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University of Miami, Physics Department Colloquium

Date: Wednesday, Jan 24, 2024
Time: 4:00 pm – 5:00 pm
Location: Wilder Auditorium – Rm 112, Knight Physics Building

Unlocking New Ways for Light Manipulation through Nonlocal Nonlinear Dynamics and Topological Phenomena

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Abstract

Our world has been transformed by photonics, powering crucial applications from ultrafast telecommunications and precise optical sensing and spectroscopy. But the ever-growing demand for information processing, both classical and quantum, is pushing the limits of light-based technologies. This raises a critical question: how can we manipulate light more effectively to bridge the gap between our information needs and current limitations?

Recent approaches have focused on multimode nonlinear waveguides and cavities, viewed as viable solutions due to their increased degrees of freedom. However, these complex systems bring new challenges. Powerful light sources with many components can be vulnerable to cascading failures caused by even tiny defects. Additionally, the intricate interplay of light within these systems can lead to chaotic behavior and distorted signals, hindering our ability to harness light's full potential. Yet, within these complexities lie hidden treasures. One fascinating phenomenon exhibited by nonlinear multimode systems is "beam self-cleaning," where beams improve their shape. Analyzing these behaviors, however, often surpasses the capabilities of standard methods and tools. Fortunately, a novel theoretical framework called optical thermodynamics offers a powerful way to study these complex systems by understanding their nonlinear dynamics through the lens of thermodynamics and statistical mechanics.

In this talk, I'll delve into my recent work on overcoming these challenges and unlocking the full potential of light in complex systems. Firstly, I'll explore the emergence of a novel class of bright solitons, unique light waves arising from nonlocal nonlinear interactions, holding exciting possibilities for manipulating light. Next, I'll discuss how harnessing complex nonlocal interactions allowed us for the first realization of the Haldane model (the subject of the Nobel Prize in 2016) on an active photonics platform. This finding paves the way for novel topological lasers with enhanced robustness against fabrications imperfections. Finally, I'll present our progress in developing the optical thermodynamics framework. This framework has led us to the first experimental observation of optical thermodynamics processes at negative temperatures, opening new avenues for manipulating light behavior. In conclusion, I'll discuss future directions for utilizing these principles to maximize topological currents and predict phase transitions between weak and strong nonlinear regimes in multimode fibers.

Biography

Pawel Jung is a research scientist and instructor at the College of Optics and Photonics (CREOL) at the University of Central Florida. His research primarily focuses on emergent phenomena in optics resulting from the interplay between non-Hermitian and topological phenomena, coupled with optical nonlinear processes. His work spans fundamental sciences and applications, including on-chip light sources, and nonlinear optical dynamics and solitons. He obtained his PhD in Physics with Honors from the Faculty of Physics at Warsaw University of Technology in 2016, following his completion of the Integrated Long cycle Program in Applied Physics for both his master’s and bachelor’s degrees at the same university in 2009. He has been honored with various awards and fellowships, notably the University of Central Florida Preeminent Postdoctoral Program from 2020 to 2023, and a prestigious scholarship for outstanding PhD students through the European Union program in 2014. His research contributions have secured multiple funding opportunities in the United States and the European Union. Notably, he served as the Principal Investigator for a grant awarded by The Polish Ministry of Higher Education (MNISW) from 2018 to 2021.