Knowledge superposition

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In this article, a brief explanation is provided for the reasoning behind why the probabilistic descriptions of the quantum phenomenon do not violate the observable physical reality of the universe. In this proposed interpretation, such systems acquire an internal state; but describing that state will be always probabilistic without fully observing the actual internal state. Even with partial observations, the system state can only be described probabilistically, necessitated by the uncertainty surrounding the observation of the system state. Since the Copenhagen doctrine in quantum physics is a theoretical model that is most widely accepted, to provide a general description of these systems without direct observation; this uncertainty surrounding the observation of quantum states is often misinterpreted as the physical existence of superposition states in these systems. This misinterpretation can be attributed to the lack of clarity regarding the nature of probabilistic descriptors used in the Copenhagen doctrine. In this proposal, an update to the Copenhagen doctrine called the principle of state information; using the Landauer's principle is suggested, to alleviate this confusion. This update incorporates the notion of system state versus the knowledge of the system state duality, with the help of Landauer's principle; that establishes any information as a distinct physical entity and therefore any such probabilistic state descriptors of a system behavior can be explained without the need for exotic ideas such as the existence of physical state superposition. When this updated Copenhagen doctrine is used to describe such systems, the existence of the superposition states is only within the knowledge domain and not in the actual state of the system itself; which foregoes the need for interpreting these systems using the belief that physical state superposition exist. To further illustrate this duality of the knowledge of the system state versus the actual physical system state, a simple thought experiment is also proposed in the article.

The primary consideration in this proposed ***principle of state information*** addendum to the Copenhagen doctrine is that: the information itself is treated as a separate physical phenomenon with real and distinct energy costs associated with its storage and retrieval. This conclusion can be derived by applying the Landauer's principle.

Therefore, the internal state of the system and the knowledge of the internal state of the system are two distinct physical phenomenon, considering the fact that the knowledge about the internal state of the system requires the acquisition of information about the system's internal state.

The output of a system represented by the function: $\boldsymbol{f(x)}$, with multiple possible outcomes: $\boldsymbol{Ks}_{outcome}$, with the final state of the system when an observation is made regarding the state of the system, represented by: $\boldsymbol{Ks}_{final}$.

Outcomes of f(x):

$$f(x) = \begin{cases} Ks_{outcome} \text{ (All possible outcomes of the system)} \\ Ks_{final} \text{ (Final state of the system at the observation point)} \end{cases}$$

Knowledge of f(x) outcome:

$$f(x) = \begin{cases} k(f(x)) \text{ (Without observing the outcomes)} \\ k_o(f(x)) \text{ (With observation of the outcomes)} \end{cases}$$

Corresponding probability mass functions:

- $Ks_{outcome} \mapsto p^{ks_{transition}}$
- $Ks_{final} \mapsto p^{ks_{final}}$
- $k(f(x)) \mapsto p^{k}(k(f(x)))$
- $k_o(f(x)) \mapsto p^{ko}(k_o(f(x)))$

General properties:

$$Ks_{final} \subset Ks_{outcome}$$

$$k_o(f(x)) \subset k(f(x)) \subset Ks_{outcome}$$

Principle of state information, causal uncertainty and superposition:

Both $\boldsymbol{k(f(x))}$ and $\boldsymbol{k_o(f(x))}$ are equally valid, mutually exclusive descriptors of the $\boldsymbol{f(x)}$ outcome.

The causal uncertainty can be viewed as the description of ***f(x)*** outcomes only using ***k(f(x))***, where there is no single outcome with a probability of 1.

$$|k(f(x))| > 1 \text{ and } 1 \notin p^{k}(k(f(x))) \Rightarrow \textbf{superposition}$$

The application of causal uncertainty through knowledge superposition, does not violate the locally observable nature of the physical universe or require superposition of the actual outcomes; since ***k(f(x))*** is just the superposition of the knowledge of all the possible outcomes and ***k(f(x))*** can only exist without observing the outcome associated with the system ***f(x).***

This interpretation of causal uncertainty can be called the Landauer's principle update to the Copenhagen doctrine or simply referred to alternatively as the principle of state information.

Collapsing superposition:

Once an observation regarding the internal state of a system is made, the function to describe the outcome switches from ***k(f(x))*** to $k_o(f(x))$.

This switch in functions is due to energy costs associated with acquiring, storing and retrieving information of the system state.

If at least one of all the possible outcomes return a probability of 1, then this can be considered the equivalent to the concept of collapsing superposition.

$$1 \in p^{ko}(k_o(f(x))) \Rightarrow \textbf{collapsing superposition}$$

Observer effect:

The final outcomes of the system at the observation point may or may not be the same as the knowledge of the outcomes.

$$Ks_{final} \stackrel{?}{=} k_o(f(x)) \Rightarrow \textbf{observer effect}$$

Hidden states and information asymmetry:

The observer may not have access to observing all possible outcomes of the system. This could be due to the presence of hidden states or stemming from a partial knowledge of the system outcomes due to information asymmetry.

$$Ks_{outcome} \stackrel{?}{=} k(f(x)) \Rightarrow \textbf{hidden states}$$

$$Ks_{outcome} \stackrel{?}{=} k_O(f(x)) \Rightarrow \textbf{information asymmetry}$$

Stability of systems and observation uncertainty:

The final outcome of the system at the point of observation may or may not a singleton set.

