Q 29: Photonics

Time: Wednesday 11:00–13:00 Location: HS 1221

Q 29.1 Wed 11:00 HS 1221

Thermally Expanded Core Fiber: a Novel Platform for Meta-Fibers — •Mohammadhossein Khosravi^{1,2}, Jisoo Kim^{1,2}, Malte Plidschun^{1,2}, Torsten Wieduwilt^{1}, Matthias Zeisberger^{1}, and Markus Schmidt^{1,2,3} — ^{1}Leibniz Institute of Photonic Technology, 07745, Jena, Germany — ^{2}Abbe Center of Photonics and Faculty of Physics, FSU Jena, 07745, Jena, Germany — ^{3}Otto Schott Institute of Material Research, FSU Jena, 07745, Jena, Germany

Meta-Fibers, incorporating 3D-printed Metalens technology into optical fiber facets, offer versatility in imaging, optical trapping, and electromagnetic wave manipulation. While Single-Mode Fiber (SMF) is prized for its precise output, its limited mode field diameter presents challenges, often necessitating fusion splicing with Multi-Mode Fiber (MMF) or intricate 3D-printed structures to expand the usable beam cross-section. However, these methods are complex and risk damaging the Meta-Fiber. This study proposes an alternative solution by replacing SMF with Thermally Expanded Core (TEC) fiber, known for its significantly larger mode field diameter. This novel approach facilitates optical trapping and imaging through the integration of a 3D laser-printed ultra-high numerical aperture metalens into TEC fibers, demonstrating effective performance in diverse environments. The results not only broaden the applications of Meta-Fiber but also present a more efficient, robust, and scalable solution for optical wavefront manipulation. Moreover, the study underscores the potential of TEC fibers in advancing optics and photonics technology.

Q 29.2 Wed 11:15 HS 1221

Overview of waveguides based on Pancharatnam-Berry Phase — •Stree Vithya Arumugam^{1}, Chandroth P Jisha^{1}, Alessandro Alberucci^{1}, and Stefan Nolte^{1,2} — ^{1}Friedrich Schiller University, Institute of Applied Physics, Albert-Einstein-Str. 15, 07745, Jena, Germany — ^{2}Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Albert-Einstein-Str. 7, 07745, Jena, Germany

Dielectric optical waveguides utilize refractive-index modulation to confine light by manipulating the dynamic phase gained across the beam cross-section. Recently, it was shown that waveguides based on the Pancharatnam-Berry phase (PBP) can guide light without any transverse refractive-index gradient. A PBP waveguide is realizable in an anisotropic material, if a point-dependent rotation of the optic axis across the transverse plane is accompanied by a periodic rotation along the propagation direction. Ideally, the modulation period must be synchronized with the natural rotation of light polarization to permit a net accumulation of PBP: in this case a spin-dependent effective trapping potential proportional to the rotation axis emerges.

Here, we theoretically investigate the properties of the PBP waveguide addressing the robustness of the confinement in the presence of a mismatch between the birefringence length and the modulation period. In the spatial domain, such a mismatch provides an additional degree of freedom in controlling the polarization structure of the quasi-modes. In the temporal domain, the PBP waveguides exhibit a higher optical dispersion than GRIN waveguides due to the inherent resonance condition.

Q 29.3 Wed 11:30 HS 1221

Multiple quasi-phase-matched dispersive waves generation in dispersion oscillating liquid-core-fibers — •Xue Qi and Markus A. Schmidt — Leibniz Institute of Photonic Technology, Albert-Einstein-Str. 9, 07745 Jena, Germany

Widely wavelength-tunable femtosecond light sources play a vital role in many research fields and technologies. Although fiber lasers are on the edge in the development of such sources, the widespan spectral tunability of femtosecond pulses remains a prime challenge. Dispersive wave (DW) generation, offers a powerful approach to fulfill these demands. In this work, the concept of quasi-phase-matching (QPM) for multi-order DW formation with record-high spectral fidelity and femtosecond durations is exploited. We introduce liquid(CS2)-core fibers (LCFs) with periodically controlled dispersion of a higher-order mode along the fiber, achieved by axial modulation of the liquid core diameter. The implementation of LCFs with periodically varying core diameters is realized by controlled partial collapses of the hole of a fiber-type silica capillary and subsequently filling it with CS2. By launching femtosecond pulses (1570 nm, 36 fs) through an s-waveplate and an in-coupling lens to excite the TE01-mode in the 5 cm long LCFs, multiple QPM-related spectral peaks are formed on both sides of the DW0 (referred as the zero-order DW, at 2.4 μm) extending the spectrum to 3 μm. The density of these QPM-DWs can be tuned by the period length of the diameter-modulated LCFs. Optical experiments and nonlinear simulations confirm the conversion process.

Q 29.4 Wed 11:45 HS 1221

Selective Higher Order Mode Excitation in a Nanoprinted Hollow Square-Core Waveguide — •Diana Pereira^{1,2}, Marta S. Ferreira^{1}, and Markus A. Schmidt^{2} — ^{1}i3N & Physics Department, University of Aveiro, Portugal — ^{2}Leibniz Institute of Photonic Technology, Jena, Germany

Tailoring the excitation of higher order modes (HOM) is of great importance across several applications within the photonics field, including optofluidics sensing, nonlinear phenomena generation, imaging, and in fiber communication systems. Nevertheless, effectively exciting specific HOM still remains a challenge. Currently, HOM can be achieved resorting to certain optical devices such as spatial light modulators and modal couplers. However, these devices are not fully integrated in the waveguide, which can impose some drawbacks such as difficult coupling and the requirement of high precision in the alignment. With the recent advancements in the 2-photon polymerization (2PP) printing technology, a novel methodology for the excitation of HOM can be explored. The figures of merit of this method rely on the capability of designing extremely smooth structures at a nanoscale, and with a very high detail accuracy. Thus, new platforms based on a waveguide integrated modulator are being pursuit. Within this context, we present a reliable and highly reproducible method to effectively exciting HOM. Resorting to the 2PP technology, a nano-phase plate integrated into a nanoprinted hollow square core waveguide is proposed. The 580 nm thick phase plate is configured in two different designs, inducing the excitation of the LP11 and LP12 modes.

