

Juan Rafael Álvarez

(he/him)

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🌐 juanralvarez.github.io/mypage/

Born 31/03/1993 in Medellín, Colombia

Speaks: Spanish, English, French



About me

- Experimental physicist interested in quantum information processing and fundamentals of quantum mechanics using light.
- Postdoctoral fellow (C2N - CNRS) in the team led by Prof. Pascale Senellart between March 2023 and August 2024.
- Obtained PhD in March 2023 at the University of Oxford, in the Atom-Photon connection group led by Prof. Axel Kuhn.
- International experience in research groups in France, UK, Spain, Austria, USA and Colombia.
- Nine publications: three first-author, four second-author.
- Teaching, outreach, paper reviewing and institutional responsibilities.

Professional experience

- 01/2025–Present **Assistant Professor (Enseignant-Chercheur) in Photonics, Télécom Paris - Institut Polytechnique de Paris, Palaiseau, France**
Group of Optical Telecommunications (GTO), Communications and Electronics (COMELEC) department.
Experimental and theoretical work in Optical Telecommunications with Quantum light
- 03/2023–08/2024 **Postdoctoral Researcher, Centre de Nanosciences et de Nanotechnologies, C2N, CNRS, Université Paris Saclay, Palaiseau, France**
Group of Optics in the Solid State - Advisors: Prof. Pascale Senellart, Dr. Nadia Belabas
Experimental and theoretical work:
-Direct measurement of the Wigner function of a single photon emitted by a quantum dot single photon source.
-Development of quantum communication protocols using on-demand single photon sources.
-Development of high-dimensional quantum communication protocols using frequency bin entangled four wave mixing sources.

Skills

- Experiment Proficiency in operation of single photon sources with Rubidium atoms and quantum dots in cavities. Operation and design of advanced optical systems in the near infrared. Operation of external cavity diode lasers, femtosecond lasers, continuous wave fiber lasers and optical frequency combs. Basic operation of vacuum systems, cryostats, optical cavity mounting and alignment, and laser cooling systems for neutral atoms. Skills in electronic circuit analysis.
- Software Mathematica, Matlab (Modeling and simulation of quantum optical systems), Python (Experimental control, modeling, simulation). Basic usage and understanding of Tensorflow/Keras and QuTiP, Lumerical MODE Solutions. Adobe Illustrator, Inkscape. Web design in Wordpress and HUGO.
- Others Strong interest and experience in communication and outreach in quantum optics. Public tenders (purchase of fourteen SNSPDs at C2N - Liaising with suppliers and support from Thorlabs, Toptica, Single Quantum, Menlo Systems and PhotonSpot).
- Languages **Spanish** (Native language) | **English** (fluent - TOEFL iBT 112/120) | **French** (fluent - DELF B2 74.5/100) | **German** (Intermediate - Minor in German Language - Universidad de los Andes, Colombia).
- Safety Trained in First Aid and fire marshaling.
- Hobbies Photography ([link here](#)), generative art, swimming, basic piano, drone piloting.

Education

- 10/2018–01/2023 **Doctorate of Philosophy in Atomic and Laser Physics, University of Oxford, United Kingdom**
Horizon 2020 MSCA fellowship - LIMQUET Innovative Training Network.
Atom-Photon Connection Group - Supervisor: Prof. **Axel Kuhn**.
Pushing cavity-based single photon sources to the limit: Photon feedback, coherent repumping and multilayer cavities
-Contributed to simulations in Python and Mathematica to model the driving of ^{87}Rb atoms in cavities. With the full structure of the atomic line modelled in QuTiP, I calculated the efficiencies for multi-photon production.
-Developed calculations and simulations for the time-resolved photon interference between long photons produced by atoms in optical cavities.
-Joined the experimental team, using devices such as superconducting nanowire single photon detectors, frequency combs and locking electronics for stabilizing the frequencies of different lasers in the laboratory.
-Proposed experiments for the improvement of single photon production by making use of the complete structure of Rubidium. Publication [7]

- 09/2016-09/2018 **Master in Photonics, *Europhotonics POESII Master - Erasmus+ Scholarship***
Year 1: Aix-Marseille Université - Marseille, France. (GPA 17.097/20.00 - **Mention Très Bien**)
Year 2: Photonics BCN (UAB-UB-UPC-ICFO) - Barcelona, Spain. (GPA 9.21/10.00)
Master thesis title: Coherence-based quantum random number generator. Director: Prof. **Juan P. Torres**. ([Link here](#))
 Deployment, automation and data processing of random number generation from two tuneable telecom lasers. Publication of results in Optics Express [3].
- 01/2012-08/2016 **Bachelor of Mathematics, *Universidad de los Andes*, Bogotá, Colombia**
 GPA 4.47/5.00
Undergraduate thesis: Stokes phenomena in classical special functions: Bessel and Weber functions with applications.
 Supervisor: Prof. **Alexander Getmanenko**.
- 01/2011-12/2014 **Bachelor of Physics, *Universidad de los Andes*, Bogotá, Colombia**
 GPA 4.52/5.00
Undergraduate thesis: Coupling the spatial and polarization degrees of freedom of light: Applications in measurement theory and open quantum systems
 Participated in six semesters of undergraduate research under the guidance of Prof. **Alejandra Valencia**, resulting in participation in the FiO 2015 and QIM 2017 conferences, and publications in the Journal of Optics [1] and Optics Express [2].

