Quantum Entanglement and Spacetime

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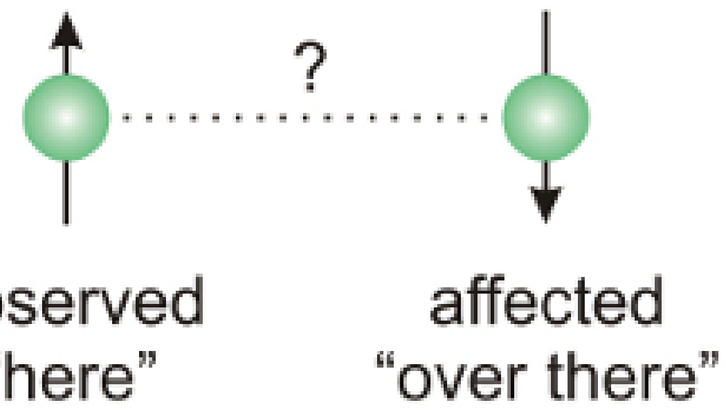
1. What is Entanglement?

- Entanglement is a quantum mechanical phenomenon that exhibits non-local physical correlation.
- Two entangled systems are correlated in such a way that they can change each other's physical state when arbitrary distance apart.
- Entanglement entropy is a quantity used to measure the entanglement between two quantum systems. One can think of entanglement entropy as a measure of how much information is shared between the entangled systems.

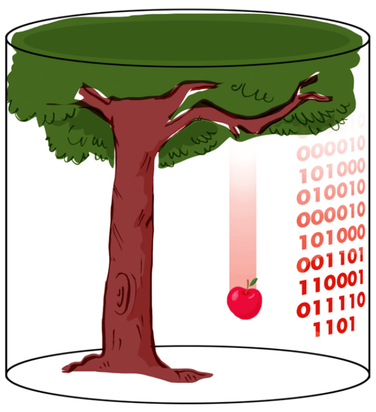


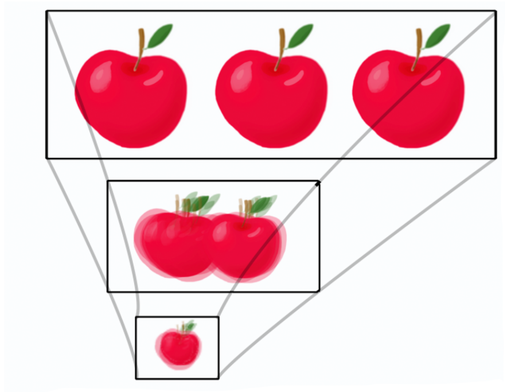
2. Entanglement and Quantum Computers

- Entanglement is crucial to understanding and building quantum computers.

  "Entanglement is the essential non-classical ingredient which provides the computational speed-up in quantum algorithms as compared to algorithms based on the processes of classical physics" — Richard Jozsa

- It is important to understand theoretically large quantum bits [*qubit*] systems for the development of real quantum computers. Current prototype lab systems are only working with small number of *qubits*.
- Quantum computation can be realised in holographic settings where the tensor network of the reconstructed spacetime is the quantum circuit.



