

# HOW MIGHT QUANTUM SOLUTIONS IMPACT ENVIRONMENTAL CHALLENGES?

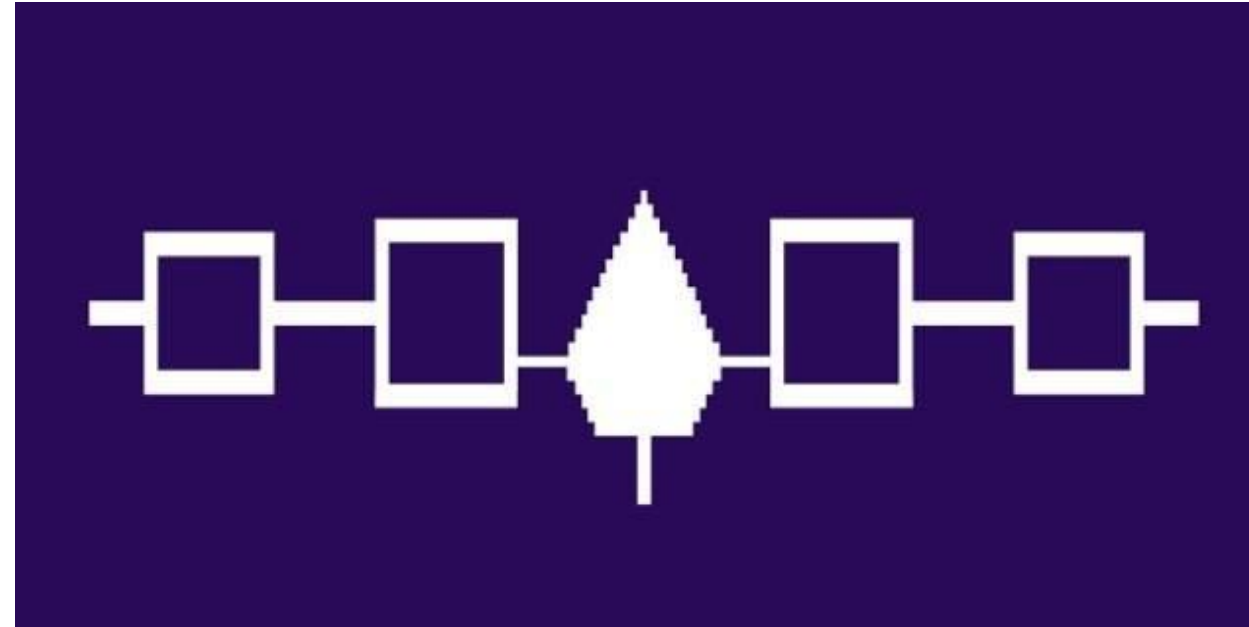
## Quantum for Environment Lunch & Learn



# LAND ACKNOWLEDGEMENT

*Commit to learning and acting*

We are situated on the territory of the Anishinaabeg, the Haudenosaunee, and the Neutral Peoples. We are on the Haldimand Tract, the land granted to the Six Nations that includes six miles on each side of the Grand River.



