

2023 ICFO PhD Thesis Awards

Four ICFO PhD graduates awarded for their creative and ambitious research in experimental, theoretical and industrial fields

December 17, 2024

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 ICFOnians who have obtained particularly successful results and who have contributed to extend significantly the frontier of scientific and technological knowledge worldwide.?

In 2023, 31 ICFO PhD students defended their theses. 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 13th, the 2023 awards were presented to **Dr Ipsita Das** and **Dr. Craig Chisholm** in the **experimental field**, **Dr. Valerio Di Gulio** in the **theoretical field**, **Dr Yongjie Wang** in the **industrial field.**

AWARD CITATIONS:

Dr. Craig Chisholm in the research group led by ICREA Professor at ICFO Dr. Leticia Tarruell: ICFO recognizes the exceptional experimental doctoral thesis i¿½Raman Dressed Bose-Einstein Condensates with Tunable Interactions: Topological Gauge Theories and Supersolidsi¿½.

Craig's PhD work advanced quantum simulation in two key research directions: the simulation of gauge theories and the realization of supersolid phases. His achievements include extending quantum simulations of gauge theories with ultracold atoms to continuum systems and to a new class of theories: topological gauge theories. Additionally, Craig mad a pivotal contribution to the experimental investigation of the supersolid stripe phase in spin-orbit coupled Bose-Einstein condensate, integrating experiments and theory at th highest level

Craig's work resulted in impactful publications in prestigious journals such as Nature and Physical Review Letters. More work will be published and built upon his contribution. Of particular note, Craig performed at the highest level both experimentally and theoretically, extending the capabilities of the group apparatus, performing a high number of numerical simulations, and coming up with novel ideas on how to implement analytical expressions originally developed for conventional mixtures of Bose-Einstein condensates - that he learned about in a summer school - to describe the supersolid excitations.

Dr. Ipsita Das, in the research group led by Prof. Dmitri Efetov: ICFO recognizes the exceptional experimental doctoral thesis i¿½Investigation of the Interaction Driven Quantum Phases in Magic-Angle Twisted Bilayer Graphenei¿½.

In her PhD Thesis Dr. Das has made exceptional contributions to experimental condensed matter physics, contributing groundbreaking work in exploring twisted bilayer graphene has unraveled novel topological quantum phases and enriched the understanding of moire materials, positioning her research among the most pioneering in the field.

Her achievements include the discovery of Chern insulators and re-entrant correlated insulators at high magnetic fields, documented in widely cited works such as Nature Physics and Physical Review Letters. With an impressive mastery of experimental techniques in quantum transport measurements, Dr. Das's research exemplifies deep scientific insight.

Beyond her scientific achievements, Dr. Das has been a mentor and leader, fostering a collaborative and innovative spirit among her colleagues. Her recent postdoctoral work at LMU Munich and now at Princeton continues to reflect her pursuit of excellence in experimental physics.

We are proud to recognize Dr. Das's remarkable contributions and to highlight her as a great example of the scientific excellence and innovation fostered at ICFO.

Dr.Valerio Di Gulio in the research group led by ICREA Professor at ICFO Dr. Javier Garcia de Abajo: ICFO recognizes the exceptional theoretical doctoral thesis i¿½Nanophotonics with

charged particlesi¿½.

Dr. Di Gulio's PhD thesis develops a novel and comprehensive framework to describe the quantum-optical interactions between free electrons and light, an approach that has become the gold standard in the field.

The thesis is focused on the study of the interaction between electrons traveling in free space and the optical modes supported by nanostructures using a wide range of theoretical methods that combine traditional techniques from classical electrodynamics, capable of describing the optical response of nanostructures, with novel quantum mechanical approaches that capture the quantum nature of both electrons and light.

Using these methods, Dr. Di Gulio addresses in an original and rigorous manner a collection of relevant scientific problems involving free propagating electrons and nanophotonic platforms with a highly original approach that has opened new lines of research in the field of nanophotonics and triggered a significant research effort from a theoretical as well as an experimental perspective. His work exploits the coupling between evanescent light, harnessed in the vicinity of material boundaries, and charged free particles to access new effects only found at the point where nanophotonics, quantum optics and high-energy physics meets through strong light-matter interaction.

