**Curriculum vitae**

## PERSONAL INFORMATION

Family name, First name: Crescini, Nicolò

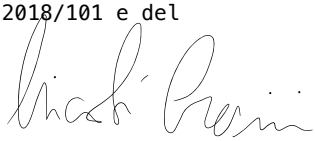
ORCID: 0000-0002-9232-4760

Date of birth: [redacted]

Nationality: [redacted]

URL for web site: Google Scholar

Autorizzo il trattamento dei dati personali presenti nel CV ai sensi del D. Lgs. 2018/101 e del GDPR (Regolamento UE 2016/679)



## ☐ EDUCATION

2016 – 2019 Ph. D. in Physics cum laude
Dipartimento di Fisica "Galileo Galilei" – Università degli Studi di Padova (Italy)
Supervisors: Giovanni Carugno and Giuseppe Ruoso

2018 Visiting Ph.D., supervisor: Michael Romalis
Department of Physics, Princeton University (New Jersey, USA)

2016 Master degree in Physics, 110L/110
Dipartimento di Fisica "Galileo Galilei" – Università degli Studi di Padova (Italy)

## ☐ CURRENT POSITION

2021 – Marie Skłodowska-Curie Postdoctoral Fellowship
Institut Néel – Centre National de la Recherche Scientifique, Grenoble (France)

## ☐ PREVIOUS POSITIONS

2020 – 2021 SNSF Postdoctoral Fellowship
IBM Research – Zürich, Rüschlikon (Switzerland)

2019 – 2020 Research Fellowship
INFN – Laboratori Nazionali di Legnaro, Legnaro (Italy)

## ☐ FELLOWSHIPS AND AWARDS

2021 – 2023 Marie Skłodowska-Curie Fellow – Institut Néel, CNRS
2022 IBM Patent award for a novel readout technique of quantum devices
2021 Winner of the "Bruno Rossi" Prize of INFN for the best thesis in Astroparticle physics
2020 Winner of the Research 4 Innovation program of INFN-Tech Transfer

## ☐ REVIEWING ACTIVITIES

2022 – Scientific Advisory Board, Quantum at Trento Projects – Call 2022,
University of Trento, CNR, and INFN (Italy)
2020 – Peer-reviewer of journal papers for Physics of the Dark Universe, Measurement Science and Technology, Physical Review and Annalen der Physik

## ☐ OUTREACH

2020 Participation to GiovedìScienza 34th edition
2018 Tutor of high school students in the project "Stage ai Laboratori Nazionali di Legnaro"
2017 – 2019 Guide for visitors to the Laboratori Nazionali di Legnaro (Italy)

## ☐ MAJOR COLLABORATIONS AND CONFERENCES

Triangle consortium – Çağlar Girit, Cristiano Ciuti, Helene Le Sueur, Philippe Joyez and Daniel Esteve, from Collège de France, Université Paris Cité and CEA-Saclay (France). The consortium uses different approaches to study the physics of phase-charge duality and Bloch oscillations in Josephson junctions.

Quantum coherence – Andreas Fuhrer and Clemens Müller from IBM Research and Zürich Instruments (Switzerland). By using a newly developed readout of quantum devices the group studied peculiar features in the noise of superconducting resonators that indicate the presence of two-level systems in the chip oxides. Noise mitigation is also assessed.

Single microwave photon counter – Leonid Kuzmin, Andrey Pankratov, Anna Gordeeva from Chalmers University (Sweden) and Nizhny Novgorod State Technical University (Russia). The team recently demonstrated the readout of rare single thermal photons using a Josephson junction, and the I am in charge of the device calibration and data analysis.

QUAX collaboration – Caterina Braggio, Giuseppe Ruoso and Giovanni Carugno, from INFN and Padua University. The effort continued from the time of the my Ph.D., during which I gave a major contribution in the design, building and operation of the experiment's apparatus from scratch. Nowadays QUAX keeps being improved, and excludes the presence of axions in unexplored mass ranges.

Other minor collaborations (see Figure 5) include the laboratory of Michael Romalis at Princeton for the development of optical co-magnetometers, the laboratory of Yasunobu Nakamura in Tokyo for the study of quantum circuits hybridised with spins, and Aaron Chou at Fermilab for quantum non-demolition detection applied to axion searches.

