Q 36: Photonics II

Time: Wednesday 14:00–15:45 Location: S Gr. HS Maschb.

Q 36.1 Wed 14:00 S Gr. HS Maschb.

Observation of local symmetry in a photonic system — •Nora Schmitt[1], Steffen Weimann[1], Christian Morfonios[2], Malte Röntgen[2], Peter Schmelcher[2,3], and Alexander Szameit[1] — [1]Institute of Physics, University of Rostock, Albert-Einstein-Str. 23, 18059 Rostock, Germany — [2]Centre for Optical Quantum Technologies, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Hamburg Centre for Ultrafast Imaging, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

The concept of local symmetry is a powerful tool in predicting complex transport phenomena in aperiodic structures. In contrast to the idealized scenario of global symmetries, instances of local symmetries abound in nature. Similarly, they can be incorporated into synthetic structures as novel approach to tailoring global material properties. The effect of local symmetries on the dynamics of light propagation in waveguide arrays governed by a Schrödinger equation is readily described by a non-local discrete continuity formalism. However, the experimental demonstration of this mechanism is elusive so far. In our work, we show how non-local boundary currents and non-local charges can be retrieved from intensity-only measurements, and verify that they in fact satisfy the non-local continuity equation. We fabricated representative examples of locally symmetric, globally symmetric and fully non-symmetric configurations in fs laser-written photonic arrays and probed the corresponding system dynamics via single-site excitation. Our approach of evaluating the non-local continuity equation provides a method to distinguish all three types of structures.

Q 36.2 Wed 14:15 S Gr. HS Maschb.

Refraction and reflection from an interface between two artificial photonic gauge fields — •Christina Jörg[1], Moshe-Ishay Cohen[2], Yaakov Lumer[2], Yonatan Plotnick[2], Mordechai Segev[2], and Georg von Freymann[1,3] — [1]Physics Department and Research Center OPTIMAS, TU Kaiserslautern, Germany — [2]Physics Department and Solid State Institute, Technion, Haifa, Israel — [3]Fraunhofer Institute for Industrial Mathematics ITWM, Kaiserslautern, Germany

In classical optics, a beam incident on an interface between two optical materials is reflected and refracted, according to the angle of incidence and polarization. With the recent search for topological systems, which necessitate gauge fields, it was shown that refraction and reflection can also occur between two regions of the same material, if each domain has a different gauge field [1,2]. Here, we formulate an analytic model — an alternative Snell's law — for refraction and reflection from an interface between gauge fields. We experimentally demonstrate it in a photonic structure of two identical 2D-arrays of evanescently coupled waveguides. The arrays are oppositely tilted with respect to the propagation direction. The sample is created by a 3D-micro printer, first printing its inverse by direct laser writing and then infiltrating it with SU8 [3]. We measure the relation between the incident and transmitted wavevectors, validating our formulation.

[1] K. Fang and S. Fan, PRL **111**, 203901 (2013).
[2] M. I. Cohen, *et al.* in CLEO FM3G.4 (OSA, 2017).
[3] C. Jörg, *et al.*, New J. Phys. **19**, 083003 (2017).

Q 36.3 Wed 14:30 S Gr. HS Maschb.

Non-Abelian geometric phases in photonics and their optimal design strategy based on quantum metric — •Lucas Teuber, Mark Kremer, Alexander Szameit, and Stefan Scheel — Institut für Physik, Universität Rostock, Albert-Einstein-Str. 23, 18059 Rostock, Germany.

We showed in a proof-of-principle experiment how to synthesize a non-Abelian geometric phase in a system of photonic waveguides that possesses a degenerate dark subspace. A cyclic adiabatic evolution in this subspace then results in a matrix-valued and thus non-Abelian geometric phase. The crucial condition of adiabaticity is fulfilled by optimization of the waveguide structure utilizing the so-called quantum metric. Based on this metric we established a distance measure on the underlying control parameter manifold, i.e. the manifold of waveguide couplings. Minimizing this measure along the cyclic evolution under additional experimental constraints yields the optimally adiabatic process. Our results prove the possibility to implement a non-Abelian geometric phase in a photonic system and showcase the quantum-metric-based optimization of an adiabatic process.

Q 36.4 Wed 14:45 S Gr. HS Maschb.

