Q 8: Quantum Optics and Photonics I

Time: Monday 10:30–12:30 Location: S Ex 04 E-Tech

Q 8.1 Mon 10:30 S Ex 04 E-Tech

Resonant state expansion for exterior perturbations in photonic crystal fibers — •Swaathi Upendar[1], Izzatjon Allayarov[1], Markus Schmidt[2,3], and Thomas Weiss[1] — [1]4th Physics Institute and Research center SCoPE, University of Stuttgart, Germany — [2]Leibniz Institute of Photonic Technology, Jena, Germany — [3]Otto Schott Institute of Material Research, Friedrich Schiller University, Jena, Germany

Photonic crystal fibers guide light in a central defect core surrounded by a periodic cladding using a bandgap effect. It is known that the guiding properties of the photonic crystal fiber depend on the structureand the nature of materials in the core and cladding and that small changes in the cladding affect the fundamental core mode. We present our formulation of the so-called resonant state expansion as a perturbation theory for studying structural and material perturbations such as diameter disorder in the claddings of photonic crystal fibers [1]. Resonant states are solutions of Maxwell's equations with outgoing boundary conditions in the absence of source terms. A key element in our formulation is that we derived an analytical method to correctlynormalize both guided and leaky modes.Here, we will present examples for perturbations in the interior and the exterior of the fiber cladding.

[1] S. Upendar, I. Allayarov, M. A. Schmidt, and T. Weiss, "Analytical mode normalization and resonant state expansion for optical fibers - an efficient tool to model transverse disorder," Opt. Exp. **26** (17), 22536 (2018).

Q 8.2 Mon 10:45 S Ex 04 E-Tech

Realization of a non-quantized topological insulator using photonic Aharonov-Bohm cages — •Mark Kremer[1], Ioannis Petrides[2], Eric Meyer[1], Matthias Heinrich[1], Oded Zilberberg[2], and Alexander Szameit[1] — [1]Institut für Physik, Universität Rostock, Albert-Einstein-Straße 23, 18059 Rostock, Germany — [2]Institut für Theoretische Physik, ETH Zürich, Wolfgang-Pauli-Straße 27, 8093 Zürich, Switzerland

The discovery of topological insulators opened up a new realm of physics with numerous enthralling effects. This new state of matter is fully characterised by topological invariants, which in turn can be deduced solely from bulk properties. Nevertheless, they allow predictions about boundary modes and their robustness. In our work, we extend the perception of such systems by introducing topological insulators with non-quantized topological invariants. Moreover, the quantization only reveals itself upon squaring the Hamilton operator. To this end, we study a quasi-one-dimensional chain of so-called Aharonov-Bohm cages, which are known to support robust edge states. By squaring the Hamiltonian, we find a SSH-type model to be the topological origin of the robustness. Experimentally, we use the femtosecond laser writing technique to create waveguide arrays as versatile platform for probing topological effects. In this vein, we combine bulk dynamics with observations of localised edge modes to confirm our theoretical findings.

Q 8.3 Mon 11:00 S Ex 04 E-Tech

Switching Light at Interfaces between Anomalous Floquet Topological Insulators — •Francesco Piccioli, Lukas Maczewsky, Mark Kremer, Matthias Heinrich, and Alexander Szameit — Institut für Physik, Universitat Rostock, Albert-Einstein-Str. 23, 18059 Rostock, Germany

Anomalous Floquet Topological Insulators (A-FTIs) are time-driven systems in which topological edge modes arise across a bandgap with non-vanishing Winding number. Our theoretical proposal outlines an A-FTI based on the honeycomb geometry with two different bandgaps and topological edge modes across both of them. We study the interface between two mutually detuned incarnations of such systems. The detuning results in a relative shift of the respective band-structures that, due to the periodicity in time, effectively exchanges the position of the two bandgaps. Since both sub-systems are characterized by a unitary winding number, their interface is not expected to support topological states. Indeed, tight binding simulations merely reveal states with quasi-flat dispersion that are not connected to any bulk band and therefore do not appear to be of topological nature. Rather, they can be intuitively understood to stem from the interplay between counter-propagating topological modes existing at the inside edges of the two sub-systems. However, we show how a topological edge mode can be forced to interact with these states, and demonstrate the suppression of the interfacial state for certain values of the modes wave vector. In this vein, our proposed system may serve as switch for the interface state via the topological mode wave vector.

