Epistemic-ontic interpretation of quantum mechanics: quantum information theory and Husserl’s phenomenology

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Ontic and Epistemic approaches

- **Epistemic**
  - relating to knowledge
  - Bohr; Copenhagen interpretation, quantum information theories, etc.
  - Experiments and their most direct interpretation

- **Ontic**
  - relating to (real) existence
  - Einstein; hidden variables theories, many worlds interpretation, etc.
  - Common sense in classical world

• But: the complete interpretation should unite both of them
Quantum information theory

- Epistemic: Quantum physics is science of knowledge.
- Information equals reality.
- Information cannot be endlessly divisible; N systems → N bits of information.
- Objectivity of outer world: on the basis of invariants and the inter-subjective agreement.
- But: no direct connection between the information and “that something this information is about.”

Kant’s epistemic system:

“Things-in-itself”  

Phenomena  

→ no direct causal connection
Connections with philosophy

Physics and Kant’s system:

“Things-in-itself”

Phenomena

The place of physical objects is solely on the side of phenomena
Connections with philosophy

The transmission of Kant’s method to QM:

“Things-in-itself” : Phenomena

Observed : Information
Connections with philosophy

- Kant → the problem of the lack of permeability between the “thing-in-itself” and the phenomenon.
- Husserl → mainly epistemic but maintains the permeability
- Husserl’s phenomenon: the object as has been given to me by itself, in the way to have a meaning (exactly) to me.

The observed

The observer

Phenomenon
Husserl’s phenomenology + Quantum information theory

• **The information** as the direct answer to the question about observed. The basis for the information is **the observed itself**.
The connection: information–observed → observer

The information and the observed are in two ways connected to the observer:

1. To the observer as observer per se, as to the one for whom they have a meaning (the answer to “Why information?”/ “Why quantum?”)

2. To the observer as to the part of an environment, as to the one, who, by trying to get any information, already (necessarily) has an influence on the observed and on the information about it.
The transition: quantum to classical

• **Decoherence** (entanglement of a coherent quantum system with the environment)

• **Two logical postulates:**

1. Our every day concepts are classical concepts (rely on complex systems) – there is no basis for the transmission to coherent quantum systems.

2. To describe something it is necessary to be outside the described set. (Heisenberg cut)
Delayed choice for entanglement swapping

\[ M_i = \left| \Phi^- \right\rangle_{23} \langle \Phi^- \right| \]

\[ M_{ii} = \left| HH \right\rangle_{23} \langle HH \right| - \left|VV\right\rangle_{23} \langle VV \right| \]

## Delayed choice for entanglement swapping

<table>
<thead>
<tr>
<th>Photon pairs</th>
<th>Measurement $i$</th>
<th>Measurement $ii$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>State fidelities</td>
<td>Entanglement witness</td>
</tr>
<tr>
<td>Photons 2 and 3</td>
<td>0.645 ± 0.031</td>
<td>-0.145 ± 0.031</td>
</tr>
<tr>
<td>Photons 1 and 4</td>
<td>0.681 ± 0.034</td>
<td>-0.181 ± 0.034</td>
</tr>
<tr>
<td>Photons 1 and 2</td>
<td>0.301 ± 0.039</td>
<td>0.199 ± 0.039</td>
</tr>
<tr>
<td>Photons 3 and 4</td>
<td>0.274 ± 0.039</td>
<td>0.226 ± 0.039</td>
</tr>
</tbody>
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Interpretation on ontic-epistemic basis

- Individual values of measurements → Our information
- Entanglement witness → the relationship between the info.
- Photons 1,2,3,4 → what this information is about

→ On the one hand information has a meaning only as long as it is information about the observed systems. On the other hand investigation of possible entanglement is based on measurement, which gives the information, and afterwards on the interpretation of this information.