



2022 ICFO PhD Thesis Awards

Three ICFO PhD graduates awarded for their creative and ambitious research

December 18, 2023

The ICFO PhD Thesis Award distinguishes particularly brilliant PhD theses presented at ICFO. With the award, ICFO wishes to highlight and reward extraordinary PhD students whose research progress at the institute has proven to be highly creative and ambitious. The award seeks to draw attention to the ICFOonians who have obtained particularly successful results and who have contributed to extend significantly the frontier of scientific and technological knowledge worldwide.?

In 2022, 33 ICFO PhD students defended their theses at the institute. From this pool, the PhD Committee launched an in-depth deliberation to determine the recipients of the PhD Thesis Awards. During the annual ICFO Day event which took place on Friday December 15th, the 2022 awards were presented to **Dr Paolo Abiuso** in the theoretical field, **Dr Ugaitz Elu**, in the industrial field, and **Dario Lago-Rivera** in the experimental field

Award Citations:

Dr. Paolo Abiuso in the research group led by Prof. Antonio Acin: ICFO recognizes the exceptional doctoral thesis *“Optimization and Geometry for Quantum Information tasks”*.

In his PhD thesis, Dr. Abiuso, reports original theoretical work in the fields of quantum thermodynamics and quantum information science, studying the optimization of operational tasks involving quantum resources and the geometric properties of the physical objects involved.

In the field of quantum information, Paolo contributed to the construction of an experimentally friendly method for measurement-device-independent entanglement detection for continuous-variable quantum systems, leading a collaboration, and linking this problem to results obtained in quantum estimation, making an original connection between two a priori unrelated problems. He further developed a quantum optical scheme to demonstrate the non-classical properties of single photon entangled states using quantum networks.

His contributions to quantum thermodynamics, developed largely independently of his PhD supervisor in collaborations with international researchers, include important results on the optimization of thermodynamic processes, and the relation between Markovianity and Fisher information.

The exceptional quality of Paolo's work has received widespread recognition by the international scientific community. His PhD research resulted in 6 published articles, 4 of them as first author and, exceptionally, 4 published independently of his supervisor. Two manuscripts were submitted as preprints. Additionally, Paolo contributed to 2 articles and 2 manuscripts during his PhD that were not included in the PhD thesis. These include 1st author publications in prestigious journals such as Physical Review Letters, twice, Physical Review Research, SciPost Physics, and Entropy.

Throughout his PhD, Paolo demonstrated exceptional maturity and independence as a researcher, a willingness to learn and explore new research directions, demonstrated by the breadth of his activities, and a collaborative spirit within his group, and with leading researchers internationally, helping to establish several new scientific collaborations. His PhD thesis manuscript demonstrates his creative theoretical abilities and deep understanding of his field. It is extremely rich and presents results and methods with high impact, using the most profound methods of contemporary theoretical physics and quantum information science.

Dr. Ugaitz Elu in the research group led by Prof. Jens Biegert: ICFO recognizes the exceptional doctoral thesis *“High-peak-power mid-infrared OPCPA for extreme nonlinear*

photonic*s*i¿½.

In his PhD thesis, Dr. Elu, reports the development and application of world-record 7-octave frequency comb single-cycle pulse generation.

Ugaitz Elu pioneered the study of ultrafast science and nonlinear optics, specifically mid-IR self-phase modulation, optical parametric chirped-pulse amplification, pulse metrology and electro-optical sampling of the newly generated waveforms. Throughout his PhD research he repeatedly demonstrated his excellence and global leadership in mid-IR photonics with application to attosecond science, extreme nonlinear optics, and solid-state physics. Specific highlights of Ugaitz's thesis are: the generation of single-cycle mid-IR waveforms for the first time; a 7-stage OPCPA system to achieve world-record mid-IR power; the combination of the single-cycle pulses with new nonlinear crystal BGGSe to create the world's most brilliant coherent source, covering 7 optical octaves without tuning; and the application of the source for high harmonic spectroscopy to detect all quantum phases of the high-Tc superconductor YBCO for the first time.

The exceptional quality of Ugaitz's work has received a widespread recognition by the international scientific community. These include publications in high level journals such as such as Opt.Lett, Optica, Science Advances, Nature Photonics with his 7-octave coherent source and a PNAS paper showing the quantum phases of high-Tc YBCO. His PhD thesis manuscript demonstrates his creative experimental design and deep understanding of both the experimental and theoretical aspects of his work.

Dr. Dario Lago-Rivera in the research group led by Prof. Hugues de Riedmatten: ICF recognizes the exceptional doctoral thesis i¿½Remote distribution of quantum states assisted by multimode quantum memoriesi¿½.

In his groundbreaking PhD thesis, Dr. Lago-Rivera made significant contributions to the field of experimental quantum optics and quantum technologies. The core of his research involved conducting a series of experiments focused on the remote distribution of quantum states using entangled photon pair sources and multiplexed solid-state quantum memories. The three key achievements of his thesis include the experimental demonstration of entanglement between a telecom photon and a solid-state on-demand quantum memory, the implementation of multiplexed quantum teleportation from a telecom photon to a solid-state memory with active feed-forward, and the successful demonstration of heralded entanglement between two quantum memories. These experiments mark crucial milestones toward the realization of quantum networks and repeaters utilizing solid-state resources. Dr. Lago-Rivera's work was not only scientifically impactful but also innovative. His patent application on phase stabilization of long fibers using entanglement reflects his forward-thinking approach to practical challenges in building quantum networks. Despite the collaborative nature of experimental work, Dr. Lago-Rivera stood out as the driving force behind these endeavors. His tireless work, ingenuity, and enthusiastic approach played a

pivotal role in achieving exceptional results.

The culmination of Dr. Lago-Rivera's thesis showcased the demonstration of heralded entanglement between solid-state quantum memories located in different laboratories. This achievement, achieved amidst the challenges of the COVID-19 lockdown, underscored his determination and results-driven mindset.

The impact of Dr. Lago-Rivera's work extended beyond the outlined contributions, crucially influencing several other publications in reputable journals. His research, featured in high-impact journals such as *Nature*, *Nature Communications*, and *Physical Review Letters*, has earned him recognition in the scientific community. The widespread media attention garnered by his showcased achievement of heralded entanglement between solid-state quantum memories extended not only across Spain but also internationally. This accomplishment received prominent coverage on the front page of *El País* and other newspapers, and was highlighted on radio shows and online news websites.

Considering the exceptional quality of his work, the innovative aspects of his contributions, and the widespread acclaim from the scientific community, we wholeheartedly endorse Dr. Dario Lago-Rivera as a deserving recipient of the ICFO 2022 PhD Thesis Award.

The entire ICFO community congratulates Paolo, Egaitz and Dario for the dedication, hard work, and scientific insight that have earned them this ICFO 2022 PhD Award.