TQT

Transformative  
Quantum  
Technologies

GreenHouse  
purpose • action • impact

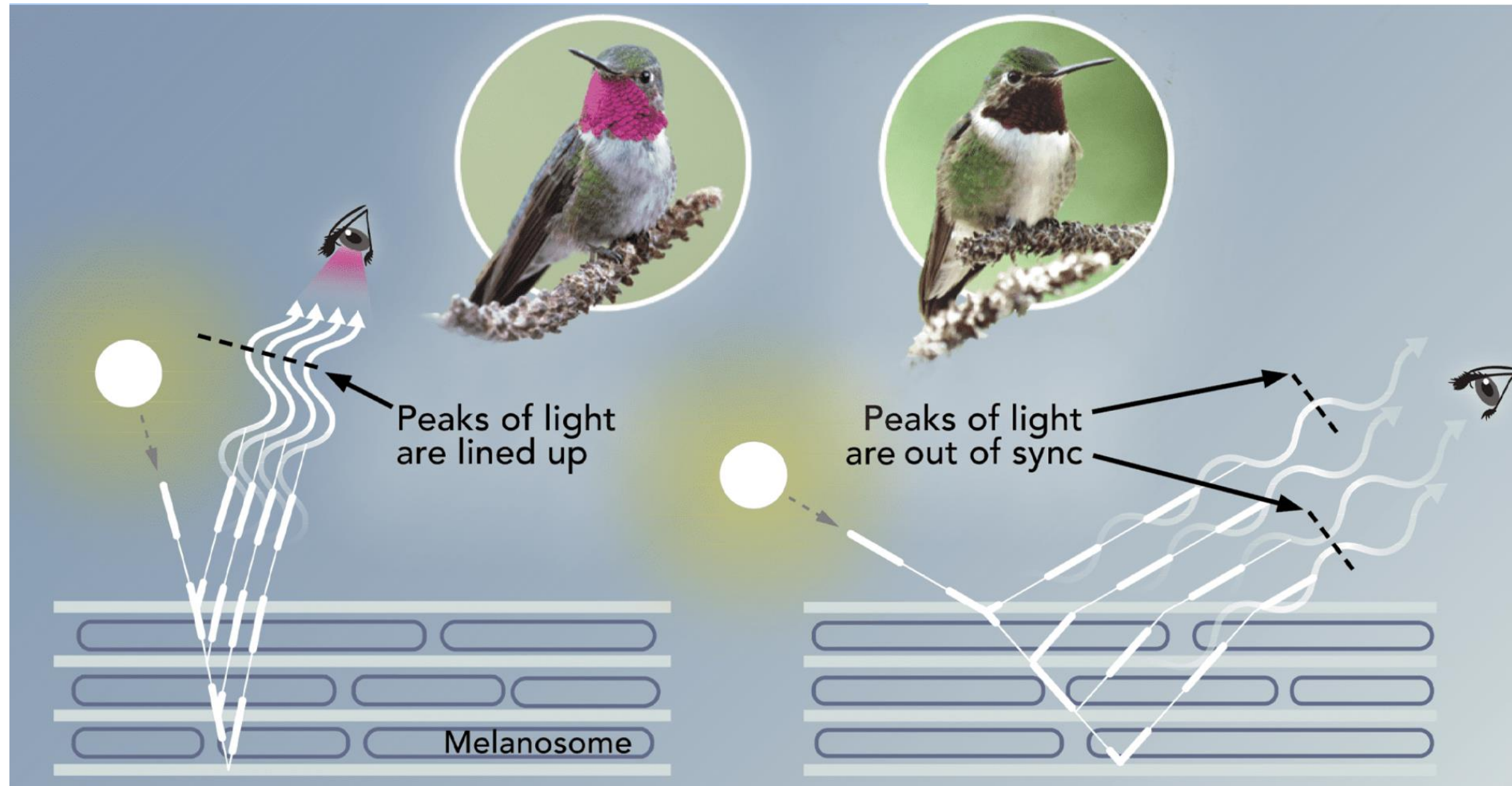


QUANTUM  
FOR  
ENVIRONMENT

Quantum Ethics Project logo featuring a stylized 'Q' and 'E' with arrows, and the text 'QUANTUM ETHICS PROJECT' below it.

