PERSONAL INFORMATION

Paolo De Natale

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http://www.ino.it and http://scholar.google.it/citations?user=kC_WPz0AAAAJ

ORCID: 0000-0002-3308-8569

Sex Male | Nationality Italian

EDUCATION AND TRAINING

2013 **Italian habilitation to full university professor for Experimental Physics-Structure of Matter**

1993 **PhD/Diploma in Optics**
University of Florence – Italy

1987 **Degree in Physics "magna cum laude"**
University Federico II, Naples - Italy

WORK EXPERIENCE

2025 – present **Scientific Coordinator**
of the Research Infrastructure I-PHOQS Joint Research Unit-JRU, after CNR, Politecnico di Milano and LENS (Firenze) signed the post-PNRR JRU Statute, on Feb. 6th, 2025

2025 – present **Acting Director**
(since Feb. 1st)
National Institute of Optics (INO) of the Italian Research Council (CNR), Italy

2003 - present **Research Director**
National Institute of Optics (INO) of Italian Research Council (CNR), Italy

2010 - 2021 **Director**

2025 – present **Founder and first director of the National Institute of Optics (INO) of the Italian Research Council (CNR), Italy**

2007 - 2010 **Director**
National Institute of Applied Optics (INOA) of CNR, Italy

2001 - 2007 **Director**
INOA Unit in Pozzuoli, Italy

1997 - 2003 **Senior Research Scientist**
National Institute of Optics (INO) of Italian Research Council (CNR), Italy

1996 - 1997 **Research Scientist**
National Institute of Optics (INO) of Italian Research Council (CNR), Italy

1988 - 1996 **Permanent staff position**
European Laboratory for Nonlinear Spectroscopy (LENS), University of Florence, Italy

AWARDS, FELLOWSHIPS

2015 Appointed Italian representative of **ICO** – International Commission for Optics

2015 Awarded with **OSA** (the Optical Society of America) **Fellowship**

2012 "All-Optical Radiocarbon Dating" by D. Mazzotti, S. Bartalini, S. Borri, P. Cancio, I. Galli, G. Giusfredi, and P. De Natale selected as one of the **best 3 contributions in Optics in 2012 by OSA**

2012 Awarded with **SPIE** (the International Society for Optical Engineering) **Fellowship**

2010 Awarded as one of the best contributions in Optics in 2010 in OPN by **OSA**, *Quiet Cascade*

PERSONAL SKILLS

Mother tongue(s) Italian

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	C1	C1	C1

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

Organisational / managerial skills

ORGANIZATION OF SCIENTIFIC MEETINGS AND PARTICIPATION TO CONFERENCES COMMITTEES (SELECTION)

2024-25 Program sub-committee member CLEO/Europe (Semiconductor Lasers)
2022-24 Chairman International Quantum Cascade Lasers School and Workshop-IQCLSW 2024
2015 - 2017 Program sub-committee member CLEO Europe (Optical Sensing and Metrology)
2015 Scientific committee FISMAT (Condensed Matter Physics)
2013 - 2015 Program sub-committee member CLEO USA (Laser Science to Photonic Applications)
2011 - present Executive and Scientific committee HRMS (High-Resolution Molecular Spectroscopy) - held every 2 years
2010 - 2017 Executive committee Fotonica (Photonic Technologies)
2009 Chairman HRMS (High-Resolution Molecular Spectroscopy)
2009 Co-chairman Fotonica (Photonic Technologies, Italy)
2008 Executive committee Elettroottica (Electro-optic methods and instruments, Italy)

MAIN RESEARCH ACHIEVEMENTS

1. Pioneering pure frequency measurements of fundamental constants that have challenged our current understanding of quantum electrodynamics in hydrogen and helium; experimental tests of theories in simple molecules. (see e.g.: *Europhysics Letters* 24, 635 (1993); *Physical Review Letters* 73, 42 (1994); *Nature Communications* 13, 7016 (2022)).
2. Finding new ways to extend optical frequency comb synthesizers to the infrared and far infrared (THz) range, demonstrating novel schemes for high precision and high sensitivity measurements in molecular samples. (*Nature Communications* 3, 1040 (2012); *Physical Review X* 4, 021006 (2014)).
3. Probing the ultimate limits, set by thermodynamic noise, for sensing static and dynamic deformations ($\Delta L/L$) by optical fibers. (*Science* 330, 1081 (2010)).
4. Spectroscopic and advanced optical fiber sensing know-how was exploited to pioneer geophysical measurements in seismic and volcanic areas: for this and for coordinating an international project (*Development of an integrated spectroscopic system for remote and continuous detection of volcanic gases*. Funded (2003-2005) by INGV and GNV. Other partners: Cambridge Univ., UK; Rice University Houston, TX, USA; II Univ. Naples. (Total amount: 465 k€)) involving several expeditions on Italian

