Te Mana Tangata Whakawhanake
MacDiarmid Institute
Advanced Materials & Nanotechnology

Te Whai Ao
Dodd-Walls Centre
for Photonic and Quantum Technologies

Photonic and quantum technology capabilities in New Zealand

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MacDiarmid Institute for Advanced Materials and Nanotechnology
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Photonic and quantum technologies – NZ institutions and networks

Tertiary Education Commission
Te Amorangi Mātauranga Matua

Te Whai Ao Dodd-Walls Centre
for Photonic and Quantum Technologies

doddwalls.ac.nz

Photonics, the generation, transmission, and manipulation of light, and the study of matter and energy at the quantum level

University of Otago Ōtākou Whakaihu Waka · The University of Auckland Te Whare Wānanga o Tāmaki Makaurau New Zealand · AUT Auckland University of Technology New Zealand · Victoria University of Wellington Te Herenga Waka · Massey University Te Kunenga ki Pūrehuroa University of New Zealand · UC University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand · Measurement Standards Laboratory of New Zealand

Three beacons:

- **The One – quantum technologies and photonic sensing**
- The Many – many-body quantum and classical systems
- The All – optical imaging and spectroscopic sensing

Quantum Technologies Aotearoa

Te Mana Tangata Whakawhanake
MacDiarmid Institute
Advanced Materials & Nanotechnology

macdiarmid.ac.nz/

Innovative, sustainable materials that will improve the lives of people in Aotearoa and around the world

Massey University Te Kunenga ki Pūrehuroa University of New Zealand · UC University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand · The University of Auckland Te Whare Wānanga o Tāmaki Makaurau New Zealand · University of Otago Ōtākou Whakaihu Waka · GNS Science Te Pū Ao · Victoria University of Wellington Te Herenga Waka · CallaghanInnovation New Zealand's Innovation Agency

Four research programmes:

- Towards zero waste – Reconfigurable Systems
- Towards zero carbon – Catalytic Architectures
- **Towards low energy tech – Hardware for Future Computing**
- Sustainable resource use – Pūtaiao Māori Research Programme

Quantum Technologies Aotearoa

qta.otago.ac.nz

Te Whai Ao Dodd-Walls Centre
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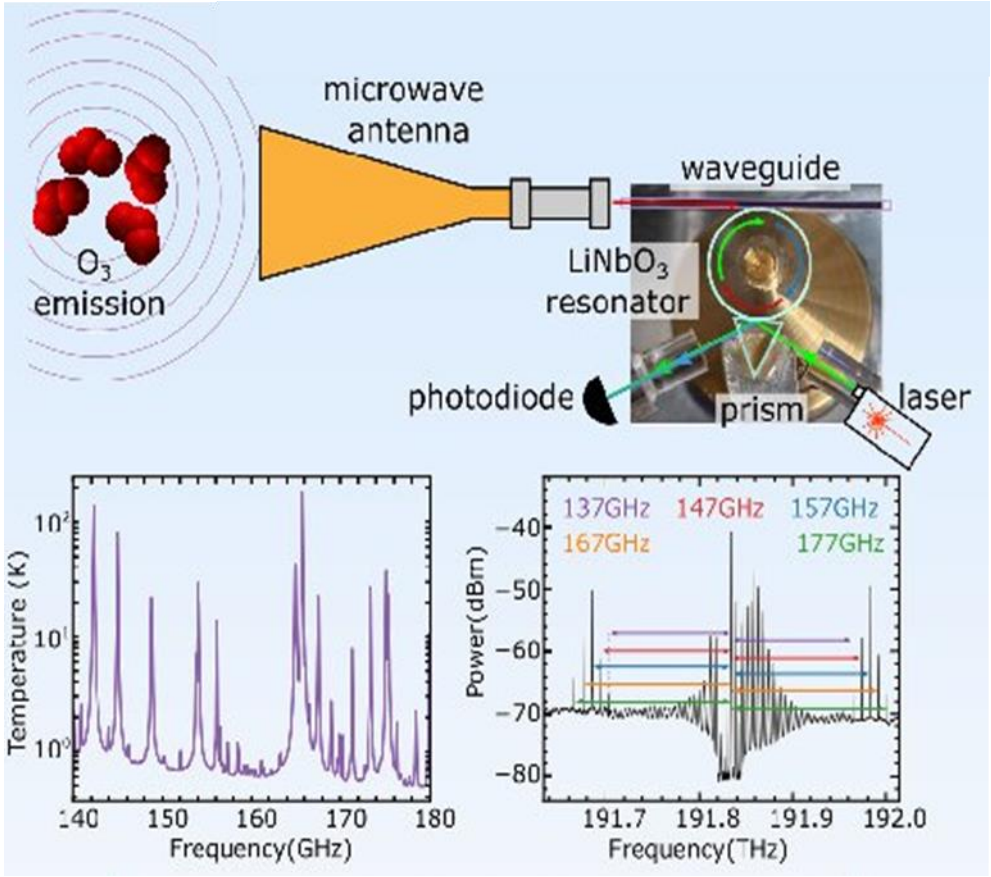
- A globally connected research programme to ensure NZ benefits from the advancement and adoption of quantum technologies
- Five year programme 2024-2028.
- Focus is international collaboration with 6 target countries:
  - US, UK, Germany, Singapore, Japan, South Korea
- Administered by DWC. Funded by MBIE Catalyst Strategic Fund.