# INTRODUCTION TO QUANTUM AND HOW IT MIGHT BE APPLIED TO ENVIRONMENTAL CHALLENGES

# QUANTUM IN NATURE



*Photo by Steven Kessel.*

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

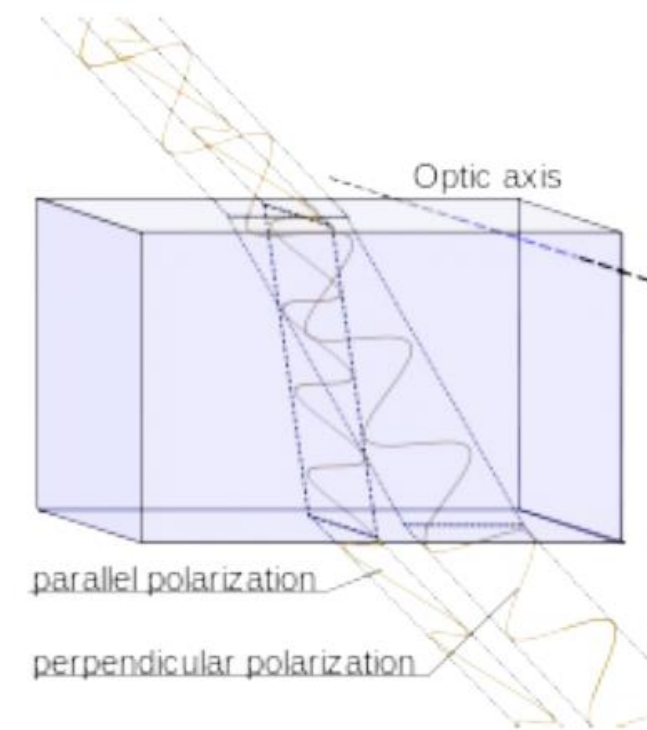
# EARLY QUANTUM TECHNOLOGY



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

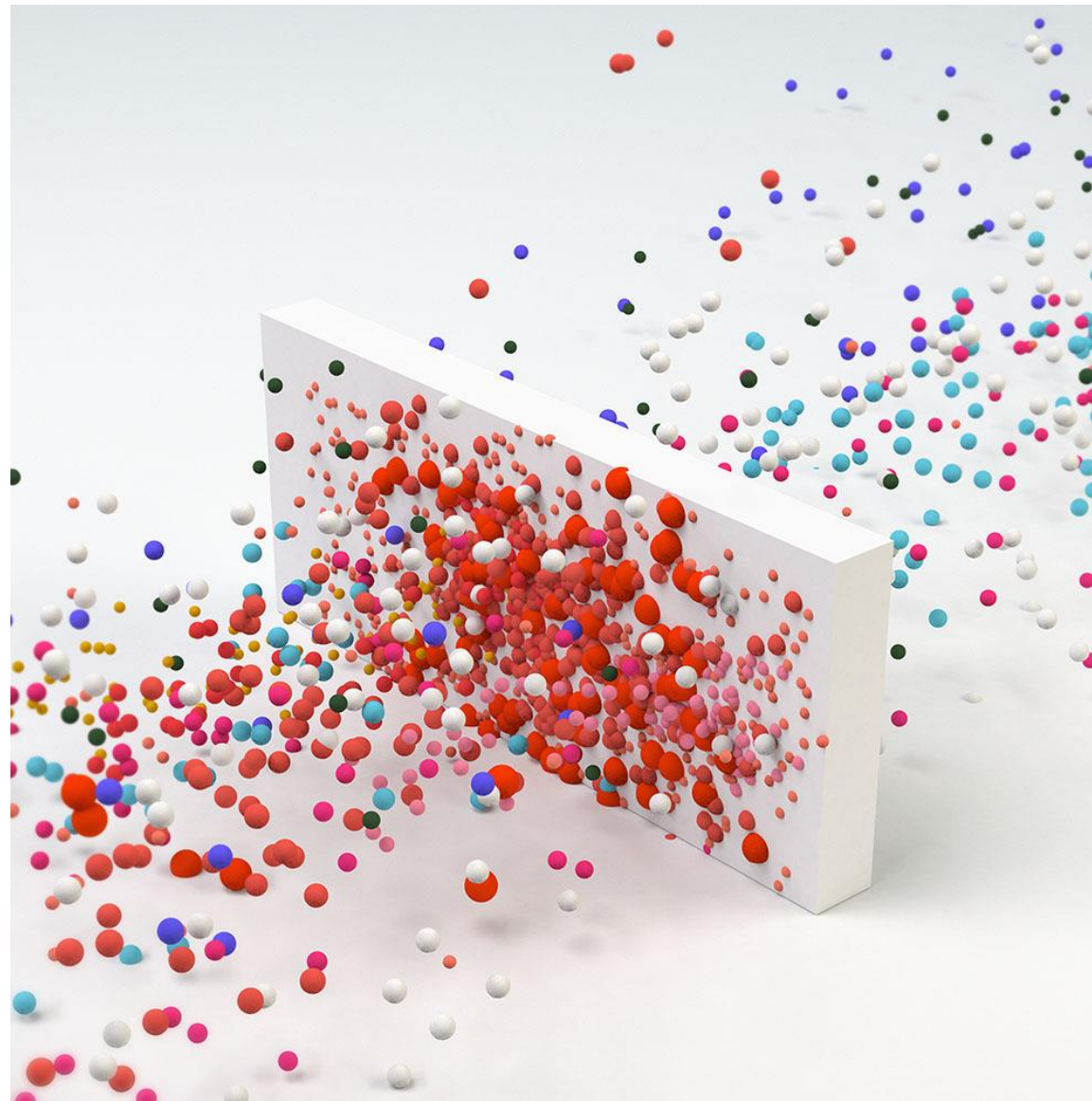


**Birefringence**



# QUANTUM PROPERTIES

- Quantization and Tunneling
- Superposition
- Entanglement
- Parallelism



Tunneling

Ref. Quantum made simple

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



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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.