The broad range of topics addressed in the thesis include:

the theoretical investigation of quantum-mechanical aspects associated with photon-induced near-field electron microscopy (PINEM) demonstrating that improved control over electron pulse shaping, compression, and statistics can be gained by replacing coherent laser excitation by interaction with quantum light, such as phase- and amplitude-squeezed optical fields.

the role played by fluctuations of the electromagnetic vacuum in the coupled dynamics of a free-electron beam and a macroscopic object, producing elastic diffraction and decoherence, showing that diffraction can dominate over decoherence, therefore suggesting a nondestructive approach to microscopy based on the specific choice of parameters that minimize the inelastic interaction with the specimen.

the study of the interference produced in the cathodoluminescence emission by the synchronized interaction of free electrons and dimmed laser pulses scattered by the specimen, showing that such an effect may enable measurements combining the spectral and temporal selectivity of the light with the atomic resolution of electron beams to resolve the phase associated with optical modes in the sample

the demonstration that elastic diffraction is also experienced by conduction electrons in a two-dimensional material, therefore altering its properties by adding a neighboring neutral structure

the potential of confined optical modes to assist electron-positron pair production arising from the scattering of gamma rays by surface polaritons propagating along a material

interface.

Valerio's PhD research is exceptionally creative and productive, and his PhD thesis demonstrates a deep understanding of the field. Amazingly, the thesis is based on 14 publications in the best international journals (8 as the first author, 6 co-authored), with several further publications that are not included in the thesis, and numerous presentations at international conferences. During his PhD, he played an active role in mentoring younger students, and in teaching courses at the Universidad Autonoma de Barcelona.

Dr. Yongjie Wang in the research group led by ICREA Professor at ICFO Dr. Gerasimo Konstantatos: ICFO recognizes the exceptional industrial doctoral thesis ¡¿½Eco-friendly solar cells with cation-engineered AgBiS2 nanocrystalsi¿½

Yongjie Wang's PhD thesis focuses on the development of AgBiS? nanocrystals and their application in high-efficiency, environmentally friendly, and ultra-thin solar cells.

The citation from the PhD defense jury noted that, in his PhD, Yongjie demonstrated a high degree of versatility and mastery across diverse fields in chemistry, physics, and materials science, and in device design, testing and characterization. He achieved outstanding results, and the deep analysis presented in his PhD thesis manuscript opens the prospect of further device improvements.

A landmark result of Dr. Wang's work was the discovery of a novel mechanism to control optoelectronic properties through cation disorder engineering, leading to a record-breaking solar cell power conversion efficiency with absorber layers as thin as 30 nm, work which was published in Nature Photonics in 2022, attracting significant attention in the field.

Additionally, he developed a simple, eco-friendly solution-phase ligand exchange method using water-based solvents, which reduced the environmental impact of solar cell fabrication without compromising performance. These groundbreaking contributions pave the way for new advancements in sustainable and cost-effective photovoltaic technology.

Dr. Wang's achievements extend beyond device performance, encompassing innovation in synthesis, characterization, and modeling. He successfully synthesized and engineered AgBiS? nanocrystals, optimized their deposition into thin films, and utilized advanced characterization and simulation techniques to comprehensively analyze device performance. His research demonstrated an outstanding ability to connect experimental findings with theoretical insights, supported by collaborations established with international researchers.

Yongjie's work is highly original, as it introduces a previously unexplored material and achieves results that address major challenges in photovoltaics, including efficiency, cost reduction, and environmental sustainability. His thesis has been recognized as innovative and impactful, with two first-author publications in top-tier journals (Nature Photonics and Advanced Energy Materials). His scientific contributions include work on heavy-metal-free colloidal quantum dots for short-wave infrared image sensors, published in Nature Photonics

(2024). This achievement resulted in two patent applications and collaboration with industrial partners, underscoring his ability to conduct interdisciplinary and translational research.
The quality and impact of Yongji's work is demonstrated by his outstanding record of high-impact publications - his 35+ publications have already attracted 2000+ citations, and his h-index of 25, is comparable of that of many faculty members - the patents submitted, and collaborations established and maintained with researchers in both industry and academia.
His thesis thus sets a new standard for excellence in the fields of photovoltaics and optoelectronics, both in fundamental research and in developing innovative industrial applications, and demonstrates his impressive depth of knowledge, scientific maturity, independence and creativity.



Drs. Di Guilio and Wang received their awards in person during the award ceremony



Dr. Craig Chisholm connected virtually from New Zealand to receive his award



Dr. Ipsita Das connected virtually from the USA to receive her award