

Rule 4 Statistics

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When a conscious observer is part of a quantum mechanical system, rule (4) cuts off solutions to the Schrödinger equation. It is important to show that this interruption of the Hamiltonian dynamics does not effect the statistical predictions of the theory. The initial case considered is that of a two atom radioactive source. It is found that when the predictions of standard (Born rule) quantum theory are verified by using a particular experimental procedure, the result is the same as that predicted by quantum theory qualified by rule (4). This example is generalized, and the result is found to be the same.

Introduction

Standard quantum theory (i.e., the equations of motion plus Born's interpretation) is limited to ensembles of quantum mechanical events. It cannot be generally applied to individual members of an ensemble. The theory is furthermore limited in that it cannot be applied to systems that include a conscious observer. However, it is found in previous papers [1, 2] that when the Born rule is discarded and other rules put in its place, quantum mechanical systems *can* include conscious observers, and the mechanics *can* be applied to individual cases.

Four new rules are required to accomplish this broadening of quantum theory. The fourth of these rules is a selection rule on brain states that disrupts the flow of probability current to second order transitions. It would seem that this interruption of the

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smooth application of Hamiltonian dynamics would have an adverse experimental effect. It would seem that rule (4) would skew the statistics of a quantum mechanical system in which a conscious observer is present. However, it is shown in this paper that that is not the case. It is found that the theoretical amendment imposed by rule (4) actually mimics a valid experimental procedure that can be used to verify the mechanics. The predictions of the theory (including rule 4) are therefore found to be independent of the presence of a conscious observer. Rule (4) does not contradict the predictions of standard theory, and it allows those predictions to be correct when an observer is continuously present *inside* the system.

A Two-Atom Radioactive Source

Consider a two-atom radioactive source where each atom is initially in a state $a(t)$, and decays to a state $a_0(t)$. The final state a_0 is assumed to include the emitted particle. The initial state of the system is then written

$$\phi = (a + a_0)(a + a_0)d$$

where d is a detector that is not yet interacting with the source. In any product such as aa , it is assumed that the first a is a state of the first atom, and the second a is a state of the second atom. The square modulus is given by

$$\phi^*\phi = (a^*a + a_0^*a_0)(a^*a + a_0^*a_0)d^*d$$

which will be written

$$\Phi = (A + A_0)(A + A_0)D$$

where $\Phi(t) = \phi^*\phi$, $A(t) = a^*a$, $A_0(t) = a_0^*a_0$, and $D = d^*d$. Again, the first A in a product like AA refers to the square modulus of the first atom, and the second refers to the second atom.

Expanding gives

$$\Phi = [AA + (AA_0 + A_0A) + A_0A_0]D \quad (1)$$

so when the detector becomes entangled with the emitted particle in each case, we have

$$\Phi = AAD_0 + (AA_0 + A_0A)D_1 + A_0 A_0D_2 \quad (2)$$

where D_0 is the detector with no counts, D_1 is the detector with 1 count, and D_2 is the detector with 2 counts. In the entangled form of eq. 2, the emitted particle is no longer assumed to be associated with A_0 . It is captured by the detector.

Setting $A = e^{-kt}$, and $A_0 = (1 - e^{-kt})$, it is clear that each atom remains normalized in time. Applying these values to eq. 1 gives

$$\Phi(t) = [e^{-2kt} + 2e^{-kt}(1 - e^{-kt}) + (1 - e^{-kt})^2] \quad (3)$$

inasmuch as D has a square modulus equal to 1.0. The first component in eq. 3 is the rate of decay of the radioactive source. The second component $2e^{-kt}(1 - e^{-kt})$ is the rate at which a single particle is captured, and the third component $(1 - e^{-kt})^2$ is the rate at which two particles are captured. For very small times given by $\varepsilon = kt$, eq. 3 becomes

$$\Phi(t = 0) = \{1 - 2\varepsilon\} + \{2\varepsilon\} + \{0\} = 1$$

The first component initially loses square modulus in the amount 2ε , and this goes entirely into the second component. The third component is not initially affected. This is because the Hamiltonian of the system does not provide a direct connection between the first and the third components.

The probability current flowing into each of these components is given by

$$J(t) = d\Phi/dt = -2ke^{-2kt} + \{-2ke^{-kt} + 4ke^{-2kt}\} + \{2ke^{-kt} - 2ke^{-2kt}\} = 0$$

The initial current flow at $t = 0$ goes into the second component only

$$J(t = 0)/2k = -1 + 1 + 0 = 0$$

Again, current flows only from the first to the second component. It will not go to the third component until the second has acquired some amplitude.

Empirical Verification

The statistical outcome in eq. 3 must be empirically verified. Imagine that the observer keeps an eye on the detector from the time t_0 that he starts the clock. He marks the time t_1 when the first capture occurs, at which time he zeros the clock so it can record

the time t_2 between the first and the second count. When the second count occurs, he again zeros the clock so it can record the time t_3 between the second and the third count. This process is continued until a time t_n has been reached such that $\sum_n t_n \leq t$, and $\sum_n t_{n+1} > t$. The detector will then record n counts at the time t . Repeating this process many times establishes the distribution of counts that can be found at time t . This should be the same as the distribution given by eq. 3 at time t . Stopping and starting the clock in this way may seem to be an unnecessary complication. However, it is procedurally correct, and it parallels the action of rule (4) in refs. 1, 2.

Continuous Observation – Rule (4)

In this experiment, the system is continuously observed by the experimenter. Before the first particle capture at time t_1 (i.e., before the first stochastic hit), eq. 2 is amended to read

$$\Phi(t_1 > t \geq 0) = AAD_0\underline{B}_0 + (AA_0 + A_0A)D_1B_1 + A_0A_0D_2B_2 \quad (4)$$

where the second and third components involving the experimenter's brain states B_1 and B_2 are equal to zero at $t = 0$. The underline state \underline{B}_0 is a conscious state, and the non-underlined states B_1 and B_2 are ready brain states.