# QUANTUM TECHNOLOGY “PUSH”



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ENVIRONMENT

# 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



# ENVIRONMENTAL NEEDS “PULL”

# ENVIRONMENT NEED

QUANTUM PROPERTY

Parallelism

Entanglement

Superposition

Quantization & Tunneling

Greenhouse Gases

Tree Health

Credit Trading

Energy Efficient Materials

Optimization for Power Grids

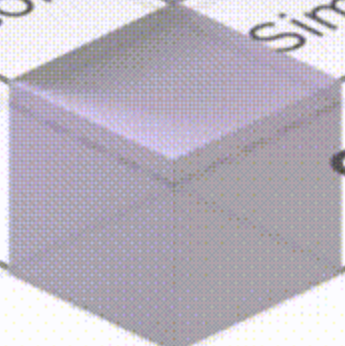
Sensing

Communication

Simulation

Computation

QUANTUM MODALITY



# QUANTUM ETHICS PROJECT

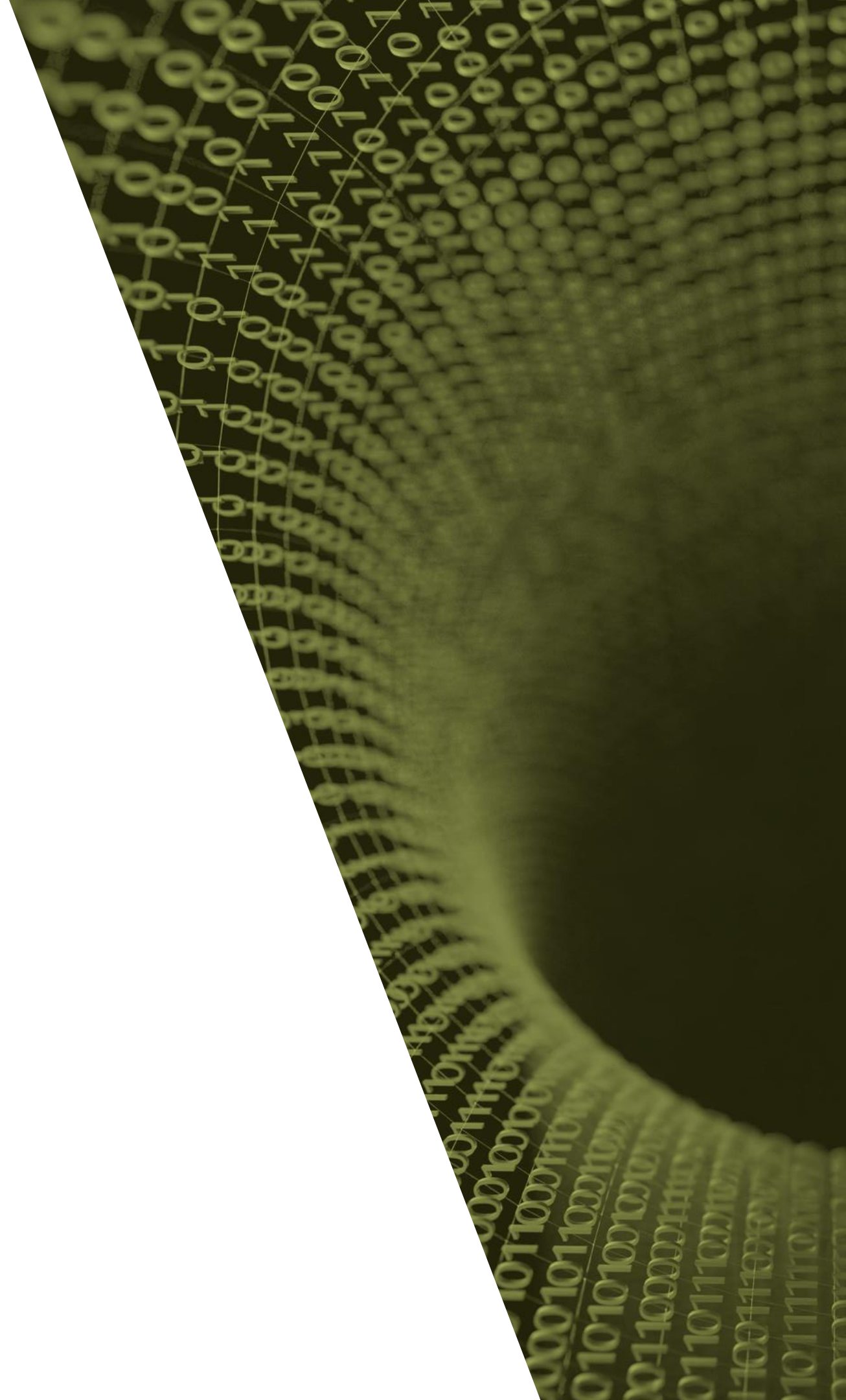


**QUANTUM ETHICS**  

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**PROJECT**

[quantumethicsproject.org](http://quantumethicsproject.org)



