmetry-breaking perturbation, they break up into caustics that are stable. In the Airy case, this is a hyperbolic umbilic catastrophe. Associated with the stable caustics are a variety of exact solutions of the paraxial wave equations.

Konstantin Bliokh

Optical momentum, spin, and angular momentum in dispersive and inhomogeneous media

We examine the momentum, spin, and orbital angular momentum of structured monochromatic optical fields in dispersive inhomogeneous isotropic media. There are two bifurcations in this general problem: the Abraham-Minkowski dilemma and the kinetic (Poynting-like) versus canonical (spin-orbital) pictures. We show that the kinetic Abraham momentum describes the energy flux and group velocity of the wave in the medium. At the same time, we introduce novel canonical Minkowsky-type momentum, spin, and orbital angular momentum densities of the field. These quantities exhibit fairly natural forms, analogous to the Brillouin energy density, as well as multiple advantages as compared with previously considered formalisms. We apply this general theory to inhomogeneous surface plasmon-polariton (SPP) waves at a metal-vacuum interface and show that SPPs carry a "super-momentum", proportional to the wave vector $k_p > \omega/c$, and a transverse spin, which can change its sign depending on the frequency ω.

Claudio Conti

Pseudo-quantum-gravity: Planck scale physics by classical and quantum nonlinear optics

We will review some our recent work concerning simulation and emulation of Planck scale phenomenology by using classical and quantum nonlinear optics. We will show how the concept of generalized uncertainty principle (GUP) enters readily in the classical optical propagation in the non-paraxial regime. We will also show the way nonlocal nonlinearity allows realizations of the generalized Planck-scale harmonic oscillator and non-commutative geometry. Classical and second-quantized scenarios will be described by also resorting to phase-space representations and stochastic simulations. Our work is related to other non-commutative scenarios that arise in Chiral Photonics and pave the way to a number of surprising interdisciplinary connections.

Mark R. Dennis and Miguel A. Alonso

Swings and Roundabouts: Operators and Rays for structured Gaussian beams

The analogy between the Poincaré sphere describing polarization, and the Laguerre- and Hermite-Gaussian beams of order 1, is a well-understood principle of understanding structured Gaussian beams. Mathematically, the Poincaré sphere describes the orbits of a classical orbits of a classical two-dimensional harmonic oscillator, in terms of the formalism of Hamiltonian mechanics. Many properties of Hermite-, Laguerre- and Ince-Gaussian beam families can be understood with these as eigenfunctions of certain operators, such as the angular momentum operator, corresponding to Hamiltonian constants of the motion (themselves related to Stokes parameters). This correspondence can be approached semiclassically, where any self-similar Gaussian beam family can be constructed from a hyperboloidal family of straight rays. This ray-based description also provides a simple explanation for many aspects of structured Gaussian beams, such as “self-healing” and the Gouy and Pancharatnam–Berry phases. If there is time, I will outline potential generalizations to other structured beam families, including Bessel beams and Airy beams.

R. R. Naraghi and Aristide Dogariu

Phase transitions in the diffusion of light

Light encounters different stages of evolution as it penetrates into a random medium. We will demonstrate that these “phase transitions” in the transport of light are direct consequences of competing mechanisms of interaction between light and complex media. In strongly multiply scattering media, waves can propagate along reciprocal multiple scattering paths, generating additional interferences seen as closed loops in their trajectories. This increased probability of returning to the starting point effectively slows down the normal diffusion and this constitutes the first phase transition in the diffusion of light: from normal to anomalous. On the other hand, the near-field coupling between constituents of complex media has the tendency to destroy these loops by leaking energy into new channels [1]. The longer the propagation paths the more such events and, as a result, the loops of energy flows are destroyed more and more, and the diffusive propagation gradually returns to normal. This constitutes a second phase transition in the diffusion of light: from anomalous to normal [2].

[1] R. Rezvani Naraghi, S. Sukhov, J. J. Sáenz, and A. Dogariu, Phys. Rev. Lett. **115**, 203903 (2015).

[2] R. Rezvani Naraghi and A. Dogariu, Phys. Rev. Lett., **117**, 263901 (2016).

