Geometrical phase resonators

Yuma Kawaguchi[1], Daria Smirnova[2], Filipp Komissarenko[1,3], Daria Kafeeva[1], Svetlana Kiriushechkina[1], Anton Vakulenko[3], Andrea Alu[5], Jeffery Allen[4], Monica Allen[4], Alexander B. Khanikaev[1]

[1]Department of Electrical Engineering, The City College of New York, New York, NY 10031, USA
[2]Research School of Physics, The Australian National University, Canberra, ACT 2601, Australia
[3]Optics & Photonics, CREOL, UCF, Orlando, FL 32816, USA
[4]Air Force Research Laboratory, Munitions Directorate, Eglin AFB, Eglin, FL 32542, USA
[5]Photonics Initiative, Advanced Science Research Center, City University of New York, New York, USA.

Abstract. Geometrical phases play a central role in numerous phenomena across physical fields and systems, from optical waveguides and metasurfaces to quantum systems and topological materials. Acquired during the adiabatic evolution of the multimodal system, it can add up to the conventional propagation phase and alter interference phenomena and resonance conditions of the system. Here we introduce a new type of resonator whose resonant condition is defined solely by the geometrical phase – a geometrical phase resonator. In such a resonator, based on photonic topological metasurfaces, topological boundary modes are designed to undergo an adiabatic evolution that gives rise to the net geometrical phase of 2π, rendering resonance without any propagation phase. This renders the resonance condition invariant with respect to its shape and length, which we confirmed both using first-principles simulations and in experiments. Specifically, we show that a set of samples with completely different geometries exhibit an extremely stable "geometrical resonance" pinned to a specific frequency. Therefore, we believe that geometrical resonators can be of profound importance for applications where such spectral stability of resonances is needed, including arrays of precisely tuned lasers, sensors, geometrical cavities coupled to quantum emitters.