Topological physics with a hybrid light-matter system

S. Klembt[1,*], T.H. Harder[1], O.A. Egorov[2], M. Sun[3], J. Beierlein[1], P. Gagel[1], K. Winkler[1], R. Ge[4], M. Emmerling[1], I.G. Savenko[3], T.C.H. Liew[4], M. Bandres[5], C. Schneider[1], M. Segev[5], S. Höfling[1,6]

[1]Technische Physik, Physikalisches Institut and Wilhelm Conrad Röntgen-Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

[2]Institute of Condensed Matter Theory and Solid State Optics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena, Germany

[3]Center for Theoretical Physics of Complex Systems, Institute for Basic Science (IBS), Daejeon 34126, Korea

[4]Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, 21 Nanyang Link, 637371, Singapore

[5]Physics Department and Solid State Institute, Technion, Haifa 32000, Israel

[6]SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, KY16 9SS, United Kingdom

* ***sebastian.klembt@physik.uni-wuerzburg.de***

Topological insulators (TIs) are a striking example of materials in which topological invariants are manifested in robustness against perturbations, as originally observed in the integer quantum Hall effect. However, during the past decade the concepts of topological physics have been introduced into numerous fields beyond condensed matter, ranging from microwaves, photonic and polaritonic systems to cold atoms, acoustics, mechanics and electrical circuits. Topology has emerged as an abstract, yet surprisingly powerful, new paradigm for controlling the flow of an excitation, e.g. the flow of light. As such, it holds great promise for a wide range of advanced applications.

Topological phenomena in polaritons are fundamentally different from all topological effects demonstrated experimentally thus far: exciton-polaritons are part-light part-matter quasiparticles emerging from the strong coupling of quantum well excitons and microcavity photons. We show that by placing exciton-polaritons in artificial lattices that emulate two-dimensional materials, we can engineer a wide range of exotic band structures hosting flat bands as well as Dirac cone dispersions. Based on this precise technological control, we have demonstrated experimentally the first exciton-polariton TI [1]. Due to the strong interactions and a large nonlinearity displayed by the exciton-polariton system, this platform promises a wide range of novel many-body effects and resulting functionalities. Here, we will briefly discuss the progress towards a topological polariton laser [2-4].

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