Andrew Forbes

Manipulating higher-order Poincare sphere beams for classical and quantum applications

Spin-orbit states of light, as described by the higher-order Poincare sphere, have found many applications of late, both classical and quantum. Controversially, such classical states have been referred to as "classically entangled", mimicking some quantum properties by virtue of their non-separability in spatial mode and polarisation. In this talk I will outline how to create, propagate and detect such states of light at both the quantum and classical regimes. I will cover how to create them on-demand directly from the source, and how to detect them in a deterministic manner without photon loss. Finally, I will show how their non-separability can be used to not only blur the quantum-classical divide, but also to realise hybrid classical-quantum processes that exploit the best of both worlds.

Kiko Galvez

Polarization Twists in Non-Collinear Paraxial-Beam Crossings

We extract the 3-D polarization structure of light in the crossing of paraxial beams in opposite states of circular polarization. We confirm previous predictions by Freund that polarization twists are ubiquitous in these types of superpositions. These twists are half-integral only when one or both beams carry optical vortices; situations that produce Möbius strips when following the polarization along closed trajectories. In this work we do experiments using coherent light beams prepared with a spatial light modulator and then measure the light using polarization projections.

Ebrahim Karimi

Revealing magnetic structure of materials with twisted electrons

Electrons have played a significant role in the development of many fields of physics during the last century. The interest surrounding them mostly involved their wave-like features prescribed by the theory of quantum mechanics, which was developed just a few years earlier. In particular, these features correctly predict the behaviour of electrons in various physical systems including atoms, molecules, solid state materials. Ten years ago, new breakthroughs were made, arising from the new abilities to shape the wavefunction of electrons. For example, free electrons have been shown to have the ability to carry orbital angular momentum (OAM), a property which, in conjunction with its charge, attributes several additional magnetic properties that are intrinsically related to the transverse structure of such twisted electron waves. These features allow such electrons to effectively interact with magnetic fields in unprecedented ways and have motivated materials scientists to find new methods for generating twisted electrons and measuring their OAM content, with the ultimate goal of using them as nanoscale magnetic probes. Our recent studies in shaping and sorting electron vortex beams and their application to explore magnetic structures of material will be the subject of my talk.

Kobus Kuipers

Light twists at the nanoscale

We use a near-field microscope to visualize light fields in and around nanophotonic structures. The microscope gives us access to the amplitude and phase of not only the electric but also the magnetic in-plane field components [1,2]. Thus, we gain access to the full in-plane electric and magnetic “Poincaré sphere”. We can visualize both phase and polarization singularities. In a chaotic cavity the superposition of random waves leads to a distribution of phase singularities in space reminiscent of that of particles in an ionic liquid, but not quite due to lights vectorial nature [3]. As a parameter of the system is changed, e.g., the optical frequency, the singularities perform a Brownian motion. Sometimes they are created in pairs. And sometimes a pair of singularities annihilates. We observe that the “life and death” of pairs that annihilate with their creation partner and therefore exhibit life-long fidelity, seems to take place predominantly in the parameter range where the random light field patterns show coherence. Promiscuity occurs all the time [4].

[1] B. le Feber, et al., Nature Photonics Vol. **8**, 43-46, (2014).

[2] N. Rotenberg and L. Kuipers, Nature Photonics Vol. **8**, 919-926, (2014).

[3] L. De Angelis, et al., Phys. Rev. Lett. **117**, 093901 (2016).

[4] L. De Angelis, et al., submitted.

Wolfgang Löffler

Quantum dot cavity-QED: single photon interference & chirality

Semiconductor quantum dots in high-quality optical micropillar cavities are a promising system for high-speed photonic quantum gates. This is due to efficient photon-photon interaction by single photon nonlinearities enhanced by cavity-QED effects, while still maintaining a Gaussian transverse shape of the optical mode which enables good optical coupling and polarization control. Polarization plays an intriguing role in such devices due to optical selection rules and various energy non-degeneracies in the system, for instance, the response can be tuned from achiral to chiral using external magnetic fields. This enables a novel self-homodyne quantum interference technique involving coherent light, photon-subtracted coherent light, and single photon states; for instance, we show how this can be used to transform coherent light into either high-purity single photons, or into a stream of strongly correlated photons.