Q 29.5 Wed 12:00 HS 1221

Engineering and characterization of phase randomness in driven χ^3 optical resonators — •Sayonil Mollah^{1}, Christopher Spiess^{1,2}, Meritxell Cabrejo Ponce^{1,2}, and Fabian Oliver Steinlechner^{1,2} — ^{1}Friedrich Schiller University, Institute of Applied Physics, Abbe Center of Photonics, Albert-Einstein-Strasse 15, Jena 07745, Germany — ^{2}Fraunhofer Institute for Applied Optics and Precision Engineering, Albert-Einstein-Strasse 7, Jena 07745, Germany

Optical parametric oscillators (OPO) have long been used as a source of tunable, narrow-linewidth and coherent light in various aspects of photonics. Particularly, the recent applications of twin frequency degenerate OPOs have garnered attention in quantum technologies for quantum random number generation (QRNG). This is due to the randomness of the generated signal/idler fields which causes them to lock on to the pump field, when the gain is above threshold. Since the signal and idler fields are offset by a phase π, the phase sensitive gain gives rise to a bi-phase state.

Here, we present experimental efforts to generate and characterize a bi-phase state from a degenerate OPO in a silicon nitride (χ^3) microresonator and a fiber cavity. The output from a dual wavelength pulse-pumped resonator is collected and measured in time and spectral domains. The degenerate signal is filtered and self-interfered to characterize the phase. Additionally, we perform simulations and theoretical calculations to establish suitable operational regimes for stable oscillation. Our results pave the way for an all optical QRNG with a simplified detection protocol and no post-processing.

Q 29.6 Wed 12:15 HS 1221

Light-propelled anisotropic refractive microswimmers — •Matthias Rüschenbaum^{1}, Elena Vinnemeier^{1}, Jörg Imbrock^{1}, and Cornelia Denz^{1,2} — ^{1}Institute of Applied Physics, Münster, Germany — ^{2}Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

Self-propelled microswimmers offer a wide range of applications, for example in biomedicine or colloidal systems. Among the various drive mechanisms, light-propelled microswimmers offer many advantages such as high biocompatibility and precise control. In our approach, the refraction of light provides a directed propulsion for the particles.

These particles have an asymmetric geometry and are several micrometers in size. In addition, chiral particle shapes ensure a rotating motion. The light-driven microswimmers are fabricated by direct laser writing using two-photon polymerization, which enables high versatility and accuracy. The laser light-induced movement is then evaluated and compared for the different particle shapes.

Q 29.7 Wed 12:30 HS 1221

Fabrication of mechanically tunable 3D protein-based hydrogel microstructures by two-photon lithography for onchip cell microenvironments — •Jesco Schönfelder[1], Dustin Dzikonski[1], Dominika Ciechanska[2], Jörg Imbrock[1], Cornelia Denz[3], and Albrecht Schwab[2] — [1]Institute of Applied Physics, University of Münster, Germany — [2]Institute of Physiology II, University of Münster, Germany — [3]Physikalisch-Technische Bundesanstalt, Germany

Microfluidic polydimethylsiloxane (PDMS) devices are a powerful tool for mimicking in-vivo cell microenvironments. PDMS offers high experimental versatility and biocompatibility while microfluidic channels provide laminar flow and allow for thoroughly monitored flow parameters. However, the tunability of mechanical and topological properties of PDMS microchannels is limited by the spatial precision of the applied fabrication method. We utilize two-photon lithography to fabricate spatially intricate 3D protein-based hydrogel structures with sub-micron resolution in order to create defined cell environments with high biocompatibility and tissue-like elasticity. The direct writing procedure allows for fabricated structures to be embedded into microfluidic channels. Via variation of the exposure time and illumination intensity, the mechanical properties of the polymerized media can be tuned. We present results on Young's moduli of the hydrogel structures measured by atomic force microscopy and discuss applications of the 3D microstructures for biophotonic applications.

Q 29.8 Wed 12:45 HS 1221

Characterizing of complex random media and biological tissue with self-consistent quantum field theory — Andreas Lubatsch[1] and •Regine Frank[2,3] — [1]Physikalisches Institut, Rheinische Friedrich Wilhelms Universität Bonn — [2]College of Biomedical Sciences, Larkin University, Miami, Florida, USA — [3]Donostia International Physics Center, 20018 Donostia-San Sebastian, Spain

We present a quantum field theoretical method for characterizing disordered complex media with short laser pulses and (OCT). We introduce so called weighted essentially non-oszillatory solvers (WENO) for the analysis of highly nonlinear and discontinuous processes including interference effects and Anderson localization of light in time-of-flight (ToF) and pump-probe experiments. The results are a measure of the coherence of multiple scattering photons in passive matter as well as in soft mat-ter and biological tissue.

[1] A. Lubatsch, R. Frank, Phys. Rev. Research 2, 013324 (2020) [2] D. Huang, et. al., Science 254, 1178 (1991) [3] K. C. Zhou, et. al.,Nat. Photon. 13, 794 (2019)