Curriculum Vitae for PhD Program

Lang Li

(Fifth year PhD)

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Place & Date of Birth: Chongqing, 5th Oct, 1998

Research Area & Research Topic

- **Research Area:** Quantum physics, Quantum optics, Quantum cryptography, Quantum Communication, Quantum sensing, Integrated quantum photonics, etc.
- Integrated quantum photonics, continuous-variable quantum key distribution, quantum access network, practical security of quantum information processing, etc.
- **Research Topic：** High-performance on-chip continuous-variable quantum key distribution, High-performance on-chip semi/device-independent quantum information processing, practical security of continuous-variable quantum information processing, Integrated quantum access network, Quantum metrology breaking fundamental limits, etc.

Education

- **Doctor of Engineering:** Shanghai Jiao Tong University (SJTU), Shanghai, China (09/2020-Present)
- **Bachelor of Engineering:** Chongqing University (CQU), Chongqing, China (09/2016-06/2020)
- **Visiting Scholar:** Joint PhD Program, Centre for Quantum Technologies (CQT), National University of Singapore (NUS), under the supervision of Prof. Chao Wang and Prof. Charles Lim (09/2024–04/2025).

- **Invited academic conference:** In 2023 Photonics & Electromagnetics Research Symposium (PIERS), Prague, the Czech Republic (07/2023)

Selected Research Cover Letter——On-chip Quantum Communication for the Quantum Internet

My research focuses on advancing quantum information science through integrated quantum photonics and its applications in secure communication, sensing, and information processing. I aim to transform foundational breakthroughs in quantum physics into practical, scalable technologies. For the large-scale secure deployment of communication and sensing integrated quantum resources in the quantum internet, my research focuses on three areas: high-performance on-chip continuous-variable quantum communication devices and system mechanisms, quantum-secure semi-device-independent on-chip quantum random number generation, and the practical security of quantum resources.

I. High-Performance On-Chip Continuous Variable Quantum Key Distribution for the Quantum Internet

(1) 100 km-Level Continuous Variable Quantum Key Distribution Based on On-Chip Light Sources

Integrated photonic chips for quantum key distribution (QKD) offer high scalability and stability, making them a promising solution for the construction of global quantum communication networks. The integration of on-chip quantum light sources has been a key challenge for fully integrated QKD systems, particularly for continuous variable quantum key distribution (CV-QKD) systems that rely on coherent detection, which demands extremely stringent requirements for light sources. Since the GG02 protocol was proposed 20 years ago, the challenge of integrating light sources has persisted. Through fundamental mechanism and technological innovations, I have, for the first time, proposed and realized two on-chip tunable lasers suitable for CV-QKD, building a high-performance quantum key distribution system. Benefiting from high output power, fine tunability, and narrow linewidth, this system ensures precise shot-noise-limited detection of quantum signals, wavelength alignment of the non-homodyne lasers, and suppression of untrusted excess noise. The system achieves a real-time secure key rate of 0.75 Mb/s over 50 km of optical fiber and a secure transmission distance of over 100 km.

Specifically, I proposed a novel approach to integrate continuous variable quantum light sources for local local oscillator (LLO)-CV-QKD systems on a chip. First, by utilizing III-V materials on silicon nitride and a new mechanism based on the detuning load effect, a feedback loop structure was developed to narrow the Lorentzian linewidth to about 2 kHz, meeting the stringent requirements for precise control and evolution of quantum states on a chip. Second, Vernier microring resonators were used for highly efficient mode filtering, with a long-range tunability of over 70 nm and a continuous fine-tuning resolution of 30 GHz, achieving a side-mode suppression ratio of up to 75 dB. This overcame the challenge of aligning the slight frequency difference between non-homodyne quantum states and the local oscillator over long distances. Third, by utilizing silicon nitride as the waveguide material, which has low loss and a high nonlinear threshold, we achieved an on-chip output power of up to 47.3 mW, overcoming the power damage

limitations of traditional materials like lithium niobate. Supported by these innovations, the system achieved a real-time secure key rate of 0.75 Mbps over a 50 km optical fiber distance and a 0.14 kbps key rate over 100 km.