NZ capabilities - photonic sensing

Up-conversion
Dr. Mallika Suresh
Dr. Florian Sedlmeir
A/Prof. Harald Schwefel
Dr. Domink Vogt
Dr. Dmitry Strekalov (JPL, Pasadena)
Prof. Luis Enrique Muñoz (UC3M, Madrid)

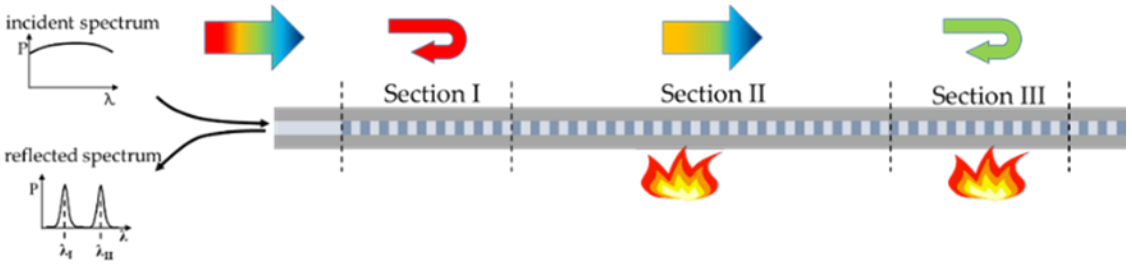
Atmospheric Science
A/Prof. Annika Seppälä
Hannah Kessenich
Dr. Richard Querel (NIWA, Lauder)

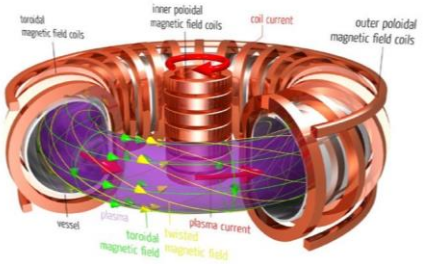
Astrophysics & Space Engineering
Prof. John Cater
Dr. Nick Rattenbury



- Converting microwaves into light for more sensitive detection
- Current project – detection of ozone in the stratosphere
- **Capability: enhanced photonic sensing for hard-to-detect gases**