Internships and Secondments

- 01-03/2020 **Secondment, *Stéphane Guérin group*, Institut Carnot de Bourgogne, Dijon, France**
Project: Estimation of mode volume for leaky optical cavities.
 - Developed simulations in MATLAB and Mathematica to model the propagation of light through a cavity whose mirrors were made of multilayer dielectric stacks.
 - It yielded a publication [4], and involved simulations in Mathematica and MATLAB as well as the theoretical modeling of the mode propagation in multilayered structures. This project was done in close collaboration with Astghik Saharyan, a PhD student from the Carnot institute.
- 06-09/2018 **Summer Fellowship - ICFO - Fundació Catalunya-La Pedrera, *Quantum Engineering of Light Group*, ICFO, Barcelona, Spain**
Project: Random number generation by coherent detection of quantum phase noise.
 - This project was made in connection with my master's thesis.
- 05-09/2017 **Internship, *Rupert Ursin Group*, IQOQI Vienna, Austria**
Project: QPOINTS: Quantum POLarization-based mINiatuRized phoTon pair Source.
 - Experimental project to produce a proof of concept for a single-photon emitting CubeSat. Produced photon pairs using a type 0 PPKTP crystal embedded within SM1 mounts. Developed electronics, refrigeration and automation of operation.
- 11/2016 - 02/2017 **Student research, *Thomas Durt Group*, Aix-Marseille Université - École Centrale de Marseille, France**
Project: Bouncing oil droplets: Wave-particle duality at the macro-scale.
 - Theoretical project performed in pairs with another master student, Riya Sett.
- 06-07/2015 **Internship, *Jin Suntivich Lab*, MSE - Cornell University, Ithaca, NY, USA**
Project: Design of a ring resonator for strong cavity-matter coupling.
 - Computational project performed as undergraduate research for the summer of 2015. Used Lumerical FDTD to understand strong light-matter coupling in a resonator design.

Publications

- [9] **Decoherence Assisted Quantum Key Distribution**
 D.R. Sabogal, D.F. Urrego, J.-R. Álvarez, A.F. Herrera, J.P. Torres, A. Valencia - [arXiv preprint - arXiv:2405.20153 \(2024\)](#).
- [8] **Measuring Wigner functions of quantum states of light in the undergraduate laboratory**
 J.-R. Álvarez, A.M. Silva, A. Valencia, - [arXiv preprint - arXiv:2310.17525 \(2023\)](#).
- [7] **Bursts of polarised single photons from atom-cavity sources**
 J.O. Ernst, J.-R. Álvarez, T.D. Barrett, A. Kuhn, - [J. Phys. B: At. Mol. Opt. Phys. 56 205003 \(2023\)](#).
- [6] **How to administer an antidote to Schrödinger's cat**
 J.-R. Álvarez, M. Ijspeert, O. Barter, B. Yuen, T.D. Barrett, D. Stuart, J. Dilley, A. Holleczek, and A. Kuhn. [J. Phys. B: At. Mol. Opt. Phys. 55 054001 \(2022\)](#).
- [5] **Equivalence regimes for geometric quantum discord and local quantum uncertainty**
 O. Cordero-Boronat, A. Villegas, J.-R. Álvarez, R. J. León-Montiel, M. Passos, and J.P. Torres. [Phys. Rev. A 104, 042401 \(2021\)](#)
- [4] **Light-matter interaction in open cavities with dielectric stacks**
 A. Saharyan, J.-R. Álvarez, T. Doherty, A. Kuhn, and S. Guérin. [Appl. Phys. Lett. 118, 154002 \(2021\)](#). (short video of research [here](#))
- [3] **Random number generation by coherent detection of quantum phase noise**
 J.-R. Álvarez, S. Sarmiento, J. A. Lázaro, J. M. Gené and J. P. Torres. [Optics Express 28, 4, 5538 \(2020\)](#)
- [2] **Implementation and characterization of a controllable dephasing channel based on coupling polarization and spatial degrees of freedom of light**
 D.F. Urrego, J.-R. Álvarez, O. Calderón-Losada, J. Svozilik, M. Nuñez and A. Valencia. [Optics Express 26, 9, 11940 \(2018\)](#).