This work was published as the cover article in the top-tier journal Photonics Research (IF: 7.254), where it was selected as a cover feature by the journal's editor, IEEE/AAAS/APS Fellow and Washington University professor Lan Yang. This breakthrough has also been positively cited by Austrian Academy of Sciences member and APS/OSA Fellow Professor Philip Walther, Danish quantum physicist Professor Tobias Gehring, Academician Peng Kun-Chi from Shanxi University's State Key Laboratory of Quantum Optics and Quantum Devices, and was featured in the Peking University-Huawei Quantum Lab white paper. Additionally, this work was cited by Light: Science & Applications (IF: 27.2) and Applied Physics Reviews (IF: 11.9), and was covered by major media outlets such as Tencent News, Sohu, Sina Weibo, and the Chinese Laser Press. It was also selected for display by the National Key Laboratory of Optical Fiber Communication Networks and New Optical Communication Systems as part of their "14th Five-Year Plan Key Achievements" during its "Science and Technology Open Week."

(2) Fully Integrated Continuous Variable Quantum Key Distribution Chip

Continuous variable quantum key distribution (CV-QKD) offers advantages such as high channel capacity and strong compatibility with existing optical communication infrastructure, making it a key technology for quantum secure communication. Quantum photonic technology presents a promising solution for developing low-cost, miniaturized, portable, scalable, and highly stable CV-QKD systems. However, achieving high performance and security with fully integrated CV-QKD chips remains a significant challenge. This study reports the latest advances in the practical security, high-performance light source integration, and optoelectronic integration of on-chip CV-QKD systems. This work was presented as an invited talk at the 2023 PIERS conference and was published as a first-author paper.

II. High-Security On-Chip Quantum Random Number Generation for the Quantum Internet

(3) High-Speed Source-Device-Independent Quantum Random Number Generator Chip

Quantum resources inherently provide true randomness, which has significant applications in cryptography, scientific simulations, and computing. Silicon photonic chips offer a superior platform for the large-scale, low-cost deployment of next-generation quantum systems. However, the potential vulnerabilities of chips can pose security challenges, particularly the risk of hacking, which threatens the secure generation of quantum random numbers. I proposed and implemented the first on-chip source-device-independent quantum random number generator (SDI-QRNG), which ensures system security through distortion-free detection of quantum resources, successfully eliminating classical noise interference. In actual chip environments, I introduced on-chip criteria to estimate secure entropy, ensuring system security. The SDI-QRNG chip achieved a secure bit rate of 146.2 Mbps in a packaged system and 248.47 Gbps on a bare chip, with all extracted secure bits passing the NIST randomness tests.

This innovation solves the challenge of securely extracting intrinsic randomness from quantum resources for large-scale quantum network deployments and further supports the development of new devices, such as

field-deployed continuous variable quantum communication chips. This work was published in Photonics Research as the cover article and was selected as Editor's Pick by IEEE Fellow Lan Yang. It was also featured on the homepage of Shanghai Jiao Tong University's official website, alongside news of SJTU students Sun Yingsha and Wang Chuqin winning gold at the 2024 Paris Olympics. Additionally, this work was widely covered by media outlets such as Quantum Insider and China Laser Press, marking a significant breakthrough in the field of quantum random number generator chips.

III. Practical Security Research on On-Chip Quantum Resources for the Quantum Internet

(4) Practical Security of On-Chip Continuous Variable Quantum Key Distribution

The integration of on-chip CV-QKD systems is a key technological route for building high-performance, low-cost quantum key distribution systems, with significant potential for constructing quantum metropolitan networks. However, as systems shrink down to the micro- and nanoscale, many macroscopic physical effects could pose potential security risks. I investigated the practical security of on-chip CV-QKD systems at both the source and detection ends, revealing that the imperfections of chip modulators could threaten system security. I proposed two preliminary countermeasures to address these issues. This work was published as a first-author paper in Physical Review A and was listed as a global significant advancement by QuantumCTek. This work was also highly praised by Quantum Insider, which stated that it "pioneered the practical security research of on-chip quantum key distribution systems."