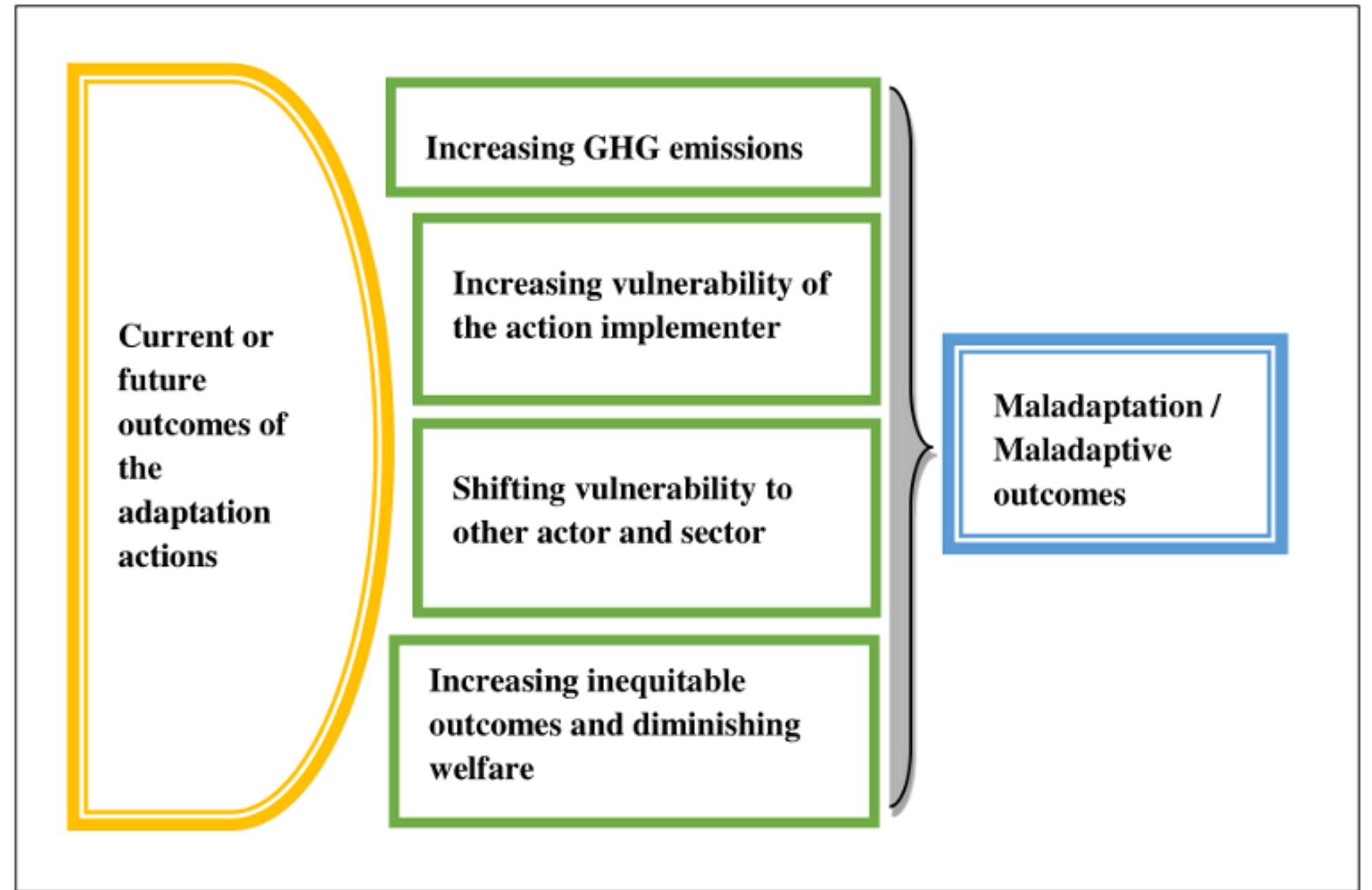
# HIPPOCRATIC OATH FOR SCIENTISTIS

"I promise to work for a better world, where science and technology are used in socially responsible ways. I will not use my education for any purpose intended to harm human beings or the environment. Throughout my career, I will consider the ethical implications of my work before I take action. While the demands placed upon me may be great, I sign this declaration because I recognize that individual responsibility is the first step on the path to peace."

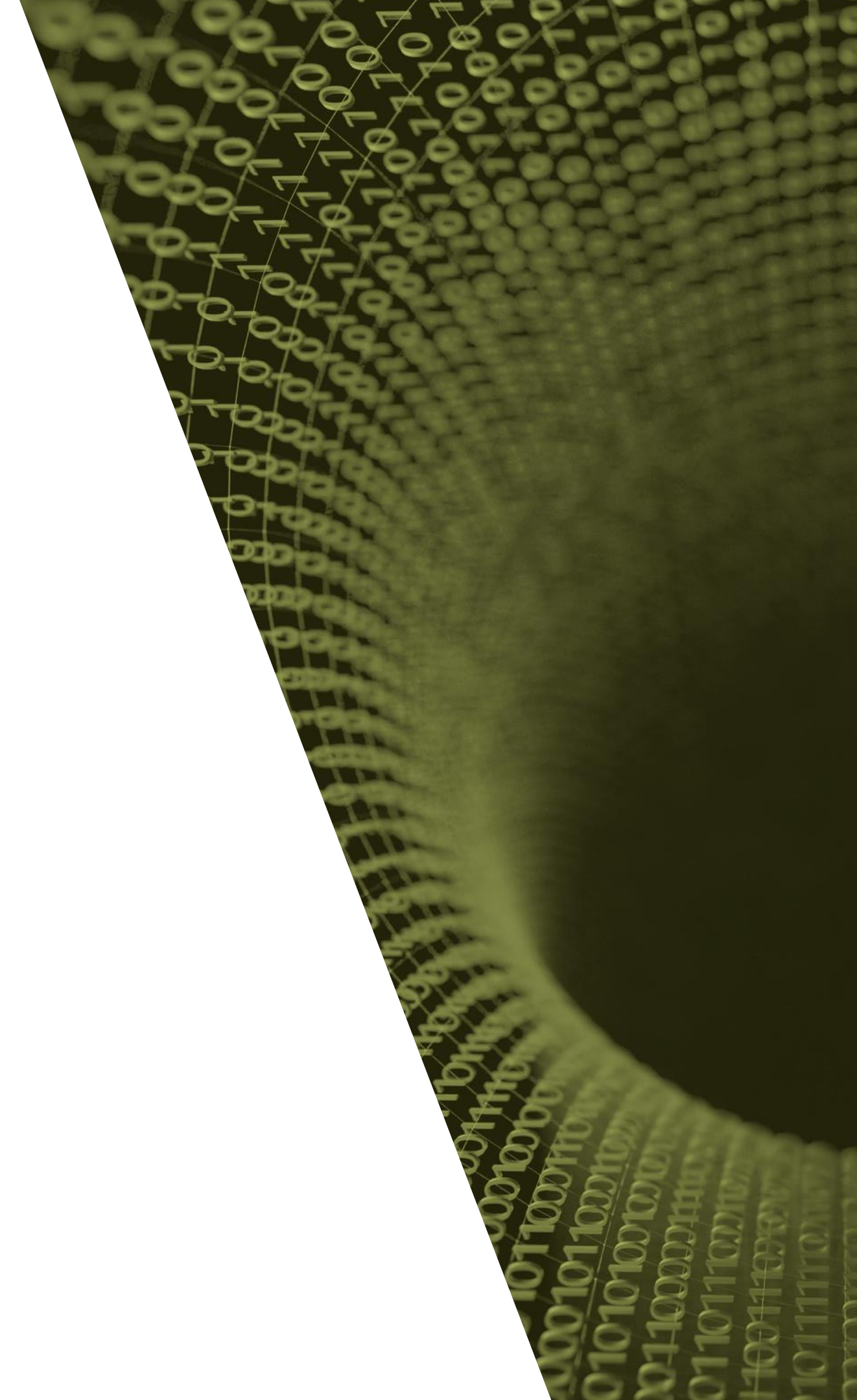
*Sir Joseph Rotblat, Science Editorial, 1999*



