

Imperial College  
London

A very warm welcome to you !



Quoll  
Tasmanian  
Carnivorous Animal

# QUANTUM OPTICS & LASER SCIENCE

DEPARTMENT OF PHYSICS

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## TODAY'S SCHEDULE

- 15:30** Welcome and Introduction - Prof John Tisch (Head of Group)
- 15:45** PhD opportunities
- 16:15** Q & A
- 17:00** End

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## QOLS GROUP

Divided into 4 interconnected activities

### Our Mission:

To carry out basic science using lasers.

To investigate, utilise and control photonic and material states and processes down to the quantum level.

Staff: 15  
Post-Docs: 30  
PhD Students: 60

eXtreme Light Consortium (XLC)

Centre for Cold Matter (CCM)

Controlled Quantum Systems experimental (CQSe)

Controlled Quantum Systems theoretical (CQSt)

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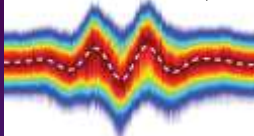
## XLC

eXtreme Light Consortium

We develop and use light with extreme timescales, intensities and wavelengths, to explore new frontiers in measurement and control.

Jon Marangos  
David Ayuso  
Vitali Averbukh  
Leszek Frasinski  
Mary Matthews  
Geoff New  
John Tisch

Measurement of attosecond pulses



High-power, femtosecond laser systems

Attosecond science and technology

Free-electron laser experiments & x-ray science

Measurement and control of electron dynamics in matter

Applications in time-resolved imaging, photosynthesis, catalysis, ultrafast optical-switching,...

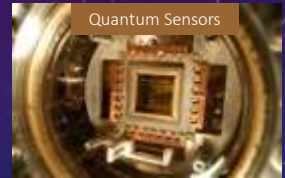
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# CCM

Centre for Cold Matter

We use cold atoms and molecules to test fundamental physics, measure tiny forces, and control the interactions between quantum systems.

Ben Sauer  
Mike Tarbutt  
Joe Cotter  
Jongseok Lim

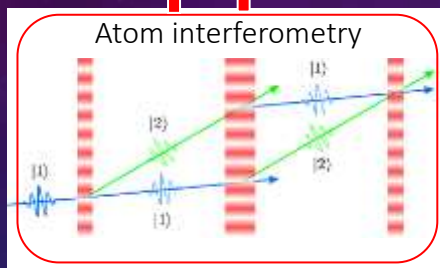
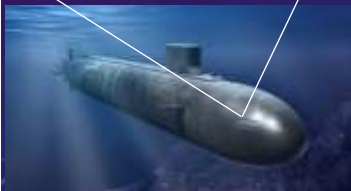


- Controlled quantum dynamics
- Tests of Standard Model
- Ultra-cold atoms/molecules
- Quantum Technology
- Quantum Sensors

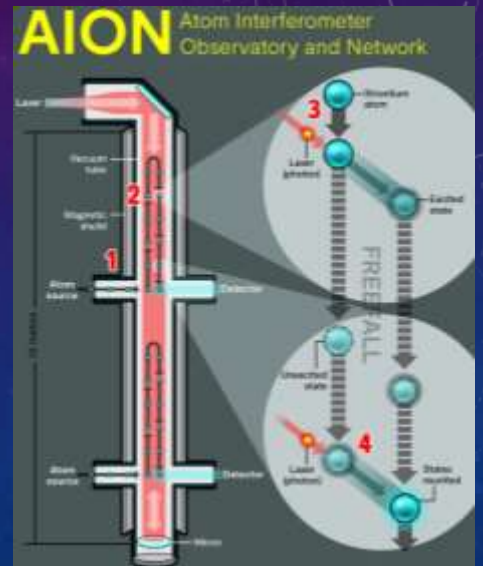
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## Activities at the Centre for Cold Matter

Inertial navigation



Detecting gravitational waves & dark matter



Funded PhD studentship available  
Contact: Prof Mike Tarbutt  
[m.tarbutt@imperial.ac.uk](mailto:m.tarbutt@imperial.ac.uk)

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# CQSe

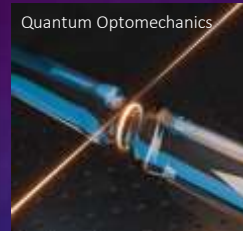
## Controlled Quantum Systems experimental

We precisely control isolated quantum systems of trapped ions, mechanical resonators, and optical fields, to study basic quantum science and its applications including sensing, spectroscopy, and information processing.