(5) Forced Carrier Perturbation Opens a Loophole for On-Chip Continuous Variable Quantum Key Distribution Systems

At the detection end, my research demonstrated that forced carrier perturbation could lead to security risks in on-chip CV-QKD systems. In traditional studies, the quantum efficiency of detectors is often assumed to be constant. However, in on-chip systems, due to waveguide inhomogeneity and free-carrier absorption, the quantum efficiency dynamically changes. I proposed a detector model based on chips, showing through simulations that changes in quantum efficiency could reduce system security. I also proposed two countermeasures to address this issue. This research was published in Optics Express, breaking the traditional assumption that detector quantum efficiency can be pre-calibrated, and suggested stricter consideration of practical security in the development of on-chip CV-QKD systems.

Publications

- **Li, L.**, Cai, M., Wang, T., Tan, Z., Wu, K., &Zeng, G. On-Chip Source-Device-Independent Quantum Random Number Generator. *Photonics Research, 12 (7), 1379-1394,* **2024.** **（中科院1区TOP, Chinese Academy of Sciences Category 1 TOP Journal, IF：7.6）(On the cover)**

- **Li, L.**, Wang, T., Li, X., Huang, P., Guo, Y., Lu, L., Zhou, L., & Zeng, G. Continuous-variable quantum key distribution with on-chip light sources. *Photonics Research*, 11(4), 504-516. **2023.（中科院1区TOP, Chinese Academy of Sciences Category 1 TOP Journal, IF：7.6）(On the cover)**

- **Li, L.**, Huang, P., Wang, T., & Zeng, G. Practical security of a chip-based continuous-variable quantum-key-distribution system. *Physical Review A*, 103(3), 032611, **2021.** **（中科院2区TOP, Chinese Academy of Sciences Category 2 TOP Journal, IF：3.14）**

- **Li, L.**, Huang, P., Wang, T., Yin, H., & Zeng, G. Forced carrier perturbation opens a loophole for chip-based continuous variable quantum key distribution system. *Optics Express*, 32, 33423-33441, **2024.** **（中科院2区TOP, Chinese Academy of Sciences Category 2 TOP Journal, IF：3.2）**

- **Li, L.**, Wang, T., Huang, P., Xu, Y., Liu, X., Zhao, H., & Zeng, G. Practical Source Security of On-chip Continuous Variable Measurement Device Independent Quantum Key Distribution. In 2024 Photonics & Electromagnetics Research Symposium (PIERS) (pp. 1-6). IEEE. **2024. (Oral presentation)（国际电磁学领域顶会, Top international conference in the field of electromagnetics.）**

- **Li, L.**, Wang, T., Huang, P., & Zeng, G. Quantum Photonics Enhances Continuous Variable Quantum Key Distribution. In 2023 *Photonics & Electromagnetics Research Symposium (PIERS)* (pp. 529-535). IEEE. **2023. (Oral presentation, Prague, Czech Republic)（国际电磁学领域顶会, Top international conference in the field of electromagnetics.）**

- **Li, L.**, T. Wang, P. Huang and G. Zeng, Continuous Variable Measurement Device Independent Quantum Key Distribution with Flawed On-Chip Light Sources, *the International Conference on Quantum Photonics (QPhotoniX 2023)* Jinhua , China, November, **2023.（Oral Presentation）（全国量子信息领域顶会, Top national conference in the field of quantum information.）**

- **Li, L.,** et al. On-chip quantum communication with optical continuous variable. *China Quantum Cryptography Academic Annual Conference*, Nanjing, Jiangshu, **2024. (Oral Presentation)（全国量子密码领域顶会, Top national conference in the field of quantum cryptography.）**

- **Li, L.,** et al. Hundred-kilometers level continuous-variable quantum key distribution system with on-chip light sources. *China Quantum Cryptography Academic Annual Conference*, Haikou, Hainan, **2023. (Oral Presentation)（全国量子光学领域顶会, Top national conference in the field of quantum optics.）**

