# Congratulations to New ICFO PhD Graduate

## Dr. Luke Mortimer graduated with a thesis entitled " A Variety of Optimization Techniques Applied In the Context of Quantum Information Theory"

October 06, 2025

We congratulate Dr. Luke Mortimer who defended his thesis this morning in ICFO's Auditorium.
Dr. Mortimer obtained his MSc in Theoretical Physics from the University of York, before joining the Quantum Information Theory research group led by professor Dr. Antonio Acin.?
His thesis titled " A Variety of Optimization Techniques Applied In the Context of Quantu Information Theory" was supervised by Prof. Dr. Antonio Acin

**ABSTRACT:**
The thesis considers a number of optimisation techniques applied in the context of quantum information theory. After a pedagogical introduction of both quantum information theory and optimisation, it considers three main avenues of research. The first is the well-known

foundational open problem of mutually unbiased bases, which consists of finding sets of orthonormal bases that are each unbiased with one another. More specifically, it remains unknown whether one can find a set of 4 mutually unbiased bases in dimension 6. A variety of optimisation techniques are applied, including non-linear semidefinite programming, see-saw optimisation, semidefinite programming relaxations, branch-and-cut, gradient descent methods and the method of Lagrange multipliers, each providing further insights into the problem. The second avenue is that of Bell nonlocality, more specifically attempting to simplify the hierarchy of semidefinite programs known as the NPA (Navascues-Pironio-Acin) hierarchy used to find bounds on the maximum quantum violation of Bell inequalities. For the case in which one has a large number of inputs per party, advantage in both memory and time versus state-of-the-art solvers is demonstrated using a combination several optimisation techniques. The third avenue is that of many-body quantum physics, which encompasses a wide range of topics. The thesis considers the problems of bounding expectation values of observables over the steady-states of open quantum systems, finding improved Fermion-to-qubit mappings and solving the graph colouring problem with a novel qudit-inspired optimisation algorithm. In each case, advantage versus comparable methods is demonstrated.

**Thesis Committee:**

Prof. Dr. Miguel Navascues Cobo, Austrian Academy of Sciences

Prof. Dr. Darrick Edward Chang, ICFO

Prof. Dr. Victoria Jane Wright, Quantinuum