

# **OUANTUM** FOR ENVIRONMENT





# Introduction to quantum and how it might be applied to environmental challenge



# 1) Quantum for Environment Design Challenge



### Quantum for Environment Design Challenge

Launched in June 2023, design submissions due February 2024.

Open to all students and post-doctoral fellows at the University of Waterloo. Must apply as a team. Opportunity to receive mentorship.

Awards up to \$5,000 CAD.



tqt.uwaterloo.ca/q4e



### WHAT IS THE CHALLENGE

Transformative Quantum Technologies (TQT) presents a design challenge to search for opportunities where quantum technology can advance environment (monitoring, stewardship). This challenge is open to University of Waterloo undergraduate and graduate students, and postdocs.

#### WHY QUANTUM FOR ENVIRONMENT

Quantum technologies allow us to perform tasks with more efficiency and greater precision than is possible in the classical world. Quantum solutions can achieve what would otherwise be impossible. It is compelling to mate these exciting new technologies with the pressing need to advance environmental monitoring and stewardship. Through this challenge, TQT aims to uncover new ways that quantum technologies might have impact in both the near and long term.

Quantum computing – select computational tasks may be exponentially faster.

Quantum simulation – obtain new insights into nature.

Quantum communications – absolute information security.

Quantum sensing – more efficient, more sensitive, more versatile, more tailorable.

The focus is to bring forth ideas that expand the potential reach of quantum technologies, there is no need to reduce ideas to practise to participate in this challenge.

Quantum technology is rapidly emerging (as we will see with the case studies in a moment). The challenge asks that you assume that the quantum technology you need exists, including fault tolerant quantum computers, versatile quantum simulators, secure quantum communication systems, and quantum sensors capable of preparing and using entanglement.

### WHO SHOULD PARTICIPATE IN QUANTUM FOR ENVIRONMENT

The Q4Environment challenge is looking for well-motivated, quantum-based ideas that can lead to innovation.

The focus is on the impacts that new technologies can have.

In the design proposal, the technology side should be well founded, but the expectation is that it will not have been reduced to practise. No prototype is required, but the design document should be convincing that the proposed future is possible.

We take a broad view of the environment to include climate change, energy as well as oceans, and the north, for example.

Teams need not have deep knowledge in either the quantum or environment fields, but should have explored what is in general possible. TQT will run a series of short courses to provide introductions to both quantum concepts and environment needs.

#### All design submissions must be team based, with a minimum of two people (up to any number).

The proposal must demonstrate basic knowledge and creativity in environment and in quantum.

### 2) Introduction to Quantum



### Quantum in Nature





Photo by Steven Kessel.

Graphic by A.M. Dokter and Jillian Ditner; Broad-tailed Hummingbird photos from Macaulay Library by <u>Ryan Sanderson</u> (left) and <u>Isoo O'Brien</u> (right).



# Early Quantum Technology



late 10<sup>th</sup> century navigation



### Quantum Properties

- Quantization and Tunneling
- Superposition
- Entanglement
- Parallelism



### Tunneling

Ref. Quantum made simple

https://toutestquantique.fr/en/tunnel-effect/



QUANTUM FOR ENVIRONMENT

### Quantum Capabilities to Impact

- Quantum computing select computational tasks may be exponentially faster.
- Quantum simulation obtain new insights into nature.
- Quantum communications absolute information security.
- Quantum sensing more efficient, more sensitive, more versatile, more tailorable.

### 3) Quantum technology "push"



### **Opportunity Space**

Underlying quantum effects lead to large efficiency gains

- superconducting materials for lossless power transmission
- improved efficiency of solar conversion, from 18% to 40%
- spintronics for non-volatile memory and improved classical electronics, theoretical gain is a factor of 600
- quantum simulation for new energy-efficient materials
- high-resolution imaging for remote earth observation
- highly-sensitive/selective/precise sensors for pollutants, critical minerals
- quantum algorithms that bring a quantum advantage for important environmental problems
- the list goes on...



### Select Examples

Is there a potential role for quantum?

- Quantum solutions to improve aerosol observation
- Ocean sensing
- Optimizing eDNA technology for use in aquaculture systems
- Quantum-enhanced soil carbon monitoring
- Quantum-improved tree health monitoring
- Quantum-improved reliability of satellite-derived measures of methane release
- ... and more



### 4) Environmental needs "pull"



### **ENVIRONMENT NEED**

Greenhouse Gases

Tree Health

Credit Trading

Simulation

FEETERS FEET computation

Energy Efficient Materials

Optimization for Power Grids

QUANTUM MODALITY



QUANTUM PROPERTY

Quantization & Tunneling Superposition

sensing

### Visit tqt.uwaterloo.ca/q4e

- Request access to Q4E slack
- Register your interest in Q4E
- Connect with mentor(s)



tqt.uwaterloo.ca/q4e



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### Important Dates

- Q4Environment Design Submissions Due: February 2024
- Q4Environment Awards Announced: March 2024





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