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Sensing in photonics and electronics using non-hermitian systems

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This review provides an overview of the theory behind non-Hermitian Hamiltonians—specifically PT-symmetric and anti-PT-symmetric Hamiltonians—in the contexts of optics and electronics, with a particular emphasis on recent advancements in sensing applications. Non-Hermitian Hamiltonians were first introduced in the 20th century to model open systems. These Hamiltonians typically exhibit complex eigenvalues and non-orthogonal eigenstates. Exceptional points (EPs) occur where two or more eigenvalues and their corresponding eigenstates coalesce simultaneously. The discovery of real eigenvalues in non-Hermitian systems has expanded research opportunities, leveraging the unique properties of exceptional points.

Significant theoretical and experimental research has been conducted on PT and anti-PT symmetries, particularly in optics. This research covers various phenomena, including power oscillations, PT-symmetric lasers, non-reciprocal optical propagation, unidirectional lasing and invisibility, coherent-perfect absorption, electromagnetically induced transparency, orbital angular momentum lasers, nonlinear switching, nonlinear quantum spectroscopy, optomechanical actuation and amplification, and magneto-optic isolation. Among these applications, sensing has garnered considerable interest due to its high sensitivity at EPs. The eigenvalues at an EP are highly responsive to small perturbations, exhibiting a square-root dependence (ε 1/2) on the perturbation ε. This extreme sensitivity justifies the significant interest in applying non-Hermitian systems to sensing technologies..

Biography

Francesco De Leonardis is IEEE Senior Member, Associate Editor of Sensors (MDPI). He is Associate professor in Electronics at the Department of Electrical and Information Engineering, Politecnico di Bari, Italy. His research interests are in the field of the integrated Optoelectronics, Nanophotonics, Nonlinear and Quantum Photonics. In particular he developed, giving significant and original improvements, the physical-mathematical modelling, the design and the simulations of both passive and active photonic devices for a large number of applications, such as communications, sensing, optical filtering, quantum and space applications. He has published more than 200 papers in international journals and conferences.