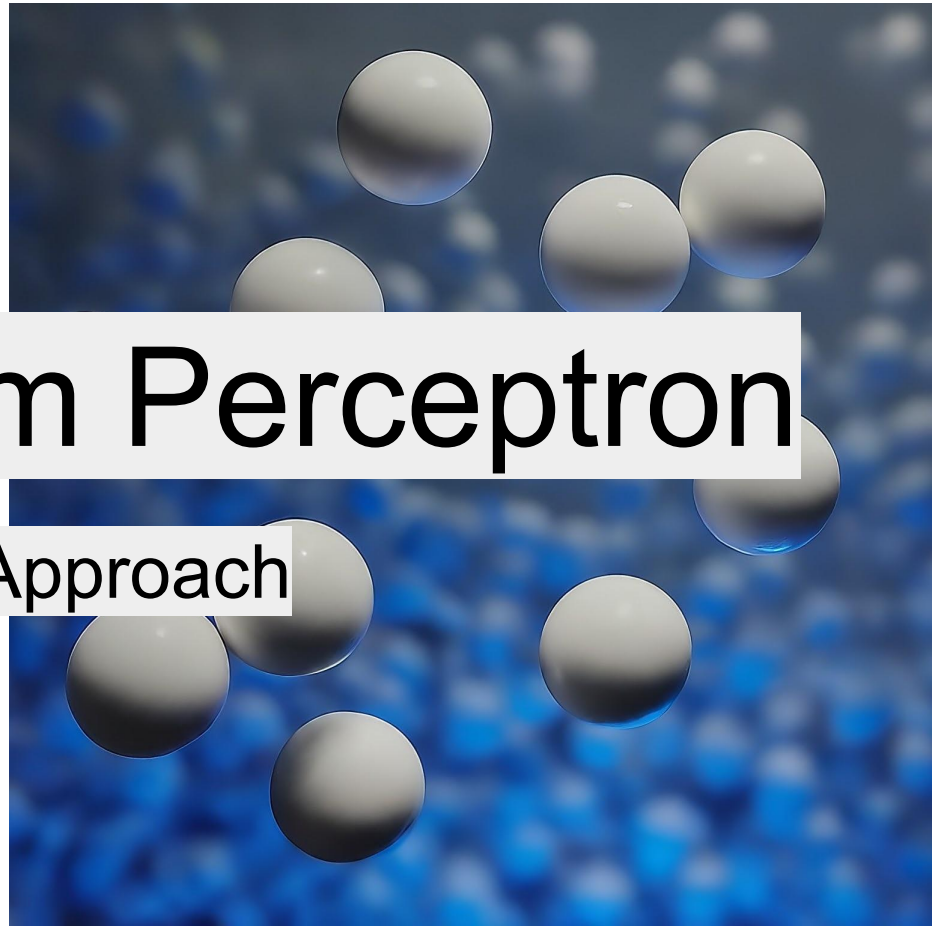
The Quantum Perceptron

A First Approach



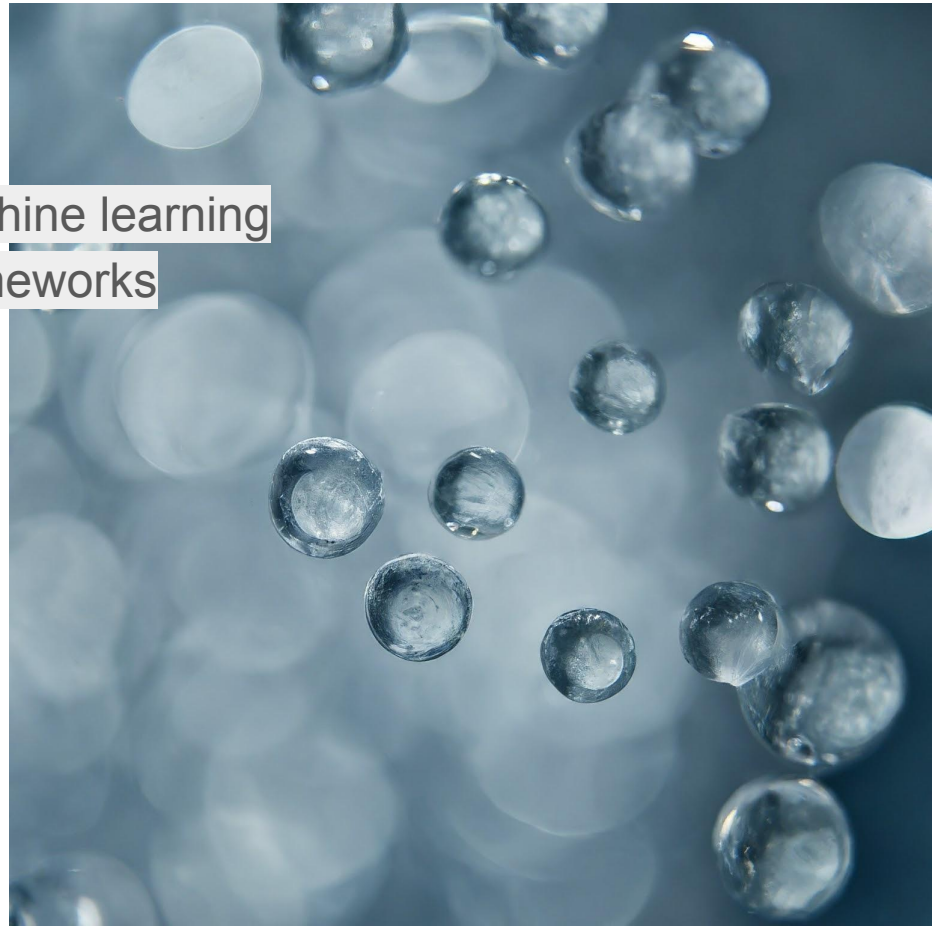
Literature Review

- Several papers on quantum machine learning
- Various quantum computing frameworks
- Quantum biology

Wiebe, Nathan, Ashish Kapoor, and Krysta Svore. "Quantum algorithms for nearest-neighbor methods for supervised and unsupervised learning." *arXiv preprint arXiv:1401.2142* (2014).