volcanoes, two appointments (see 16.) were received (*Appl. Phys. B - Rapid Comm.* 70, 467 (2000); *Measurement Science and Technology* 19, 085306 (2008) and *highlight in Optics & Photonics News*, 11, 44 (2000))
5. Measuring quantum-limited frequency fluctuations (intrinsic linewidth from the Schawlow-Townes formula) in quantum cascade lasers (QCLs), unveiling the effects of nonradiative relaxation on the unusually narrow linewidth of QCLs emitting at mid and far-IR wavelengths. (*Physical Review Letters* 107, 270802 (2011); *Nature Photonics* 6, 525 (2012)).
6. Inventing a new spectroscopic technique, named SCAR (Saturated Absorption Cavity Ringdown) that has pushed spectroscopic detection of simple molecules to the record level of a few parts-per-quadrillion (10^{-15}), allowing for the first time to single-out, with an all-optical technique, radiocarbon dioxide ($^{14}CO_2$) in natural abundance ($1x10^{-12}$) challenging AMS (accelerator mass spectrometry) in a number of key applications, from Climate change as well as nuclear waste assessment, to bio/fossil materials certification, dating of ancient manufacts and pharmaceutical studies. (*Physical Review Letters* 107, 270802 (2011); *Optica* 4, 385-388 (2016); *Advanced Photonics Research* 2, 2000069 (2021); *PNAS* 119, e2122122119 (2022)).
7. Discovery of new ways to generate frequency combs by nonlinear quadratic processes. New methodologies for thorough characterization of frequency comb emissions and first demonstration of full phase-stabilization of a THz comb emitted from a QCL. (*Nature Photonics* 13 (8), 562-568 (2019), *Nature Communications* 10, 2938 (2019); *Physical Review Letters* 121 (9), 093903 (2018)).
8. Proposal of novel cavity-enhanced laser-based analytical set-ups using liquid-droplets, fiber resonators and photoacoustic detection schemes to significantly advance environmental sensing. (*Advanced Optical Materials* 2, 1155-1159 (2014); *Scientific Reports* 7 (1), 41997 (2017); *Light: Science & Applications* 13, 11 (2024); *Physical Review Letters* 120 (7), 073902 (2018)).
9. Pioneering experiments in Quantum Technologies, exploring the classical to quantum noise limits for infrared radiation sources, deploying quantum key distribution networks, devising new schemes for quantum simulation of electron transport in semiconductor lasers, like QCLs, by use of degenerate fermionic atom gases. (e.g. *Advanced Quantum Technologies* 4, 2100044 (2021); *Advanced Quantum Technologies* 6, 2200061 (2023); *Optics Letters* 49, 1733-1736 (2024))
10. PDN is editor of 8 scientific books/special volumes and co-author of the book on *Laser-Based Measurements for Time and Frequency Domain Applications – A Handbook* (CRC Press –Taylor & Francis Group, first edition 2013, 764 pages). Another book, *Frequency Metrology of Infrared Molecular Spectra* (by P. Maddaloni, L. Consolino, P. De Natale authors, Springer Nature editor) is planned for publication within 2024.

Since the beginning of the scientific activity, in 1990, the number of publications/citations/h-index, from the main databases, is the following (June 21st, 2025, **ORCID: 0000-0002-3308-8569**):
In **Scopus**, about 514 indexed works, 8648 citations with an h-index = 49.
In **Google Scholar**: 11448 citations, h-index=56.

