DYNAMICAL MEANING OF QUANTUM SUPERPOSITION PRINCIPLE, OR ANTI-EVERETT

1. Introduction

The Everett's idea and the similar ones about "the parallel worlds" are based on the following statement: our experience confirms the probabilistic model, and such model should physically be grounded on the real existence of *all* possible outcomes. When we cannot *now and here* find out them in our Universe, should we search for them? Have we a convenient alternative for "multi-world" idea? I believe, yes, we have it.

As M. Born firstly proposed, one may calculate a probability for some physical quantity x (that is determined on a set {X}) to have a value x_0. In order to obtain it we have to solve several equation (Shrodinger's one, Dirac's one, etc.). Between the interactions the closed system state may be generally presented as a pure states superposition. This presentation contains corresponding coefficient for every basic state, the square of the coefficient is proportional to the probability for the system to be detected in the corresponding pure state. Such detection one *physically* treats as a *transition* from the superposed state to a pure basic state. From the mathematical viewpoint it may be considered as the projecting of a multidimensional Hilbert space point on its axis. This presents so called "wave function collapse". Everett says, we have a splitting of the quantum reality between different worlds (see Fig. 1)

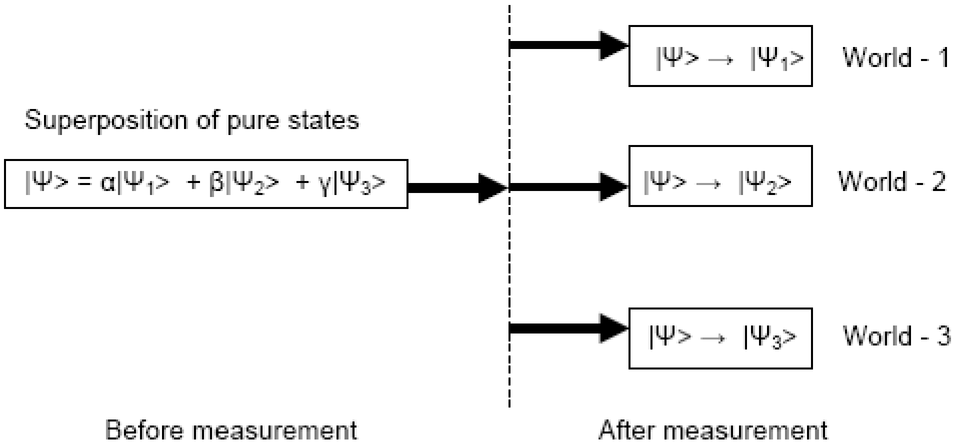


Figure 1. Everett's multi-words picture

2. Alternative dynamical model

On the other hand, I propose the alternative hypothesis. The partial probabilities for a particle to have any pure state *realize because this particle alternatively transits from a pure state to the next one during some small time period.* Each part of this period is proportional to the square of the coefficient for the corresponding pure state. Any Observer (see for Fig. 2) selects randomly a time moment and detects the pure state #2. If he repeats his observations many times, he fix the probabilities α^2, β^2, and γ^2 for the pure states $|\Psi_1>$, $|\Psi_2>$, and $|\Psi_3>$ respectively.