Ioffe, L. B., and M. V. Feigel'man. "Possible realization of an ideal quantum computer in Josephson junction array." *Physical Review B* 66, no. 22 (2002): 224503.

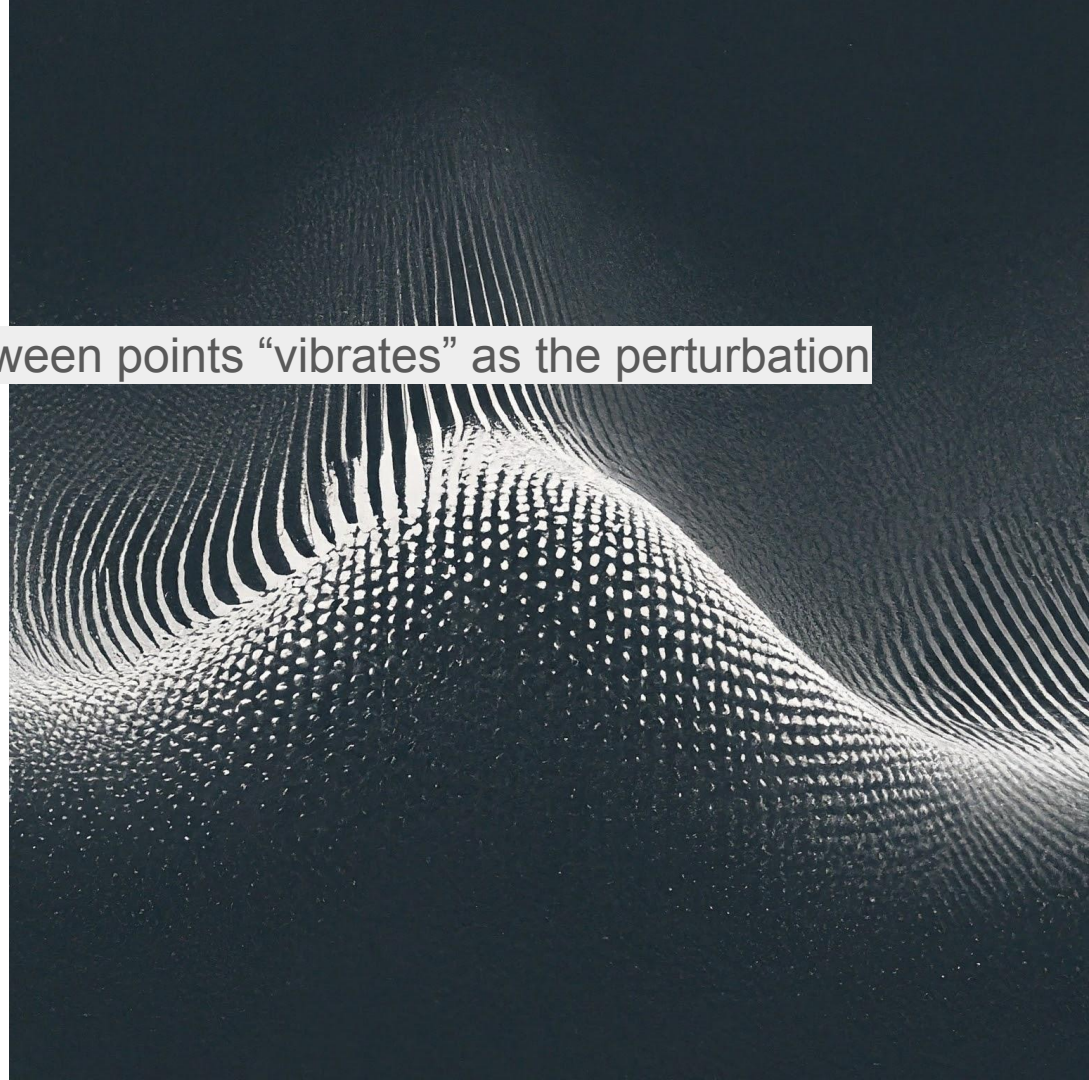
Mohseni, Masoud, ed. *Quantum Effects in Biology.* Cambridge: Cambridge University Press, 2014. https://doi.org/10.1017/CBO9780511863189.



