Universe a Quantum Computer?

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Introduction...

- Universe - physical system following quantum mechanics rules in storing and processing information.

- Quantum information - interpretation for nature.

- Physics(particles, fields of force, space-time) - built upon “yes-no” devices such as a computer.

- Analysis on parts of computer doesn’t give a full view over the computation that is being performed.
Computer vs. Universe

➢ Computer: built on materials, forces and laws of physics. **Output** depends on input and set logic.

➢ Universe: creates “particles without particles, fields without fields, space-time without space-time and law without law”. **Output** present a level of unpredictability.

➢ All calculations compromise between accuracy and cost

➢ All users must choose right answers from the wrong
Why Quantum?

Einstein: “...time and space are modes by which we think and not conditions in which we live”

• Quantum theory sees sensations as “yes-no” and so they fit in the quantum pattern.
• Quantum happens at such low level that we do not usually consider it...could that be the case of the Universe?

• Ex.: Looking at a painting involves quantum mechanics but we do not consider the computation behind. We have to regard the “yes-no” character of the computation.
The Big Bang

- inexplicable character
  so...quantum?

- This “weird” way of laws of physics appearing along with the particles and forces to follow them is accounted to the weirdness of quantum.
Substance

- Particles, fields of force, space-time - intermediate entities in the construction of the Universe.

- The Monad (Leibniz, 1662) - the ultimate building unit:
  - Simple substance which makes up computers
  - Elements of things - true atoms of nature
  - Each Monad is different from every other.
Yes / No

Wootters (1980) - device for determining the polarization between yes and no answers.

**Input**: direction of arrival

**Output**: yes/no (depending on hit of photons from the laser.)

**Question**: How does $p(\text{yes})$ depend on $\theta$?

**Answer**: $\cos^2 n\theta$

Electrons & Neutrinos: $n = \frac{1}{2}$;

Photons: $n = 1$; Gravitons: $n = 2$. 
Capacity

“Computational Capacity of the Universe”-Seth Lloyd(2002)

• Approximate value for capacity of computation since the BigBang
• $10^{120}$ operations on $10^{90}$ bits ($10^{10}$ age of Universe)
• $\approx(T/tp)^2$ ops* to be performed over the lifetime of a closed Universe
• In an open Universe the nr. gives us the amount of computation that can have been performed in the part of the Universe that we are causally connected to
cont...

These numbers of ops and bits can represent:
1) upper bounds on amount of computation
2) lower bounds on materials needed for simulation
3) ops and bits needed for the computation that is being performed
Conclusion

As Bohr (1958) states we cannot state the final measured results of an experiment until this has finished and is found in an irreversible state.

This tells us:

➔ if the Universe is a computer then it must be irreversible
➔ we cannot state an answer to the question <Is The Universe a computer?> because the experiment hasn’t come to an end.