Reducibility of non-Abelian holonomies in waveguide optics — •Julien Pinske, Lucas Teuber, and Stefan Scheel — Institut für Physik, Universität Rostock, Albert-Einstein-Str. 23, 18059 Rostock, Germany

Classical waveguide optics are a well known tool for the simulation of Hamiltonian systems [1]. This is due to the analogy of the paraxial Helmholtz equation to the Schrödinger equation. Implementation of a system with degenerate eigenstates generates a non-Abelian gauge field which yields a non-trivial holonomy group. The holonomy can thus be used to generate unitary gates which are the key building blocks of quantum information processing [2]. Irreducibility of the holonomy group corresponds to computational universality.

For means of illustration we consider a Hamiltonian with a 4-dimensional degenerate subspace. Thus generating a subgroup of U(4) for the set of realizable gates.

We present the non-Abelian gauge field of the system as well as the field strength tensor. The Ambrose-Singer theorem [3] is the state of the art method for examining reducibility of holonomies. We find that our system spans up a true subgroup of the unitary group U(4) and is therefore reducible. We believe that the implementation of non-Abelian holonomies through coupled waveguides could become a key tool for building quantum networks.

[1] F. Dreisow, A. Szameit et al: PRL Vol. 105, 143902 (2010).
[2] P. Zarandi, M. Rasetti: PLA Vol. 264, 94 (1999).
[3] W. Ambrose, I. M. Singer: Trans. AMS Vol. 75, 428 (1953).

Q 36.5 Wed 15:00 S Gr. HS Maschb.

State generation by quantum feedback in parametric down-conversion — •Melanie Engelkemeier, Evan Meyer-Scott, Jan Sperling, Sonja Barkhofen, Benjamin Brecht, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

We put forward a time-multiplexed all-optical scheme capable of efficiently generating complex tensor network states and higher-order Fock states. The core operation of this scheme is quantum feedback in parametric down-conversion (PDC). Feeding back one output of the PDC leads to a coherent self-stimulation of the process that generates new correlations in the output state. The so-generated states are well suited for quantum communication and computation applications [1]. In this talk, we report on the theoretical and experimental advances of this ambitious project.

[1] I. Dhand et al., Phys. Rev. Lett. 120, 130501 (2018).

Q 36.6 Wed 15:15 S Gr. HS Maschb.

Time-multiplexed photonic quantum walks with 4D coins — •Lennart Lorz[1], Evan Meyer-Scott[1], Thomas Nitsche[1], Václav Potocek[2], Aurél Gábris[2], Sonja Barkhofen[1], Igor Jex[2], and Christine Silberhorn[1] — [1]Integrated Quantum Optics, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Brehová 7, 115 19, Praha 1, Czech Republic

Discrete time quantum walks, realized in time-multiplexed architectures, are an essential tool to experimentally study quantum transport phenomena. We have implemented the well-established time-multiplexing scheme in a Michelson interferometer loop, in contrast to the standard Mach-Zehnder setup. By exploiting the two different traveling directions in the loop in addition to the two possible polarizations of the walker, we devise a four dimensional coin space for a one dimensional quantum walk. Making use of the extra degrees of freedom, we are able to generate quantum walks on loop structures of various sizes and topologies, with mixing and non-mixing coins and different input positions and polarizations. By capitalizing on the full dimensionality of the coin, we demonstrate walk evolutions on so-called figure of eight graphs consisting of two loops connected by a central vertex of rank four.

Q 36.7 Wed 15:30 S Gr. HS Maschb.

Investigation of the next-nearest- neighbor-coupling in evanescently coupled dielectric waveguides — •Julian Schulz[1], Christina Jörg[1] und Georg von Freymann[1,2] — [1]Physics Department and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Fraunhofer Institute for Industrial Mathematics ITWM, Kaiserslautern, Germany

The tight-binding model is a simple approximation to describe the dynamics in periodic potentials, such as in solids or photonic crystals. Often in these structures, only the couplings to the next neighboring sites are considered and those further away are neglected. In measurements [1] and simulations of the band structure, however, asymmetries can be seen, which are due to a non-negligible next-nearest-neighbor(NNN)-coupling.

To further investigate the effects of the NNN-coupling, the propagation of light in a chain of adjacent evanescently coupled dielectric waveguides is considered. The fabrication of corresponding waveguide structures follows the direct-laser-writing based principle used in [2].

By arranging the chain in a zig-zag shape, the distance to the NNN and by that, the NNN-coupling can be varied. Two independent simulation methods show, in the case of a non-bended linear chain, that the NNN-coupling is negative. This suggests that the NNN-coupling can be increased to zero, if the correct angle in the zig-zag-arrangement is chosen.

[1] F. Bleckmann, *et al.*, Phys. Rev. B **96**, 045417 (2017).
[2] C. Jörg, *et al.*, New J. Phys. **19**, 083003 (2017).