- **Li, L.,** et al. Practical security of on-chip continuous-variable quantum key distribution. *The 19th National academic Conference on Quantum Optics*, Nanchang, Jiangxi, **2021. (Oral Presentation)（全国量子光学领域顶会, Top national conference in the field of quantum optics.）**

- **Li, L.,** et al. Practical security of a chip-based continuous-variable quantum-key-distribution system. *The 11th Annual Conference on Quantum Cryptography*, Roeterseiland Campus, Nieuwe Achtergracht 166, 1018 WD Amsterdam, The Netherlands, Agust, **2021.（国际量子密码领域顶会, Top international conference in the field of quantum cryptography.）**

- **Li, L.,** et al. Forced carrier perturbation opens a loophole for chip-based continuous-variable quantum key distribution system. *The 12th Annual Conference on Quantum Cryptography*, Academia Sinica, Taipei, Taiwan, China, Agust, **2022.（国际量子密码领域顶会, Top international conference in the field of quantum cryptography.）**

- **Li, L.,** et al. Forced carrier perturbation opens a loophole for chip-based continuous-variable quantum key distribution system. *The 20th National academic Conference on Quantum Optics*, Qingyuan, Guangdong, **2022.（全国量子光学领域顶会, Top national conference in the field of quantum optics.）**

- **Li, L.,** et al. Forced carrier perturbation opens a loophole for chip-based continuous-variable quantum key distribution system. *China Quantum Cryptography Academic Annual Conference*, Shenyang, Liaoning, China, **2022.（全国量子密码领域顶会, Top national conference in the field of quantum cryptography.）**

- Yu, T., Li, X., **Li, L.**, Huang, J., Li, H., Wang, T., Zhou, L., & Zeng, G. Surpassing the Quantum Limit in Bosonic Loss Estimation without Quantum Probes. *Physical Review Letters*, 133(060801), **2024**. **(Prestigious journal in the field of physics, 中科院1区TOP, Chinese Academy of Sciences Category 1 TOP Journal, IF：9.0)**

- Wang, T., Zuo, Z., **Li, L.**, Huang, P., Guo, Y., & Zeng, G. Continuous-Variable Quantum Key Distribution Without Synchronized Clocks. *Physical Review Applied*, 18, 014064, **2022. (JCR Q1 TOP IF: 4.99)**

- Yuehan Xu, Tao Wang, **Li, L.**, Huanxi Zhao, Peng Huang, Guihua Zeng; Simultaneous continuous-variable quantum key distribution and classical optical communication over a shared infrastructure. *Appl. Phys. Lett.* ,123 (15):154001., **2023. (JCR Q1 TOP IF: 3.97)**

- Dong, J., Wang, T., **Li, L.**, Huang, P., & Zeng, G. Efficient frame synchronization using a weak coherent state for continuous-variable quantum key distribution. *Physical Review A*, 105, 052407, **2022. (中科院2区TOP, Chinese Academy of Sciences Category 2 TOP Journal, IF: 3.14)**

- Dong, J.; Wang, T.; He, Z.; Shi, Y.; **Li, L.**; Huang, P.; Zeng, G. Effective Excess Noise Suppression in Continuous-Variable Quantum Key Distribution through Carrier Frequency Switching. *Entropy* 2023, 25, 1286, **2023. (中科院2区TOP, Chinese Academy of Sciences Category 2 TOP Journal, IF: 2.7)**

- Wang, T., Huang, P., **Li, L.**, Zhou, Y., & Zeng, G. High key rate continuous-variable quantum key distribution using telecom optical components. *New Journal of Physics*, 26(2), 023002. **2024. (中科院2区TOP, Chinese Academy of Sciences Category 2 TOP Journal, IF: 3.3)**

- Xiang, J., Wang, T., **Li, L.** et al. Pre-calibration and compensation of quadrature components in continuous-variable quantum key distribution. *Quantum Inf Process* 22, 33. **2023. (中科院2区TOP, Chinese Academy of Sciences Category 2 TOP Journal, IF: 2.5)**