Selected Presentations at large International Conferences (2018-2024):

-**SPIE Photonics West**, *S. Francisco-CA (USA), >24000 attendees in 2025*:
Keynote Talk (2018),
Invited Talks (2020, 2023, 2025)
-**CLEO USA**, *S. Jose-CA (USA), >2000 attendees in 2023*:
Tutorial Talk (2020/Virtual),
Invited Talk (2023)
-**PIERS**- Progress In Electromagnetics Research Symposium, *about 1300 attendees expected in 2025*:
Invited Talk (*Toyama, Japan* 2018, 2025),
Keynote Talk (*Prague-CZ* 2023)
-**ISMS**- International Symposium on Molecular Spectroscopy, *Urbana-Champaign-IL (USA), around 700-800 attendees (average)*:
Invited Talk (2018)
- **EGAS** Conference - European Group for Atomic Spectroscopy - 50th Anniversary, *Krakow (PL)*:
Plenary presentation (2018)
-**Analytica**, *Munich Fair (Germany), 2225 attendees, around 34000 visitors*:
Invited Talk (2024).

MANAGEMENT ACTIVITY

Across 14 years (2/2007-2/2021) PDN directs INOA and then INO-CNR, without any gap. In 2010, INOA becomes part of the scientific Network of CNR with 67 overall employees, the headquarters in Florence and two local Units (Lecce and Naples). Since the foundation of INO-CNR and during the

years 2010-2021, the Institute grows and, in 2/2021, at the end of the term of PDN as Director, the Institute has about 300 scientists and employees working throughout the 8 units located all over Italy, with 45 people in the technical and administrative staff. At that date, about 90 national and international projects are active, in the area of Atomic, Molecular and Optical-AMO Physics.

2024-present **Member**
appointed by MUR, of the **Working Group** to write the Italian **National Strategic Plan for Quantum Technologies** (https://www.mur.gov.it/it/news/mercoledi-26022025/tecnologie-quantistiche-al-la-consultazione-pubblica-sulla-strategia)

2024 **Member**
at the **G7 Table under the Italian Presidency**, as national expert, for drafting the document: *Accelerating the new frontiers of production: Artificial Intelligence (AI) and Quantum Technologies (QT) for the next generation of Production Ecosystems* (https://www.g7italy.it/wp-content/uploads/G7-Industry-Tech-and-Digital-Ministerial-Declaration-Annexes-1.pdf)

2021 - present **Member**
of the **Advisory Committee** to implement the **Framework Agreement** between the **CNR** and the Italian Ministry of Defense-General Secretariat (**SegreDifesa**)

2020 – present **Co-founder**
of the CNR-INO **Spin-off** company : **QTI Srl**

2020 **Member**
appointed by MIUR, of the Working Group to write the National Research Plan-**PNR 2021-2027** for the area: ***Quantum Technologies*** (https://www.mur.gov.it/sites/default/files/2021-01/Pnr2021-27.pdf)

2019 – present **Member**
of the **LENS Executive Council** (the only member elected by LENS personnel)

2018-2020 **President**
of **CNR Research Area (AdR) in Sesto Fiorentino (FI)**, with >500 units of personnel operating in the AdR.

2016 - present **Co-founder**
of the CNR-INO **Spin-off** company: **ppqSense Srl**

2017 - Present **Italian representative**
in the **Quantum Community Network-QCN Board of the EU Quantum Technologies Flagship**, defining the EU strategy on these themes and also contributing to draft the EU Strategic Research and Industry Agenda 2030 (https://qt.eu/media/pdf/Strategic-Reseach-and-Industry-Agenda-2030.pdf)

2017 - present **Italian academic representative**
within the **European Defence Agency-EDA** for the CAPTECH (Technological Capacity) **Optronics**

2016 - 2022 **Member of the Board of Directors**
of the Company: Collezione Nazionale dei Composti Chimici e Centro Screening (Italian National Collection of Chemical Compounds and Screening Center) – **CNCCS S.c.ar.l., as representative of the CNR shareholder.**

2010-2021 **Founder and first Director**
of **INO-CNR**, created from the fusion of INOA, INFM and CNR groups

2007 - 2010 **Director of INOA-CNR**

2002 - 2012 **Member of the Scientific Board and** of the **Board of Directors**
of the **public consortium** for Environmental Risk Analysis and Monitoring - **AMRA S.c.ar.l.**

2001 – 2007 **Founder and first Director**
of the **INOA-CNR unit in Pozzuoli**. The Unit grew from 2 to 10 employees in that period. 35 ISI

papers were published in 2006.

2002 - 2005 **Member of the Scientific Board**
of the National Group of Volcanology (**GNV**)-INGV.

