

# Zacharie M. Léger

POSTDOCTORAL RESEARCH ASSOCIATE · QUANTUM SENSING AND COMPUTING GROUP  
OAK RIDGE NATIONAL LABORATORY

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## Professional Experience

### POSTDOCTORAL RESEARCH ASSOCIATE

June 2024-Present

Quantum Information Science Section, Oak Ridge National Laboratory

Oak Ridge, USA

**Supervisor: Prof. Alberto Marino**

- Building a continuous variable photonic cluster state generated from rubidium-85 vapor cells for a measurement-based quantum computing testbed.

### POSTDOCTORAL FELLOW

Apr. 2024-June 2024

Dept. of Electrical & Computer Engineering, University of Toronto

Toronto, Canada

**Supervisor: Prof. Amr Helmy**

- Demonstrated polarization and time-energy hyperentangled photon pairs from a single BRLs.
- Used non-local dispersion cancellation for coincidence to accidental ratio enhancement in BRLs (Under review).

### DOCTORAL RESEARCHER

Sept 2018-March 2024

Dept. of Electrical & Computer Engineering, University of Toronto

Toronto, Canada

**Supervisor: Prof. Amr Helmy**

- Led and implemented the experiments demonstrating a multichannel source of ultra-broadband polarization and time-bin entanglement photon pairs from Bragg reflection waveguide laser diodes (BRLs) (Under Review).
- Developed and demonstrated in PPLN a new power-efficient scheme to generate squeezed light sources and scale them to multiple coherent sources. Homodyne detection and phase-sensitive amplification were used to enable sub-shot noise measurements.
- Worked on noise resilient quantum LiDAR, using non-local dispersion cancellation (DOI: 10.1038/s41467-022-33376-9).
- Conducted several experiments measuring nonlinear frequency conversion of different BRL geometries, including Fabry-Pérot, distributed feedback, discrete mode laser diodes, colliding pulse (DOI: 10.1109/LPT.2022.3225374) and photonic crystal (DOI: 10.1109/JLT.2024.3406253).

### MASTERS RESEARCHER

Sept 2016-Aug 2018

Dept. of Electrical & Computer Engineering, University of Toronto

Toronto, Canada

**Supervisor: Prof. Amr Helmy**

- Theoretically demonstrated entanglement enhancement with single photon subtraction of continuous variable Gaussian states in an N-mode system for the first time (DOI: 10.1103/PhysRevA.97.062303).

### ADVANCED PHOTOVOLTAICS AND DEVICES (APD) FELLOW

May 2016-Aug. 2016

Dept. of Electrical & Computer Engineering, University of Toronto

Toronto, Canada

**Supervisor: Prof. Nazir Kherani**

- Built a Monte Carlo simulation of metallic nanoslits in COMSOL Multiphysics demonstrating plasmonic lensing effects with hyperspectral focusing in the far-field (DOI: 10.1109/IPCon.2017.8116273).

## Education

### PH.D., PHOTONICS

Sep. 2018-Dec. 2023

Dept. of Electrical & Computer Engineering, University of Toronto

Toronto, Canada

**Supervisor: Prof. Amr Helmy**

- Relevant courses: ECE1508H —From Quantum Communications to Quantum Internet (A)

## M.A.Sc., PHOTONICS

Dept. of Electrical & Computer Engineering, University of Toronto

Sept. 2016-Aug. 2018

Toronto, Canada

**Supervisor: Prof. Amr Helmy**

- Relevant courses: ECE1478H —Lasers and Detectors (A+), PHY2204H —Quantum Optics II (A-)
- Transferred to a Ph.D. program without graduating from the M.A.Sc.

## H.B.Sc., PHYSICS SPECIALIST, MATHEMATICS MINOR

Faculty of Arts and Science, University of Toronto

Sept. 2012-Jun. 2016

Toronto, Canada

**Supervisor: Prof. Nazir Kherani**

- Modeled direct light coupling from optical fibers into bull's eye plasmonic grating structures amenable for next-generation sensing and imaging applications (DOI: 10.1109/IPCon.2017.8116273).

**Supervisor: Prof. Daniel F. V. James**

- Researched the quantum dynamics of laser-cooled trapped ions concerning their application in quantum computing.

## Publications

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### JOURNAL ARTICLES

- Z. M. Léger**, T. J. Stirling, M. L. Lu, and A. S. Helmy, “Deterministically separated polarization-entangled photons from battery-powered diode lasers,” (Under Review)
- P. S. Blakey, **Z. M. Léger**, T. J. Stirling, M. L. Lu, and A. S. Helmy, “Increased Photon Pair Fidelity from a Bragg-Reflection Waveguide Laser Through Non-Local Dispersion Cancellation,” (Under Review)
- B. Janjua, **Z. M. Léger**, J. Atkinson, M. L. Lu, A. Khan, J. H. Schmid, P. Cheben, and A. S. Helmy, “Difference Frequency Generation in Edge Emitting Photonic Crystal Lasers,” J. Light. Technol. 42, 5996 - 6002 (2024).
- B. Janjua, M.L. Lu, **Z. Léger**, Z. Yan, and A.S. Helmy, “Colliding-Pulse Mode-Locking Produce 130 fs Pulses, Enabling Record  $\chi^2$  Frequency Conversion,” IEEE Photonics Technology Letters 35 (2), 105-108, (2023).
- P. S. Blakey, H. Liu, G. Papangelakis, Y. Zhang, **Z. M. Léger**, M.L. Lu, and A. S. Helmy, “Quantum and non-local effects offer over 40 dB noise resilience advantage towards quantum lidar,” Nature Communications 13 (1), 5633, (2022).
- Z. M. Léger**, A. Brodutch, and A. S. Helmy, “Entanglement enhancement in multimode integrated circuits,” Physical Review A, 062303 (2018).

