

Quantum For Health

Launch Event

Case Study Presenters



Mohammad
Kohandel



Raffi
Budakian



Michael
Reimer



Michal Bajcsy



Jelena
Mirkovic



Subha
Kalyaanamoorthy



Connor
Kapahi



Troy
Borneman



Mohammad Kohandel

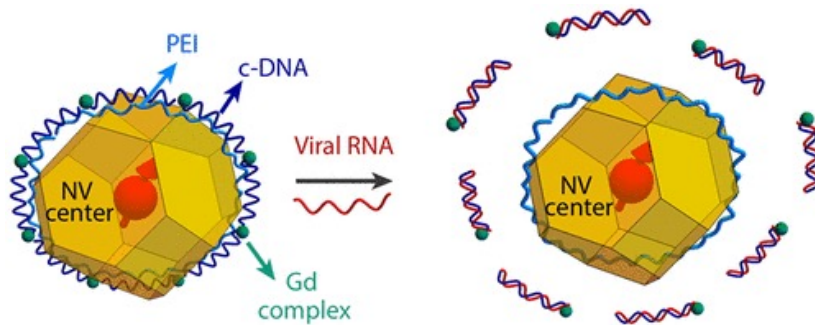
kohandel@uwaterloo.ca

Professor
Department of Applied Mathematics,
University of Waterloo

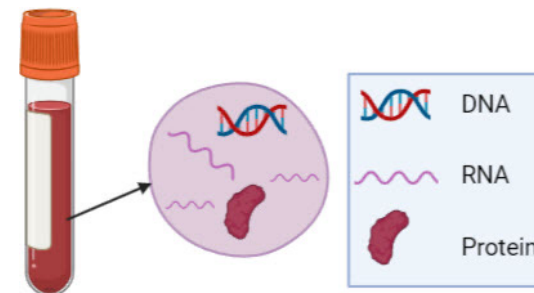
Biomedical applications of quantum sensors (M. Kohandel, UW)

Quantum sensors have provided an incredible opportunity to build powerful tools for biomedical diagnostics, including **virus detection**, **early cancer detection**, and **personalized medicine**!

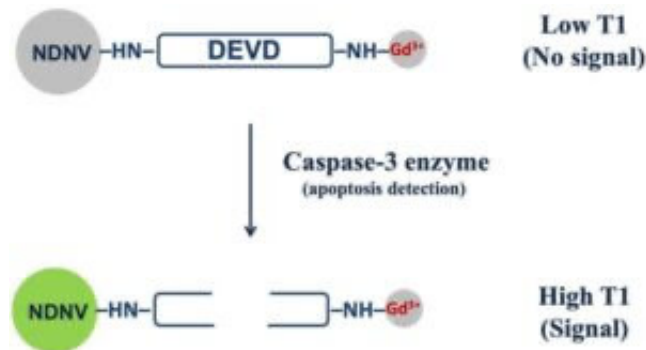
SARS-CoV-2 Quantum sensor based on nitrogen-vacancy centers in diamond (Li et al. 2021).



Genetic material from a cancerous tumour is detected in the blood.



Quantum nanodiamond sensors can be used as optical sensors and drug delivery probes for chemotherapy.