If the cardinality of the final outcome is greater than one, it suggests an unstable system.

$$|Ks_{final}| \stackrel{?}{=} 1 \text{ and } 1 \notin p^{ks_{final}} \Rightarrow \textbf{stable / unstable outcome}$$

But, if none of the observed outcome probabilities have a value of 1, this can be considered the equivalent of observation or measurement uncertainty.

$$|k_O(f(x))| \stackrel{?}{=} 1 \text{ and } 1 \notin p^{ko}(k_O(f(x))) \Rightarrow \textbf{observation uncertainty}$$

Remanan's ugly sweater wearing cat thought experiment:

Consider a hermetically sealed box that an observer cannot look inside.

Setup inside the box consisting of the following:
- A cat not wearing an ugly sweater
- A sweater robot that can make the cat wear an ugly sweater
- A fair coin toss machine that controls the robot

The cat is made to wear an ugly sweater every time the robot gets a head on the coin toss machine after a single coin toss.

Once the sweater robot has finished making the cat wear the ugly sweater, the observer has the choice to observe the internal state of the system.

This thought experiment constructs a virtual system where a local stochastic phenomenon binds the global system state behavior.

In this case, the internal state of the system; where the cat wearing an ugly sweater or not; is determined by whether or not a fair coin toss returns a head by the fair coin toss machine.

$$Ks_{outcome} = \begin{cases} \textbf{Cat wearing an ugly sweater} \\ \textbf{Cat not wearing an ugly sweater} \end{cases}$$

From within the system, since the observation of the state transitions are continuous; the probability of whether the cat is wearing the sweater or not, is a continuous variable between 0 and 1.

$$pk_{stransition} = \begin{cases} \textbf{Cat wearing an ugly sweater} \mapsto p \in \mathbb{R}, [0, 1] \\ \textbf{Cat not wearing an ugly sweater} \mapsto 1 - p \end{cases}$$

For an outside observer, there is an uncertainty about the description of the final internal state of the system without actually observing that final state.

But, from within the system itself; there is no uncertainty and the cat has either worn the ugly sweater or not depending on the coin toss outcome.

$$Ks_{final} = \begin{cases} \textbf{Cat wearing an ugly sweater} \\ \textbf{Cat not wearing an ugly sweater} \end{cases}$$

$$pk_{sfinal} = \begin{cases} \textbf{Cat wearing an ugly sweater} \mapsto p \in \{0, 1\} \\ \textbf{Cat not wearing an ugly sweater} \mapsto 1 - p \end{cases}$$

In order to describe the system from the outside, without any observations regarding the internal state; can be only be possible by using the probabilistic descriptor of the internal states.

$$k(f(x)) = \begin{cases} \textbf{Cat wearing an ugly sweater} \\ \textbf{Cat not wearing an ugly sweater} \end{cases}$$

$$p^{k}(k(f(x))) = \begin{cases} \textbf{Cat wearing an ugly sweater} \mapsto p \in \{0, 1\} \\ \textbf{Cat not wearing an ugly sweater} \mapsto 1 - p \end{cases}$$

In this particular example, the observation of the internal state is only possible, after the sweater robot has completed the task of making the cat wear the ugly sweater and therefore the outside observer is not privy to any of the intermediate states where the cat is only partially wearing the ugly sweater.

Hence, the observed states have no uncertainty and they are mutually independent of each other.

Thus the outside observer can describe the internal state of the system after observing it, with a resultant probability of 1 for only one of the outcomes.

$$k_o(f(x)) = \begin{cases} \textbf{Cat wearing an ugly sweater} \\ \textbf{Cat not wearing an ugly sweater} \end{cases}$$

$$p^{k_o}(k_o(f(x))) = \begin{cases} \textbf{Cat wearing an ugly sweater} \mapsto p \in \{0, 1\} \\ \textbf{Cat not wearing an ugly sweater} \mapsto 1 - p \end{cases}$$

Infinite number of Remanan's ugly sweater wearing cats:

This is a variation of the Remanan's ugly sweater cat thought experiment where an infinite large number ***(very large N)*** collection of Remanan's ugly sweater wearing cat experiments.

The ratio of total number of sweater wearing cats versus the non sweater wearing cats is always a constant and equal to 1.

The total number of sweater wearing cats versus the non sweater wearing cats will be also a constant and equal to N / 2.

$$\Sigma p^{k}(k_i(f(x))) = \Sigma p^{k_o}(k_{oi}(f(x))) = \begin{cases} \textbf{Total cats wearing an ugly sweater } (N / 2) \\ \textbf{Total cats not wearing an ugly sweater } (N / 2) \end{cases}$$

The overall behavior of the system becomes easily predictable to an outside observer, just with the knowledge of the likelihood of the probabilistic system's outcome and therefore a valid description of the system even without any individual observations regarding each and every experimental outcomes.

God doesn't play dice problem:

The term '*God doesn't play dice'*, often attributed to Albert Einstein; is often used to discredit the Copenhagen doctrine. What Einstein was referring to with this statement is the local observable reality of the universe and he was attempting to point out that Copenhagen doctrine violated this principle.

This interpretation arises simply because of the confusion between the probabilistic state descriptors without observation of outcomes ($\boldsymbol{k(f(x))}$) and the state outcome descriptors following observation ($\boldsymbol{k_O(f(x))}$); since these are not equivalent due to reasons explained above.

In conclusion, according to this proposal; the internal state of a system and the knowledge of the internal state of the system are two distinct physical phenomenon and should always be treated as such, even in quantum systems.

References:

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