Background on G-waves

- Metric perturbations
- Spatiotemporal separation between points “vibrates” as the perturbation crosses

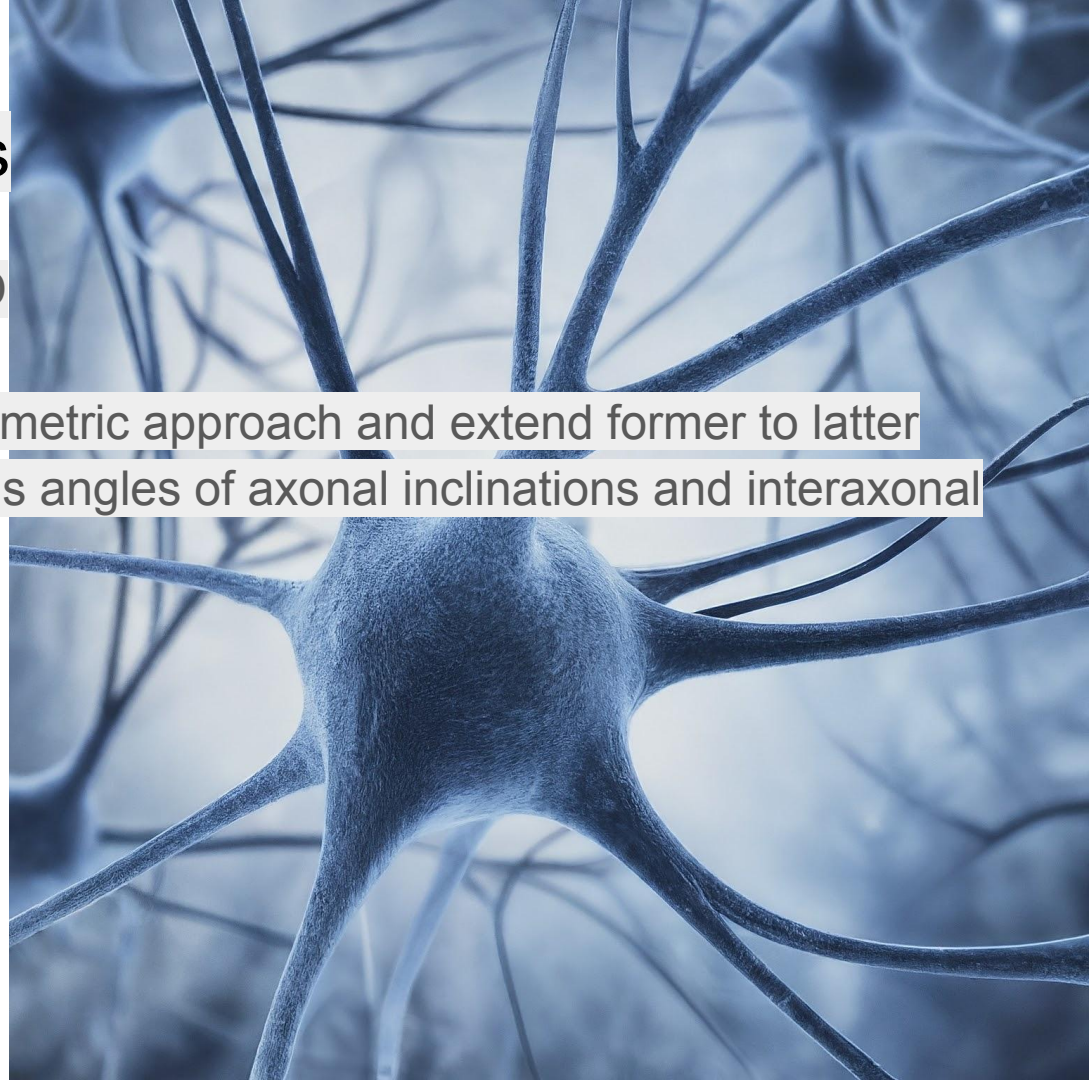
Barreto, W. O., J. A. Crespo, H. P. de Oliveira, and E. L. Rodrigues. 2018. “A Galerkin-Collocation Domain Decomposition Method: Application to the Evolution of Cylindrical Gravitational Waves.” *Class. Quantum Grav. 36 (2019) 215011*, January. doi:10.1088/1361-6382/ab4733.