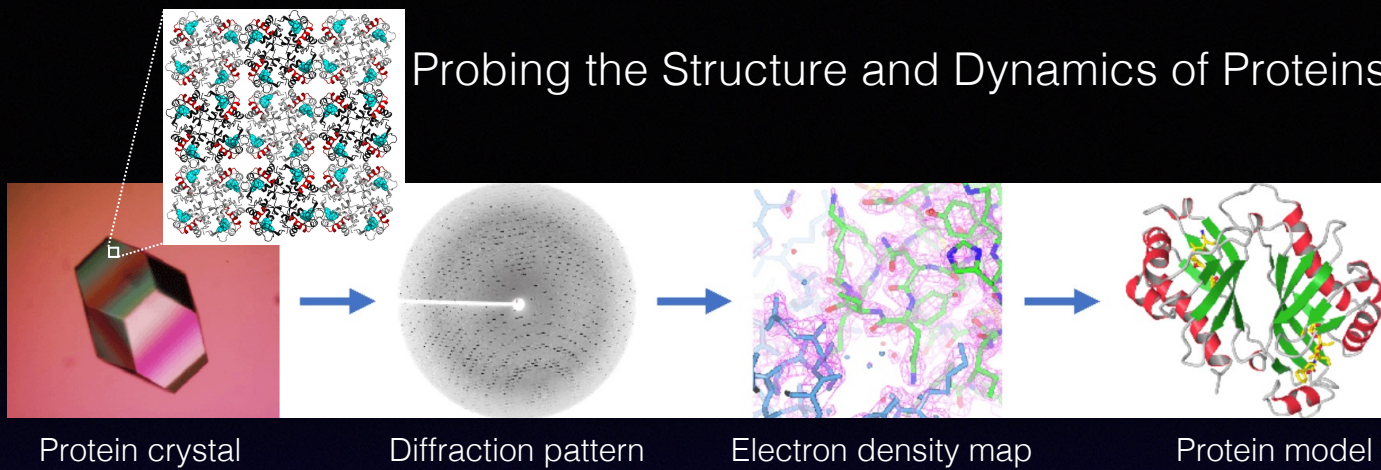
Raffi Budakian

rbudakian@uwaterloo.ca

Professor

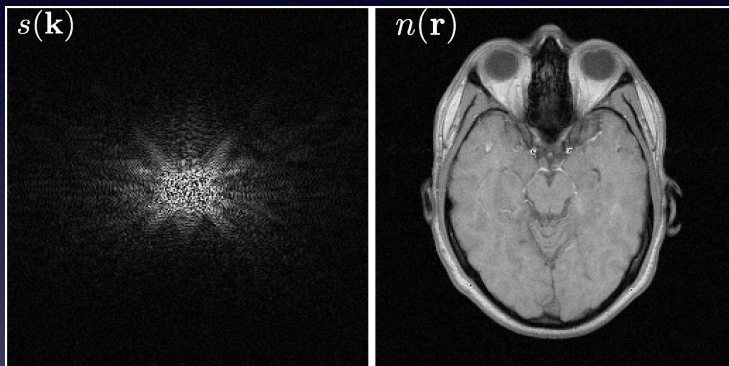
Department of Physics and Astronomy,
University of Waterloo

Probing the Structure and Dynamics of Proteins at the Atomic Scale with MRI

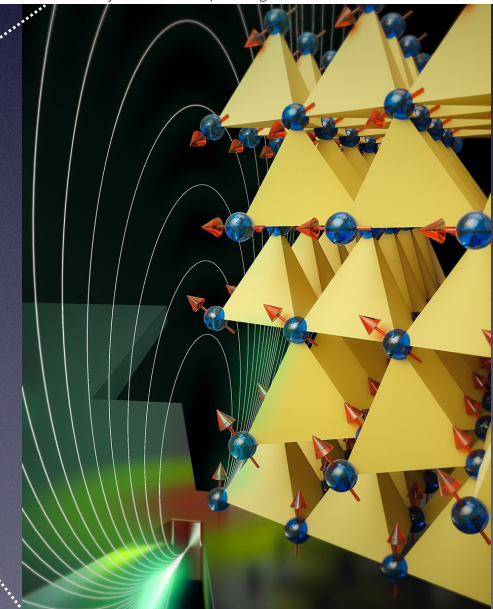
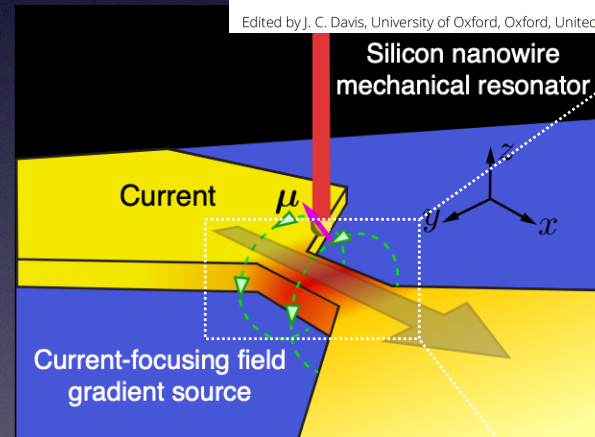
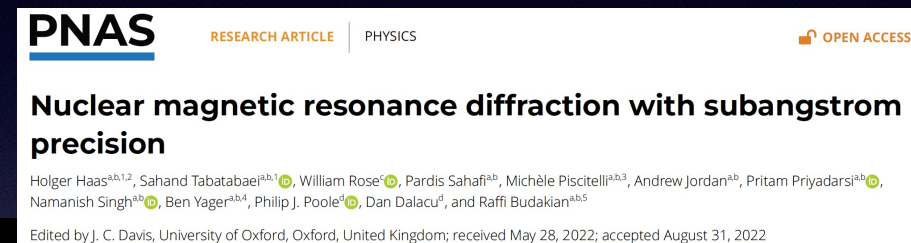


- ✦ X-ray diffraction is the most widely-used technique for protein structure determination

MRI



- ✦ NMR diffraction (NMRd) was first proposed by Mansfield and Grannell to extend the Fourier imaging capabilities of MRI to the atomic scale.
- ✦ NMRd—phase-sensitive, chemically-selective, and non-destructive technique to measure the structure of crystalline materials utilizing the spectroscopic capabilities of NMR.



- ✦ Our work focuses on the application of NMRd to study the structure and dynamics of nano-crystalline materials, e.g., protein nanocrystals, with potential applications to structural biology.



