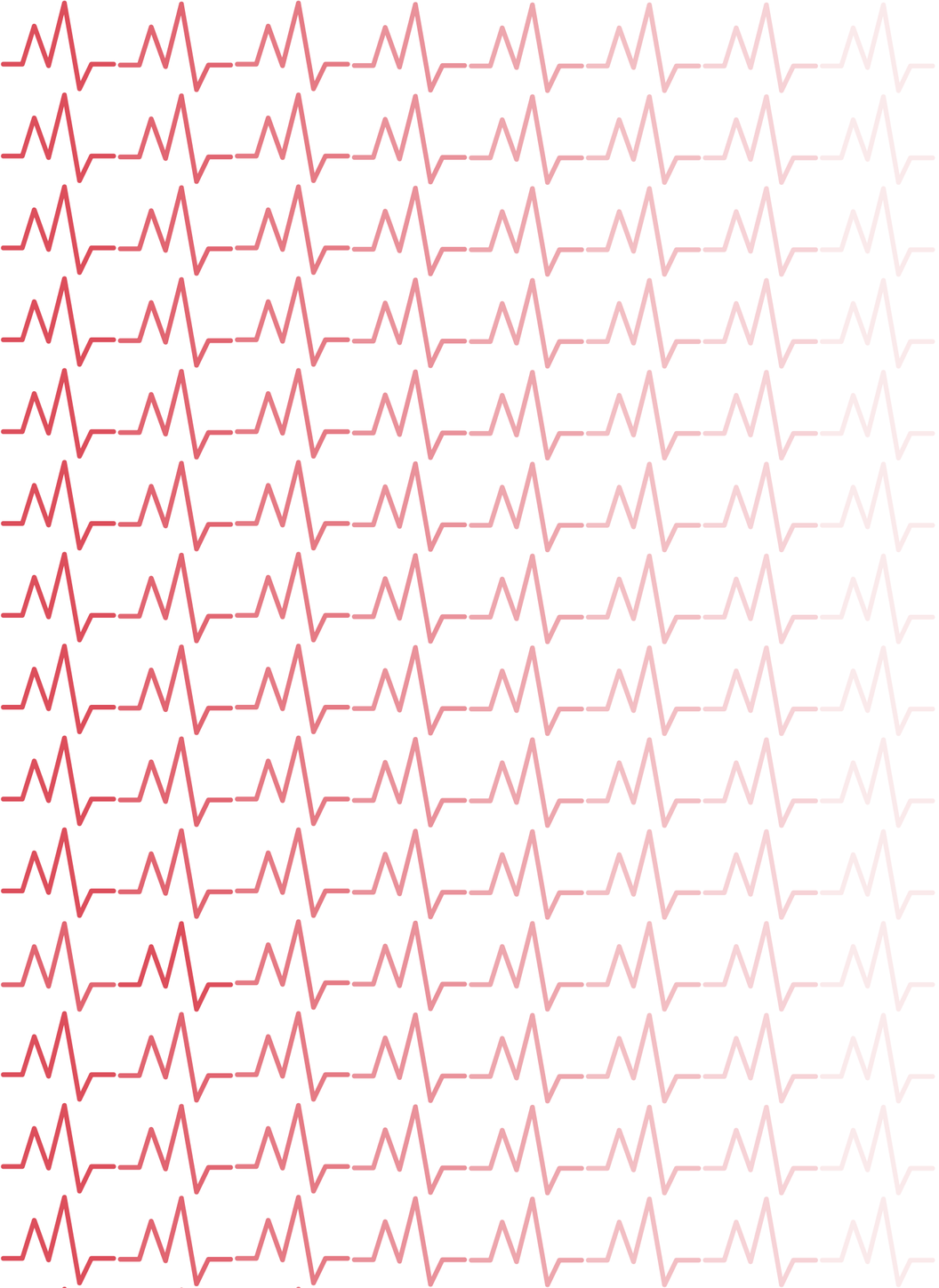

Quantum For Health Launch Event

Brainstorm session

September 19, 2022

TQT Transformative Quantum Technologies

Q1- Quantum Sensing

1. Measure protein structure and dynamics with MRI
2. Field Sensing
    a. NVs- DNA Detection
    b. SQUIDS
        i. Brain activity imaging
        ii. YBCO for low resource settings
3. Single photon nanowires
4. Spin state control for chemical manipulation [H4-2]
5. Superconducting resonators
    a. ESR [H1-2]
6. Quantum Illumination
    a. Imaging [H7] [H2-1] [H5-2]
7. Nuclear spin in biological environment- detection/tracing? [H5, H1, H5-1]
8. NQR [H1-5]
9. X-Ray detector using Reimer's ideas

Q2- Quantum Communication

1. Encryption – QKD [H6-3]
2. Entanglement verification/state tomography
3. Quantum imaging- Dose monitoring [H4-2]
4. Tissue and fluid tests for screening & diagnostics – toxicology, spectroscopy
5. State manipulation
6. Quantum LIDAR
7. Entangling multiple quantum states into a single photon
8. Quantum teleportation protocols
9. Securely storing/ transmitting health records/ data
    a. Reduces probability of data leaks
10. Screening & diagnostics
11. Quantum repeater
12. High- dimensional encodings & measurements
13. Quantum effect in the brain functions- neuron communication [H5]