- [1] **Interference of two pulse-like spatial beams with arbitrary transverse separation.**
J. Flórez, J.R. Álvarez, O. Calderón-Losada, L.J. Salazar-Serrano and A. Valencia. [Journal of Optics](#), 18, 125201 (2016).

Selected participation in Conferences

- 2024 **Talk - Interference between quantum-dot emitted single photons and weak coherent states**
◦ Quantum 2.0 2024, Paper QM5B.2 - Rotterdam, The Netherlands.
- 2023 **Talk - Measuring Wigner functions of quantum states of light in the undergraduate lab**
◦ ETOP 2023, Cocoa Beach, FL, USA, paper 127232U
- 2022 **Talk - Administering an antidote to Schrödinger's cat**
◦ [Quantum 2.0 2022](#), paper QTh3C.1 ◦ Upgraded to invited talk ◦ Student paper finalist.
◦ Atomic and Laser Physics Seminar Oxford Physics, 14/02/2022. [Link here](#).
- 2020 **Talk/Poster: Cavity-based photon-generation schemes using STIRAP re-preparation**
◦ **Poster** - QTech 2020 Conference ◦ **Poster** - OSA Siegman School All Stars. ([Virtual poster here](#)) ◦ **Talk** - YAO 25 Conference - Hamburg, Germany. ◦ **Talk** - CAMEL XV conference, Nesebar, Bulgaria.
- 2017 **Poster - Spatial Interference of light: a method to generate structured environments to study quantum dynamics**
[QIM IV Conference](#), April 2017, Paris, France.
- 2016 **Talk - Synthesizer of arbitrary polarization states**
J.R. Alvarez, D. F. Urrego, M. Nunez Portela, and A. Valencia. [LAOP Conference](#), (OSA 2016), paper LTh2B.5.
- 2015 **Proceedings - Light Interference in Position and Momentum Variables: the Spatial Alford and Gold Effect**
J. Florez, O. Calderon-Losada, L.-J. Salazar-Serrano, J.R. Alvarez, and A. Valencia. [FiO 2015](#), OSA paper FTh1C.5.
- 2015 **Poster - Grupo de Óptica de los Andes - OSA Student Chapter**
OSA Student Chapter Leadership Conference 2015, San Jose, CA, USA.
- 2015 **Proceedings - Making optics appealing in Colombia through low-cost experiments with lasers**
J.R. Álvarez, N. Barbosa, S. Cotrino, D.A. Guzmán, V. Mahecha, C. Medina, M.C. Navarrete, L. Uribe and A. Valencia. [Proc. SPIE 9793 - ETOP 2015](#), 979333 (Oct 8, 2015).

Awards

- 2018-22 **Marie Skłodowska Curie Early Stage Researcher grant**
Awarded to perform my DPhil in the Innovative Training Network LIMQUET, Light Matter interfaces for QUantum Enabled Technologies.
- 2022 **Zuegel family scholarship**
Awarded to attend the 2022 Siegman School on Lasers. Merit-based award focused on global diversity and academic achievement.
- 2021 **Oxford Physics Instagram Photography Competition**
Awarded for a photography competition showing the most representative images of my research on Instagram.
- 2018 **ICFO summer fellow**
Awarded for performing research in the summer of 2018 at the Institute of Photonic Sciences (ICFO) in Barcelona, Spain.
- 2016 **Erasmus Mundus EMJMD**
Fully funded master program, provided by the Europhotonics POESII Master.
- 2015 **Uniandes - Cornell University Summer Undergraduate Research Fellow**
Awarded to 25 students from the Universidad de los Andes to perform research fully funded in the summer of 2015 at Cornell University, in Ithaca, New York.
- 2010 **Olimpiadas del Conocimiento Medellín**
Awarded full scholarship and monetary stipend for performing undergraduate studies in Medellín (I turned this scholarship down). Third runner up in a municipal competition, out of 80 000 students.

Teaching Experience

- 2021-23 **Oxford Physics - Lab demonstrator**
Lab Demonstrator for Oxford Physics Computing
Helped students and marked practicals for year 1 and year 2 Oxford undergraduate students with computing problems.
In the fall of 2022 I was appointed senior demonstrator, training new demonstrators in the lab.
Year 1 topics include an introduction to MATLAB, numerical methods (RK4, polynomial fitting, numerical integration), and the simulation of simple physical phenomena: Rocket launching, projectile motion, Monte Carlo simulations, radioactive decay and LCR circuits.
Year 2 topics include the simulation in MATLAB or Python of more complex computational physics problems: Ferromagnetism, Fourier Optics, Solitons, Heat equations, and Schrödinger's equation.
2023: 60 hours - **2022:** 45 hours - **2021:** 30 hours