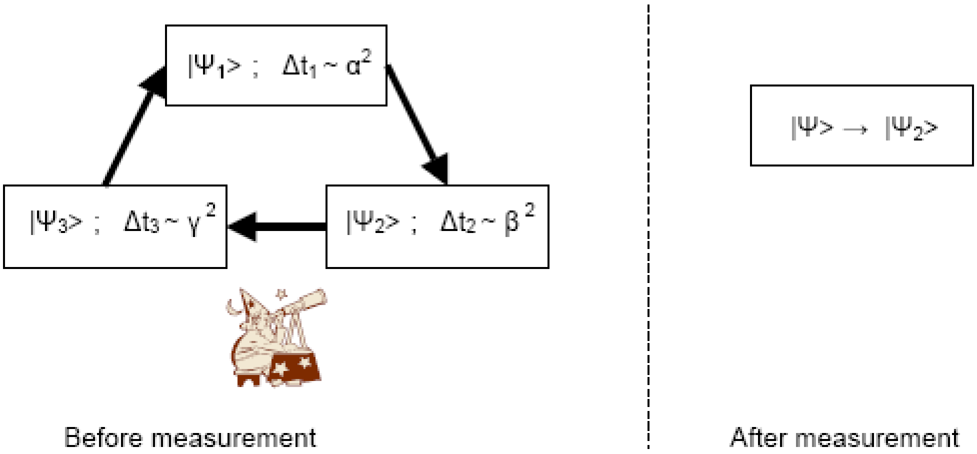


Figure 2. Superposed state dynamical picture

We also can illustrate these two models by the following humorous pictures (Fig. 3, standard Windows clips were used). At the left side, a girl dreams about three young men, but she can marry one of them in the different worlds only. Contrary, at the right side, a young lovelace has periodically the meetings with three young girls. Once his wife "detects" him with one of them (but only with one!).

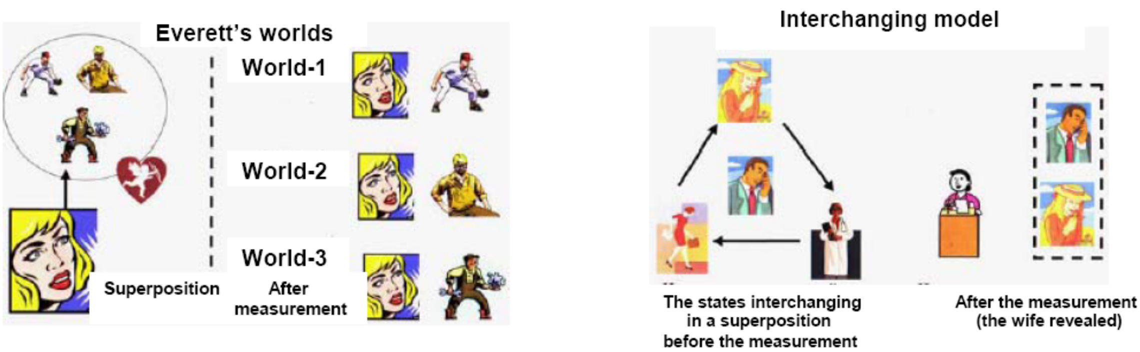


Figure 3. Love stories

I believe, this hypothesis solves the measurement problem of the quantum mechanics (QM). As it is well known, the problem consists in an *irreversible* and *spontaneous* (as one usually thinks) transition of an object from the superposed state to a pure one during measurement. Why does a quantum object transit into one or another pure state? Why is that transition irreversible, although any irreversibility is not presented during the object evolution between two detections? However, if we accept the proposed hypothesis, all becomes clear. At a *randomly selected* time moment we *fix* by the measurement the state that the object just has at this moment. So, the irreversibility is due to the *external* observer manipulation, not due the quantum object evolution itself.

One usually talks about such physical quantities as spin, polarization, etc. However, it is more complicate to think about the particle different positions, because they may be separated by extremely long distances at the close time moments. As one of my friends said, “it is very difficult to imagine a particle that coordinates might vary like a galactic size in the twinkling of an eye”.

In fact, it is very difficult to imagine it. But it is not *more difficult* that to imagine a particle, which travels from one 4D point to another one at once by the all possible in the Universe trajectories, as R. Feynman described. Nobody promised to replace QM by a simple and completely understandable classical model. The all that I propose is only some developing of the QM modeling presentation, which allows to explain several its (fundamental) problems. By the way, when we talks about small coordinate difference all seems to be acceptable.

We have just such situation in the case of two slits standard experiment **[Feynman et al., 1963]**, when a particle may fly to some detector through two holes that are separated by a very small distance (not a galactic size). For a long time all the physicists have to admit that electron or photon can wonderfully propagate *at once* through the both slits.

However, our hypothesis leads, the term “at once” is not strongly exact. In fact, the particle coordinate interchanges two distinct values, which correspond with two pure states that are the first slit position and the second one. Clearly, the partial duration of every state is very small, because of that we can *approximately* only say that “the particle propagate *at once* through the both slits”.