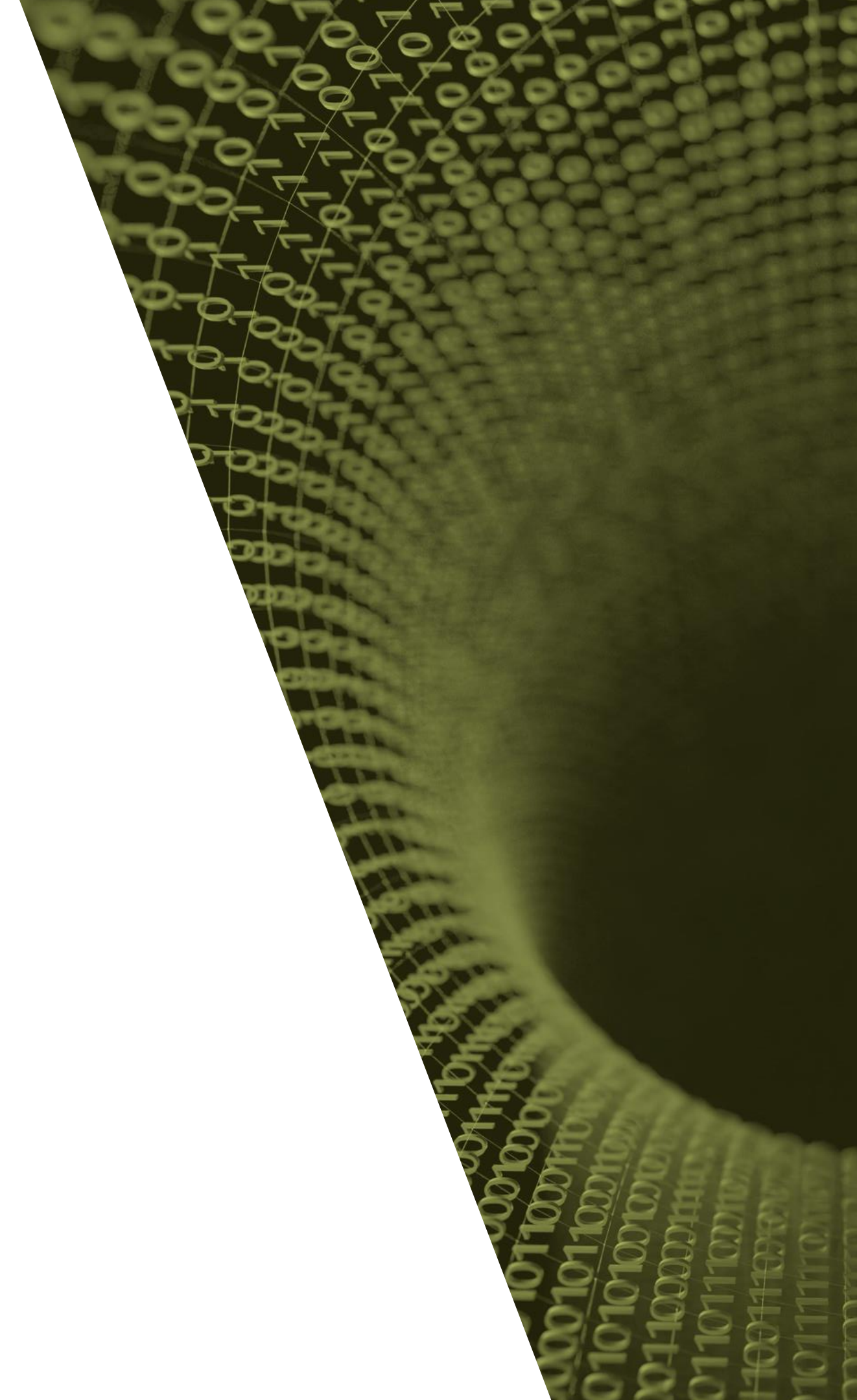




**Quantum ethics  
starts with you!**



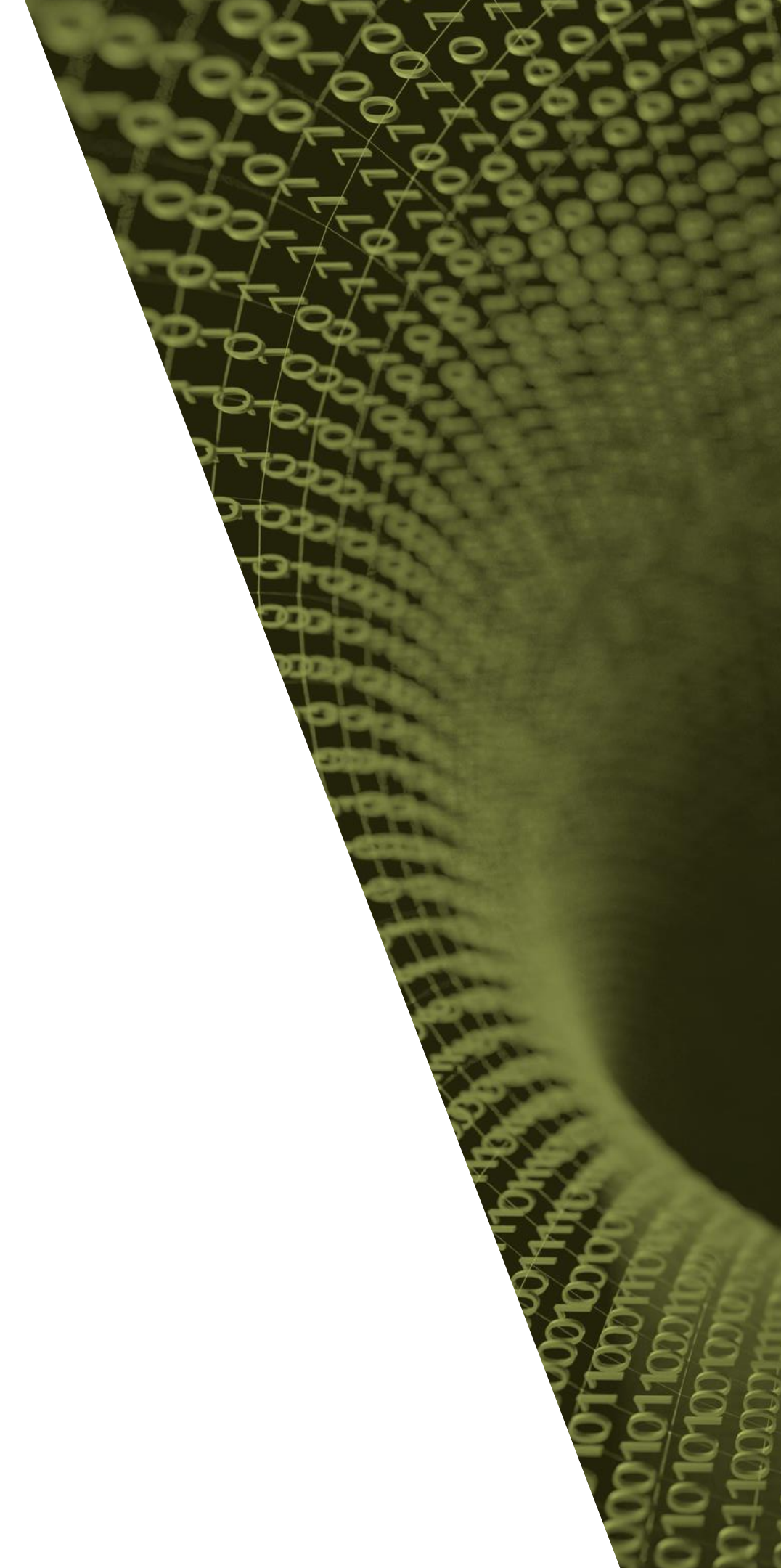
# TIME TO DISCUSS



# ROUNDTABLE DISCUSSION

## Round 1: Introduction and Exploration

- Introduce yourself and any background or prior interest in quantum technology or environmental challenges.
- Share what brought you to this event today.



# WHITEBOARD ACTIVITY

## Round 2: Opportunities Identification

- Choose an environmental challenge from the whiteboards around the room.
- In small groups, discuss if/how quantum technology could address the identified challenge.
- Consider: Can quantum provide unique solutions unavailable through existing industries/technologies? Can quantum provide these solutions in a timely and equitable manner?

# NEXT STEPS



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ENVIRONMENT

## 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](https://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.

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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.