Background on 3D Tracts

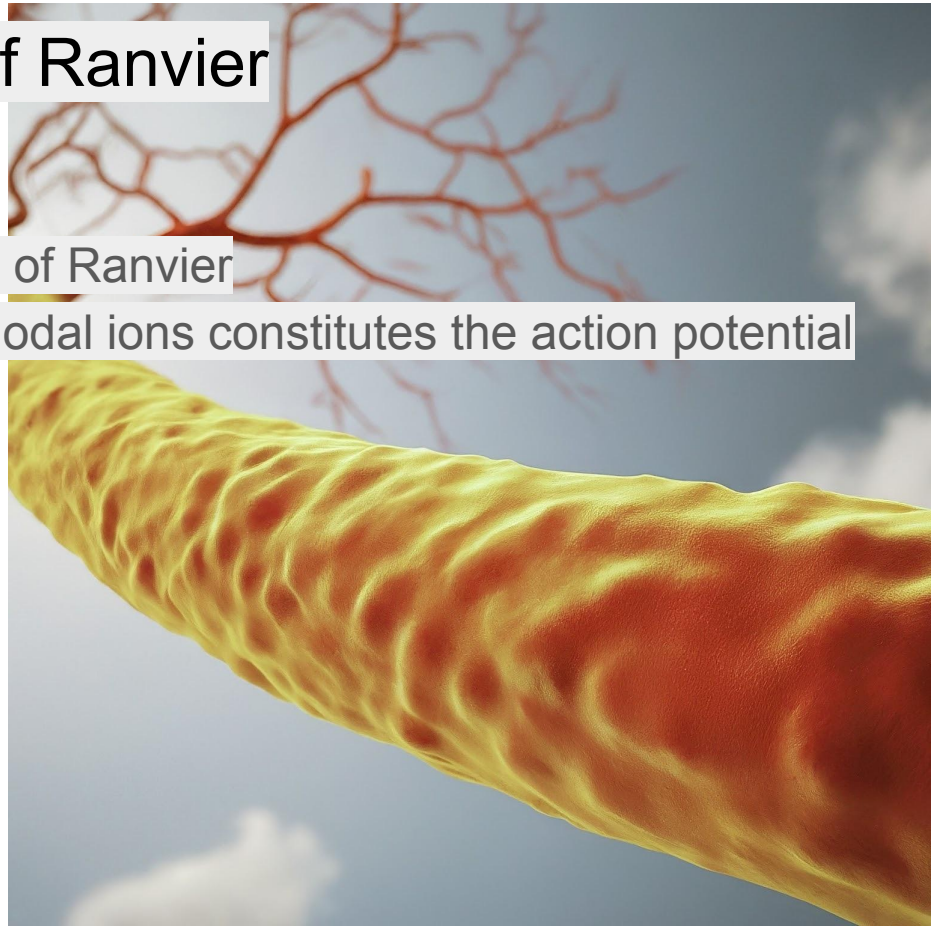
- Hodgkin-Huxley equation is 1D
- Nervous system is 3D
- Use a vector/projection/trigonometric approach and extend former to latter
- Yields an equation that contains angles of axonal inclinations and interaxonal distances