### CONFERENCE PUBLICATIONS

- Z. M. Léger**, D. Thomas, S. Kim, M. A. Feldman, and Alberto M. Marino, “Towards Cluster State Generation with Spatial Modes,” Quantum 2.0 Conference and Exhibition, (accepted).
- Z. M. Léger**, T. J. Stirling, M. L. Lu, and A. S. Helmy, “Fully On-Chip Source of Hybrid Polarization and Time-Energy Entangled Photons,” Quantum 2.0 Conference and Exhibition, (accepted).
- Z. M. Léger**, Z. Yan, A. S. Helmy, “Quantum sensing technologies,” Smart Photonic and Optoelectronic Integrated Circuits 2025, PC133700M.
- B. Janjua, **Z. M. Léger**, M. L. Lu, A. Khan and A. S. Helmy, “Widely Tunable Frequency Conversion with Self-Pumped Bragg Reflection Photonic Crystal Lasers,” 2023 IEEE Photonics Conference (IPC), Orlando, FL, USA, 2023, pp. 1-2.
- B. Janjua, M. L. Lu, **Z. Léger**, Z. Yan, and A.S. Helmy, “133 fs Pulses generated in Colliding-Pulse Mode-Locking, Enable Record  $\chi^2$  Frequency Conversion,” CLEO 2023, Technical Digest Series (Optica Publishing Group, 2023), paper STh3Q.1.
- P. S. Blakey, H. Liu, G. Papangelakis, M. L. Lu, Y. Zhang, **Z. M. Léger**, and A. S. Helmy, “Quantum Enhanced LIDAR using Nonlocal Dispersion,” in Conference on Lasers and Electro-Optics, Technical Digest Series (Optica Publishing Group, 2022), paper STu50.4.
- Z. M. Léger**, A. Brodutch, and A. S. Helmy, “Entanglement Enhancement in Multimode Integrated Circuits,” in Frontiers in Optics / Laser Science, OSA Technical Digest (Optica Publishing Group, 2018), paper JTU2A.89.
- M. Shayegannia, **Z. Léger**, N. Kazemi-Zanjani, and N. P. Kherani, “Spectral plasmonic lensing of an array of metallic nanoslits,” 2017 IEEE Photonics Conference (IPC), Orlando, FL, 2017, pp. 665-666.

## Awards, Fellowships, & Grants

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\$ 21,000 (per annum)	<b>Natural Science and Engineering Research Council Post-Graduate Scholarship</b> , Natural Science and Engineering Research Council of Canada	2019-2022
\$ 720	<b>School of Graduate Studies Conference Grant</b> , University of Toronto	2018
\$ 2,000	<b>APD Fellowship</b> , Dept. of Electrical and Computer Engineering, University of Toronto	2016
\$ 2,000	<b>President's Entrance Scholarship</b> , University of Toronto	2012
\$ 1,000	<b>Objectif 2000</b> , Fontation Objectif 2000	2012

## Teaching Experience

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<b>TUTOR</b>	Jan. 2024 - May 2024
Skule™ Tutors	Toronto, Canada
<ul style="list-style-type: none"><li>One-on-one tutor for University of Toronto students, covering topics in electromagnetism (ECE221H1 &amp; ECE259H1) and quantum mechanics (PHY294H1).</li></ul>	
<b>TEACHING ASSISTANT</b>	Sept. 2016-Apr. 2023
Dept. of Electrical & Computer Engineering, University of Toronto	Toronto, Canada
<ul style="list-style-type: none"><li>Led the tutorial for the following courses: Calculus III (MAT291H1), Electric and Magnetic Fields (ECE221H1).</li></ul>	
<b>INSTRUCTOR, DEEP SUMMER ACADEMY</b>	Feb. 2016-Aug. 2019, May 2022-Aug. 2022
Engineering Outreach Office, University of Toronto	Toronto, Canada
<ul style="list-style-type: none"><li>Designed the curriculum and taught the following courses: Foundations of Quantum Mechanics, Simulations of the Quantum, Classical and Quantum Cryptography: From Caesar to BB84, Computational Physics: Programming Solutions.</li></ul>	

## Outreach & Professional Development

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<b>EXECUTIVE OFFICER</b>	May 2018-Oct. 2023
SPIE and Optica University of Toronto Chapter	Toronto, Canada
photonics.utoronto.ca/spie-optica/	
<ul style="list-style-type: none"><li>Planned and helped organize several events to engage students and the Toronto community at large with research in optics and photonics.</li></ul>	
<b>OFFICER</b>	Aug. 2018-Oct. 2023
Photonics Innovation Center, University of Toronto	Toronto, Canada
photonics.utoronto.ca/	
<ul style="list-style-type: none"><li>Helped organized and publicized the Photonics Seminar Series and other large events like OptoFest.</li><li>Reviewed submissions for Research Expansion Grant, four \$10,000 grants to University of Toronto graduate students partnering with research groups outside their department, encouraging cross-disciplinary collaborations.</li></ul>	

## Research Skills

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<b>Computational</b>	Python, COMSOL Multiphysics, Lumerical FDTD, KiCAD, NI Multisim, LabVIEW, Mathematica
<b>Data Analysis</b>	High level of experience and expertise with data acquisition, processing, visualization, and interpretation.
<b>Languages</b>	English, French