Visit [tqt.uwaterloo.ca/q4e](https://tqt.uwaterloo.ca/q4e)

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



[tqt.uwaterloo.ca/q4e](https://tqt.uwaterloo.ca/q4e)



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Upgrade Plan

Threads

Later

Drafts & sent

Canvases

Slack Connect

Files

More

Starred

# general

Channels

# articles

# funding

# random

+ Add channels

Direct messages

TQT you

Indrani Ray

Nick Cheng

ogulsayi

Sreesh

Wilson Zhou

Zelda Brown

+ Add coworkers



# articles ▾



Monday, August 21st ▾



TQT 12:11 PM

[https://isr.nyas.org/events/world-banks-measuring-development-mitigating-the-risks-\[...\]impacts-of-climate-change/?mc\\_cid=45ae6aebf1&mc\\_eid=63a48988e0](https://isr.nyas.org/events/world-banks-measuring-development-mitigating-the-risks-[...]impacts-of-climate-change/?mc_cid=45ae6aebf1&mc_eid=63a48988e0)

Thursday, August 24th ▾



TQT 1:15 PM

Quantum Sensing for Energy Applications: Review and Perspective

<https://onlinelibrary.wiley.com/doi/full/10.1002/qute.202100049> (edited)

Monitoring Methane Emissions from Oil and Gas Operations:

<https://journals.aps.org/prxenergy/pdf/10.1103/PRXEnergy.1.017001>

Monday, August 28th ▾



TQT 1:13 PM

Quantum technologies for climate change: Preliminary assessment

<https://arxiv.org/abs/2107.05362>

Quantum Computing Opportunities in Renewable Energy

<https://link.springer.com/article/10.1007/s42979-021-00786-3>

Quantum computing in power systems

<https://ieeexplore.ieee.org/document/9831167>

Quantum computing for smart grid applications

<https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/gtd2.12602>

QuEnergy: Exploring the role of quantum computing for the electric grid

<https://quantumconsortium.org/quenergy22/>

arXiv.org

Rich text editor toolbar: Bold, Italic, Underline, Link, Bulleted list, Numbered list, Indent, Code, Undo

Message #articles

+ Aa 😊 @ 📎 🗑️



# IMPORTANT DATES

Q4Environment Design Submissions Due: February 2024

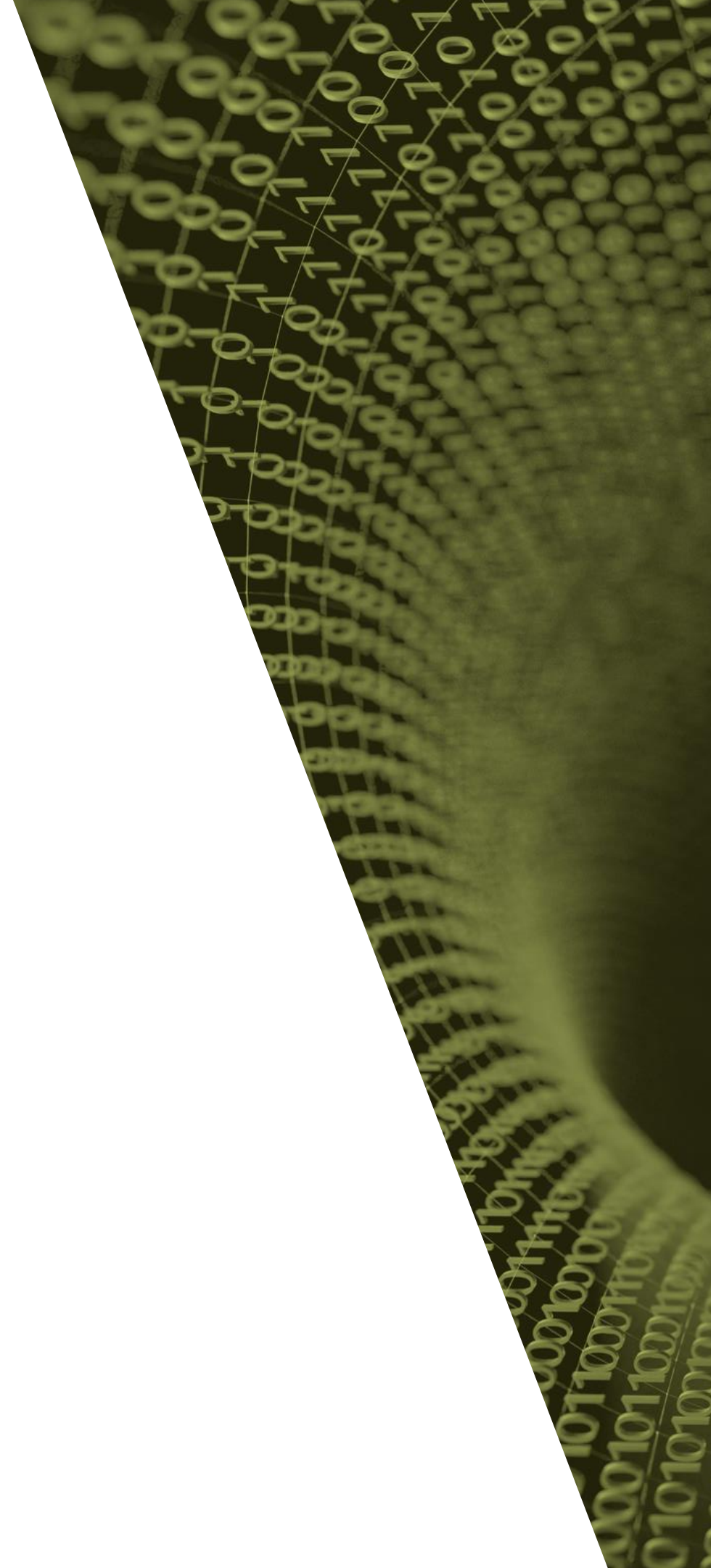
Q4Environment Awards Announced:  
March 2024

# NEXT STEPS



## Social Innovators in Training

- Know your innovative self
- Stakeholder discovery plan
- Ideation and prototyping
- Testing your idea
- Storytelling for social impact
- Engaging with funders
- Government relations
- Pitching your idea
- Social Impact Showcase



# NEXT STEPS



# SHARE WITH THE ROOM

## Round 3: Idea Sharing + Pitch

- What is one quantum technology or environmental challenge that you are interested in or passionate about?
- Pitch to the room – what are you looking for today? Team members for a design challenge? Mentorship? People with expertise in x, y, z?