Q3- Quantum Simulation

1. Phonons: hearing aid
2. Of mental health/models of cognition/theory of learning [H5-4]
3. Light- matter interactions:
4. Photons + crystalline structures
    a. Photo- activated structures for energy acquisition: powering portable medical devices, e.g. hearing aid, glucose detector [H4]
    b. Artificial retina
5. Particle characterization/fluorescent markers, Laser induced incandescence (heat-induced emission)
    a. Infer-size from emission shape/composition
    b. Photons +Amorphous structures
        i. Scattering in tissues: deep-tissue imaging: brain+organs
    c. Photons + quasi-crystalline
6. Binding to particular particles/molecules for killing dangerous cells [H4-1]
7. Osmosis simulation with trace particles
8. Chirality simulation in molecular structures [H8]

Q3- Quantum Simulation (continued)

9. Sensing/Quantum -enhanced [H8]
    a. Phase transition/ Quantum phase transition
10. Critical systems: [H4-6]
    a. Draw analogy between QPT and critical phenomena in biology cancer onset epidemiology
11. Steady-state/eqiuilibrium properties vs out-of-equilibrium (time dynamics) e.g. chaotic behaviour in how drugs bind with receptors, retention of societies to disease (open quantum systems) [H1-1]
12. Networks + information diffusion in remote regions
13. Fake news in networks identification [H6]
14. Metabolism for health susceptibility to disease

Q4- Quantum Computing

1. Drug discovery/ molecule simulation
2. Data processing/diagnostics (QMC- Quantum Machine Learning)
3. Simulating Biological Processes [H5-1]
4. Healthcare resource distribution optimization
5. Population Health trends prediction

H1- Personalized Medicine, wearables, diabetes, metabolomics

1. Implement diagnostics into eyewear/footwear
2. Metabolites spectroscopy in urine (smart toilet) [Q1-5]
3. Increase access to dermatological screening with iPhone scope (extension) + diagnostic algorithm [Q3-9]
4. Magnetic resonance-based glucose monitor
5. Rapid/sensitive wrist band utilizing sweat to detect and diagnose exposure [Q1-8]
6. Improvements to sleep diagnostic devices/apps [Q1-7]

H2- Eye Health

1. Early-stage retinal Disorder Diagnosis [Q1-6]
2. OCT imaging of the eye to diagnose potentially blinding diseases [Q1-3]
3. AI classifiers for OCT imaging (QML) [Q4-2]
4. Navigation technologies for low vision patients
5. Optical aids for visually impaired patient
6. Securely transmit eye health data & images for remote review (telehealth)
7. Leveraging technology to offer a hybrid model of in-person & telehealth eye care
8. Imaging neural activity in the retina
9. Neurodegenerative disease- retinol proteins [Q1-6]

H3- Technology for Healthy Aging

1. Alert systems to the public for missing persons with dementia
2. Simple home biomarker tracking
3. Precise geolocation sensor (track fall or wandering of elders) [H1]
4. Medication monitoring (Dose adjustment, meds compliance) [H4]
5. Alert system for early warning biometric red flags [Q3-10]
6. Robotics (AI) for treatment and surgery
7. Early detection of cognitive decline, with population modelling (cognitive assessment tools)
8. Risk detection using population dynamics [Q4-5]
9. Nuclear medicine in Alzheimers (nuclear isotopes)
10. Early detection of Alzheimer's (3x Tg-AD) signs in retina

H4- Cancer diagnostics, pathology

1. Drug/cell receptor binding dynamics
    a. Look at naturally occurring variants [Q4-3]
2. Dose-monitoring for cancer treatment using efficient single-photon detectors [Q1-4]
3. Use structured light beams to study pathology samples to develop biomarkers of disease based on simultaneous information on optical activity, birefringence, etc.
4. Detect cancer using metabolisms of cells and biomarkers imbalance (early detection)
5. Using structured light to image the polarization field of retina (retinol neurodegeneration, AD, Melanoma) [Q3-3]
6. Detecting endometriosis in blood, serum
7. Improve endoscopic methods to diagnose pathologic changes
8. Analyze pathology digital slides [Q4-2]

H5- Brain Health and Function

1. Blood Brain Barrier Integrity + Neurodegenerative disease [Q1, Q4]
2. Amyloid protein identification in vivo [Q1]
3. Functional MRI- dynamics of brain
4. Non-invasive neuro-modulation [Q3]
5. Quantum effects in the brain (in biology).
    a. Effect of nuclear spin, especially in medicine (nuclear medicine), chiralities in drug design) [Q4-3] [Q3-8]
6. Quantum effects in biological environment- new technologies
7. Using data to diagnose mental disorder/illness

H6- Health in Low Resource Settings

1. Take advantage of high selectivity / low energy quantum sensing to transmit diagnostic imaging/date over low bandwidth connections [Q2]
2. Nunavut has increased depression- [Q2]
3. AI for remote care [Q4-2]
4. Low-cost diagnostic testing [H1-1]

H7- Imaging

1. Mode-selective measurement vs faster scanning [Q1-6]
2. NMR diffraction Angstrom scale [Q1]
3. In vivo imaging of sperm with QDs [Q1-7]
4. Live imaging of microrobots (magnetic, wireless) for in vivo applications
5. Online Image segmentation using quantum nanobiosensors

H8- Structural Biology, Pharmacology

1. Spectroscopy of chiral isomers enhanced by cavities with chiral mirrors
2. Protein characterization using EPR especially in membranes [Q3-3]
    a. Simulate, e.g. light-matter interactions for light-activated protein especially if protein can be described (simply) by a Hamiltonian
3. Proteinomics and genomics to develop climate change-resistant crops [Q3-11]

Summary