Marco Scigliuzzo Curriculum Vitae

Basic information

Male
Avenue de la Poste, 18, Renens, 1020, Switzerland +41767794367
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Postdoctoral researcher in prof. Kippenberg's group. From 11/2021 – Now.
Career break 1 month (June 2022), birth of son (Leonardo Alan Scigliuzzo).
Personal website: https://scigliuzzo.netlify.app

Higher education degrees and evaluations

PhD in quantum optics (3rd September 2021). *Chalmers University of Technology*, Sweden. Supervisor: Per Delsing. Thesis: Effects of the environment on quantum systems. ISBN: 978-91-7905-534-9 .

M.Sc. Physics (22nd February 2016). *University of Salento*, Italy. 110/110 Laude. Supervisor: Giuseppe Maruccio. Thesis: Optimization of SAW filters and resonators. doi:10.13140/RG.2.2.27702.19521.

Main Scientific Achievements

All citations refer to the "list of publications" section.

Quantum optics and quantum acoustic - I have made widely recognized contributions to circuit quantum electrodynamics and acoustodynamics, particularly in the ability to control photonic [10,11] and phononic [9,16,17] degrees of freedom in artificial systems at the quantum level. In the electromagnetic domain, I demonstrated frequency and time-domain control of a delocalized atomic excitation (atom-photon bound state) [11]. This work has opened new directions in qubit bath engineering and enabled the simulation of spin chains with all-to-all connectivity. I also contributed to implementing a Selective Number-dependent Arbitrary Phase (SNAP) gate, which generated Wigner-negative states. This technique, used to realize cubic phase states in an aluminum three-dimensional cavity for the first time [10], demonstrated full control of a universal set of quantum gates. In mechanical systems, I achieved two-mode squeezing and multimode entanglement in surface acoustic wave (SAW) resonators [9], leveraging Kerr nonlinearity for mechanical modes. During my postdoc, I contributed to advancing circuit optomechanics by developing a theoretical scheme to sense oscillations of ultra-strong vacuum via the generation of mechanical excitations [16]. This method provided measurable effects for vacuum fluctuations. Additionally, I prepared and measured the ground state of a collective ensemble (N=6) of mechanical resonators [17], observing quantum-mechanical sideband asymmetry and √N enhancement of optomechanical coupling—paving the way for multipartite entanglement and quantum metrology advancements.

***Figure 1**: Optomechanical hexamer*

High coherence devices - I have made critical contributions to understanding and mitigating sources of decoherence in superconducting circuits, spanning phononic [4,15], photonic [5], and two-level systems

(TLS) [3] loss channels. I introduced lower bounds on losses arising from electromechanical conversion in superconducting devices fabricated on piezoelectric substrates [4]. This work has alerted the community to the importance of decoupling electric fields from piezoelectric materials to optimize superconducting and hybrid platforms (e.g., microwave-to-optical converters). I also contributed to studies showing the temporal fluctuations of TLS, highlighting the necessity for long-term statistics to fully characterize qubit coherence times [3]. This has raised awareness within the circuit QED community about the importance of statistical approaches in evaluating qubit performance. Additionally, I developed a method for mechanically switching off TLS loss channels using SAW resonators, and I introduced a qubit-photonic bath thermometer based on the thermal bath's effect on the coherence of a strongly coupled qubit [5]. This tool is now a crucial asset for quantum thermodynamics experiments. During my postdoc, I contributed to the discovery of mechanical shock effects on superconducting qubits [15], further emphasizing the need for phononic shielding in quantum technologies.

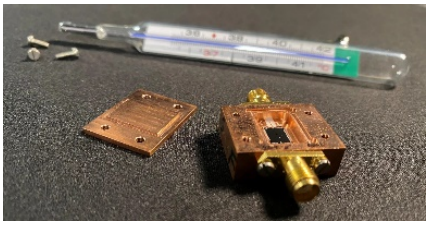

Figure 2 *Packaged thermometer qubit.*

Fabrication and improvements of superconducting circuits - I played a key role in advancing state-of-the-art fabrication processes now widely used in the superconducting technologies community. I contributed to the development of a three-angle evaporation method for in-situ bandaging of Josephson junctions [6]. This process, now adopted across the field, eliminates an additional lithography step and reduces contamination risks from the lift-off process. Additionally, I successfully replicated the fabrication of a traveling-wave parametric amplifier based on trilayer Nb/AlOx/Nb Josephson junctions at EPFL. Though the process itself is not new, its successful implementation enables the creation of compact, low-loss metamaterials for quantum applications. Finally, in [14,19] I contributed to developed high kinetic inductance materials at EPFL, successfully used them to study disorder in coupled cavity arrays and currently integrating them with standard aluminum fabrication [23].