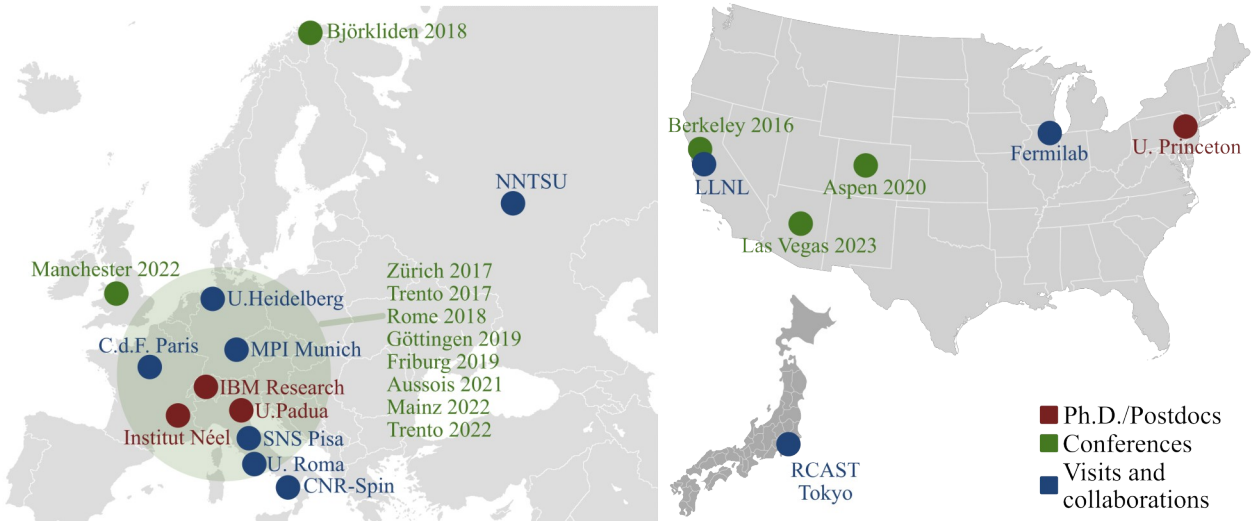



Figure 5. The map shows my movements throughout my career, outlining the interaction with the scientific community and the research mobility.

## ☐ GRANTS

| *Project Title* | *Funding source* | *Amount (Euros)* | *Period* | *Role* | *Topic* |
|---|---|---|---|---|---|
| SHRiMp | INFN-CNTT | 29 000.00 | 2020 – 2022 | Proposer | Precision magnetometry |
| QMET | MSCA-IF (EU) | 184 707.84 | 2021 – 2023 | Proposer and | Quantum metrology with superconducting |

| | | | | | |
|---|---|---|---|---|---|
| | | | | researcher | circuits |

**Early achievements track-record**

During the Ph.D. the I built from scratch an haloscope (paper 5) and completed other precision tests of the Standard model (paper 4, patent 2) always devising and performing the experiments in first person. Afterwards, I dived more in the field of quantum technologies by studying their fundamental limits (paper 3) and inventing new investigation and measurement techniques (paper 2, patent 1). Eventually, in my Marie Curie project, I combined different techniques to observe an elusive quantum effect: dual Shapiro steps (paper 1). In total I published 22 scientific papers, of which 11 first authored, supervised one Postdoc, three Ph.D.s and several master students, demonstrating creativity and independence by obtaining original results in all the steps of my career, as the following selected publications show.

## ☐ SELECTED PUBLICATIONS

1) Evidence of dual Shapiro steps in a Josephson junctions array

N. Crescini, S. Cailleax, W. Guichard, C. Naud, O. Buisson, K. Murch and N. Roch

*Nature Physics* 19, 851–856 (2023). DOI: 10.1038/s41567-023-01961-4

This work is the results of my MSCA project, and as such was driven by me and N.R., the action's supervisor. I made the preliminary simulations which results were used to design and choose the circuit's parameters, then developed the recipe and fabricated the actual devices. With the help of S.C. — a 1st year Ph.D. student working under my supervision — I designed and benchmarked the measurement circuitry in a dilution refrigerator, and programmed a dedicated data acquisition and analysis setup. Measurements and data analysis were performed by me, while further simulations are due to S.C. The results were discussed among the authors, and with expert colleagues like D. Haviland, T. Duty, and M. Devoret. I wrote the original paper draft which was then reviewed mainly by K.M. and N.R., and submitted. This was achieved in the timespan of one year. The scientific importance of the result was endorsed by several colleagues, and the paper received enthusiastic reviews, saying that this work "[...] *represents a genuine breakthrough for the worldwide research in condensed matter physics*", and that "*they do not rely only on transport measurements* […] *but they use microwave spectroscopy using a circuit QED architecture. This represents a formidable and unique tool* [...]*"*.

2) Readout of quantum devices with a sideband microwave interferometer immune to systematic noise

N. Crescini, E.G. Kelly, G. Salis, A. Fuhrer

*Phys. Rev. Applied,* 20, 044072 (2023). DOI: https://doi.org/10.1103/PhysRevApplied.20.044072

The accuracy of microwave measurements is not only critical for applications in telecommunication and radar, but also for future quantum computers. Qubit technologies such as superconducting qubits or spin qubits require detecting minuscule signals, typically achieved by reflecting a microwave tone off a resonator that is coupled to the qubit. In this work we demonstrated an approach to detect phase and amplitude changes of a device under test based on the differential measurement of microwave tones generated by two first-order sidebands of a carrier signal. I proposed the interferometric detection scheme, realised it, fabricated the devices under test, performed the measurements, and wrote the manuscript, which afterwards was reviewed by all the authors.