Talukdar, S., R. Shrivastava, and S. Ghosh. 2019. “Modeling Activity-Dependent Reduction in after Hyper-Polarization with Hodgkin-Huxley Equation of Action Potential.” *Biomedical Physics and Engineering Express* 5 (4). doi:10.1088/2057-1976/ab1a1d.



Background on the Node of Ranvier

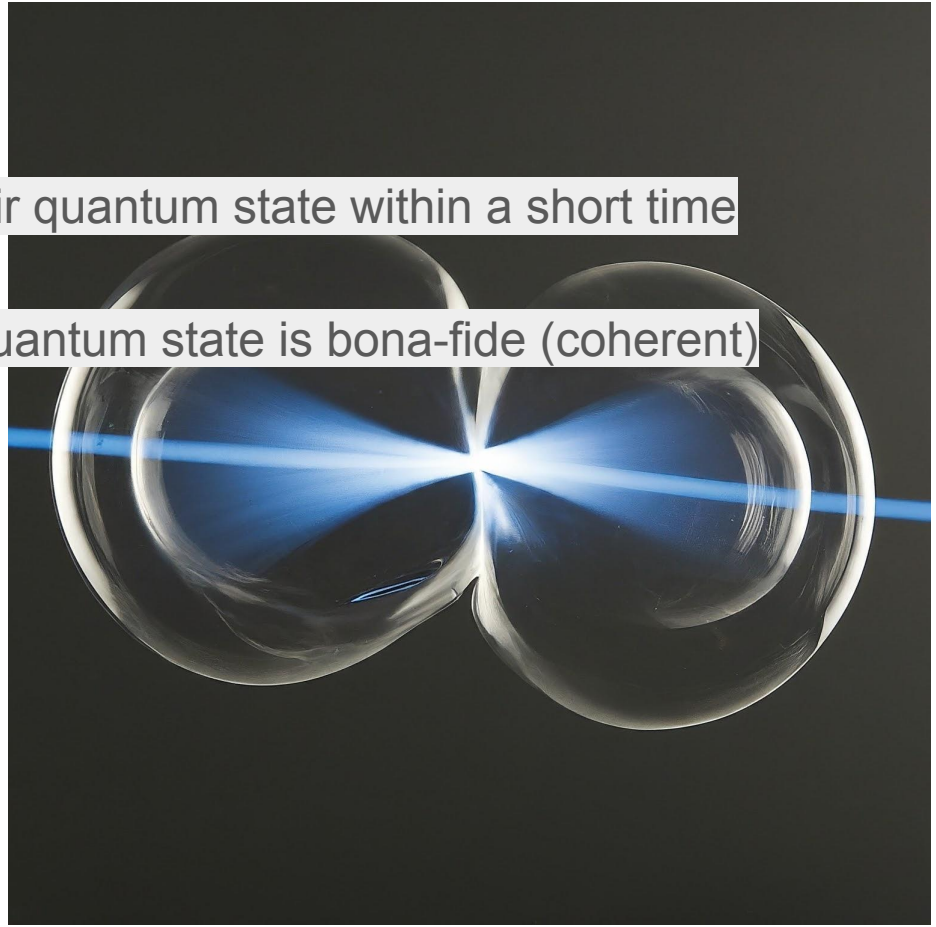
- Ions flow through ion channels
- These are concentrated at nodes of Ranvier
- The inward and outward flow of nodal ions constitutes the action potential profile



Dolma, Sonam, and Abhijeet Joshi. 2023. “The Node of Ranvier as an Interface for Axo-Glial Interactions: Perturbation of Axo-Glial Interactions in Various Neurological Disorders.” *Journal of Neuroimmune Pharmacology* 18 (1–2): 215–34. doi:10.1007/s11481-023-10072-z.