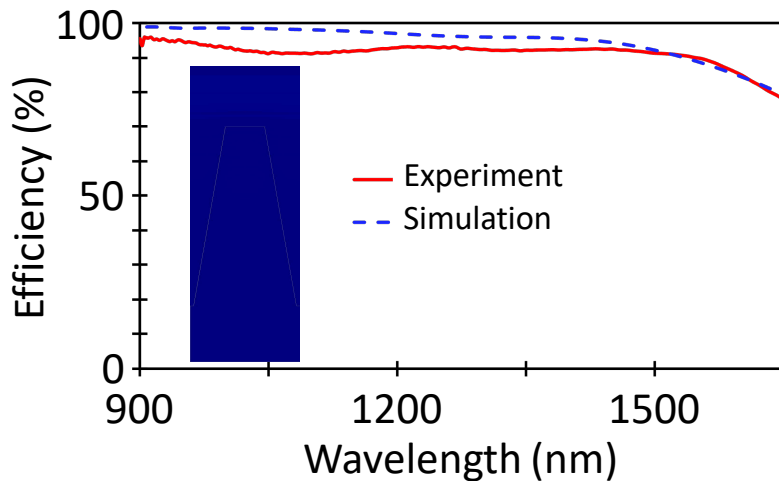
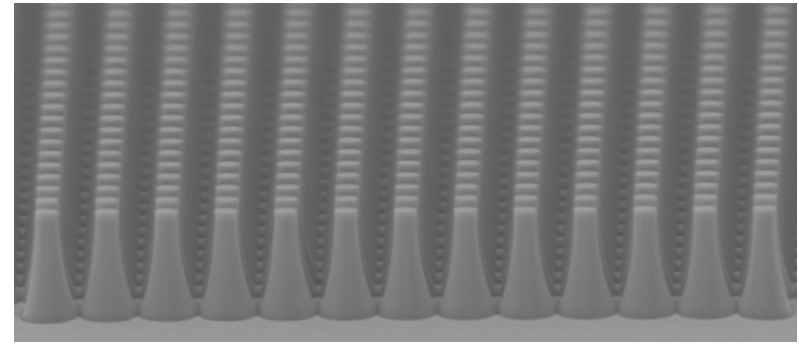
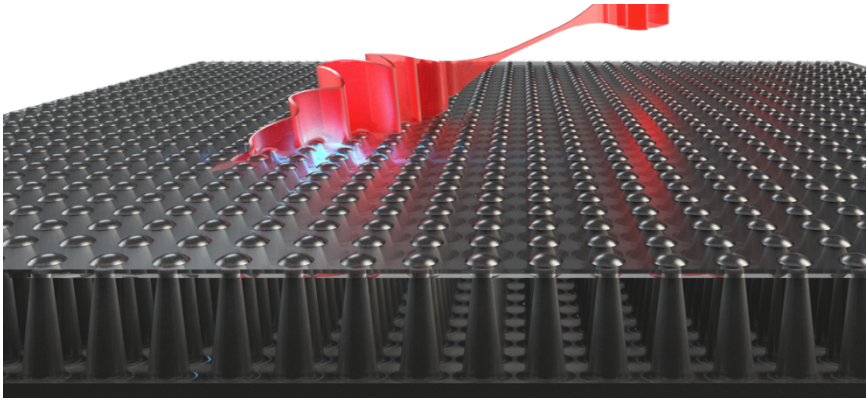
Michael Reimer

mreimer@uwaterloo.ca

Associate Professor
Department of Electrical and Computer
Engineering, University of Waterloo

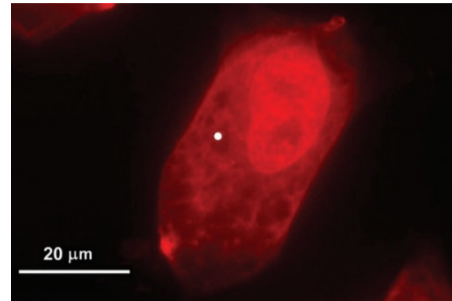
Quantum sensing for health

TQT Transformative Quantum Technologies



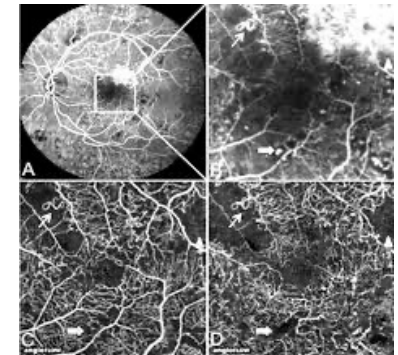
B. Tekcan *et al.*, *Sci. Rep.* **12**, 9663 (2022)

Dose monitoring for cancer treatment



P.R. Ogilby, *Chem. Soc. Rev.* **39**, 3181-3209 (2010)