Q 8.4 Mon 11:15 S Ex 04 E-Tech

Towards a Photon Bose-Einstein Condensate in the Vacuum-Ultraviolet Spectral Regime — •Thilo vom Hövel, Christian Wahl, Frank Vewinger, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, D-53115 Bonn

We propose an experimental approach for photon Bose-Einstein condensation in the vacuum-ultraviolet spectral regime (100 - 200 nm), based on the thermalization of photons in a noble gas-filled optical microcavity. Current experiments realizing photon Bose-Einstein condensates operate in the visible spectral regime with organic dyes as a thermalization medium. To reach the vacuum-ultraviolet spectral regime, we plan to replace the dye medium by high pressure xenon gas, with absorption re-emission cycles on the transition from the ground to the lowest electronically excited state of the noble gas for thermalization. We here report the results of current spectroscopic measurements, investigating VUV line profiles of dense Xenon ensembles. To achieve sufficient spectral overlap between the atomic absorption and the diatomic excimer emission, found at 146.9 nm and 172 nm, respectively, noble gas pressures of up to 180 bar are investigated. Alternatively, liquid xenon at temperatures down to -110 °C could be used.

Q 8.5 Mon 11:30 S Ex 04 E-Tech

Broad-angle SU(1,1) interferometer with bright squeezed vacuum — •Gaetano Frascella[1,2], Eugeniy E. Mikhailov[3], Naoto Takanashi[4], Roman T. Zakharov[5,6], Olga V. Tikhonova[5,6], and Maria V. Chekhova[1,2,5] — [1]Max-Planck Institute for the Science of Light, Erlangen, Germany — [2]Univ. of Erlangen-Nuremberg, Erlangen, Germany — [3]Department of Physics, College of William & Mary, Williamsburg, Virginia, USA — [4]School of Engineering, Univ. of Tokyo, Tokyo, Japan — [5]Physics Department, Moscow State Univ., Moscow, Russia — [6]Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State Univ., Moscow, Russia

Bright squeezed vacuum raises interest due to its nonclassical features, like the macroscopic photon-number entanglement, and due to the potential applications ranging from imaging to remote sensing and quantum communication.

We produce this state of light through the high-gain parametric down conversion (PDC) in a nonlinear crystal and, using a double-pass configuration, we build a broad-angle SU(1,1) interferometer. The correction of the angular divergence of PDC in the first pass enables the phase-sensitive amplification/de-amplification of the spatially multimode radiation, while the mode content remains stable as the phase changes. In comparison to previous arrangements, our construction features a richer spatial mode structure.

We prove the quantum signature of the interferometer by measuring quadrature squeezing of 3.9 dB with optical parametric amplification, which amplifies one quadrature while attenuating the other.

Q 8.6 Mon 11:45 S Ex 04 E-Tech

Theoretical description of a multi-mode SU(1,1) interferometer using matrix approach — •Alessandro Ferreri, Polina Sharapova, Kai Hong Lou, Harald Herrmann, and Christine Silberhorn — University of Paderborn, Paderborn, Germany

Photon sensing is an important branch of Quantum Metrology and one of the main task thereof is to improve the precision of the measurement via overcoming the classical shot noise limit (SNL) and reaching the quantum limit, called Heisenberg limit (HL).

In this work we show the protocol we used in order to investigate a new type of device, called SU(1,1) interferometer, which is able to overcome the SNL even by using vacuum input state. We considered a SU(1,1) interferometer having two multi-mode parametric down-conversion (PDC) sections. By performing the Schmidt decomposition of joint spectral amplitude (JSA), we are able to describe the PDC processes in terms of multi-mode squeezers and we can therefore use a matrix approach to investigate features of such interferometer.

This technique allows to explore the SU(1,1) with two identical or different JSAs of the crystals. The influence of the gain as well as the number of modes on properties of the SU (1,1) interferometer is taken into account. It was shown that in the case of two identical JSAs a perfect interference between the signal and idler photons occurs and a supersensitivity region appears, whereas the interference process is partially inhibited for two different JSAs .

Q 8.7 Mon 12:00 S Ex 04 E-Tech

Nonlinear spectroscopy with nonclassical light — •Fabiano Lever and Markus Gühr — Universität Potsdam, Institut für Physik und Astronomie

Two photon absoption of biphotons generated with Spontaneous Parametric Down Conversion (SPDC) exploits quantum time-energy correlations to enhance the overall yeld and selectivity of the process, when compared with a classical pump-probe setup, while mantaining femtosecond time resolution. In this work, we explore the quantum-classical transition comparing a classical pump-probe exper- iment on a diatomic molecule to its quantum enhanced counterpart, where the pump and probe pulses are substitued by the signal and idler beams of a SPDC source. The results indicate that the quantum improvements in yeld are caused by a more efficient use of the total power available for the process.

Q 8.8 Mon 12:15 S Ex 04 E-Tech

Two-Dimensional Fluorescence Spectroscopy with Entangled Photon-Pairs — •Leonardo A. Pachon and Miguel Hincapie — Universidad de Antioquia, Medellin, Colombia.

The entangled photon-pair two-dimensional fluorescence spectroscopy (EPP-2DFS) is extended to include contributions from the singly-exited manifold. Experimental advantages and simplifications as well as quantum-enhanced characteristics are discussed.