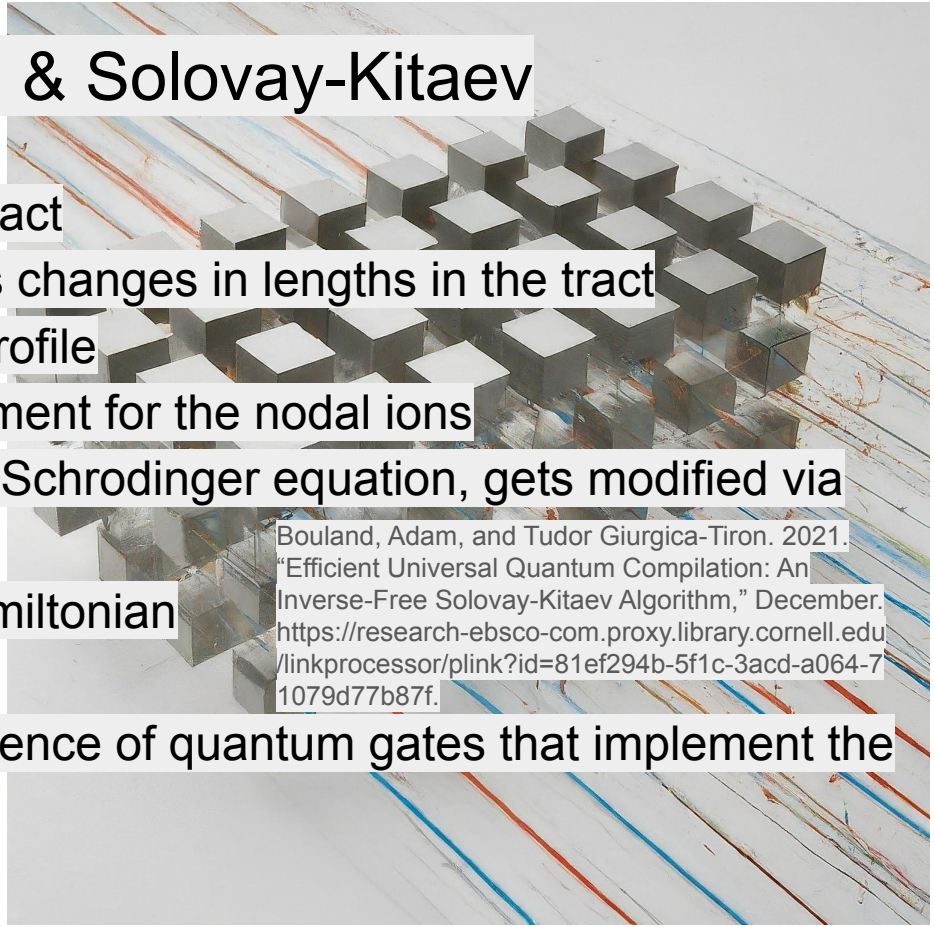
Decoherence

- Two ions collide, decohering their quantum state within a short time
- Decoherence time
- Before decoherence however, quantum state is bona-fide (coherent)



Blaum, K, S Eliseev, and S Sturm. 2021. “Perspectives on Testing Fundamental Physics with Highly Charged Ions in Penning Traps.” *Quantum Science & Technology* 6 (1): 1–15. doi:10.1088/2058-9565/abbc75.