- 2019 **Clubes de ciencia Colombia**
 Universidad EAFIT, Medellín, Colombia. (Small video [here](#))
 -Designed a one-week practical course for 30 students aged 15-16 in Medellín, Colombia.
 Topics included introductions to light, telecommunications and cryptography, as well as the practical implementation of a laser sender-receiver for the reproduction of music. - 40 hours
- 2013-16 **Universidad de los Andes - Complementary courses**
 Taught practice session courses for 10-25 students twice a week for 1 hour.
2016: Linear Algebra - complementary course (25 students): Basic vector and matrix algebra - determinants, eigenvectors and eigenvalues, abstract vector spaces, and quadratic forms. Student evaluation: 3.8/4. - 30 hours
2015: Integral calculus - complementary course (25 students): Basic techniques for integration, parametric and polar integrals, series and sequences, and an introduction to ODEs. - Student evaluation: 3.74/4 - 30 hours
2013: Prephysics - complementary course (10 students): Topics included elementary mechanics without calculus: kinematics, dynamics, conservation of energy, angular momentum and Newtonian gravitation. - Student evaluation: 3.65/4 - 30 hours
 Teaching also included personalized teaching for three hours a week for students at the **Mathematics Pentagon** (link [here](#)).
- 2012-16 **Course monitoring - Universidad de los Andes**
 Marked weekly homework for 20-100 students in a semester comprising 16 weeks of work.
2016: Electronics (20 students) - Topics included the basic components of electronic design: Kirchhoff's laws, Thévenin and Norton's theorems, RLC circuits, diodes, operational amplifiers, transistors and logic gates.
2015: Quantum Mechanics I and II (25 students) - Topics followed closely the books I and II of Cohen-Tannoudji's Quantum Mechanics.
2014: Basic Physics II (100 students) - Topics were related to basic electromagnetism and thermodynamics, but required no calculus.
2012 and 2013: Waves and fluids (25 students) - Topics followed closely the book Vibrations and Waves, by A.P. French.
- 2012-13 **Physics clinic for problem solving**
 I performed personalized tutoring for science and engineering undergraduate students in Newtonian mechanics, electromagnetism and thermodynamics, topics covered in the first two basic physics courses of the first year undergraduate students. This was done in a facility provided by the physics department, the **physics clinic for problem solving** (link [here](#)). The book used for these courses was Fundamentals of Physics, by Halliday, Resnick and Walker.

Outreach presentations

- 2021 **Schrödinger's Camel: a philosophical discussion about the nature of quantum physics**
 Michael Mahony Graduate Seminar. Mansfield College, University of Oxford.
- 2016 **Measuring the speed of light with a chocolate bar**
 Demonstrative experiments in Optics - GOA OSA Student Chapter - Bogotá, Colombia - Target: University-wide students with general knowledge.
- 2015 **The Optical Fiber - History, Working principle and applications**
 Planetarium of Bogotá, Bogotá, Colombia.- Target: University-wide students with general knowledge.

Other relevant experience

- 2021- **Student supervision**
 2023-24 - Postdoctoral Supervision: Advising PhD students (Hubert Lam, Yann Portella, Etienne Bargel, George Crisan) for projects in single photon production and quantum communications.
 2021-22 - Informal advising and laboratory introduction: MPhys (Jiawang Li) and DPhil students (Jan Ole Ernst) in the Atom-Photon connection laboratory to develop their projects in single photon production and photon demultiplexing.
- 2020- **Peer reviewer, Optica Publishing Group**
 I have reviewed 23 articles for the Optica Publishing Group in the journals Applied Optics, Optics Express, Optics Letters and JOSA B, and for the IOP in the Journal of Optics and the New Journal of Physics.
- 2021-22 **Residential Junior Dean, Mansfield College, University of Oxford**
 Support of students, Fire Safety and Welfare for the Ablethorpe/Rhodes Wolfson student residence of Mansfield College.
- 2021 **LIMQUET 2021 Conference - Student Organizer, Christ Church, University of Oxford**
 Arrangement and organization of the LIMQUET 2021 conference, happening in hybrid format in Christ Church and Online.
- 2018-21 **President (2021) - Secretary (2019-20), Oxford University Colombian Society**
 Organization of academic and entertainment events to disseminate the Colombian culture in Oxford.
- 2018-21 **Student Representative, Marie Skłodowska-Curie Actions - LIMQUET Innovative Training Network**
 Discussing logistical issues regarding the Innovative Training Network with the Project Officer and the Principal Investigators in organizational meetings.
- 2014-16 **President (2015-16) - Secretary (2014), GOA (Grupo de Óptica de los Andes) OSA Student Chapter**
 Universidad de los Andes, Bogotá, Colombia.
 Created the student chapter's web page (link [here](#))