Photonic and electromagnetic sensing of faults

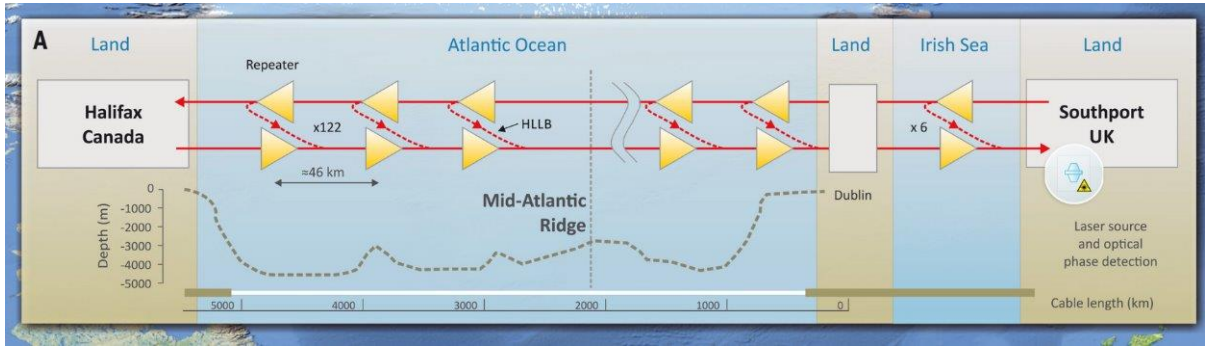




- Small-diameter, ultra-long optical fibre Bragg gratings to detect localised temperature spikes
- Current projects – magnetic field coils for fusion energy; aerospace
- **Capability: photonic sensing of temperature, gases under extremes**

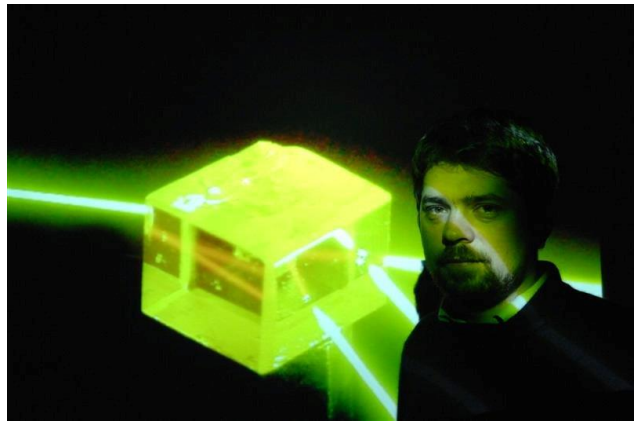
- Magnetic field sensors for non-destructive testing
- Current project – detecting electrical faults in overhead lines and loss of material from corrosion
- **Capability: electromagnetic signal detection**

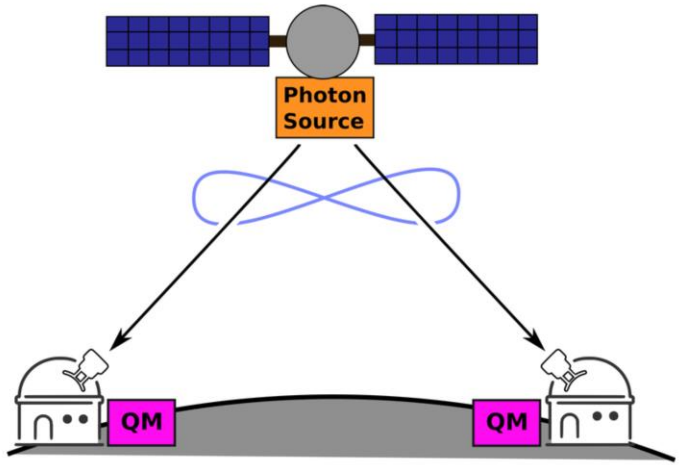
Quantum sensing in submarine optical fibre networks

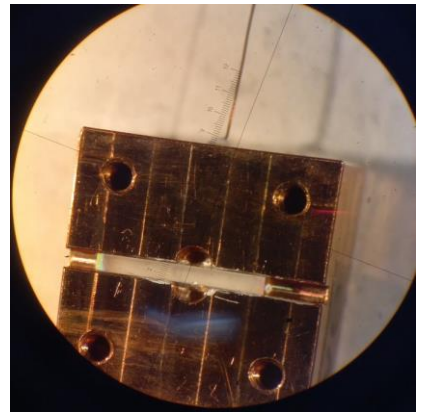


- Interferometry in undersea optical fibre cables
- Current project – detecting earthquakes, tsunamis in areas without seismometers
- First earthquakes detected in Oct 2024
- **Capability: event detection in existing fibre optic networks**

