Topological physics with light: Topological edge and corner modes in polariton lattices

Sebastian Klembt[1]

[1]*Chair for Applied Physics, Julius-Maximilians-University Würzburg & Würzburg-Dresden Cluster of Excellence ct.qmat*

(e-mail: sebastian.klembt@uni-wuerzburg.de)

Topological Photonics is an emerging and novel field of research, adapting concepts from condensed matter physics to photonic systems adding new degrees of freedom. After the first demonstrations of topological photonic insulators [1,2], the field has moved on to study and exploit the inherent non-hermiticity of photonic systems and the interplay with their topological nature. In my talk, I will attempt to give an overview about the quickly emerging field of topological photonics. In this context, I will discuss topological lasers as a prime example of using topological concepts potentially for new technologies in the broad context of synthetic (photonic) matter. Examples will be given from novel photonic lattice devices resulting from the coupling of individual vertical III-V semiconductor microresonators.

Here, the so-called exciton-polaritons – hybrid states of light and matter – can emerge in the strong coupling regime. By choosing precise lattice geometries we are able to tailor optical band structures realizing novel photonic lattice. The specific geometry as well as the hybrid light-matter nature allow for ways to break time-reversal symmetry and implement topologically non-trivial systems. We were able to experimentally demonstrate the first exciton-polariton topological insulator, manifesting in chiral, topologically protected edge modes [3]. In order to study topological effects in combination with optical non-linearities, so-called topological lasers have been envisaged and realized. We have presented the first experimental demonstration of a topological insulator vertical cavity laser array [4], using the crystalline topological insulator model. Following this works, I will discuss recent advances towards electrical operation and lasing from a topological defect [5]. In addition, so-called corner modes, fully localized topological defects in a two-dimensional lattices in breathing Kagome and 2DSSH lattices are discussed [6]. Finally, on outlook on propagation in lattice edge modes measured with a Streak camera system is given.

[1] Rechtsman et al. Nature 496, 196–200 (2013).
[2] Hafezi et al., Nat. Photon. 7, 1001–1005 (2013).
[3] Klembt et al., Nature 562, 552–556 (2018).
[4] Dikopoltsev et al., Science 373, 1514–1517 (2021).
[5] Gagel, et al., Nano Lett. 24, 6538–6544 (2024).
[6] Gagel, Düreth et al., in preparation (2024).