Eye imaging using OCT



Courtesy of K. Bizheva
UWaterloo Physics



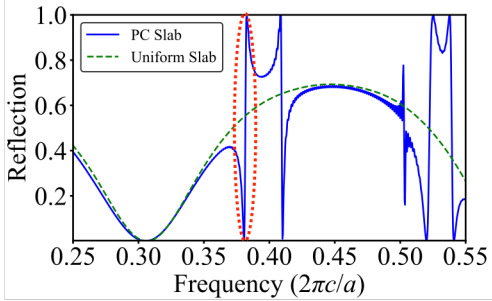
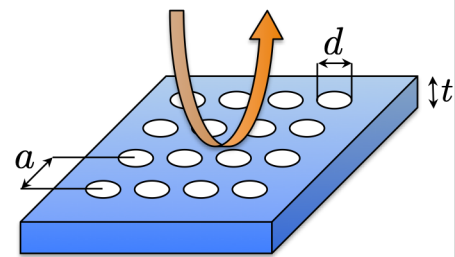
Michal Bajcsy

mbajcsy@uwaterloo.ca

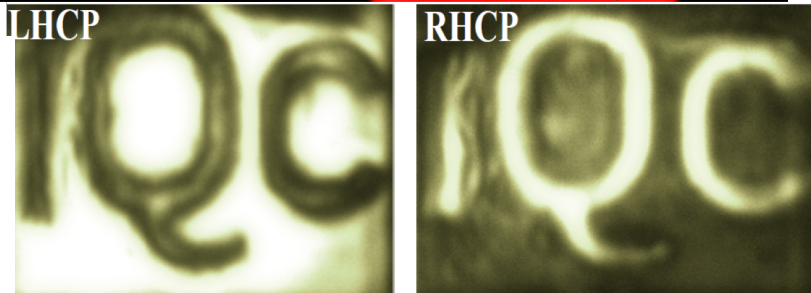
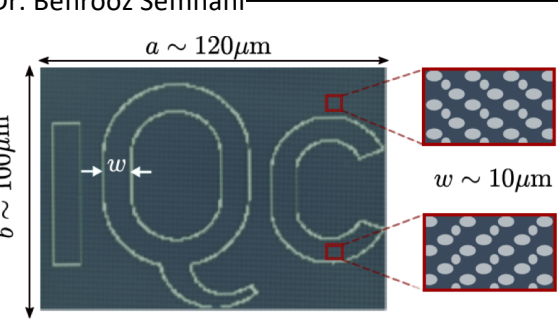
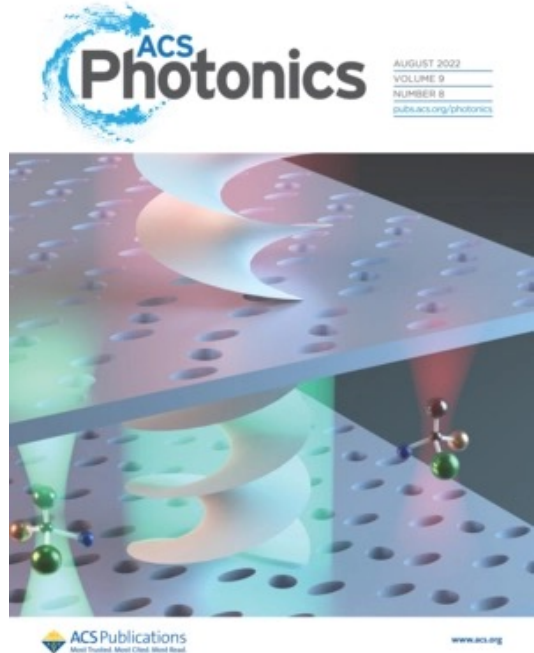
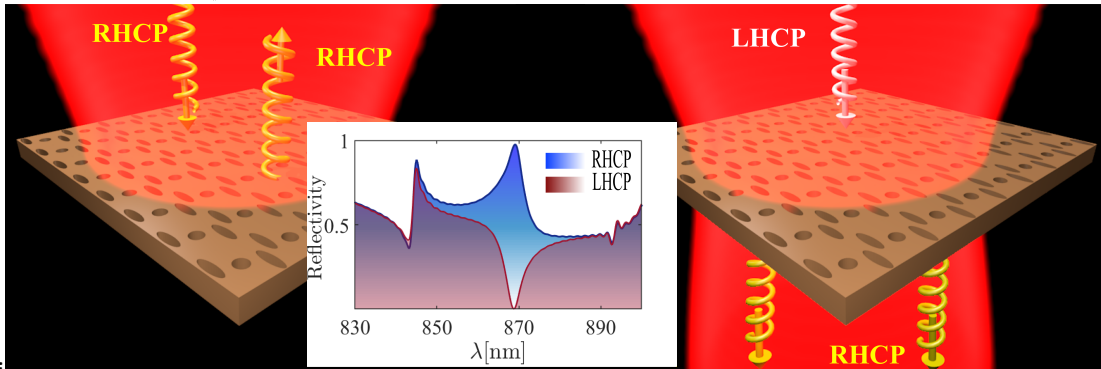
Associate Professor
Department of Electrical and Computer
Engineering, University of Waterloo

Polarization-dichroic mirrors for circularly polarized light

... photonic-crystal slabs as mirrors:



Dr. Behrooz Semnani



Light: Science & Applications 9, 1-12 (2020)

... possible application: optical resonators for enhanced detection of chiral molecular isomers (w/ specific handedness) for *enantiopure medications*

Michal Bajcsy (<https://npqo.weebly.com>)