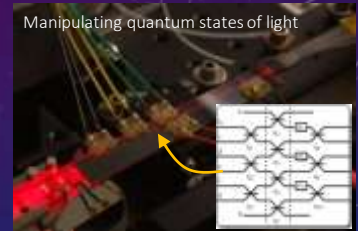
Richard Thompson  
Steve Kolthammer  
Michael Vanner  
Ian Walmsley



Ion  
Trapping



Quantum Optomechanics



Manipulating quantum states of light

Ion-trapping and quantum computing

Generation and manipulation of quantum states of light

Cavity quantum optomechanics

Quantum sensors and transducers

Table-top tests of quantum gravity

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# CQSt

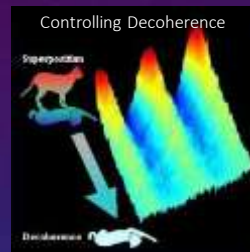
## Controlled Quantum Systems theoretical

We develop quantum theory for areas including quantum control, quantum optics, and quantum information.

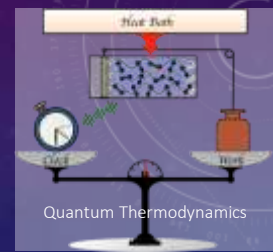
Myungshik Kim  
David Jennings  
Peter Knight  
Florian Mintert  
Terry Rudolph



Single Photon Entangled States



Controlling Decoherence



Quantum Thermodynamics

Quantum information and computing

Quantum-state engineering

Control of decoherence

Quantum thermodynamics

Gravitational effects in quantum mechanics

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## MSC PHYSICS WITH QUANTUM DYNAMICS (12 MONTHS)

October-March	Mathematical Techniques (MSc module) ACP (if not already taken) Laser cooling & ultracold atomic systems Hybrid quantum systems, quantum photonics Advanced quantum information Level 7 Options Self-Study Literature Review project in an area of Quantum Dynamics Research Skills Training Graduate School transferable skills	60 ECTS
May	Exams	
June-Sept	Summer Project - Independent full-time in Quantum Dynamics	30 ECTS
Total		90 ECTS

•Contact: Prof. Ben Sauer [ben.sauer@imperial.ac.uk](mailto:ben.sauer@imperial.ac.uk)

•Further info on masters programmes: <http://www.imperial.ac.uk/study/pg/courses/physics/>

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## FUNDED PHD OPPORTUNITIES IN QOLS (AS OF 12 JAN 2022)

- |                                      |      |                     |  |
|--------------------------------------|------|---------------------|--|
| 1. Quantum Information Science       | CQDt | Prof Myungshik Kim  | <a href="mailto:m.kim@imperial.ac.uk">m.kim@imperial.ac.uk</a>           |
| 2. Tabletop Dark Matter Detection    | CQDe | Dr Jack Devlin      | <a href="mailto:j.devlin11@imperial.ac.uk">j.devlin11@imperial.ac.uk</a> |
| 3. Free Electron Laser (FEL) Science | xLC  | Prof Jon Marangos   | <a href="mailto:j.marangos@imperial.ac.uk">j.marangos@imperial.ac.uk</a> |
| 4. Optical Quantum Computers         | CQDe | Dr Steve Kolthammer | <a href="mailto:wkoltham@ic.ac.uk">wkoltham@ic.ac.uk</a>                 |

### Note

- New funded PhD studentships can come up !
- For updates, or if you are able to self-fund, please contact Marcia Salviato (Group Administrator) [m.salviato@imperial.ac.uk](mailto:m.salviato@imperial.ac.uk)

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# THEORY OF QUANTUM INFORMATION SCIENCE (CQDT)

EPSRC DTP studentship  
3.5 years  
start Oct 2022

*Myungshik Kim*

[m.kim@imperial.ac.uk](mailto:m.kim@imperial.ac.uk)

## Potential PhD projects

### Test of quantum gravity using quantum information approach

QM and General relativity do not agree in their prediction at the Planck scale. We study how to test theories using table-top quantum optical devices and quantum informatic concepts.

### Quantum resource theory

We answer to the question on which resources of quantum mechanics do we use to outperform classical devices in quantum technology – e.g. quantum computing and quantum metrology.

### Limits of quantum sensing for complex systems

For multiparameter estimation using complex devices, the quantum limits are not clear. We study the ultimate limits for general setting.

### Development of quantum simulations and algorithms

We have good industry funding to develop quantum algorithms to simulate quantum materials and chemical reaction and for other applications.

### Optimisation of quantum interface protocols for distributed quantum computing

Matter-field interaction is at the heart of interface between various quantum processors. We study how to connect quantum processors based on matter-field interactions and optimization technology developed in ICT.

For references, visit the website '<https://www.imperial.ac.uk/people/m.kim>'

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## NEXT

- Dr Jack Devlin
- Dr Mary Matthews
- Dr Steve Kolthammer
  
- Q&A

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## FINALLY

- Thanks for attending!
- If you have any questions, single point of contact:  
**Marcia Salviato** [m.salviato@imperial.ac.uk](mailto:m.salviato@imperial.ac.uk)