

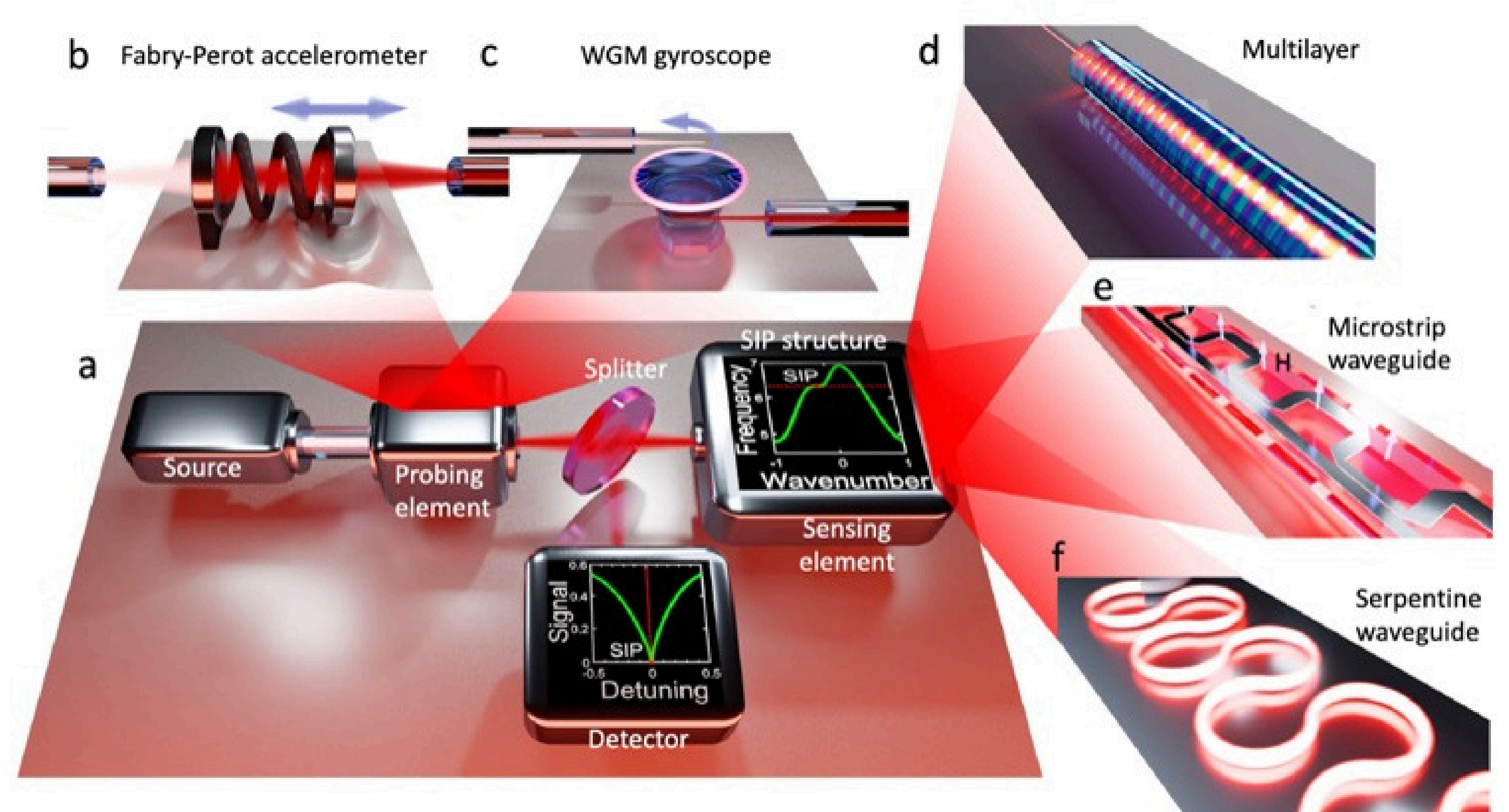
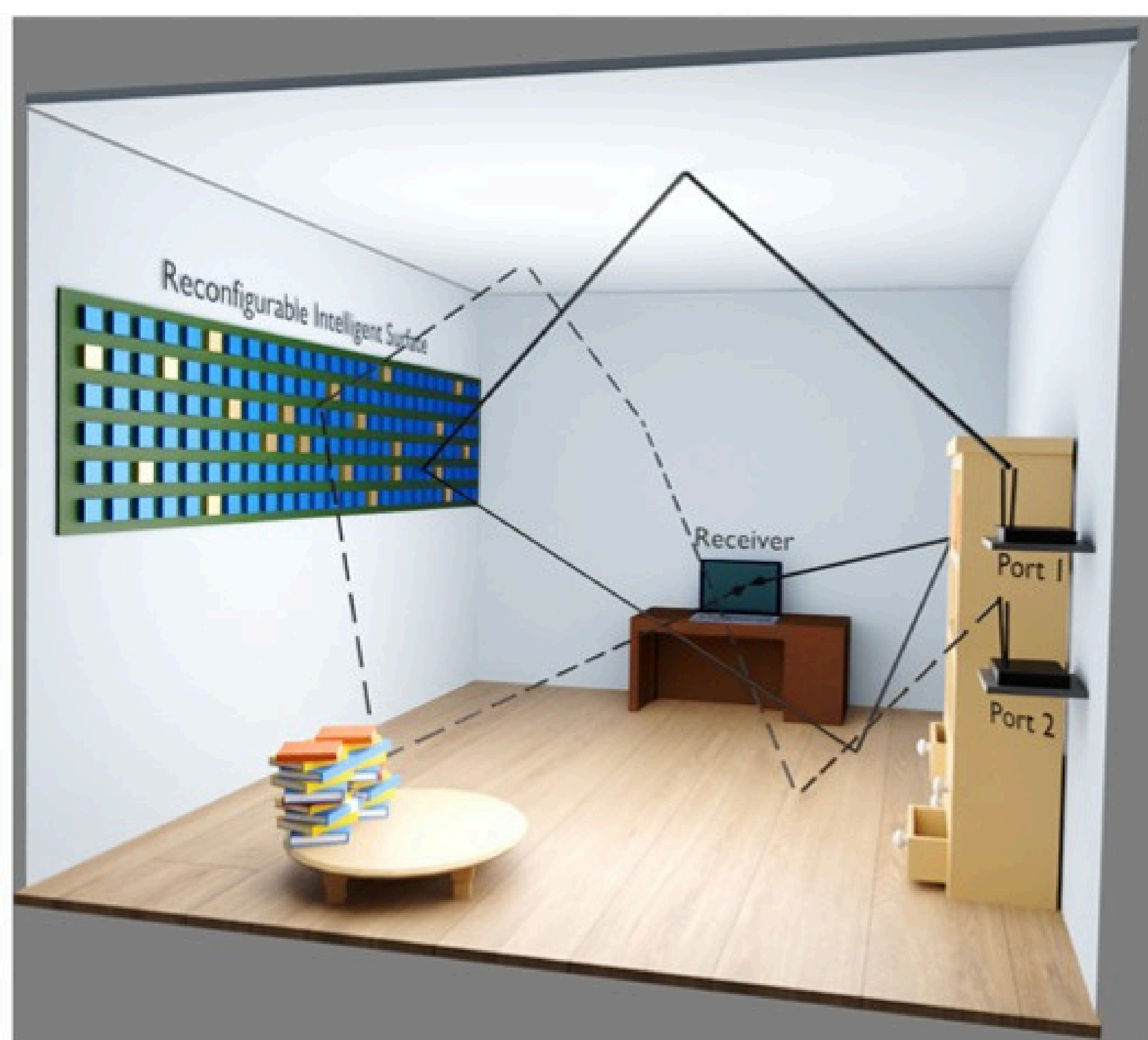
Wave Transport in Complex Systems Lab

