

This principle has the far reaching implication that for any possible measurement, for which the initial system state is not an eigenstate, the resulting state of the composite system leads to no definite system state nor any definite apparatus state. The system ~~will~~ will not ~~possibly~~ be put into one or another of its eigenstates with the apparatus reading the corresponding value, and nothing resembling Process 1 can take place.

To see that this is indeed the case, suppose that we have an arrangement with the following properties:

The apparatus and interaction are such that ~~if the initial system state is an eigenstate then after a specified time of interaction the apparatus will record this fact, i.e. be in a state which describes~~

~~the interaction is such that if the system is initially in one eigenstate, then after the interaction the system will remain in that eigenstate, and the apparatus will be changed to a state which is different for each possible system eigenstate. This property is certainly necessary if a measurement is to be performed. However, if the initial system is not an eigenstate, but a superposition of them, then we can get the final solution by simply superposing our earlier solutions to~~

To see that this is indeed the case, suppose that we have a measuring arrangement with the following properties. The initial apparatus state is ψ^A_0 . ~~$\phi_i^S \psi^A_0$~~

If ~~ϕ_i^S~~ of the system is initially in an eigenstate of the measurement, ϕ_i^S , then after a specified time of interaction the total state $\phi_i^S \psi^A_0$ will be transformed into the state $\phi_i^S \psi^A_i$, i.e., the system eigenstate shall not be disturbed, and the apparatus state is changed to ψ^A_i , which is different for each ϕ_i^S (ψ^A_i may for example be a state describing the apparatus as indicating, by the position of a meter needle, the eigenvalue of ϕ_i^S). However, if the initial system state is not an eigenstate but a superposition $\sum_i a_i \phi_i^S$, then the final composite system state is also a superposition, $\sum_i a_i \phi_i^S \psi^A_i$.

This follows from the superposition principle, since all we need do is superpose our solutions for the eigenstates, $\phi_i^S \psi^A_0 \rightarrow \phi_i^S \psi^A_i$. To arrive at the solution, $\sum_i a_i \phi_i^S \psi^A_0 \rightarrow \sum_i a_i \phi_i^S \psi^A_i$, for the general case. Thus in general after a measurement has been performed, there will be no definite system state nor any definite apparatus state, even though there is a correlation. It seems as though nothing can

thus / the requirement that a system value is definite, it is definitely measured \Rightarrow it is indefinite \Rightarrow there is also no definite apparatus state, only correlation.

This is true no matter how large or macroscopic the apparatus may be,

To see that this is indeed the case, suppose that we have a measuring arrangement with the following properties. The initial apparatus state is ψ_i^A . ~~$\phi_i^S \psi_i^A$~~

If the system is initially in an eigenstate of the measurement, ϕ_i^S , then after a specified time of interaction the total state $\phi_i^S \psi_i^A$ will be transformed into the state $\phi_i^S \psi_i^A$, i.e., the system eigenstate shall not be disturbed, and the apparatus state is changed to ψ_i^A , which is different for each ϕ_i^S (ψ_i^A may for example be a state describing the apparatus as indicating, by the position of a meter needle, the eigenvalue of ϕ_i^S). However, if the initial system state is not an eigenstate but a superposition $\sum a_i \phi_i^S$, then the final composite system state is also a superposition, $\sum a_i \phi_i^S \psi_i^A$. This follows from the superposition principle, since all we need do is superpose our solutions for the eigenstates, $\phi_i^S \psi_i^A \rightarrow \phi_i^S \psi_i^A$. To arrive at the solution, $\sum a_i \phi_i^S \psi_i^A \rightarrow \sum a_i \phi_i^S \psi_i^A$, for the general case. Thus in general after a measurement has been performed, there will be no definite system state nor any definite apparatus state, ^{even though there is a correlation.} It seems as though nothing can thus (the requirement of a system value is definite, it is definitely measured \Rightarrow it follows) that there is also no definite apparatus state, only correlation.

This is true no matter how large or macroscopic the apparatus may be, we can never be settled by such a measurement. How are we to interpret this behavior which is implied by the superposition principle?

definite apparatus state, even though there is a correlation. It seems as though nothing can ever be settled by such a measurement. Furthermore this result is independent of the size of the apparatus, and remains true for apparatus of quite macroscopic dimensions. ^{Suppose} For example, if we ~~suppose the apparatus is small~~ ~~its size does not affect the result~~ we couple a spin measuring device to a cannonball, so that if the spin is up the cannonball will be shifted one foot to the left, while if the spin is down it will be shifted one foot to the right, ~~and~~ if we

Now ~~this~~ perform a measurement with this ~~device~~ arrangement upon a particle whose spin is a superposition, say $\frac{1}{2}\uparrow + \frac{1}{2}\downarrow$, then the resulting total state will ^{also} be a superposition of two states, one in which the cannonball is ^{to the} left, and one in which it is to the right. There is no definite position for our macroscopic cannonball!

This behaviour seems to be quite at variance with our ~~experience~~ observations, since macroscopic objects always appear to us to have definite positions. ~~We~~ How can we reconcile this prediction of the wave theory with experience? ^{If we abandon it as untenable} In order to answer this question we must consider the problem of observation itself within the framework of the theory.