STEVENS INSTITUTE OF TECHNOLOGY 1870

Ph.D. DISSERTATION DEFENSE

Candidate: Chao Tang
Degree: Doctor of Philosophy
School/Department: Charles V. Schaefer, Jr. School of Engineering and Science /Physics
Date: Monday, November 25th, 2024
Time/Location: 1:00 p.m. / Babbio, 210
Title: Frequency Conversion and Dispersion Engineering on thin film Lithium Niobate

Chairperson: Dr. Yuping Huang, Department of Physics, School of Engineering &Science

Committee Members:

Dr. Chunlei Qu, Department of Physics, School of Engineering & Science
Dr. Yongmeng Sua, Department of Physics, School of Engineering & Science
Dr. Annie Zhang, Department of Mechanical Engineering

ABSTRACT

Recent advancements in thin-film lithium niobate technology have opened new avenues for creating high-performance photonic devices. Thin-film lithium niobate combines the exceptional qualities of bulk lithium niobate with the advantages of a thin-film format, including improved light confinement, reduced propagation losses, and enhanced material interactions. These features are essential for achieving high-efficiency frequency conversion and precise dispersion engineering in integrated photonic platforms.

In this thesis, I explore innovative methods for quantum frequency conversion and frequency comb generation utilizing lithium niobate waveguides and microresonators. I demonstrate multiplexed quantum frequency conversion within a single waveguide, where a three-peak periodically poled lithium niobate waveguide facilitates simultaneous up-conversion of multiple telecom-band signal beams with internal efficiencies reaching 73.6%. This approach preserves quantum correlations post-conversion, achieving a high coincidence-to-accidental ratio of 767 and offering promising applications in multiplexed quantum key distribution, quantum sensing, and computing. Furthermore, I present broadband frequency comb generation through dispersion engineering in a thin-film lithium niobate microresonator. Through optimized mode confinement and dispersion control, I achieve bandwidths of 150 nm and 25 nm at center wavelengths of 1560 and 780 nm, respectively, using a doubly resonant optical parametric oscillator.

This research paves the way for pure quadratic soliton generation, expanding the scope of nonlinear optical applications and complementing Kerr soliton frequency combs.