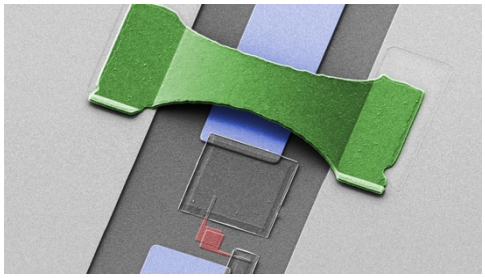

Figure 3*. Josephson Junction under a bridge.*

List of Publications

Metrics: citations 824, H-index 12, i10-Index 14 (from Google Scholar on 30th December 2024).

In preparation

23. V. Jouanny, L. Peyruchat, M. **Scigliuzzo**, A. Mercurio, S. Frasca, V. Savona and P. Scarlino. Directional emission in a giant atom superstrongly coupled to a high-impedance cavity array. (To be submitted to PRX)

22. L. Peyruchat*, M **Scigliuzzo***, V. Jouanny, P. Delsing, P. Scarlino. Tunable interaction of multiple confined surface acoustic waves modes with a SQUID array resonator. (To be submitted to Nature Communications)

EPFL affiliation (Postdoctoral researcher)

21. M Chegnizadeh*, A Youssefi*, M **Scigliuzzo**, Tobias J. Kippenberg. Mechanically-compliant superconducting vacuum gap capacitors for ultra-coherent and scalable quantum circuits. arXiv:2501.03211 https://arxiv.org/abs/2501.03211 (Submitted in PR Applied)

20. G Beaulieu, F Minganti, S Frasca, M **Scigliuzzo**, S Felicetti, R Di Candia, P Scarlino. Criticality-Enhanced Quantum Sensing with a Parametric Superconducting Resonator. arXiv:2409.19968 https://doi.org/10.48550/arXiv.2409.19968 (second round of review in PRX quantum)

19. L Peyruchat, F Minganti, M **Scigliuzzo**, F Ferrari, V Jouanny, F Nori, V Savona, and P Scarlino. Landau-Zener without a Qubit: Unveiling Multiphotonic Interference, Synthetic Floquet Dimensions, and Dissipative Quantum Chaos. arXiv:2404.10051 https://doi.org/10.48550/arXiv.2404.10051 (second round of review in npj Quantum Information)

18. V. Jouanny, S. Frasca, V.J. Weibel, L. Peyruchat, M. **Scigliuzzo**, F. Oppliger, F. De Palma, D. Sbroggio, G. Beaulieu, O. Zilberberg, and P. Scarlino. Band engineering and study of disorder using topology in compact high kinetic inductance cavity arrays. arXiv:2403.18150 https://doi.org/10.48550/arXiv.2403.18150 (accepted in Nature Communication)

17. M Chegnizadeh*, M **Scigliuzzo***, A Youssefi, S Kono, E Guzovskii and Tobias J. Kippenberg. Collective mode of multiple nearly-degenerate mechanical oscillators at quantum ground-state. Science 386 (6728), 1383-1388 (2024) https://doi.org/10.1126/science.adr8187

16. F Minganti, A Mercurio, F Mauceri, M **Scigliuzzo**, S Savasta, V Savona. Phonon Pumping by Modulating the Ultrastrong Vacuum. SciPost Physics 17 (1), 027 (2024). https://_10.21468/SciPostPhys.17.1.027.

15. S Kono, J Pan, M Chegnizadeh, X Wang, A Youssefi, M **Scigliuzzo**, T J Kippenberg. Mechanically Induced Correlated Errors on Superconducting Qubits with Relaxation Times Exceeding 0.4 Milliseconds. Nature Communications 15 (1), 3950 (2024). https://www.nature.com/articles/s41467-024-48230-3

14. S Frasca, I N Arabadzhiev, S Yves Bros de Puechredon, F Oppliger, V Jouanny, R Musio, M **Scigliuzzo**, F Minganti, P Scarlino, and E Charbon. High-Kinetic Inductance NbN Films for High-Quality Compact Superconducting Resonators. Physical Review Applied 20 (4), 044021 (2023). https://doi.org/10.1103/PhysRevApplied.20.044021.

13. A Osman, J Fernàndez-Pendàs, C Warren, S Kosen, M **Scigliuzzo**, A Frisk Kockum, G Tancredi, A Fadavi Roudsari, and J Bylander. Mitigation of Frequency Collisions in Superconducting Quantum Processors. Physical Review Research 5 (4), 043001 (2023). https://doi.org/10.1103/PhysRevResearch.5.043001

Chalmers affiliation (PhD student)

12. A M Ali, C Castillo Moreno, S Sundelin, J Biznárová, M **Scigliuzzo**, K Patel, A Osman, D P Lozano, I Strandberg, and S Gasparinetti. Engineering Symmetry-Selective Couplings of a Superconducting Artificial Molecule to Microwave Waveguides. *Physical Review Letters* 129, 12 123604 (2022). https://doi.org/10.1103/PhysRevLett.129.123604.