- T. Wang, Y. Xu, H. Zhao, **L. Li**, P. Huang, & G. Zeng. "Multi-rate and multi-protocol continuous-variable quantum key distribution," *Opt. Lett.* 48, 719-722. **2023. (中科院2区TOP, Chinese Academy of Sciences Category 2 TOP Journal, IF: 3.6)**

- Huanxi Zhao, Tao Wang, Yuehan Xu, **Li, L.**, Zicong Tan, Piao Tan, Peng Huang, and Guihua Zeng, "Continuous-variable quantum key distribution robust against environmental disturbances," *Opt. Express* 32, 7783-7799 . **2024. (中科院2区TOP, Chinese Academy of Sciences Category 2 TOP Journal, IF: 3.6)**

- Wang, T., Xu, Y., **Li, L**., Liu, X., Tan, Z., Huang, P., & Zeng, G. Continuous-variable Quantum Key Distribution Access Network. In *2024 Photonics & Electromagnetics Research Symposium (PIERS)* (pp. 1-7). IEEE. **2024. (Oral presentation)（国际电磁学领域顶会, Top international conference in the field of electromagnetics.）**

- Wang, T., Huang, P., Wang, S., **Li, L.,** Zuo, Z., Dong, J., Zeng, G. Carrier synchronization for continuous-variable measurement-device-independent quantum key distribution with a real local oscillator. *China Quantum Cryptography Academic Annual Conference*, Shenyang, Liaoning, China, **2022.（全国量子密码领域顶会, Top national conference in the field of quantum cryptography.）**

- Dong, J., Wang, T., **Li, L.,** Huang, P., & Zeng, G. Efficient frame synchronization using a weak coherent state for continuous-variable quantum key distribution. *The 11th Annual Conference on Quantum Cryptography*, Roeterseiland Campus, Nieuwe Achtergracht 166, 1018 WD Amsterdam, The Netherlands, Agust, 2022. **（国际量子密码领域顶会, Top national conference in the field of quantum cryptography.）**

- Wang, T., Huang, P., **Li, L.,** Xu, Y., & Zeng, G. Multi-rate and multi-protocol quantum key distribution system using continuous variables. *The 11th Annual Conference on Quantum Cryptography*, Roeterseiland Campus, Nieuwe Achtergracht 166, 1018 WD Amsterdam, The Netherlands, Agust, 2022. **（国际量子密码领域顶会, Top national conference in the field of quantum cryptography.）**

- Dong, J., Wang, T., **Li, L.**, Huang, P., & Zeng, G. Frame synchronization scheme based on weak coherent light. *China Cryptography Society Quantum Cryptography Academic Annual Conference*, Shenyang, Liaoning, China, 2022. **（全国量子密码领域顶会, Top national conference in the field of quantum cryptography.）**

- Wang, T., **Li, L**., Wei, S., Zhao, H., Huang, P., & Zeng, G. Advances in High-Performance Continuous-Variable Quantum Key Distribution Technology. *China Cryptography Society Quantum Cryptography Academic Annual Conference*, Shenyang, Liaoning, China, 2022. **(Invited talk)（全国量子密码领域顶会, Top national conference in the field of quantum cryptography.）**

Patents

- Huang, P., **Li, L.,** Zeng, G., An accurate estimation method of quantum efficiency based on light intensity monitoring and deep neural networks, Invention patent, No.CN113810186B, authorized, **2023.**
- Huang, P., **Li, L.,** Zeng, G., Defense method and system of security vulnerability in realistic on-chip CV-QKD system, Invention patent, No.CN113055167A, authorized. **2021.**
- Huang, P., **Li, L.,** Zeng, G., Fast estimation of quantum efficiency by interval segmentation based on light intensity monitoring, Invention patent,No.CN113836524B, authorized.2**022.**

Professional skills

- **Methods:** Theoretical background and experiment skills of basic research in the fields of continuous variable quantum communication, networking, cryptography, and their chip integration including but not limited to optical fibre communication experiment, silicon quantum photonics system design, tape-out, packaging, experiments, etc., continuous-variable quantum access network, on-chip continuous-variable quantum key distribution, quantum random number generator, Etc.
- **Programming Tools:** MATLAB, PYTHON, C, C++, Etc.