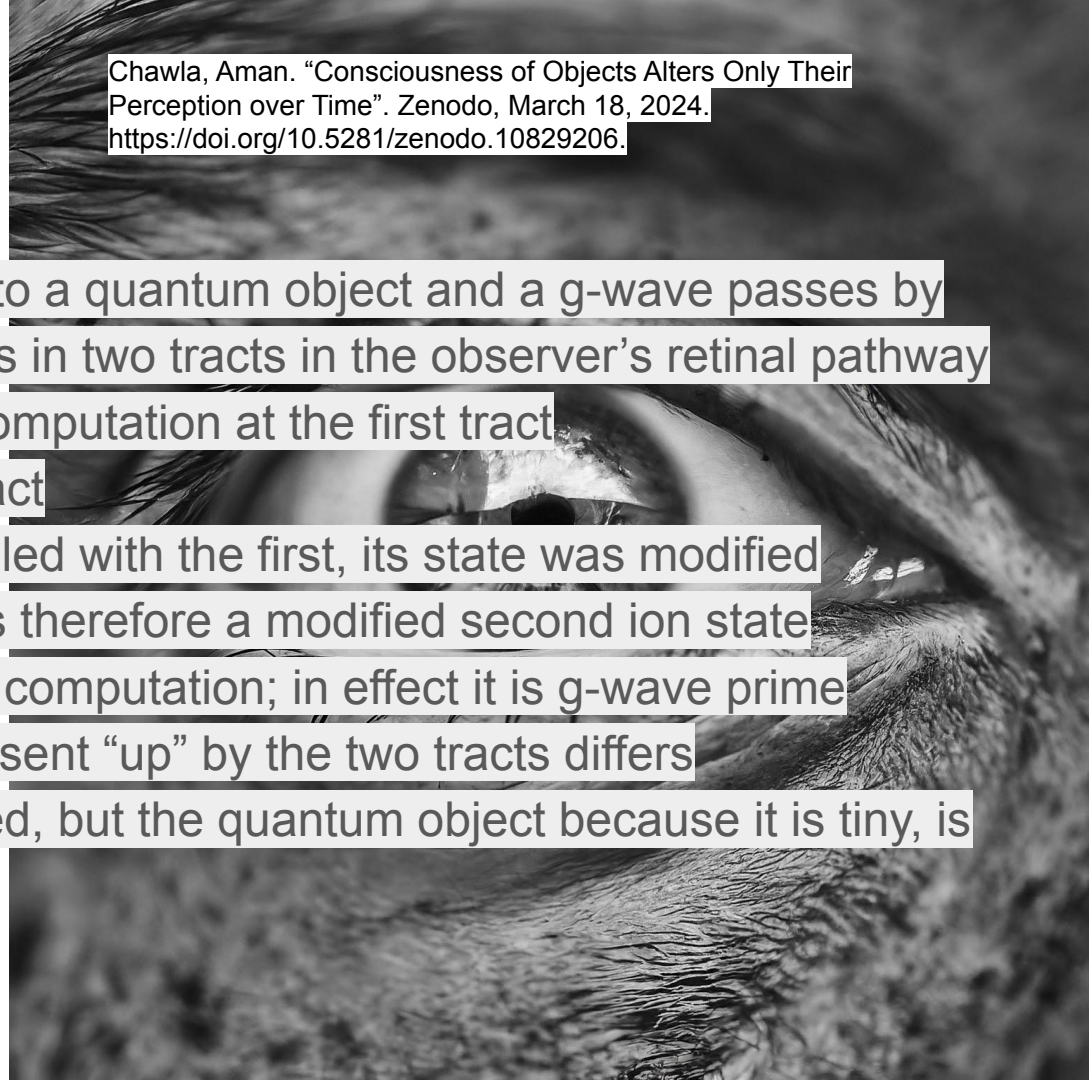
Tract Quantum Computation & Solovay-Kitaev



- Suppose a g-wave approaches a tract
- The spacetime perturbation causes changes in lengths in the tract
- This modifies the action potential profile
- The profile was setting the environment for the nodal ions
- Their quantum state, evolving by a Schrodinger equation, gets modified via the environment potential term
- This corresponds to a modified Hamiltonian
- This yields a modified unitary
- This yields, by the theorem, a sequence of quantum gates that implement the unitary at the axon

Bouland, Adam, and Tudor Giurgica-Tiron. 2021. “Efficient Universal Quantum Compilation: An Inverse-Free Solovay-Kitaev Algorithm,” December. https://research-ebsco-com.proxy.library.cornell.edu/linkprocessor/plink?id=81ef294b-5f1c-3acd-a064-71079d77b87f.