Quantum communications and networking

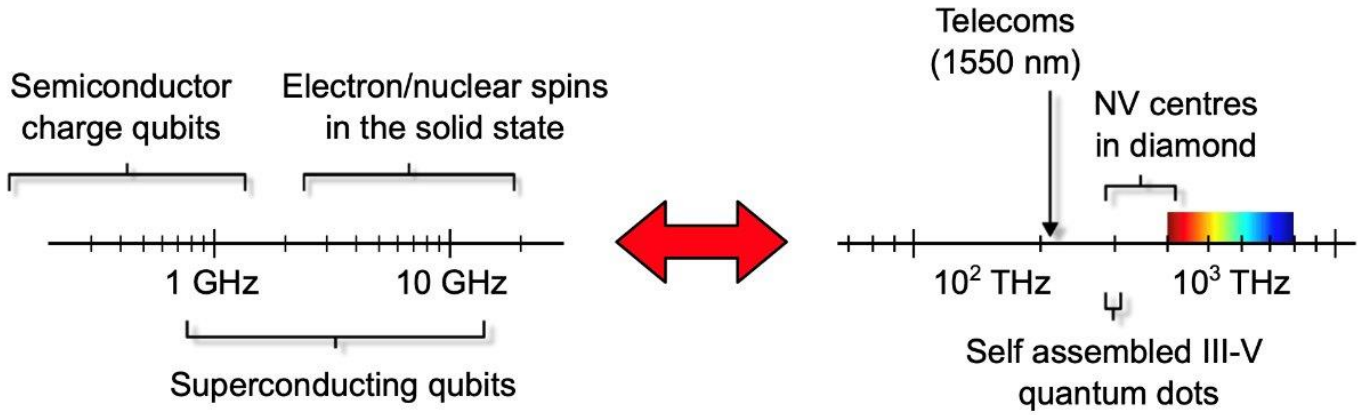


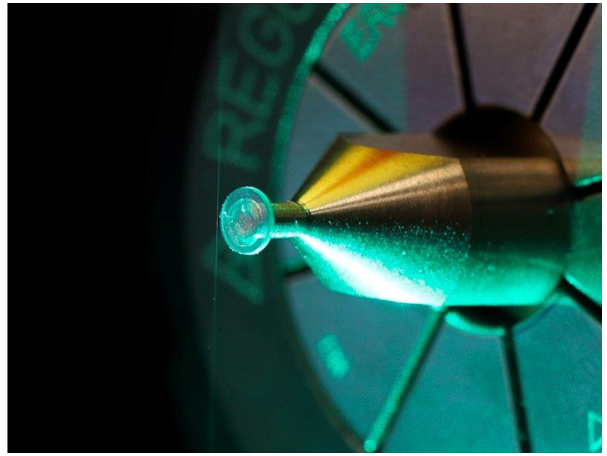




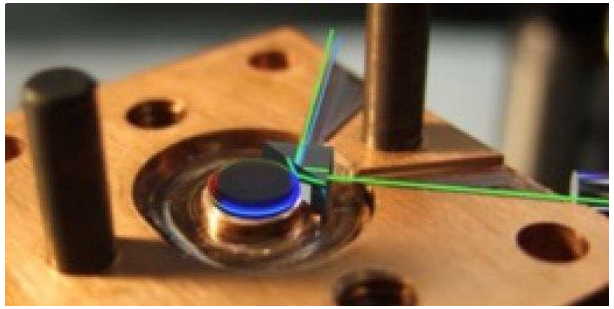
- Quantum memories for quantum-secure optical communications
- Current projects: satellite-satellite communications; ‘quantum repeaters’ to boost quantum encrypted signals
- Quantum networking and quantum internet protocols
- **Capability: components and protocols for quantum secure optical networks**