11.M **Scigliuzzo**, G Calajò, F Ciccarello, D P Lozano, A Bengtsson, P Scarlino, A Wallraff, D Chang, P Delsing, and S Gasparinetti. Controlling Atom-Photon Bound States in an Array of Josephson-Junction Resonators. *Physical Review X* 12, 3, 031036 (2022). https://doi.org/10.1103/PhysRevX.12.031036.

10. M Kudra, M Kervinen, I Strandberg, S Ahmed, M **Scigliuzzo**, A Osman, D Pérez Lozano, G Ferrini, J Bylander, …, and S Gasparinetti. Robust Preparation of Wigner-Negative States with Optimized SNAP-Displacement Sequences. *PRX Quantum* 3, 3, 030301 (2022). https://doi.org/10.1103/PRXQuantum.3.030301.

9. G Andersson, S W Jolin, M **Scigliuzzo**, R Borgani, M O Tholén, J C. Rivera Hernández, V Shumeiko, D B Haviland, and P Delsing. Squeezing and Multimode Entanglement of Surface Acoustic Wave Phonons. *PRX Quantum* 3, 1, 010312 (2022). https://doi.org/10.1103/PRXQuantum.3.010312.

8. Y Lu, A Bengtsson, J J Burnett, B Suri, S R Sathyamoorthy, H Renberg Nilsson, M **Scigliuzzo**, J Bylander, G Johansson, and P Delsing. Quantum Efficiency, Purity and Stability of a Tunable, Narrowband Microwave Single-Photon Source. *Npj Quantum Information* 7, 1, 1–8 (2021). https://doi.org/10.1038/s41534-021-00480-5.

7. G Andersson, A L O Bilobran, M **Scigliuzzo**, M M de Lima, J H Cole, and P Delsing. Acoustic Spectral Hole-Burning in a Two-Level System Ensemble. *Npj Quantum Information* 7, 1, 1–5 (2021). https://doi.org/10.1038/s41534-020-00348-0.

6. A Osman, J Simon, A Bengtsson, S Kosen, P Krantz, D P Lozano, M **Scigliuzzo**, P Delsing, J Bylander, and A Fadavi Roudsari. Simplified Josephson-Junction Fabrication Process for Reproducibly High-Performance Superconducting Qubits. *Applied Physics Letters* 118, 6, 064002 (2021). https://doi.org/10.1063/5.0037093.

5. M **Scigliuzzo**, A Bengtsson, J Besse, A Wallraff, P Delsing, and S Gasparinetti. Primary Thermometry of Propagating Microwaves in the Quantum Regime. *Physical Review X* 10, 4, 041054 (2020). https://doi.org/10.1103/PhysRevX.10.041054.

4. M **Scigliuzzo**, L E Bruhat, A Bengtsson, J J Burnett, A Fadavi Roudsari, and P Delsing. Phononic Loss in Superconducting Resonators on Piezoelectric Substrates. *New Journal of Physics* 22, 5, 053027 (2020). https://doi.org/10.1088/1367-2630/ab8044.

3. J J Burnett, A Bengtsson, M **Scigliuzzo**, D Niepce, M Kudra, P Delsing, and J Bylander. Decoherence Benchmarking of Superconducting Qubits. *Npj Quantum Information* 5, 1, 1–8 (2019). https://doi.org/10.1038/s41534-019-0168-5.

Unisalento affiliation (Master student)

2. C Maruccio, M **Scigliuzzo**, S Rizzato, P Scarlino, G Quaranta, M S Chiriaco, A G Monteduro, and G Maruccio. Frequency and Time Domain Analysis of Surface Acoustic Wave Propagation on a Piezoelectric Gallium Arsenide Substrate: A Computational Insight. *Journal of Intelligent Material Systems and Structures* 30, 6, 801–12 (2019). https://doi.org/10.1177/1045389X18803461.

1. S Rizzato, M **Scigliuzzo**, M S Chiriacò, P Scarlino, A G Monteduro, C Maruccio, Tasco, and G Maruccio. Excitation and Time Resolved Spectroscopy of SAW Harmonics up to GHz Regime in Photolithographed GaAs Devices. *Journal of Micromechanics and Microengineering* 27, 12 ,125002 (2017). https://doi.org/10.1088/1361-6439/aa8186.