TECHNOLOGY TRANSFER AND START-UP FOUNDATION

In the period 2010-2015, the overall revenues from contracts with companies amounted to about 2.2 MEuros, that is an average of more than 370 kEuros/year.
In order to properly address the theme of Technological Transfer, in 2015 PDN created, at INO, a **Tech Transfer team**, including 6 scientists/technologists, each working in a different INO Unit and already experienced in the field. The tasks of this team include: reinvestment of royalties from patents in other tech transfer-related activities, dissemination of tech transfer best practices and information towards INO scientists, promotion and commercialization of INO Patents, consultancy for spin off activities, interaction with the central CNR Tech Transfer Office (UVR) in Rome. In the period 2010-2019, 36 patents were filed by INO. INO has hosted a spin-off company, founded by INO researchers, from 2012 to 2015 in the Lecce Unit.
The International Committee appointed for the CNR internal Evaluation (performed in 2015 and evaluating the 2011-2014 period, when PDN was the director) has written for INO what follows:
"….In terms of patents, the Institute did very well in 2013 and less well in 2014, but I am less concerned about the number of patents as such rather than how they were used. In this respect, the translation of research appears to be improving, which is good to see; there are some very nice examples of technology transfer. …"
During the two years term as President of CNR Research Area in Sesto Fiorentino (Firenze), PDN started a Technology Transfer Center, named CENTRATEC, to enhance and reorganize interaction of multidisciplinary activities of CNR Institutes with Companies.

Foundation of start-up Companies

2016-ppqSense Srl

Following this intense Tech-Transfer activity, with the aim to train a generation of scientists in the field, PDN co-founded a CNR **spin-off company** on April, 29th **2016**, following formal approval by CNR and MIUR in February 2016. This company, named **ppqSense Srl**, was conceived and based on the unique scientific results achieved with the groundbreaking invention of a new laser spectroscopy technique, named *SCAR-Saturated absorption Cavity-Ringdown* first published in 2010 (*Saturated-absorption cavity ring-down spectroscopy* Physical Review Letters **104**, 110801 (2010)) which already showed a record sensitivity for $^{14}CO_2$ (radiocarbon dioxide) detection in 2011 (*Molecular gas sensing below parts per trillion: radiocarbon-dioxide optical detection* Physical Review Letters **107**, 270802 (2011)), increasing of orders of magnitude a few years later (*Spectroscopic detection of radiocarbon dioxide at parts-per-quadrillion sensitivity* Optica **3**, 385-388 (2016): this ultimate sensitivity level gave also the acronym to the Company-ppq (i.e. 10^{-15})) and very recently unfolding its potential to solve key problems in the area of Energy&Environment (*Biogenic Fraction Determination in Fuel Blends by Laser-Based $^{14}CO_2$ Detection* Advanced Photonics Research **2**, 2000069 (2021) and *Precise radiocarbon determination in radioactive waste by a laser-based spectroscopic technique* Proceedings of the National Academy of Sciences-PNAS **119**, e2122122119 (2022)).
Other key areas of application of the commercially developed SCAR spectrometer are: portable/on-site laser dating of archeological remains; leakage detection around underground reservoirs of sequestrated carbon dioxide for greenhouse effect mitigation; metabolic curve measurement for novel 14C-marked pharmaceuticals under test; precise assessment of fossil-fuels burning by local dilution measurement of radiocarbon dioxide, in view of mitigation of climate change.
Another key discovery that took to the realization of the control electronics of the Quantum Cascade Lasers-QCLs used in SCAR spectrometers, was the strong dependence of QCLs linewidth from the driving current noise (*Observing the intrinsic linewidth of a quantum-cascade laser: beyond the Schawlow-Townes limit* Physical Review Letters **104**, 083904 (2010)).
At present, two different lines of products are commercialized by ppqSense Srl: the SCAR spectrometer and a wide range of control electronics for semiconductor lasers (see also the company website: www.ppqsense.com). **Three patents**, extended in several Countries worldwide, cover these technologies.
Since April 2022, CNR had to sell to the other stakeholders its 25% of shares, the spin-off phase being

finished, at a price almost 10 times higher than the original value at the foundation.
In the last few years, ppqSense Srl has been partner in key EU projects, including two in the framework of the FET-Flagship on Quantum Technologies: QOMBS (on Quantum Simulation) just completed on July, 31st 2022 and, very recently, MUQUABIS (on Quantum Sensing), started on July, 1st 2022.
Revenues 2023: 1.1 M€, Employees: 10.