Honors & Awards

- President's Award of Shanghai Jiao Tong University. SJTU, One time (2022)
- President of the Student Union, School of Electronic Information and Electrical Engineering, Shanghai Jiao Tong University. SJTU, (2021-2022)
- The First Prize Scholarship for Doctor Program SJTU, Three times (2021, 2022, 2023)
- Outstanding doctoral student First Prize SJTU, Three times (2021, 2022, 2023)
- Annual first prize fellowship for outstanding doctoral students SJTU, Three times (2021, 2022, 2023)
- Shanghai Jiao Tong University annual outstanding student SJTU, One time (2020-2021)
- Doctoral scholarship for Excellence SJTU, One time (2022-2023)
- Excellent undergraduate graduate of Chongqing University CQU, One time (2020)
- Outstanding contributor to Chongqing's innovation capability Chongqing Municipality，One time (2020)
- Outstanding student of academic science and Technology innovation of Chongqing University CQU, One time (2019)
- Outstanding student in innovation and entrepreneurship of Chongqing University CQU, One time (2019)

- Outstanding student of Chongqing University CQU, One time (2019)
- Excellent student leader of Chongqing University CQU, One time (2018)
- Excellent individual in social practice of Chongqing University CQU, One time (2017)
- Grand Prize in the Mathorcup Global Mathematical Contest in Modeling for University Student One time (2017)
- Second prize in the National Calculus Competition One time (2017)
- The third China "Internet Empowerment" Innovation and Entrepreneurship Competition Chongqing Gold Medal One time (2017)

Selected Research & Project Experiences

Participated as a principal researcher in over 10 national basic science research projects in the fields of continuous variable quantum communication, networking, cryptography, and their chip integration, with total research funding exceeding 300 million yuan.（作为主研人员参与连续变量量子通信、网络和密码及其芯片化领域的国家级基础科学研究项目10余项，累计科研经费总额逾3亿。）

- Research on key Technologies for Continuous Variable Fiber Optic Quantum Communication Access, **Technological Innovation 2030- Quantum Communication and Quantum Computer Major Project**, No.2021ZD0300703.(11/2021-Present) (Project major member)
- Research on the New Generation Quantum Access Network and Quantum Communication System Technology, **Shanghai Municipal Science and Technology Major Project**, No.2019SHZDZX01-ZX02.(07/2019-11/2021)(Project major member)
- Demonstration network of continuous variable quantum secure communication for space ground integration, **Guangdong Province Key Field R&D Plan**, No. 2020B0303040002.(01/2020-01/2023)(Project major member)
- Research on high-performance local oscillator continuous variable quantum key distribution technology, **National Natural Science Foundation of China General Project,** No. 20024008A0824.(01/2022-01/2024)(Project major member)
- DER Energy Efficiency Comprehensive Management Platform, **entrepreneurship training program for college students**, Project No. 1210611063. (06/2017 - 06/2019) (Project leader)

News

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国外的（英翻译）

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I would like to express my deepest gratitude to the esteemed professors who have contributed significantly to my research and development. Without their care and support, I could not have had the basic foundation to complete these research work.

Advisor:

Professor Guihua Zeng (SJTU): Professor Zeng has been an exceptional mentor, always encouraging me to tackle the most challenging and significant problems in research. His high-level vision and forward-thinking insights have profoundly shaped my development as a scholar. He has taught me to approach challenges from a broader perspective, driving innovation from foundational scientific mechanisms to breakthroughs in technical capabilities.

Collaborating Professors:

Professor Linjie Zhou (SJTU): Professor Zhou's rigorous and profound foundation in integrated photonics has deepened my understanding of the field. As a Newton Scholar, his exceptional language skills have been invaluable in helping me refine my papers word by word. More importantly, I am grateful to him for providing the interdisciplinary platform support needed to pursue integrated quantum photonics.

Professor Kan Wu (SJTU): I am grateful for Professor Wu's support and collaborative spirit, which have been crucial in advancing my research efforts. Professor Wu's extensive expertise in integrated photonics and information science has provided me with numerous experimental resources.