Background to the Bristol-Macquarie Cotutelle PhD Programme:
The University of Bristol (UoB) and Macquarie University have worked together to develop a framework agreement for operating Cotutelle\(^1\) PhDs. Cotutelle PhDs are a type of PhD distinguished by a number of features that comprise a very attractive opportunity for ambitious and talented early career researchers:

- Genuine shared co-supervision with academics in both universities
- Registration at both universities simultaneously to ensure you have full access to the full range of facilities and resources at both institutions
- Your PhD is carried out at both institutions (approximately a 50/50 split) with the sequence decided by the nature of the specific PhD project – there are funds to support this mobility requirement
- The PhD is examined at both institutions, adhering to the examination requirements at each institution. Both institutions confer a degree certificate which references the Cotutelle (shared) nature of the PhD degree and the role of both institutions. A graduate will be able to use the designation PhD (University of Bristol and Macquarie University). This is highly likely to benefit your CV and career prospects
- Full membership of the Postgraduate Research communities at both universities to provide you with two postgraduate research families
- Support and training at both universities to help prepare you for your future career

These Cotutelle PhDs are of 3.5 years duration and are fully funded PhD scholarships, with the tuition fees and living expenses at both institutions covered by the studentship package (see Financial Details of the Cotutelle PhD Scholarship below). The programme of Cotutelle PhDs is cooperatively managed by the Bristol Doctoral College and the Higher Degree Research Office at Macquarie University, working in partnership with the supervisory teams.

Cotutelle PhD Project:
Quantum light sources and 3D quantum photonic circuits for next-generation quantum technologies

**Supervisors:**
Professor Ruth Oulton, University of Bristol
Professor Michael Steel, Macquarie University

**Contact for details on this PhD project:**
Ruth.Oulton@bristol.ac.uk
Michael.Steel@mq.edu.au

Cotutelle PhD Project Summary:
An exciting opportunity has arisen for a Cotutelle PhD, jointly located in two world-class photonics and quantum optics laboratories. The University of Bristol, United Kingdom and Macquarie University in Sydney, Australia have joined forces on a project to design and demonstrate the most efficient and flexible quantum photonic circuit yet made. Your PhD will involve designing and fabricating state-of-the-art laser-written glass 3D photonic waveguide circuits at Macquarie University, and combining fabricated circuits with extremely efficient quantum dot entangled photon sources in the Quantum Engineering Technology Labs (QET Labs) at the University of Bristol. Non-classical light states input into these circuits promise an array of functionalities: processing photons into higher dimensional

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\(^1\) Note: Cotutelle literally means ‘co-tutored’.
orbital angular momentum entangled states; constructing a 2D lattice of entangled photons robust to decoherence; potentially even using such states to demonstrate that photon entanglement may outperform classical calculations.

**PhD Detailed description:**
See detailed project description in attachment.

**Time spent in both Bristol and Sydney:**
During this Cotutelle PhD, you will spend approximately 50% of your time during the 3.5 years of your PhD in each location, gaining expertise and a unique perspective of research from both institutions. You will obtain a PhD from both universities. Exact details of the project and research time plan is flexible depending on previous experience.

**Requirements and training provided as part of the PhD:**
The Bristol Doctoral College (BDC) coordinates an extensive programme of personal and professional development courses for all PhD students at Bristol, free of charge. Details of these are on the BDC website.

The Department of Physics and Astronomy at Macquarie University provides a range of training programs in technical and professional skills and provides a number of leadership opportunities for higher degree research students.

**Research Environment – Bristol and Sydney:**
The Quantum Engineering Technology Labs (QET Labs) has over 100 researchers and encompasses an ecosystem of quantum technology research, training and innovation in Bristol. This includes activities such as the Quantum Technology Enterprise Centre, our entrepreneurship fellowship programme, and alignment to the Quantum Technology Innovation Centre, a centre for supporting quantum industries. QET Labs has produced world-first demonstrations in integrated quantum photonic technology, including the most complex photonic integrated circuit ever created [Carolan et al, Science 2015]. Similar circuits will be developed in this project. In 2018 we reported very efficient Quantum Dot single photon devices with the largest non-linearity ever demonstrated with a solid-state quantum emitter [Androvitsaneas et al, ACS Photonics 2019] again very similar to the structures to be used in this proposal.

The Department of Physics and Astronomy at Macquarie University has over 20 academic staff and 60 researchers overall working in the areas of theoretical and experimental quantum information science, quantum optics, photonics and laser science. We host a node of the Centre of Excellence for Engineered Quantum Systems and are a partner in the newly established Sydney Quantum Academy which has joined four Sydney universities active in quantum science to promote the development of quantum industry, innovation and investment in New South Wales. The PhD project will make extensive use of Macquarie’s world class femtosecond laser writing facilities based in the OptoFab laboratories. The Department is one of the leading research units in the University and has a strong record of research translation in photonics and quantum science. We are active proponents of a positive workplace culture and have recently received silver status in Australia’s Pleiades awards scheme for equity, diversity and inclusion in physics and astronomy departments.

**Brief Biographies on the Project Supervisors**
**Ruth Oulton** is a Professor of Quantum Photonics and a EPSRC Quantum Technologies Fellow in the Quantum Engineering Technology Labs, in the Schools of Physics and Electrical and Electronic Engineering at the University of Bristol. Her research interests centre around the use of solid-state quantum emitters that interact with light, for quantum technology applications.
Professor Michael Steel has been a researcher in photonics technologies, the study of devices for generating, controlling and detecting light for over 25 years. His interests include periodic structures, quantum optics in integrated devices, magnetic effects on light and the interaction between sound and light.

Start date:
The project is available to start between the period of November 2019 to January 2020.

Financial Details of the Cotutelle PhD Scholarship:
The studentship covers tuition fees at both institutions, plus a living allowance at Research Council UK rates for the period in the UK (for 2019/20 this is £15,009), and AUD27596 for the period in Australia. Both stipends are tax free.

Eligibility:
The studentship is only open to UK Home/EU students due to the nature of the funding by EPSRC. A first degree in physics or a related subject, normally at a level equivalent to at least UK upper second-class honours, or a relevant postgraduate master’s qualification. For full details and international equivalencies see the Physics PhD course entry.

How to Apply:
For this Cotutelle PhD Programme, interested students should apply via the Bristol application website. Please follow the instructions at https://www.bristol.ac.uk/study/postgraduate/apply/
This online system allows you to save your application as you go along. Please choose “Physics PhD” as the course and list “Quantum light sources and 3D quantum photonic circuits for next-generation quantum technologies” as the corresponding studentship advert.
Also please be aware that you can add transcripts or other requested documentation after you have submitted your application.
Please let the Project Supervisors know that you are applying to the programme.

Closing Date:
Please complete the online application by 5pm on Monday 9 September 2019.
Shortlisted candidates will be interviewed by the supervisory team.

Contact for the Cotutelle Programme:
For academic enquiries about this project, please contact Prof. Ruth Oulton (Ruth.Oulton@bristol.ac.uk) or Prof. Michael Steel (Michael.Steel@mq.edu.au). For all other enquiries and questions about the Cotutelle PhD Programme, please contact Kevin Higgins, Global Bristol PhD Programme Manager of the Bristol Doctoral College, University of Bristol or A/Prof. Alex Fuerbach, HDR Director in Physics and Astronomy at Macquarie University.