Quantum communications and networking

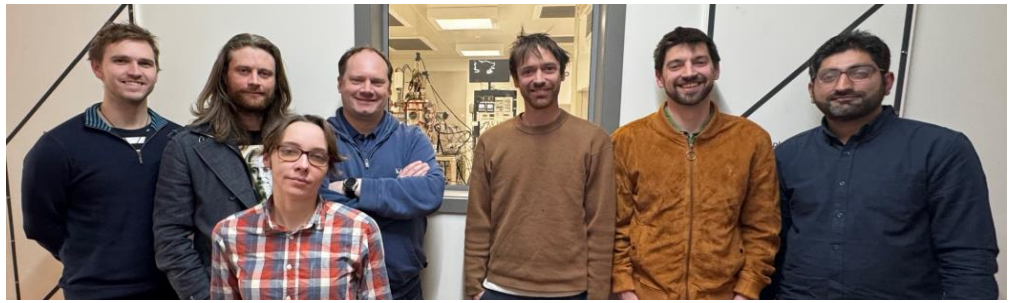


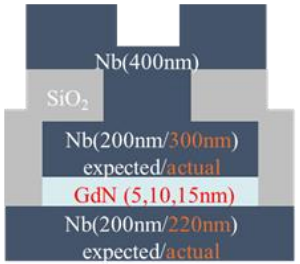


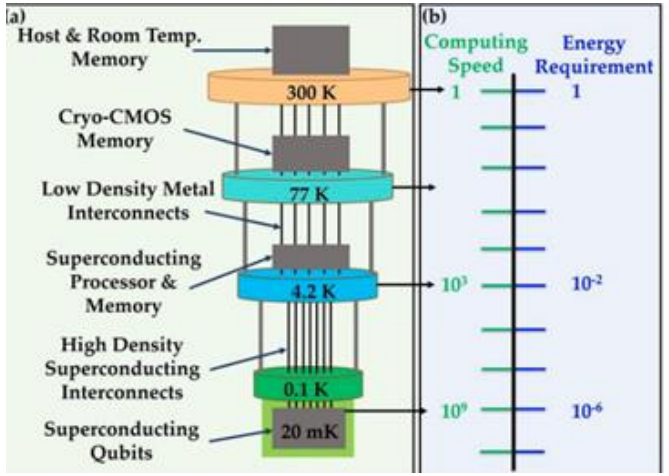
- Optical resonators “Whispering Gallery Mode” resonators
- Current projects: converting between microwave and optical signals
- **Capability: devices for the quantum internet**