Rule (4) explicitly forbids current flow from one ready brain state to another, so there can be no current flow from the second to the third component in eq. 4; and since there is no current flow from the first to the third component, it follows that the third component in eq. 4 is not in the picture. Therefore, eq. 4 takes the simpler form

$$\Phi(t_1 > t \geq 0) = AAD_0\underline{B}_0 + (AA_0 + A_0A)D_1B_1 \quad (5)$$

Consequently, current leaving the first component can only go into the second component, giving

$$J = -2ke^{-2kt} + 2ke^{-2kt}$$

This results in a probability of 1.0 that B_1 in eq. 5 will be stochastically chosen, insuring that the experimenter can measure the time t_1 .

At the moment of a stochastic hit on the ready brain state B_1 , rule (3) requires a state reduction in which the first component goes to zero, and the ready brain state B_1 becomes a conscious brain state \underline{B}_1 . Also at that moment, there is an ‘effective’ renormalization that comes about because rule (1) requires subsequent probability current flow to be divided by the new square modulus. Therefore, to the experimenter, a new (renormalized) cycle of observation begins at t_1 .

Current will then flow exclusively into the ready brain state B_2 , inasmuch as B_3 will be excluded by rule (4). This guarantees that B_2 will be stochastically chosen, causing \underline{B}_2 to become conscious, and insuring that the experimenter can measure t_2 . To the observer, t_2 begins another cycle of observation in which he is guaranteed that he will become conscious of \underline{B}_3 , thereby insuring that he can measure t_3 , etc.

It is apparent that the theoretical restraints imposed by rule (4) are mimicked by an experimental procedure that can be used to confirm the theory. The experimenter starts the experiment over each time he becomes conscious of a new capture, treating each capture as initiating a new ‘renormalized’ decay. Collecting ensembles of data of this kind, he can find the decay curve of each component in eq. 2, as well as the distribution of counts at some final time t . So a single experiment confirms the decay curves each of the cycles of measurement generated by rule (4); and at the same time, it confirms the standard quantum mechanical count distribution at time t in eq. 3. The statistics predicted by standard quantum theory must therefore be the same as the statistics observed by an on-site conscious observer who functions under rules (1-4).

The General Case

Let the initial state S_0 of a more general system evolve in time to give

$$\Phi(t \geq t_0) = S_0 + S_1 + S_2 + \dots + S_m \quad (6)$$

where the Hamiltonian connects adjacent components such as S_0 to S_1 , and S_1 to S_2 , but provides no direct link between non-adjacent components. In these circumstances, the

initial current from S_0 will go exclusively into S_1 . It is only after S_1 has gained some amplitude that current can begin to flow into S_2 , etc.

When a detector and a conscious observer are entangled with these components, we get

$$\Phi(t_{sc1} > t \geq t_0) = S_0 D_0 \underline{B}_0 + S_1 D_1 B_1 + S_2 D_2 B_2 + \dots + S_m D_m B_m$$

When rule (4) is added, components higher than S_1 are no longer in the picture prior to a stochastic hit on S_1 at time t_{sc1} (i.e., at the first particle capture). so this becomes

$$\Phi(t_{sc1} > t \geq t_0) = S_0 D_0 \underline{B}_0 + S_1 D_1 B_1 \quad (7)$$

When a stochastic hit occurs on the ready state B_1 , there will be a state reduction giving

$$\Phi(t_{sc2} > t \geq t_{sc1}) = S_1 D_1 \underline{B}_1 + S_2 D_2 B_2 \quad (8)$$

and when there is another hit on S_2 at time t_{sc2} , there will be another reduction

$$\Phi(t_{sc3} > t \geq t_{sc2}) = S_2 D_2 \underline{B}_2 + S_3 D_3 B_3 \quad (9)$$

This process will continue, resulting in as many separate equations as there are components.

Empirical Verification of Eq. 6

We empirically verify eq. 6 in the same way that we verified eq. 3. The observation begins at time t_0 . At time t_{sc1} when he is first conscious of \underline{B}_1 , he zeros his clock so that it will record the time t_1 between t_0 and t_{sc1}

$$t_1 = t_{sc1} - t_0$$

At the time of t_{sc2} when he is first conscious of \underline{B}_2 , he again zeros his clock so that it will record the time t_2 between t_{sc1} and t_{sc2}

$$t_2 = t_{sc2} - t_{sc1}$$

This process is continued until a time t_m has been reached such that

$$\sum_m t_m \leq t \text{ and } \sum_m t_m + t_{m+1} > t. \text{ where } t_m = t_{sc(m)} - t_{sc(m-1)}$$

The system will then be in a state m at time t . Repeat this procedure many times, establishing the distribution of states that can be found at time t .

The times t_1, t_2 represent the duration of each of the equations in eqs. 7 and 8, and t_m is the duration of the m^{th} equation generated by the rules. It is possible to experimentally determine the decay curve for each time interval t_m . Using this information, one can determine the distribution of counts at a final time t , and verify that result experimentally. Presumably, this will confirm the final count distribution that is predicted by standard (i.e., Born rule) quantum theory. Therefore, the statistical predictions of standard quantum theory will be consistent with the statistical predictions that follow from the decay curves of each t_m taken separately and sequentially, as mandated by rule (4).

References

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2. R. A. Mould, “Quantum Brain States”, *Found. Phys.*, **33** (4) 571-592 (2003), quant-ph/0303064