Jelena Mirkovic

jelena.mirkovic@sunnybrook.ca

Assistant Professor
Department of Laboratory Medicine &
Pathobiology - Anatomic Pathology,
University of Toronto



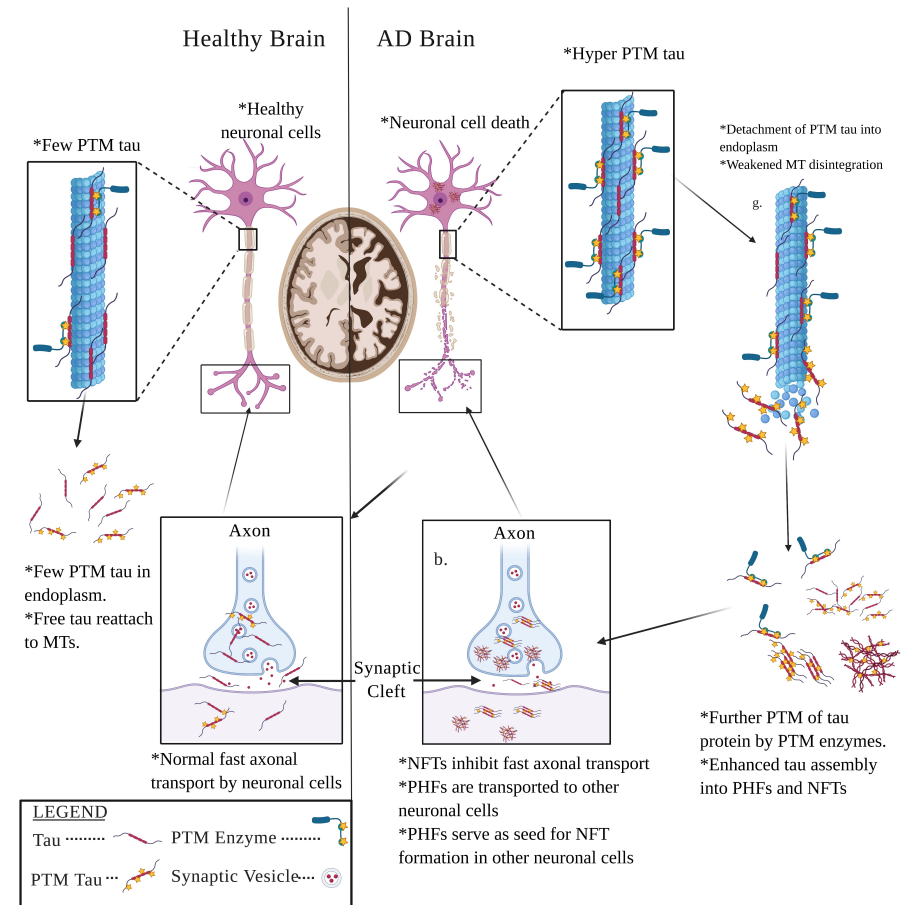
Subha
Kalyaanamoorthy
subha.kalyaanamoorthy@uwaterloo.ca

Assistant Professor
Department of Chemistry, University of
Waterloo

Q4Health

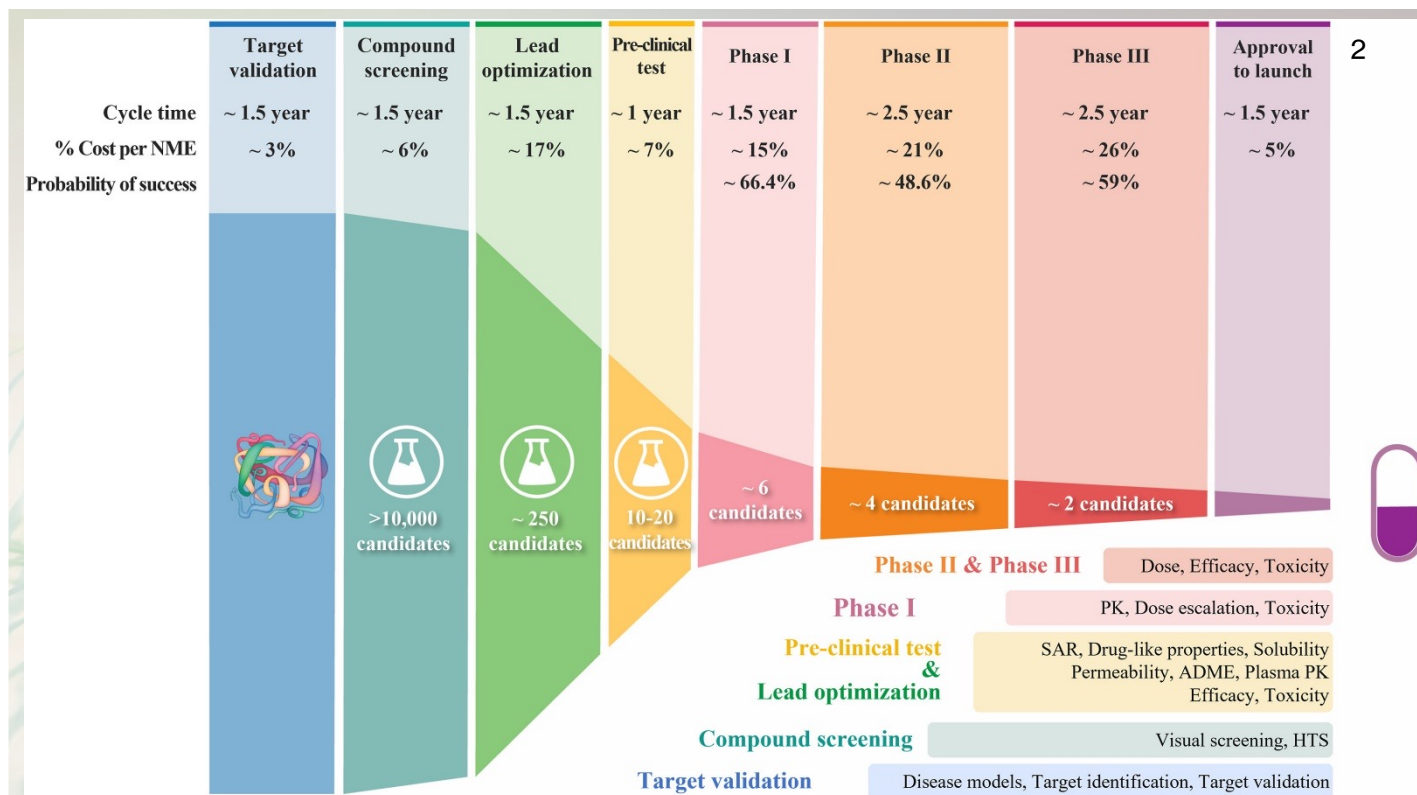
- By 2050, nearly 2 million Canadians could be living with some form of dementia¹.