Michael Mazilu

Multi-axis orbital momentum

Light beams possessing orbital angular momentum (OAM) have found many uses in modern optics such as micro-manipulation in optical trapping and information transfer in telecommunication and quantum optics. The appeal of OAM is its simplicity and fundamental origin. Typically, single mode Laguerre-Gaussian beams and Bessel beams are used to transmit pure OAM having a clearly defined orbital angular momentum value and associated vortex charge. These beams are part of a larger family of structured illumination beams such as Mathieu beams and non-diffractive parabolic beams. Here, we generalise the definition the orbital angular momentum to expand the family of structured illumination beams possessing pure orbital momentum.

Gabriel Molina-Terriza

Chirality, Optical Activity, Helicity, Angular Momentum and all that jazz

In this presentation I will give an overview of our studies on the relationship between optical activity and the helicity of electromagnetic fields. I will show, how the often-confused spin angular momentum and the electromagnetic helicity paly very different roles in this phenomenon. These differences are highlighted in experiments with nanoparticles or in non-paraxial settings. These experiments will help us to better understand how to control the optical activity to determine chiral structures in nanoparticles and even, how to induce circular dichroism in some achiral structures, by controlling the total angular momentum of the electromagnetic field.

In particular, I will show our experimental results on how a circular nanoaperture has a differential transmission of right and circularly polarized light if the spatial mode is non-Gaussian. On the other hand, I will also show that even the well-known text-book case of optical activity in chiral sugars presents a very different behaviour if the scattered light is collected in a non-forward direction.

I will finish with some ideas on how to enhance the optical activity of chiral molecules by coupling them to dual nanoparticles, i.e. particles which have the same response for electric and magnetic fields.

Lukas Novotny

Controlling Light-matter Interactions on the Nanometer Scale

The past 20 years have brought exceptional control over light-matter interactions on the nanoscale. Today, localized optical fields are being probed with nanoscale materials, and, vice versa, nanoscale materials are being controlled and manipulated with localized fields. In this talk I will review both early and recent developments in near-field optical spectroscopy and optical nanomanipulation.

Marco Ornigotti

The Effect of Orbital Angular Momentum on Ultrashort Optical Pulses

In this talk, I will present a new class of ultrashort optical pulses, namely X waves carrying orbital angular momentum (OAM). In particular, I will describe in detail the coupling between OAM and the temporal degrees of freedom of such pulses, highlighting how OAM affects both the pulse duration and its carrier frequency. An ultimate limit for the maximum amount of OAM that can be carried by single cycle ultrashort pulses will also be discussed.

G. M. Gibson, E. Toninelli, S. A. R. Horsley, G. C. Spalding, E. Hendry, D. B. Phillips, and <u>Miles Padgett</u>

Reversal of Orbital Angular Momentum arising from an Extreme Doppler Shift

The linear Doppler shift is familiar to many as the rise and fall in pitch of an ambulance siren as it passes by. Less well known, but also understood, is a rotational Doppler shift that is proportional to the rotation rate between source and observer. By analysing the orbital angular momentum (OAM) of scattered waves, the rotational Doppler effect is observable even when the linear Doppler shift is zero, and so can be used to measure the rotation rate of remote spinning objects. Using an acoustic source, we show that the frequency shift can be sufficiently large that the observed frequency becomes negative. We observe that this change of sign is associated with a reversal in the handedness of the OAM carried by the wave. No supersonic velocities are required since the measurements are made in a super-oscillatory region of the field. Our work is the rotational analogue of time reversal in the linear frame, and may be of relevance to observed frequencies from ultrafast rotating objects.

Arno Rauschenbeutel

Nonreciprocal Quantum Optical Devices Based on Chiral Interaction of Confined Light with Spin-Polarized Atoms

The confinement of light in nanophotonic structures results in an inherent link between the light's local polarization and its propagation direction [1]. Remarkably, this leads to chiral, i.e., propagation-direction-dependent effects in the emission and absorption of light by quantum emitters [2]. For example, when coupling atoms to an evanescent field, their emission into counter-propagating optical modes can become asymmetric [3]. In our group, we became aware of this chiral light–emitter coupling when studying the interaction of single rubidium atoms with the evanescent part of a light field that is confined by continuous total internal reflection in a whispering-gallery-mode (WGM) microresonator [4]. In the following, we employed this effect to demonstrate an integrated optical isolator [5] as well as an integrated optical circulator [6] which operate at the single-photon level and which exhibit low loss. The latter are the first two examples of a new class of nonreciprocal nanophotonic devices which exploit the chiral interaction of quantum emitters with transversally confined photons.

