STRUCTURED ELECTROMAGNETIC MATERIALS GROUP

MASTER PROJECT

Project title: Quantum Optics of Coherent Perfect Absorption

- **MSc**
- **Theoretical Quantum Optics**
- Method used: analytical work, supported by numerical investigations
- Desired student skills: Fundamental knowledge of quantum mechanics and electromagnetic theory

Objectives: In this project, we propose to investigate the optical properties of coherent absorbers in the quantum regime.

Background: Coherent perfect absorption (CPA) of light [1] is a surprising interference-assisted absorption process that can take place when two counter-propagating beams impinge on an absorbing medium from opposite sides. *With input light from only one side, some light would come out, but no light emerges if there is equal input from both sides*. During the interaction, the reflected part of one of the incident beams destructively interferes with the transmitted part of the other (and vice versa) that results in a trap for the coherent light which is later dissipated out. CPA is promising for photo-detection, sensing, photovoltaics and cloaking applications.

Motivation: While the physics of coherent absorbers is a rapidly developing field, investigations of CPA in the quantum regime have only recently begun [2]. Inclusion of genuine quantum effects to CPA would extend its applicable capabilities and thus, CPA could be useful for quantum information, communication and optics protocols.

Project description: The student will learn the fundamentals of quantum optics and photonics. The transfer matrix methods and input-output formalism of light in classical and quantum optics will be covered. Critical concepts, such as quantum coherence, squeezing and quantum entanglement, will systematically be introduced. After establishing the basics, the effects of CPA on genuine quantum states will be investigated and applications considered, with our recent paper as point of departure [3].

References:

[1]: Y. Chong, et al., *Coherent perfect absorbers: time-reversed lasers*, Phys. Rev. Lett. **105**, 053901, (2010).

[2]: D. G. Baranov, et al., *Coherent perfect absorbers: linear control of light with light*, Nature Rev. Mat. **2**, 17064, (2017).

[3]: A. Ü. C. Hardal and M. Wubs, *Quantum coherent absorption of squeezed light*, ArXiv:1805.02884v1 [quant-ph] (2018).

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