Dr. Tsampikos Kottos' research group studies cutting-edge problems in (classical) wave dynamics occurring in artificial materials (metamaterials) and complex real-world structures (reverberating electromagnetic rooms/buildings, atmosphere, etc) that address pressing societal needs.

Current projects involve the development of (a) wavefront protocols that harness the complexity of modern indoor electromagnetic environments for resilient wireless communications; (b) in-situ Physical Optimization Computing aiming to develop analogue computational schemes that utilize physical systems for optimizing various modalities; (c) sensing schemes with hypersensitive responses to specific (environmental) perturbations for biosensing and avionics; (d) radar and satellite protection from harmful electromagnetic radiation; (e) design of optical fibers for high power sources, bio-imaging and telecommunication purposes; (f) AI-guided exploration of self-organization phenomena occurring in physical systems (e.g. arrays of coupled lasers) and biology.



Below: An in-situ Physical Optimization Computing protocol that utilizes a reverberate room as a “computer”: A smart electromagnetic environment utilizing Reconfigurable Intelligent Surfaces for Targeted Mode Transfer that aims to receive the injected electromagnetic signal at a specific receiver channel (e.g. a cellphone or a laptop). The protocol has been developed and tested by the WTICS-team at Wesleyan.



Above: A hypersensitive sensor (a) A source emits a broadband signal to a sensing platform which acts as a high-Q frequency selective filter, with frequency-selection that depends on the applied perturbation. The reflected signal at the proximity of a stationary inflection point (SIP) frequency shows a cusp. The reflection varies sublinearly with frequency detunings from SIP which is used for ultrasensitive sensing; (b) A Fabry-Perot cavity whose one wall is acting as a test-mass that senses accelerations; (c) A gyroscope that utilizes a whispering-gallery-mode resonator whose resonant frequency is changed due to the Sagnac effect. Different structures supporting a SIP: (d) a multilayer structure; (e) a coupled microstrip-waveguide; (f) a waveguide.

All these problems require a better understanding of the fundamental principles that dictate wave transport. Such knowledge necessitates the development of methodologies and modeling schemes which will allow to establish novel device-designed protocols that mold the flow of energy and information carried by classical waves. In doing so, the Wave Transport in Complex Systems (WTICS) lab adopts a holistic approach where the development of appropriate theoretical/mathematical tools and computational modeling using modern techniques (e.g. AI and machine learning), are complemented by in-house proof-of-principle experiments with RF, microwave and optical platforms.