

Yuan Wang

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I am passionate about *quantum light-matter interaction*, *parallel computing*, and *AI for science*, with expertise in developing computational tools on GPU for quantum systems, applying machine learning to accelerate scientific discovery, and leveraging physical principles to enhance machine learning architectures (Science for AI).

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Experience

- Research Associate | University of Sheffield, UK | Jun 2025 - Oct 2025
Postdoctoral Research Fellow | University of Exeter, UK | Aug 2024 - May 2025
Topic: "*Developing machine-learning architectures integrating with optics for scientific computing applications*"
mentored by Prof. Oleksandr Kyriienko
- Visitor | University of Southampton, UK | Aug 2023 - Jul 2024
Topic: "*A Fourier neural operator approach for modelling exciton-polariton condensate systems*"

Education

- PhD in Physics | University of Southampton, UK | Sept 2018 - Sept 2023
Thesis: "*Tailored reservoir of exciton-polariton condensates*"
mentored by Prof. Pavlos Lagoudakis, Prof. Simone De Liberato, and *unofficially* Dr. Helgi Sigurðsson
- Master's Double Degree | M2 Nanoscience | University of Ferrara, Italy | Sept 2017 - Jul 2018
- Master's Double Degree | M1 General Physics | Paris-Saclay University, France | Sept 2016 - Jul 2017
- Bachelor's in Physics | Anhui Normal University, China | Sept 2012 - Jul 2016

Internship

- Quantum Theory and Technology | University of Southampton, UK | Feb 2018 - Jul 2018
Topic: "*Quantum theory of the intersubband polaritons*"
mentored by Prof. Simone De Liberato
- Quantum Optics | Sorbonne University, France | Apr 2017 - Jul 2017
Topic: "*Quantum squeezing variance in second-mode approximation*"
mentored by Dr. Simon Pigeon

Activities

- Presentation at *Math + ML + X Seminar* (online, 24th April 2025), invited by Dr. Angelica I. Aviles-Rivero
Yau Mathematical Sciences Center, Tsinghua University, Beijing, China
- Attendance at 2025 Winter School on *Physics of Machine Learning & Machine Learning for Physics*
(12 Jan 2025 - 24 Jan 2025), The Nordic Institute for Theoretical Physics (Nordita), Stockholm, Sweden
- Poster presentation at *NeurIPS 2023 AI for Science Workshop*
- Co-organizer: *QLM Summer School 2019*, guided by Prof. Hendrik Ulbricht

Languages

- Chinese (Native) & English (Fluent)

Skills

- **Programming:** C++, CUDA, MATLAB, Python **Machine learning:** PyTorch **Version control:** Git, GitHub
- **CI/CD:** GitHub Actions **Simulation:** COMSOL Multiphysics **Editing:** HTML, LaTex, Microsoft Office

Interests

- **Parallel Computing** In the field of simulating polariton condensates, there's a strong emphasis on leveraging advanced numerical methods, underpinned by a specialized computational tool that utilizes the capabilities of graphics processing units (GPUs). The split-step Fourier method (SSFM) is one of the central techniques used for these simulations, offering a streamlined approach to solving partial differential equations in parallel computing environments. This method is also notably efficient when integrated into machine learning frameworks, offering innovative solutions for complex equations. My focus lies in developing computational tools based on NVIDIA's CUDA architecture, using C++ and CUDA APIs. This expertise encompasses both CPU-based

and GPU-based GPE solvers, with a particular emphasis on utilizing SSFM for efficient problem-solving in the realm of quantum fluid dynamics.

- **Neural Operator** A plethora of next-generation all-optical devices based on exciton-polaritons have been proposed in latest years, including prototypes of transistors, switches, analogue quantum simulators and others. However, for such systems consisting of multiple polariton condensates, it is still challenging to predict their properties in a fast and accurate manner. The condensate physics is conventionally described by polariton Gross-Pitaevskii equations (GPEs). While GPU-based solvers currently exist, we propose a significantly more efficient machine-learning-based Fourier neural operator approach to find the solution to the GPE coupled with exciton rate equations, trained on both numerical and experimental datasets. The proposed method predicts solutions almost three orders of magnitude faster than CUDA-based solvers in numerical studies, maintaining the high degree of accuracy.