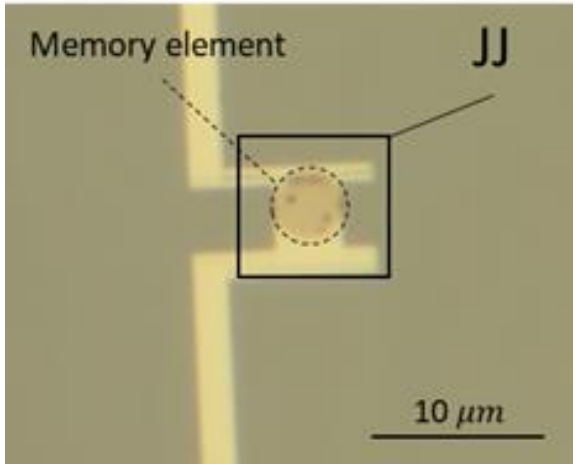


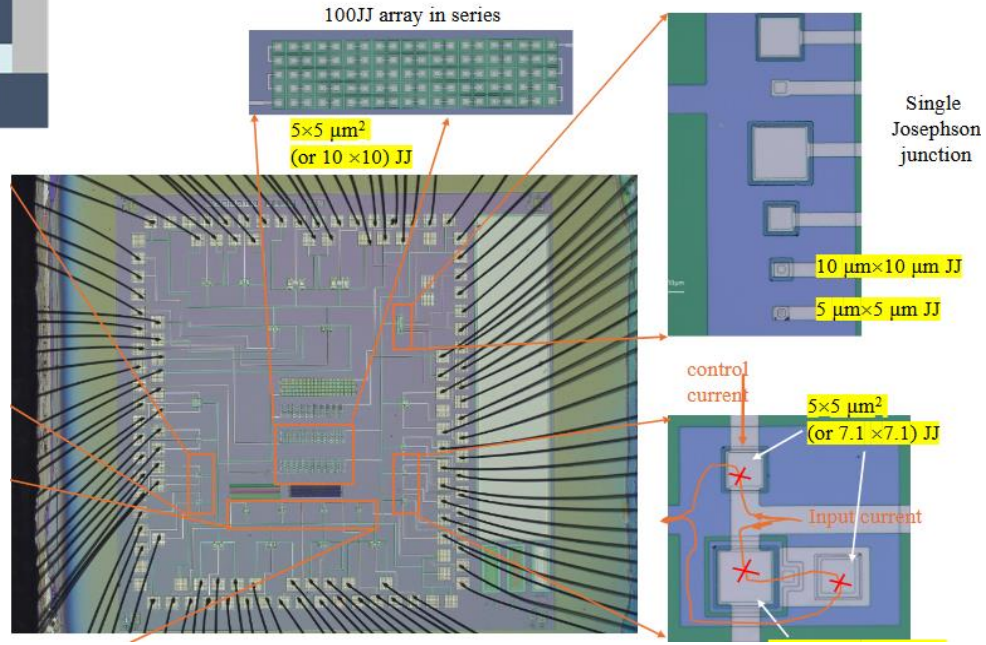
Hardware for scalable quantum computers







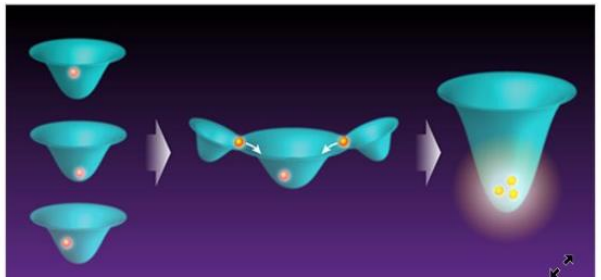


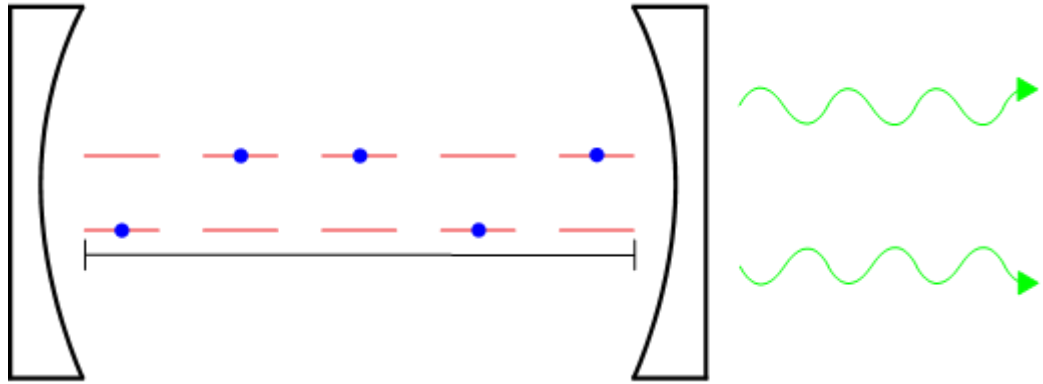


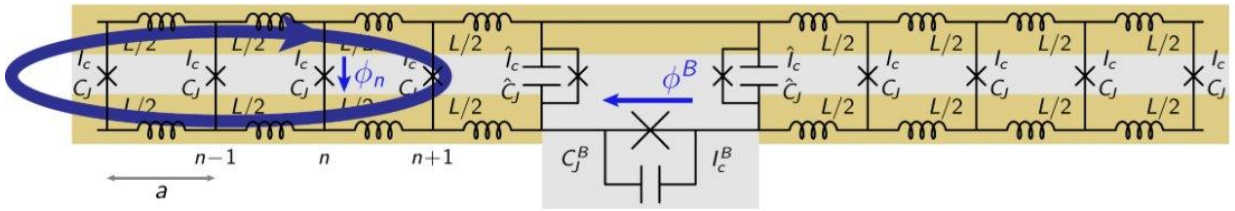
- Memory for the ultra-cold, noise-sensitive environments of quantum computer qubits
- **Capability: cryogenic electronics for quantum computers**

Quantum theory research

- Atomic superfluids
- Few-atom quantum systems
- Quantum simulators
- Tools for quantum computers (Quantum Monte Carlo, quantum algorithms)
- Cavity quantum electrodynamics
- Laser modeling
- Superconductor electronics circuit modelling



