上海数学与交叉学科研究院

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Shanghai Institute for Mathematics and Interdisciplinary Sciences

SIMIS Seminar series on Quantum computing, Quantum simulation and Strongly-correlated systems

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"Non-Hermitian optics in a microcavity "

Abstract

Non-Hermitian physics, including coherent perfect absorption (CPA), electromagnetically induced transparency (EIT), parity-time symmetry, and exceptional points (EP), has experienced rapid development and garnered extensive attention in recent years. Optical microcavities, particularly lithium niobate (LN)-based whispering-gallery-mode (WGM) resonators, offer an exceptional platform for exploring non-Hermitian phenomena due to their inherent non-Hermitian characteristics and compatibility with nonlinear processes. This talk highlights our recent advancements in leveraging nonlinear processes to engineer non-Hermitian phenomena within a single LN microcavity, thereby extending its dimensionality in the spectral domain.

By introducing nonlinearity, we demonstrate dual-color CPA (DC-CPA) through coupling fundamental and second-harmonic modes via second-order nonlinearity. Simultaneous perfect absorption at two distinct wavelengths is achieved via nonlinear interference, and coherent control of absorption is enabled by phase modulation, thus breaking the linear boundary of traditional CPA into the multi-frequency domain. Beyond absorption, nonlinearity also triggers self-induced transparency in a critically coupled cavity via SHG-induced nonlinear loss. The asymmetric coherent control and chiral emission of second-harmonic generation can be realized due to the asymmetric scattering nature of the microcavity. Additionally, we demonstrate the eigenvalue dynamics of PT-symmetric lines on Riemann surfaces, which can enhance SHG efficiency. The two crossing scenarios reveal dramatically distinct crossing dynamics and enhancement factors, reaching as high as 300. Leveraging this sensitivity, we demonstrate a nanometer-resolution distance sensor based on perturbed SHG spectra near PT lines.

These works uncover the nonlinear and non-Hermitian dynamics in LN microcavities and establish a connection between fundamental physics and practical applications, such as all-optical modulation, quantum information processing, and ultra-sensitive sensing. These findings pave the way for next-generation on-chip devices, enabling unprecedented control over light-matter interactions.

Biography of the speaker

Wenjie Wan received the B.E. from the Hong Kong University of Science and Technology in 2004 and Ph.D from at Princeton University in 2010, both in Electrical Engineering. After one-year postdoctoral training at Yale University, he joint University of Michigan-Shanghai Jiao Tong University Joint Institute as Assistant Professor and jointly appointed by Department of Physics, SJTU. His research efforts mainly lie on the nonlinear optical dynamics, especially in an optical microcavity. The recent focus of his research group is on the non-Hermitian optics inside a microcavity, exploring coherent perfect absorption, PT/ anti-PT, exceptional points and other emerging non-Hermitian dynamics and their applications.

Date and Place: Friday, July 11th 2025, 11:00h-12:00h. Room: 610. Send comments or questions to Miguel Tierz (Seminar organizer) to tierz at simis.cn