- **Positional embedding in ML**

- Graph Neural Networks (GNNs) are powerful tools for molecular property prediction, but their reliance on local message-passing mechanisms limits their ability to capture long-range dependencies in large graphs. We propose a physics-informed approach that enhances graph convolutional networks (GCNs) by incorporating positional embeddings derived from photonic dynamics simulation.
- Photonics can offer a hardware-native route for machine learning (ML). However, efficient deployment of photonics-enhanced ML requires hybrid workflows that integrate optical processing with conventional CPU/GPU based neural network architectures. Here, we propose such a workflow that combines photonic positional embeddings (PEs) with advanced graph ML models. We introduce a photonics-based method that augments graph convolutional networks (GCNs) with PEs derived from light propagation on synthetic frequency lattices whose couplings match the input graph. We simulate propagation and readout to obtain internode intensity correlation matrices, which are used as PEs in GCNs to provide global structural information. Our results show that photonic PEs improve GCN performance and support optical acceleration of graph ML.
- **Exciton-polariton condensate** The AlGaAs-like quantum wells within high-quality microcavities, can generate exciton-polaritons (polaritons) in the strong coupling regime. At cryogenic temperatures, the polariton condensates can be formed through optically excited high-energy excitons. I focus on the theoretical development of the methods for enhancing and focusing these condensates, utilizing localized nonresonant asymmetric-shaped excitation. A significant aspect of my work involves increasing spatial coherence and optimizing interaction strength between polaritons, paving the way for the realization of all-optical transistors and contributing to large-scale polariton condensates networks.

Workshop

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- [1] Surya T. Sathujoda*, **Yuan Wang***†, Kanishk Gandhi, *Exciton-Polariton Condensates: A Fourier Neural Operator Approach*, NeurIPS 2023 AI for Science Workshop (2023)

Journal/Preprint/Work in progress

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- [9] **Y. Wang** and O. Kyriienko, *Photonics-Enhanced Graph Convolutional Networks*, arXiv.2512.15549 (2025)
 - [8] K. Fripp, **Y. Wang**, O. Kyriienko, AV Shytov, and VV Kruglyak, *Magnonic Full Adder using Nanoscale Chiral Magnonic Resonators*, manuscript near submission (2025)
 - [7] **Y. Wang**, S. Scali, and O. Kyriienko, *Polaritonic Machine Learning for Graph-based Data Analysis*, arXiv.2507.10415 (2025)
 - [6] **Y. Wang***†, Surya T. Sathujoda*, K. Sawicki, K. Gandhi, A. I Aviles-Rivero, and P. G. Lagoudakis, *A Fourier Neural Operator Approach for Modelling Exciton-Polariton Condensate Systems*, accepted by Communications Physics (2025)
 - [5] K. Sawicki, D. Dovzhenko, **Y. Wang**, T. Cookson, H. Sigurðsson, and P. G. Lagoudakis, *Occupancy-driven Zeeman suppression and inversion in trapped polariton condensates*, Physical Review B **109**, 125307 (2024)
 - [4] **Y. Wang**, *Tailored reservoir of exciton-polariton condensates*, University of Southampton, PhD Thesis (2023)
 - [3] **Y. Wang**, P. G. Lagoudakis, and H. Sigurdsson, *Enhanced coupling between ballistic exciton-polariton condensates through tailored pumping*, Physical Review B **106**, 245304 (2022)
 - [2] **Y. Wang**, H. Sigurdsson, J. D. Töpfer, and P. G. Lagoudakis, *Reservoir optics with exciton-polariton condensates*, Physical Review B **104**, 235306 (2021)
 - [1] **Y. Wang** and S. De Liberato, *Theoretical proposals to measure resonator-induced modifications of the electronic ground state in doped quantum wells*, Physical Review A **104**, 023109 (2021)