[1] K. Y. Bliokh, F. J. Rodríguez-Fortuño, F. Nori, and A. V. Zayats, "Spin-orbit interactions of light," Nat. Photon. **9**, 796 (2015).

[2] P. Lodahl, S. Mahmoodian, S. Stobbe, A. Rauschenbeutel, P. Schneeweiss, J. Volz, H. Pichler, and P. Zoller, "Chiral Quantum Optics," Nature **541**, 473 (2017).

[3] R. Mitsch, C. Sayrin, B. Albrecht, P. Schneeweiss, and A. Rauschenbeutel, "Quantum state-controlled directional spontaneous emission of photons into a nanophotonic waveguide," Nature Commun. **5**, 5713 (2014).

[4] C. Junge, D. O'Shea, J. Volz, and A. Rauschenbeutel, "Strong coupling between single atoms and non-transversal photons," Phys. Rev. Lett. **110**, 213604 (2013).

[5] C. Sayrin, C. Junge, R. Mitsch, B. Albrecht, D. O'Shea, P. Schneeweiss, J. Volz, and A. Rauschenbeutel, "Nanophotonic Optical Isolator Controlled by the Internal State of Cold Atoms," Phys. Rev. X **5**, 041036 (2015).

[6] M. Scheucher, A. Hilico, E. Will, J. Volz, and A. Rauschenbeutel, "Quantum optical circulator controlled by a single chirally coupled atom," Science **354**, 1577 (2016).

P. St.J Russell and G. K. L. Wong

Chiral Photonic Crystal Fibre

Twisted photonic crystal fibre (PCF) consists of a single uniaxial chiral unit, containing one or more light-guiding cores, that is infinitely extended in the direction of the twist [Russell et al: Phil. Trans. R. Soc. A **375**, 20150440 (2017); doi:10.1098/rsta.2015.0440]. The helical periodic microstructure supports a family of unusual and fascinating effects, related to the ability of the spiralling structure to create optical vortices, i.e., act like an optical impeller. Twisting can create low loss guidance of light in a PCF with no perceptible core [Beravat et al: Science

Advances **2**, e1601421 (2016); doi:10.1126/sciadv.1601421]. The modes of twisted PCF are almost perfectly circularly polarised, exhibit optical activity and carry orbital angular momentum. They also display OAM birefringence, i.e., modes with principal OAM orders ±m have non-degenerate propagation constants, which means that OAM can be robustly preserved over long fibre lengths. Twisted solid-core PCF exhibits a series of transmission dips at twist-tunable wavelengths, with applications in sensing and filtering. Twisted single-ring hollow-core PCF offers enhanced suppression of higher order guided modes [Edavalath et al: Opt. Lett. 42, 2074 (2017); doi:10.1364/OL.42.002074].

Fabrizio Tamburini

Majorana towers in structured light beams

Majorana formulated in 1937 an alternative solution valid for bosonic and fermionic relativistic particles with null or positive-definite rest mass in the attempt to avoid the problem of the negative squared mass solution emerging from the Dirac equation that instead were due to anti-electrons. The spectrum of particles described by the Majorana solution linking the angular momentum of a particle with its mass is also known as “Majorana Tower”.

Examples of Majorana-like particles can be found in different scenarios like in condensed matter physics, where composite states of particles behave as Majorana fermions.

This is found also in photonic systems: structured light beams can show Majorana-like behaviors both in plasma and in vacuum, involving in a quasiparticle state not only spin but also orbital angular momentum together with their propagation properties.

Anatoly V. Zayats

Photonic spin Hall effects in Plasmonics and Metamaterials

Photonic spin Hall effect relies on coupling of spin angular momentum of light (associated with circular polarisation of an electromagnetic wave) and orbital angular momentum (associated with the energy flow and propagation direction), in analogy to spin-Hall effect for electrons. This effect provides interesting applications in polarization-enabled control of optical signals excitation and direction, or in reverse, controlling light polarization, as well as sensing applications and quantum optics. In this talk we will overview the effects associated with the photon spin when circular polarized light interacts with plasmonic nanostructures and metamaterials. Spin-dependent directional excitation of guided modes, spin-orbit coupling in surface plasmon scattering associated with transverse spin of surface polaritons, and spin-dependent optical forces will be discussed. Photonic spin-orbit interactions provide an additional and important tool for harvesting functionalities and applications of circularly polarized light in numerous photonic technologies.