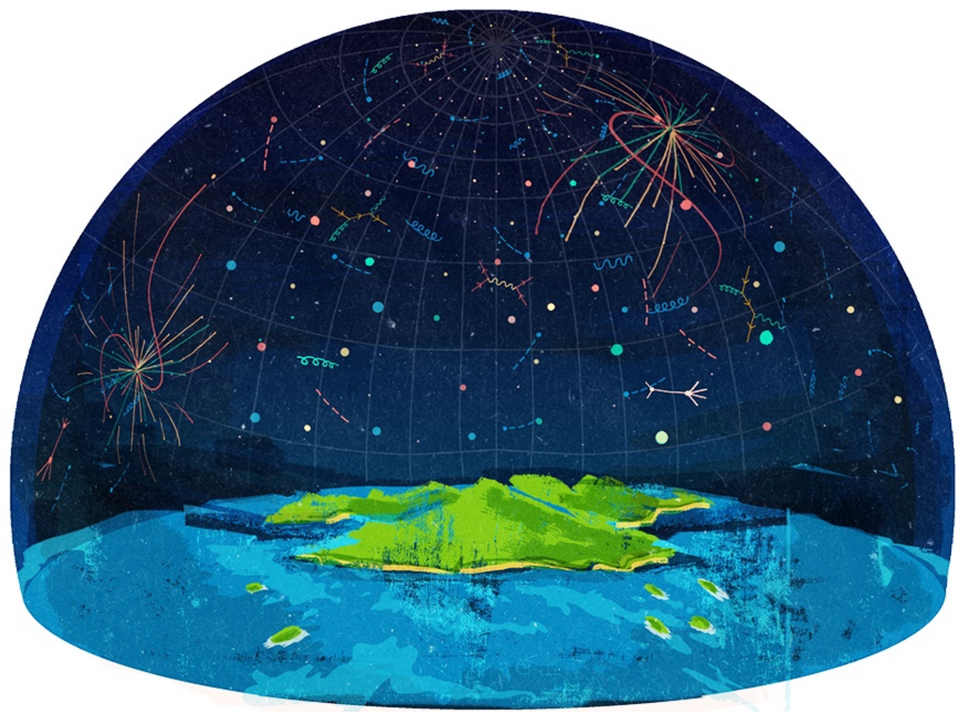


References

[1] M. Taylor and W. Woodhead: [10.1007/JHEP08(2016)165]
[2] S. Ryu and T. Takayanagi: [10.1088/JHEP(2006)045]
[3] S. de Haro, K. Skenderis and S. Solodukhin:
[Commun.Math.Phys.217,595-622(2001)]
[4] T. Faulkner, M. Gucia,T. Hartman, R. Myers, M. Van Raamsdonk:
[10.1007/JHEP03(2014)051]

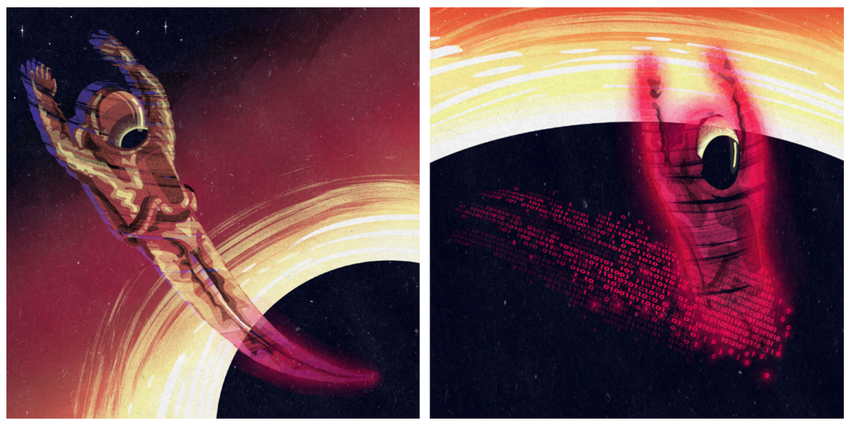
3. Holography

- Holography is an equivalence between a gravity theory in d+1 dimensions and a strongly coupled quantum field theory in d dimensions.
- The holographic AdS/CFT duality gives a duality between the gravity theory in negative curvature space and a scale invariant quantum theory.
- Holography can be used as a tool to understand entanglement in systems with many degrees of freedom.
- Entanglement entropy in quantum theory is calculated from areas of surfaces in the spacetime [2].



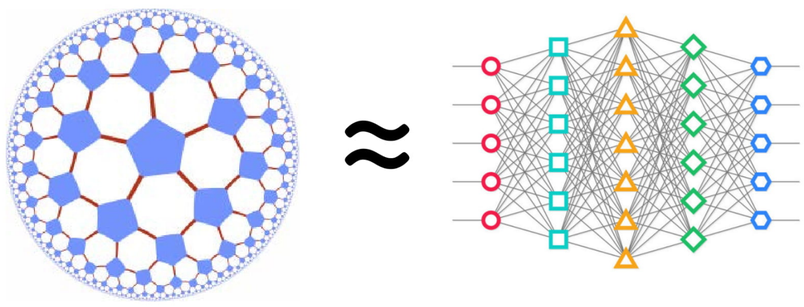
4. Goals of My Research Project

- Derive relations between geometry and entanglement, following the work of [1].
- Understand implications of holography for black holes.



- Understand how entanglement is related to emergence of spacetime [3][4].
- Relate holography and spacetime emergence to machine learning.

  "Machine Learning is a subfield of artificial intelligence with the goal of developing algorithms capable of learning from data automatically."



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