Can we develop quantum-based materials as specific diagnostics and therapeutics for neurodegeneration?



¹Navigating the path forward for dementia in Canada-Report 1-Alzheimer's society of Canada. 2022

Q4Health



Can quantum technologies help in efficient screening of drug candidates?



Connor Kapahi

c3kapahi@uwaterloo.ca

PhD Student
Institute for Quantum Computing,
University of Waterloo

Quantum Technologies

Applied to

Vision Healthcare



Problem Statement

- Macular Degeneration is a leading cause of blindness
- No effective treatment



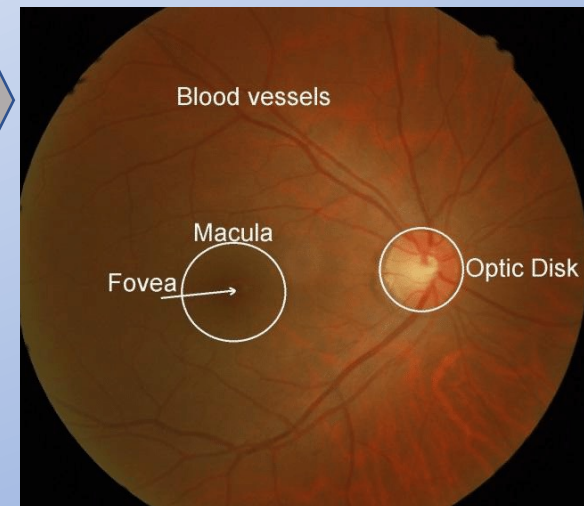


Problem Statement

- Macular Degeneration is a leading cause of blindness
- No effective treatment

Macular Properties

- Activities like reading require the high-resolution vision of the macula
- The macula acts as a weak polarizer of light