3) Out-of-equilibrium phonons in gated superconducting switches

M.F. Ritter, N. Crescini, D.Z. Haxell, M. Hinderling, H. Riel, C. Bruder, A. Fuhrer and F. Nichele

*Nature electronics* 5 (2), 71-77, 2022 (on the cover). DOI: 10.1038/s41928-022-00721-1

Sometimes theories are proven, some other times invalidated. The observation of an electric field suppressing the superconductivity of a nanowire triggered theoretical interpretations involving a field-effect. In this work we reproduced these observations, but also managed to get the same effect in the absence of a field on the nanowire, showing that there is no field-effect and that observations can be simply explained with phonons. I participated in the design of the experiment, in the measurements, in the physical interpretation of the results, and carried out the numerical simulations.

4) Search of spin-dependent fifth forces with precision magnetometry

N. Crescini, G. Carugno, P. Falferi, A. Ortolan, G. Ruoso and C.C. Speake

*Physical Review D* 105 (2), 022007, 2022. DOI: 10.1103/PhysRevD.105.022007

The result presented in this paper is the final improvement of an experimental effort started by me and G.C., which tests forces outside the Standard Model by searching for electromagnetic anomalies

in a crystal. The setup of this paper is based on an ultra-sensitive SQUID magnetometer. Here, a simple idea boosted the sensitivity of this experiment, which is a record one thanks to the effort of me and P.F., and excited the community. I carried out the design and building of the apparatus, performed its calibration, the data acquisition and analysis, and wrote the paper. The obtained limit is a two orders of magnitude improvement over the previous state-of-the-art.

5) Axion search with a quantum-limited ferromagnetic haloscope
N. Crescini, D. Alesini, C. Braggio, G. Carugno, D. D'Agostino, D. Di Gioacchino, P. Falferi, U. Gambardella, C. Gatti, G. Iannone, C. Ligi, A. Lombardi, A. Ortolan, R. Pengo, G. Ruoso, and L. Taffarello
*Physical Review Letters* 124 (17), 171801, 2020. DOI: 10.1103/PhysRevLett.124.171801

My Ph.D. project culminates in this article. Over three years, I worked on haloscope prototypes of increasing sensitivity, of which this is the last one. I worked on all the technical aspects of this work, from the refurbishing of an (old) dilution refrigerator, to the setup of the superconducting microwave lines, as the experiment was built from scratch. Furthermore, a particular attention was given to the calibration of the setup and to the theoretical modelisation of the photon-magnon hybrid system at the hearth of the haloscope, which I devised. I wrote the manuscript with the help of G.R. Here the operation of a quantum-limited amplifier based on Josephson junctions is demonstrated in conjunction with a photon-magnon hybrid system in a dilution refrigerator. The result was the most sensitive haloscope search of axions using electron spins in a ferromagnet, an instrument that the authors baptised ferromagnetic haloscope.

## ☐ PATENTS

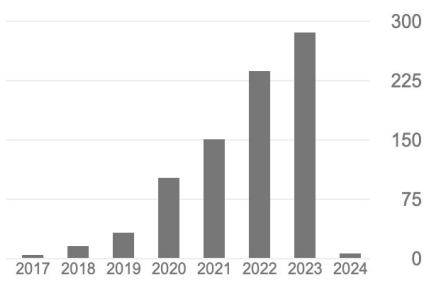
2022 1) Sideband-based microwave interferometer to probe quantum devices – N. Crescini, E.G. Kelly, G. Salis and A. Fuhrer, P202103657US01
This patent is based on my original idea, and a related publication is in progress.

2021 2) Spin hybrid resonance precision magnetometer – N. Crescini, P1434PC00
This patent stems from my original idea described in Crescini *et al.*, Phys. Rev. Applied 13 (3), 034036, 2021. I was awarded with a "Research 4 Innovation" grant from INFN to further develop the invention.

## ☐ INVITED PRESENTATIONS

| | |
|---|---|
| 05/2023 | Colloque IRL Frontières Quantiques – Université Paris Cité (France) |
| 10/2022 | Circuit QED: from Quantum Devices to Analogues on Superconducting Circuits – FBK Trento (Italy) |
| 08/2022 | CMD29 – Manchester Central Convention Complex (UK) |
| 02/2020 | Quantum Information Science for Fundamental Physics – Aspen Center for Physics (Colorado, USA) |
| 08/2019 | Axion Experiments in Germany – University of Göttingen (Germany) |
| 01/2019 | Cryogenic Nanoelectronics Workshop – Nizhny Novgorod University (Russia) |
| 04/2018 | Frontiers of Science 2018 – Björkliden (Sweden) |
| 11/2018 | Axions at the Crossroads: QCD, Dark Matter, Astrophysics – ECT* Trento (Italy) |
| 01/2017 | 2nd Workshop on Microwave Cavities and Detectors for Axion Research – Lawrence Livermore National Laboratories (California, USA) |
| 12/2016 | Sub-eV 2016 – Lawrence Berkeley National Laboratory (California, USA) |

## ☐ CITATIONS METRICS




The histogram reports the citations of my works per year, and was pictured in June 2023 (for an updated version visit Google Scholar). The trend is in constant increase, demonstrating the high momentum and impact of the scientific output.

| | All | Since 2019 |
|---|---|---|
| Citations | 839 | 816 |
| h-index | 15 | 15 |