2020-QTI Srl

More recently, and following the launch of the FET- Flagship 10-years long program on Quantum Technologies, PDN has cofounded a start-up named QTI Srl in 2020, to commercialize Quantum Communication systems (www.qticompany.com). In particular, reconfigurable quantum key distribution architectures are developed, from the design phase to the building of the final system. On July, 14th 2021, a Commercial Agreement with the TIM telecommunication group, was signed. This was a strategic step for QTI, allowing to speed up the commercialization of Quantum Key Distribution systems in combination with existing Networks: this is the only case, until now, of a big telecommunication company, in Europe, that develops quantum communication systems within the group. **Two patents** have been filed to protect QTI technologies. The technologies under development rely on a long and impactful scientific history of the founders, in the fields of quantum science and photonics. Moreover, public demonstration of these technologies has been done at national and even trans-national level (see e.g.: *Deploying an inter-European quantum network* Advanced Quantum Technologies (2023)).
Revenues 2023: 2.4 M€, Employees: 32.

RESPONSIBILITY OF RESEARCH PROJECTS (SELECTION OF THE MAIN PROJECTS)

2022-present	**PNRR-Research Infrastructures: I-PHOQS** *Scientific Coordinator.* Funded by MUR (50 M€ over 3 years), Network including 4 Infrastructures, 9 sites throughout Italy, 2 Legal entities (CNR, PoliMI) (https://www.i-phoqs.eu/)
2020-2022	**PASCQUA Infrastructural Project** Coordination**.** Funded by MUR through CNR (3.5 M€ I-year+1M€ II-year)
2015	**EU-FET (Future Emerging Technologies): UltraQCL**. Responsible for INO-CNR (for INO-CNR: 133 k€)
2011 - present	**ELI Extreme Light Infrastructure.** Responsible for INO-CNR. Belonging to the EU ESFRI roadmap and MIUR (total amount till now: about 4.5 M€).
2014 - 2015	**Progetto Premiale MIUR:** Synchronization of distributed laboratories by time&frequency standards using an optical fiber. Responsible for CNR (131 k€)
2011 - 2014	**Energia da FOnti Rinnovabili** (Renewable energy)-**EFOR**, funded by MIUR/MEF. Responsible for INO-CNR (for INO-CNR: 187 k€)
2010 - 2012	**CTOTUS** – Integrated Project for the development of Space Science&Technology in Tuscany. Funded by Toscana Region (for INO-CNR: 750 k€)
2004 - 2006	**Photonic circuits for optical communications and sensing for the study of innovative optical devices and sensors.** Funded by MIUR (562.5 k€)
2002 - 2007	Coordinator **FIRB-negoziale** (Basic Research Funding from the Italian Ministry of Univ. and Research-MIUR) for the development of techniques and photonic devices in lithium niobate. (Total amount: 3 M€)
2003 - 2005	Coordinator international research project: **Development of an integrated spectroscopic system for remote and continuous detection of volcanic gases**. Funded by INGV and GNV. Partners: Cambridge Univ., UK; Rice University Houston, TX, USA; II Univ. Naples. (Total amount: 465 k€)
2002 - 2006	**PON Integrated Environmental Monitoring System-SIMONA**. Funded by EU and MIUR (1.033 M€ + Training 697 k€)
2002 - 2006	**POR** project-(Funded by EU through Campania Region) on Analysis and monitoring of environmental risk for the realization of optical innovative sensors based on coherent sources and fiber optical technologies. (for INOA: 559 k€)

EVALUATION OF PROJECTS

PDN regularly serves as evaluator of projects for several Agencies funding Research (including EU, Belgium, the Netherlands, France, Austria, Switzerland, Finland)

PATENTS

According to the EU Patent Office
(https://worldwide.espacenet.com/publicationDetails/biblio?II=14&ND=3&adjacent=true&locale=en_EP&FT=D&date=19960202&CC=IT&NR=RM940518A1&KC=A1): 15 Patents listed

Three (3) Patents licensed from CNR to ppqSense Srl: WO2017055606A1- *Method for measuring the concentration of trace gases by SCAR spectroscopy*; WO2016067241A1 - *Low-noise current source*; WO2014170828A1- *Apparatus and method for measuring the concentration of trace gases by SCAR spectroscopy*.

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