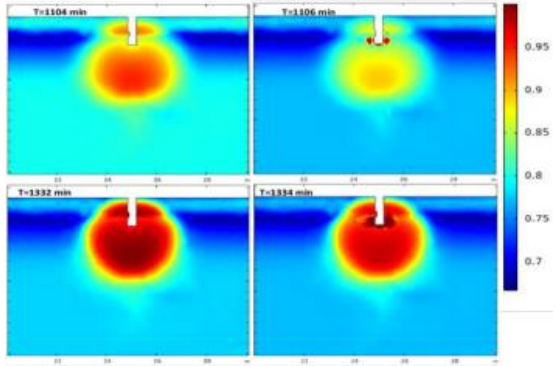




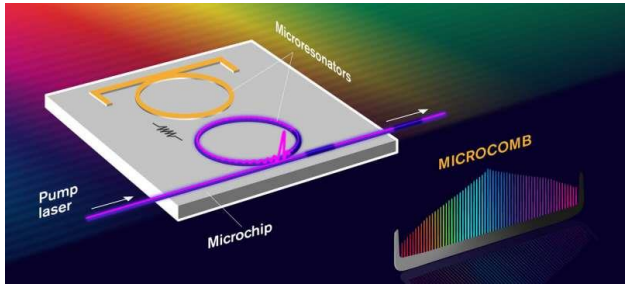
Potential areas of application - infrastructure

NZ research and technical capabilities:

- Gravity detection – buried objects or water plumes from leaks
- Acoustic sensing – listening for leaks in pipes
- Optical sensing – e.g. of gas leaks
- Electromagnetic sensing – faults in electricity networks; corrosion in overhead lines; cracking in metal infrastructure
- Communications – quantum secure devices for critical networks, e.g. traffic lights, rail signals, electricity networks



New Zealand's competitive advantages



Pockets of deep world-class expertise, patents and other IP

- Quantum optics; optical-microwave interconversion
- Cold atoms, atomic spectroscopy
- Magnetic/superconducting/photonic materials and devices

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Strong networks of NZ researchers, linking capabilities

- MacDiarmid, Dodd-Walls, QTA

Strong international partnerships with leading quantum nations

- Japan, Germany, UK, Singapore, US, EU, South Korea, Australia…

Chasing the Sir Paul Callaghan 'niche' applications ignored by others

- Photonic and electromagnetic sensing
- Quantum computer control electronics
- Quantum memories for secure communications

New Zealand's competitive advantages – who has them?

Startups, spinouts, multinationals
Few so far

We're building an optimization engine that harnesses the power of quantum computing to solve real-world logistics problems that classical methods struggle with — from container stacking and pallet packing to dynamic scheduling and resource allocation.

Research institutions and groups

- Universities, two CoREs

Strategic research (Catalyst funding)

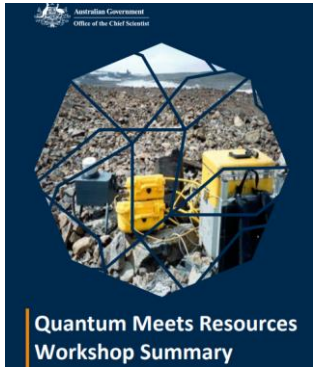
- Quantum Technologies Aotearoa (QTA) – 5 yrs supporting international collaboration (2024-2029)

Public research organisations (PROs)

- New Zealand Institute for Advanced Technology – including quantum. Setup date ~ 2026 but Q3 2025 for 'strategic investments'.
- Earth Sciences New Zealand (new home of Measurement Standards Lab)

Earth Sciences New Zealand

Useful links and information



Useful links

- Dr Cathy Foley Quantum 101 webinar 14 July (very good intro!) https://shorturl.at/kbzwk
- Quantum Meets Australia- https://www.chiefscientist.gov.au/news-and-media/quantum-meets-workshop-series
- Photonic and Quantum Technologies in Australia and New Zealand 2024 Industry report - https://shorturl.at/81XiI or search Dodd-Walls Centre site www.doddwalls.ac.nz

- Quantum Technologies Aotearoa - qta.otago.ac.nz
- MacDiarmid Institute – www.macdiarmid.ac.nz
- Paihau-Robinson Research Institute – www.wgtn.ac.nz/robinson
- www.quantuminsider.com – news, press releases (science, business and policy)
- www.qureca.com – quantum tech resources and information

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