Problem Statement

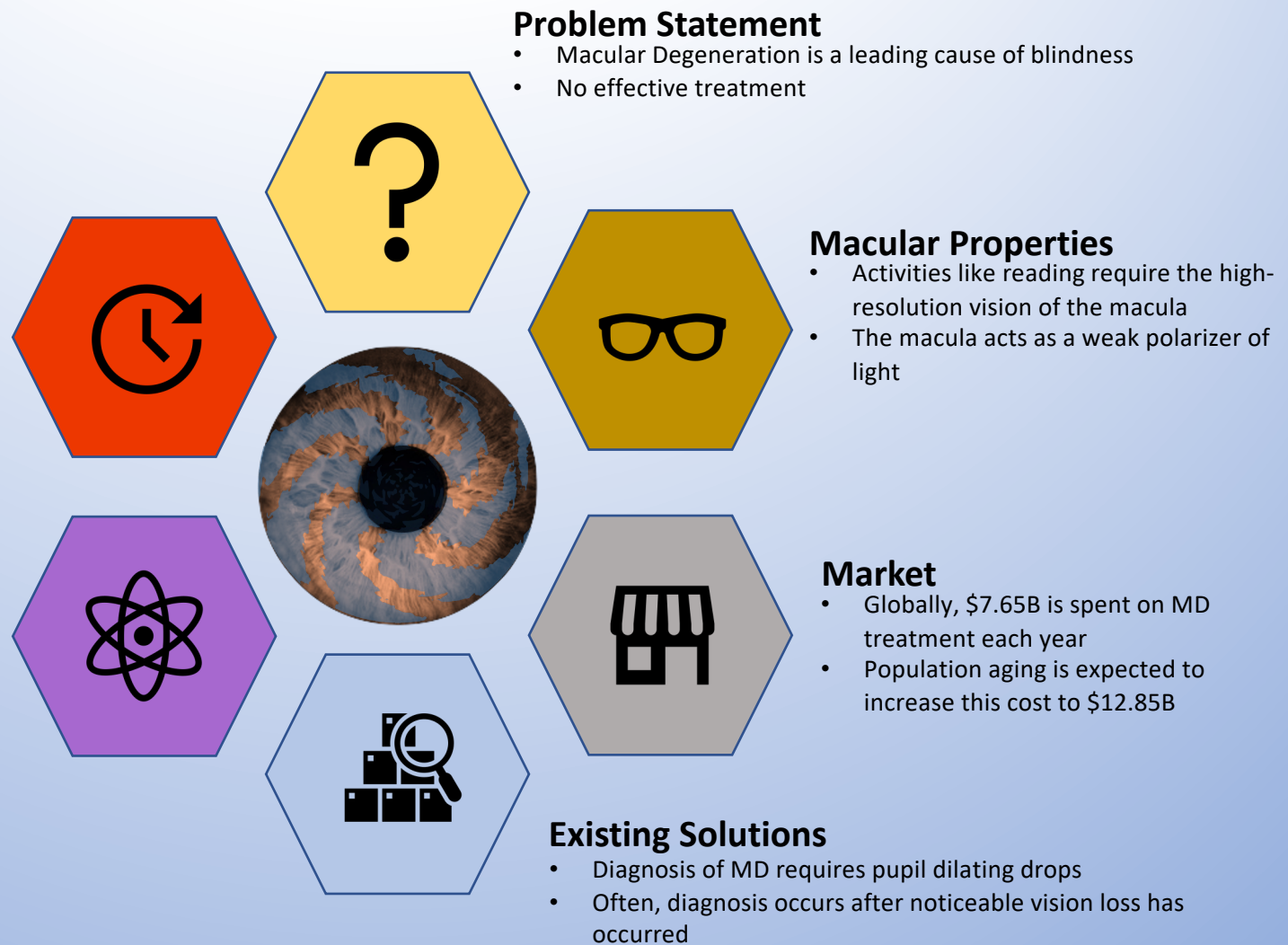
- Macular Degeneration is a leading cause of blindness
- No effective treatment

Macular Properties

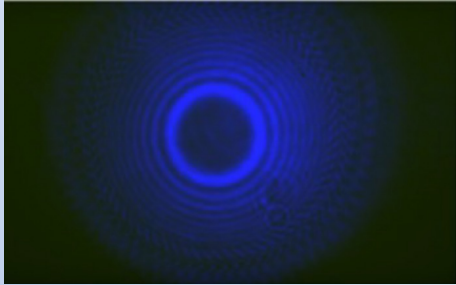
- Activities like reading require the high-resolution vision of the macula
- The macula acts as a weak polarizer of light

Market

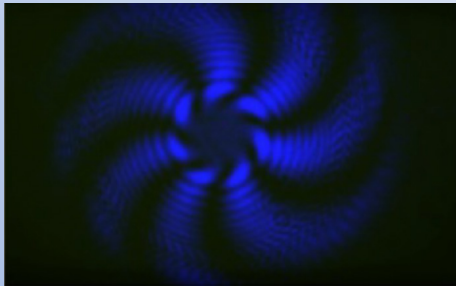
- Globally, \$7.65B is spent on MD treatment each year
- Population aging is expected to increase this cost to \$12.85B



Without Polarizer



With Polarizer



Quantum Opportunities

- Structured waves are used in quantum information processing
- Polarization structures can be created by combining structured wave of different polarization states
- Structured light can be tailored to investigate the macula or other regions of the retina

Problem Statement

- Macular Degeneration is a leading cause of blindness
- No effective treatment

Macular Properties

- Activities like reading require the high-resolution vision of the macula
- The macula acts as a weak polarizer of light

Market

- Globally, \$7.65B is spent on MD treatment each year
- Population aging is expected to increase this cost to \$12.85B

Existing Solutions

- Diagnosis of MD requires pupil dilating drops
- Often, diagnosis occurs after noticeable vision loss has occurred



Outlook

- What disorders can be investigated with structured light?
- How can a structured light device be integrated in vision health clinics?
- Who is willing to pay for early diagnostics of retinal disorders?

