Emergent Physical Phenomena in Optics

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Optics provides an excellent platform to explore and observe novel phenomena in physics. By bringing new physical phenomena into optics, we not only learn novel ways to control and manipulate light, but optics also aids in exploring these phenomena in unprecedented ways beyond the reach of other realms of physics. In this talk, I will present the observation of two unique physical phenomena in optics. The first one is branched flow. When waves propagate through a weakly disordered potential with a correlation length larger than the wavelength, they form channels (branches) of enhanced intensity that continue dividing as the waves propagate. This fundamental wave phenomenon, known as branched flow, was first observed in electrons in semiconductor heterostructures and later in microwave cavities, but it can occur for any kind of wave, regardless of wavelength. I will demonstrate how we observed branched flow of light for the first time by propagating light through thin liquid films. For the second phenomenon, I will present the observation of a new family of fundamental laser modes in stable resonators: the Boyer-Wolf Gaussian modes. We discovered these new modes by studying the isomorphism between stable laser resonator cavities and quadratic Hamiltonians and observed them by constructing a laser resonator equivalent to a quantum two-dimensional anisotropic harmonic oscillator with a 2:1 frequency ratio.

Short biography:

Dr. Bandres is an Assistant Professor at the College of Optics & Photonics (CREOL) at the University of Central Florida. He received his Ph.D. in Physics from the California Institute of Technology. He was a postdoctoral research fellow at the Technion, Israel Institute of Technology, in the group of Moti Segev. He is the recipient of the Marie Curie Fellowship, the SPIE John Kiel Scholarship, the SPIE Laser Technology Scholarship, and the Premio Nacional de la Juventud, which is awarded by the Mexican government to outstanding young professionals. His research focuses on finding and observing new fundamental phenomena that allow us to control light in nontrivial ways, such as photonic topological insulators, artificial gauge fields in optics, and non-Hermitian photonics, and on studying how these phenomena and platforms can be applied to improve or realize new photonic systems such as lasers, waveguides, photonic lattices, and optical fibers. For example, he has theoretically and experimentally observed new families of nondiffractive beams and accelerating beams, ultrafast tailored spatio-temporal pulses, and a new fundamental family of laser modes, the Ince Gaussian modes. His collaborative work launched the field of topological insulator lasers.