Research funding and grants

Innosuisse Switzerland-Korea Call 2024: *Quantum limited amplifiers with engineered pump.* **Applicant/Project manager: M Scigliuzzo**. I contributed to write and justified the grant request for studying new pumping scheme in traveling wave parametric amplifiers. **Funded for 3 years (Total all partners: 1.85M CHF, EPFL allocation 620k CHF)**. (see confirmation letter in the attachments)

Quantum center EPLF postdoctoral fellowship: *Exotic quantum states in circuit optomechanics.* **Main applicant: M Scigliuzzo**. I wrote and justified the grant request studying non-classical state generation on optomechanical system. **Funded for 2 years (200k CHF)**. (see confirmation letter in the attachments)

EPFL Equipment: *Superconducting qubit and optomechanics control and readout system.* Main applicant: prof. Kippenberg, **Support: M Scigliuzzo**. I wrote and justified the grant request for acquiring a fast time-domain setup for qubit and optomechanics measurements. I determined the technical specifications of the equipment, carried on the acceptance. **Funded 130.4k CHF**.

EPFL Equipment: *Sputtering deposition system for superconducting films and controllable oxidation.* Main applicant: prof. Kippenberg **Support: M Scigliuzzo**. I contributed to write the grant request. I wrote the tender technical specification, and I was responsible for technical inquiries during the tender. **Funded 600k CHF**.

SNF 'REQUIP *Fast turn-around dilution refrigerator for superconducting quantum circuit prototyping.* SNF Equipment Funding. Main applicant: prof. Kippenberg **Support: M Scigliuzzo**. I wrote and justified the grant request for acquiring a dilution refrigerator with short (<12h) cooldown and warm-up times. I determined the technical specifications of the equipment, and I was the responsible for technical inquiries during the tender. **Funded 382k CHF**

Meetings, Schools, National and International conferences

11. **Oral (invited)** presentation – ***Collective phenomena workshop*** - Ground State Cooling and Emission Enhancement in Collective Mechanical Modes. (Germany 2024) https://memento.epfl.ch/event/qse-center-general-assembly/ (video available at https://youtu.be/O4JVBfz6w2s?si=TVG2G6YBv-3oZDRC)

10. **Oral (invited)** presentation -***QSE Center General Assembly***: Exotic mechanical states in circuits optomechanics. (Switzerland 2024) https://memento.epfl.ch/event/qse-center-general-assembly/

9. **Oral** presentation - ***APS March Meeting*** - Progress towards a near quantum-limited Josephson travelling wave parametric amplifier based on Nb-Al/Al2O3-Nb trilayer technology. (USA 2023) https://meetings.aps.org/Meeting/MAR23/Session/Y71.8 (video available at https://www.youtube.com/watch?v=i6MOBezLl6k)

8. **Oral** presentation - ***APS March Meeting*** - Collective dynamics in circuit optomechanical systems. (USA 2023), https://meetings.aps.org/Meeting/MAR23/Session/Q66.13. (video available at https://www.youtube.com/watch?v=9sjCnvt6Np)

7. **Poster** presentation - ***Swiss Quantum Days*** - Dynamics of multiple nearly degenerate mechanical oscillators in superconducting circuit optomechanics. (Switzerland, 2023)

6. **Oral** presentation - ***APS March Meeting*** - Probing nonlinear photon scattering with artificial atoms coupled to a slow-light waveguide. (Virtual 2021), https://meetings.aps.org/Meeting/MAR21/Session/P28.

5. **Oral** presentation - ***WACQT May review e-meeting*** - Scalable quantum simulation architecture based on atom-photon bound states in an array of high-impedance resonators. (Virtual 2021)

4. **Oral** presentation - ***APS March Meeting*** - Phononic Losses in Superconducting Coplanar Waveguide Resonators on Piezoelectric Substrates. (USA 2019). https://meetings.aps.org/Meeting/MAR19/Session/K26.14

3. **Poster** presentation - ***DPG Spring Meetings*** - Phononic loss in superconducting circuits on piezoelectric substrate (Germany 2018).

2. **Poster** presentation - ***28th International Conference on Low Temperature Physics*** - Population inversion and stimulated emission of phonons in a transmon qubit coupled to phonons. (Sweden 2017)

1. **Poster** presentation - ***SAWtrain Summer School****: Physics and Applications of GHz Vibrations* - Population inversion and stimulated emission of phonons in a transmon qubit coupled to phonons (France 2017).

Services

I am actively involved in community service activity, both as reviewer and for outreach purposes (in parenthesis the number of occurrences).

- *Reviewer* for Nature Physics (1), PRX (1), Nature Communication (2), PRX Quantum (3), Communication Physics (1), Scientific Report (1).
- *Consultant* for issue of "Superconductor Week" (1).
- *Quantum Scientist To-Go!* Organized by American Physical Society (APS) (1).
- *Outreach event at EPFL* (2).