Any physical entity is quantum information

And thus: mathematical!

Vasil Penchev

- Bulgarian Academy of Sciences
  Institute for the Study of Societies and Knowledge
  Dept. of Logical System and Models
  vasildinev@gmail.com

Colloquium “What is a physical entity?”
Centro de Filosofia das Ciências da Universidade de Lisboa (CFCUL)
16-17-18 October 2017, Faculdade de Letras da Universidade de Lisboa
Centro de Filosofia da Universidade de Lisboa (CFUL)

Background and prehistory

Quantum mechanics as an information theory

- Quantum mechanics was reformulated as an information theory involving a generalized kind of information, namely quantum information, in the end of the last century
  - Furthermore, quantum mechanics is the most fundamental physical theory referring to all claiming to be physical
- Thus, any physical entity turns out to be quantum information in the final analysis
  - Quantum information is only a generalized kind of information

The omnipresent quantum information

- That deduction can be reproduced very easily:
  - Any quantum state of any quantum system (what anything is) is a wave function, i.e. a point in the complex separable Hilbert space (which is the basic mathematical formalism of quantum mechanics)
- Then, any wave function can be represented as a series of quantum bits (qubits)
  - Consequently all in the universe are qubits, i.e. quantum information

A quantum bit

- A quantum bit is the unit of quantum information
  - It is a generalization of the unit of classical information, a bit, as well as the quantum information itself is a generalization of classical information
- The concept of qubit is introduced by quantum mechanics as the normed superposition of two orthogonal subspaces of the separable complex Hilbert space
  - The separable complex Hilbert space is the structure underlying quantum mechanics

From classical to quantum information

- The philosophical meaning of the generalization from classical to quantum information can be represented not less simply:
  - Classical information refers to finite series or sets while quantum information, to infinite ones
- If a bit represents the choice between two equally probable alternatives, a qubit is the choice between an infinite set of alternatives
  - The definition of a qubit in quantum mechanics is different, but equivalent to the one suggested here

Problem

How physical dimensions appear

- Quantum information as well as classical information is a dimensionless quantity
  - If it is the overall substance of anything claiming to be physical, one can question how different and dimensional physical quantities appear both originating from it and reducible to it
- Does quantum information is equivalent to the physical quantity of action?
  - If yes, one should interpret Emmy Noether's fundamental theorems (1918) referring to action as well as to the ways it to be divided into two physical quantities

The bridge between mathematics and physics

- Furthermore, quantum information can be considered as a “bridge” between the mathematical and physical
  - The standard and common scientific epistemology, on the contrary, grants the gap between the mathematical models and physical reality
- The conception of truth as adequacy is what is able to transfer over that gap
  - One should explain how quantum information being a continuous transition between the physical and mathematical may refer to truth as adequacy and thus to the usual scientific epistemology and methodology

A short comment to the problem

Emmy Noether's theorem

- The two fundamental theorems of Emmy Noether (1918) should be involved
  - oThey determine the links between what conserve, e.g. energy, and what change, e.g. time, in any physical system
- The product of the former and latter has always the physical dimension of action (what the dimension of the fundamental Planck constant is) and thus, it can be interpreted as the physical quantity of action
- If what is changed is physical action, the theorems of Emmy Noether imply that what is conserved should be dimensionless
- Quantum information being dimensionless physically seems to be an admissible applicant for the counterpart of action

Thesis

Quantum information conservation

- Quantum information is conserved, being the counterpart of the changing action
    - If the change of action is uniform in time, energy is conserved
- However, quantum information is conserved more universally for if the action is changed (i.e. not only uniformly), its counterpart of quantum information is conserved
    - One existing example for that generalized approach to conservation is general relativity
- Energy may transform in momentum in it immediately because of the curvature of space time in it

A few corollaries from the thesis

Quantum information as the ultimate substance of the world

- 1. Quantum information is the real substance of the world for it is conserved always
    - That conclusion is consistent to the interpretation of any wave function as a value of quantum information and thus as the universal physical substance of the world
- That conservation can be described philosophically as the equivalence of possibility and actuality and thus as necessity
    - Furthermore, that necessity can be interpreted in turn as the necessity of quantum information to be conserved
- Thus, quantum information contains an internal (mathematical) proof for its necessity to be conserved