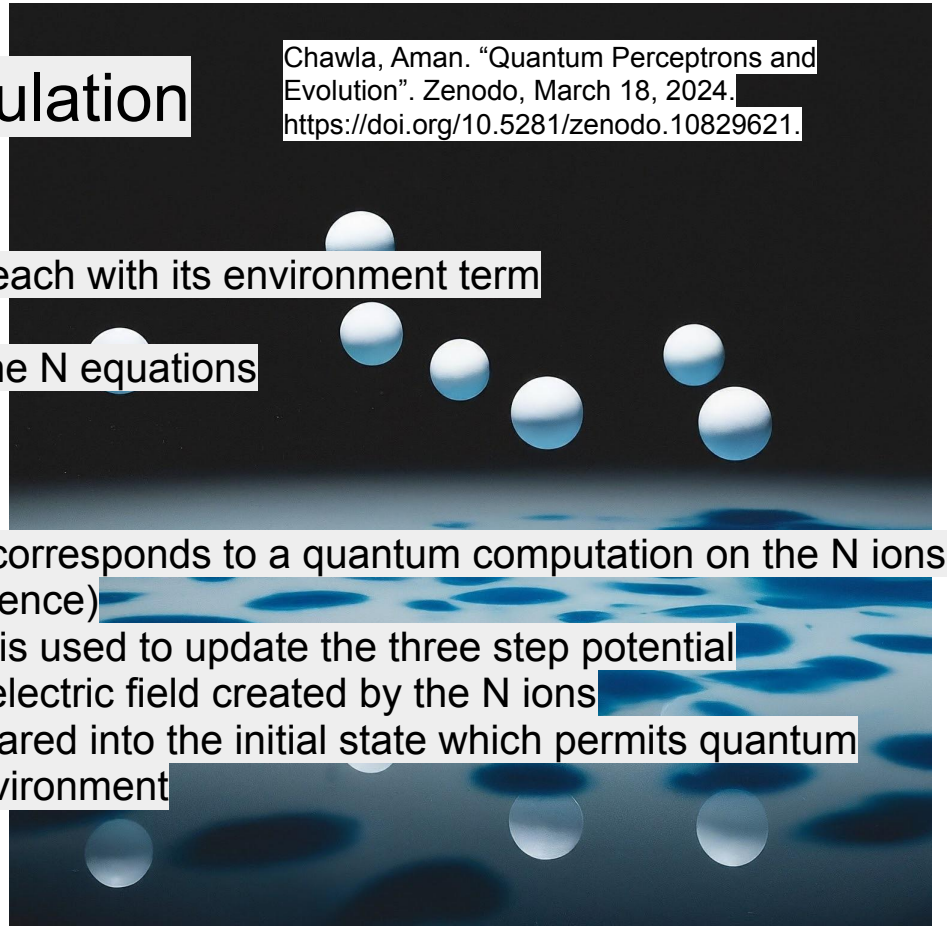
Perception and Objects



Chawla, Aman. “Consciousness of Objects Alters Only Their Perception over Time”. Zenodo, March 18, 2024. https://doi.org/10.5281/zenodo.10829206.

- Suppose an observer is close to a quantum object and a g-wave passes by
- Let there be two entangled ions in two tracts in the observer’s retinal pathway
- G-wave affects the quantum computation at the first tract
- It then moves to the second tract
- Since the second ion is entangled with the first, its state was modified
- When the g-wave arrives it has therefore a modified second ion state
- So it cannot perform the same computation; in effect it is g-wave prime
- Thus the quantum information sent “up” by the two tracts differs
- That is, perception has changed, but the quantum object because it is tiny, is unaffected by the g-wave

Quantum Perceptron Formulation



Chawla, Aman. “Quantum Perceptrons and Evolution”. Zenodo, March 18, 2024. https://doi.org/10.5281/zenodo.10829621.

- Consider a bath of ions
- In particular, N schrodinger equations, each with its environment term
- These are the q-perceptron’s data
- Next three step potential is applied to the N equations
- Step 1: dot product with weight vector
- Step 2: sum
- Step 3: activation
- By the Solovay-Kitaev discussion, this corresponds to a quantum computation on the N ions
- Finally the ions are measured (decoherence)
- The measured state and the goal state is used to update the three step potential
- The goal state is the desired quantum-electric field created by the N ions
- Post decoherence, the ions are re-prepared into the initial state which permits quantum interactions to “learn” their quantum environment