Quantum Opportunities

- Structured waves are used in quantum information processing
- Polarization structures can be created by combining structured wave of different polarization states
- Structured light can be tailored to investigate the macula or other regions of the retina

Problem Statement

- Macular Degeneration is a leading cause of blindness
- No effective treatment

Macular Properties

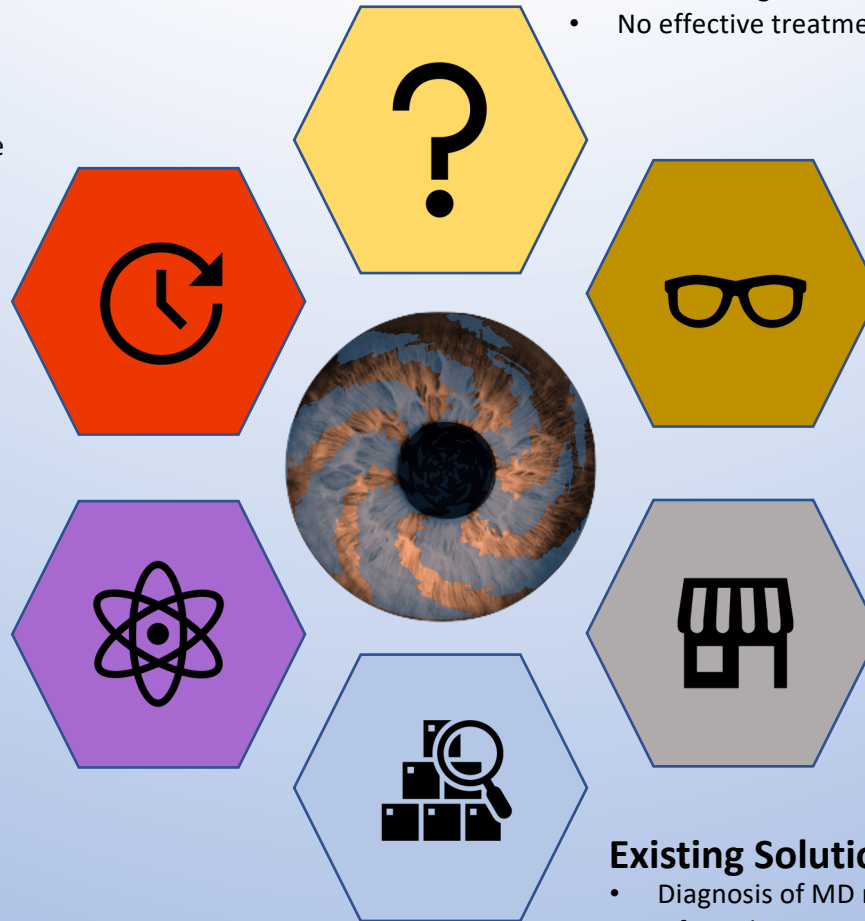
- Activities like reading require the high-resolution vision of the macula
- The macula acts as a weak polarizer of light

Market

- Globally, \$7.65B is spent on MD treatment each year
- Population aging is expected to increase this cost to \$12.85B

Existing Solutions

- Diagnosis of MD requires pupil dilating drops
- Often, diagnosis occurs after noticeable vision loss has occurred





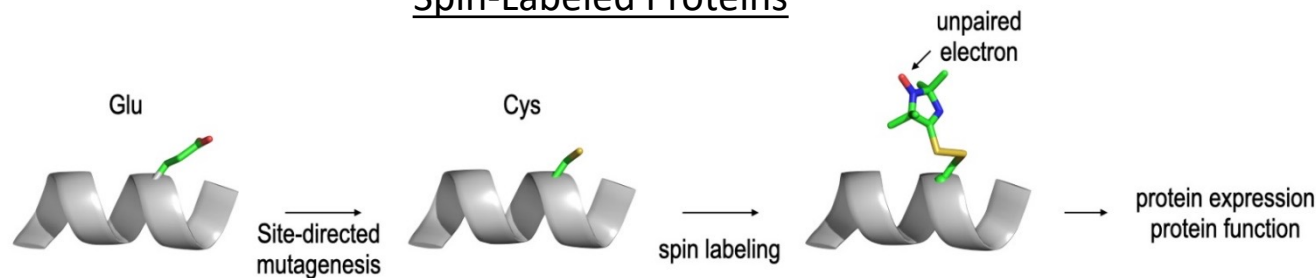
Troy Borneman

troy.borneman@highqtechnologies.com

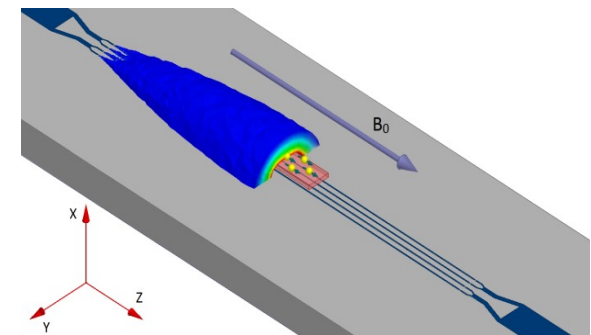
Senior Scientist
High Q Technologies

Superconducting Quantum Sensors for Protein Biophysics

Spin-Labeled Proteins



Superconducting Resonator (Sensor)



Dipolar Distance Measurement for Protein Conformational Changes