Quantum information and action

- 2. What is changed, namely physical action, appears necessarily in virtue of Emmy Noether's theorems as the counterpart of quantum information once it is conserved always, i.e. universally
    - Thus, if what is conserved necessarily is interpreted as the ultimate substance of the world, its counterpart, namely, action, is what is changed universally
- Action can be thought as the change itself at all as well as the philosophical concept of 'being' different from substance, but correlated to it even mathematically and physically

No “Creator”, but also … no “Bing Bang”

- 3. Generalizing philosophically, the being (or at least the physical being) appears necessarily in virtue of mathematical laws rather than randomly not needing any “creator” or other “ultimate cause” to be
  - Indeed the philosophical sense of the Bing Bang is that of the ultimate cause accessible by the contemporary science
- All irreversibility of time is concentrated in a single point, namely the “Bing Bang”, after which the physical quantity of time is absolutely reversible as general relativity needs
  - However, time is irreversible in thermodynamics and … our experience
- Consequently, the concept of the “Big Bang” is an artefact (and thus a kind of correction) of the reversible time utilized in science

What is changed versus what is conserved

4. Quantum information and action are the same seen from two disjunctive viewpoints correspondingly as what is conserved and as what is changed

    - Thus, they do not need the concept of truth as adequacy necessary to link them over the gap for they are the same by themselves

- If one sees both what is changed and what is conserved as the same in a fundamental ontological sense as the “being” in Heidegger’s fundamental ontology, the corresponding concept of truth would be right the “unhiddeness” (Heidegger's ἀλήθεια)

A few arguments for the thesis

The dimensionless counterpart of action

1. Noether's theorems imply only that the counterpart of action has to be dimensionless as a physical quantity

   - Thus quantum information is not more than a possible applicant for it satisfies that condition

- However, the contemporary science cannot suggest any other applicant fundamentally different

  - There is even an internal mathematical cause for the above statement

- Quantum information can be proved internally, i.e. mathematically as necessary

  - Then any other applicant is equivalent to quantum information for that necessity

Quantum mechanics as “information mechanics”

2. The fundamentality of quantum mechanics reformulated successfully in terms of quantum information is an argument for the thesis, too

  - The historical base for this reformulation is Max Born’s probabilistic interpretation of quantum mechanics (the late twenties of XX century)

- The sense of that interpretation is the equivalence of any probability distribution of quantum states to a single actual quantum state
  - Further, the relation of quantum probability distributions is interpreted as information according to the definition of information (e.g. in Kolmogorov)

Quantum information as a choice of a number of bits

3. The fundamental Planck constant having the physical dimension of action allows of any physical action to be juxtaposed a natural number

oThat natural number can be interpreted as a number of bits of information

- Quantum information by means of quantum bits can be interpreted as the choice of a certain number of bits among all natural numbers
  - o Thus, if a bit can be juxtaposed to a single natural number, a quantum bit corresponds to a certain choice of any natural number

Quantum information as openness

4. Quantum information meaning the number of choices among an infinite set of alternatives can be interpreted as the conservation of openness for choice as the necessary condition of any physical change
    - That openness can be further identified as the openness of the present or in other words, as the availability of the present always as that, in which any physical change can occur
- In turn, that fundamental openness for choice can be seen as “unhiddeness”, i.e. as Heidegger’s ἀλήθεια, a kind of the most fundamental concept of truth generalizing that of adequacy

Conclusions

1. Quantum information can be discussed as the counterpart of action

2. Quantum information is what is conserved, action is what is changed

3. The gap between mathematical models and physical reality, needing truth as adequacy to be overcome, is substituted by the openness of choice

4. That openness in turn can be interpreted as the openness of the present as a different concept of truth recollecting Heidegger's one as "unhiddeness"

5. Quantum information as what is conserved can be thought philoso[hically as the conservation of that openness

Obrigado pela sua atenção!

Estou aguardando sua pergunta e comentários!

Thank you for you kind attention!

I am waiting for your question and comments!