Also is clear, when we try to detect one slit that the particle transverses, we break the states interchanging and *randomly fix one of them*. Because of that we block the next particle travel as *a superposition* of two states.

What is a difference between the Everett’s model and the proposed one? When we talk about a *mixture of states*, we think about any *static* matrix of the individual state probabilities having diagonal elements only. The theory of decoherence considers the transition from the superposed state to the mixture of states as the transition from the left density matrix to the right one **[Zurek, 2002]**:

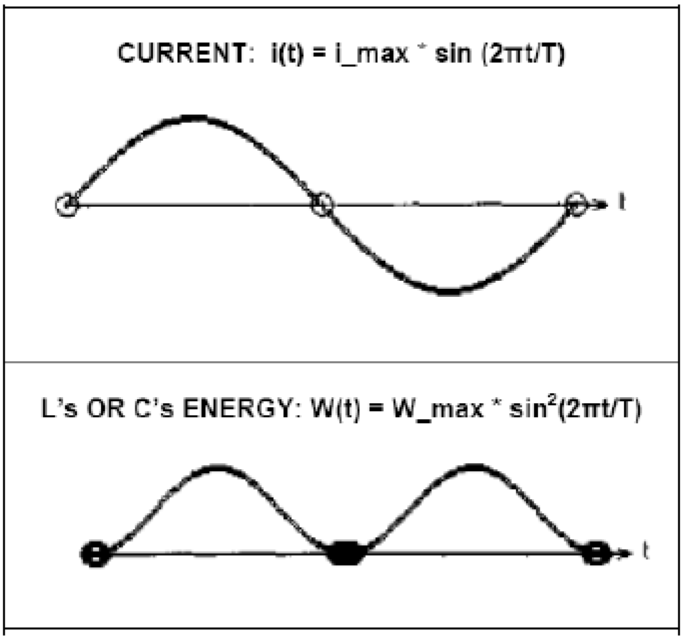
$$\begin{bmatrix} |C_1|^2 & C_1 C^*_2 \\ C^*_1 C_2 & |C_2|^2 \end{bmatrix} \longrightarrow \begin{bmatrix} |C_1|^2 & 0 \\ 0 & |C_2|^2 \end{bmatrix}$$

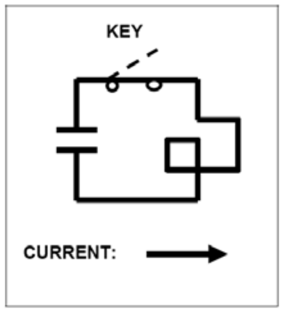
where left matrix contains the non-diagonal elements like the product $C_i \cdot C^*_j$, which inform us about the *transition rate* between the state *i* and the state *j* (note, some interference is due to this product). Hence, we can think about a superposed state *dynamically*, as the right sides of the Fig.2 and Fig.3 demonstrate. In fact, it changes each time moment, and we should talk about mean duration values only.

How should we understand the origin of such interference? In QM (as well as in the stochastic process theory) the matrix non-diagonal elements correspond with *transition probabilities* between the states. The diagonal terms are the real numbers, however, the non-diagonal elements present the complex ones. But this fact shows they oscillate with a frequency that is equal to the difference between the final and initial ones. So, we have a reason to say that *a superposed state is really a complicate one, in which the transitions happen between basic pure states. These transitions are quantitatively balanced, and the transition rates evolve harmonically*.

3. Simple classical example

And now we will present an example of the purely classical system, for which the same superposed description is applicable. Such system presents an electrical oscillator that includes a capacitor and an inductance (Fig. 4). When the connecting knife-switch (key) is enclosed, the periodical recharge happens in the circuit. The energy of the capacitor C and this one of the inductance L vary (in the opposite phase) from zero up to maximal value, their summary energy is always constant, the each element mean energy over the period is equal to the half of the complete circuit energy. The energy stream from one element to another is alternative, its mean value is zero, but its root-mean-square is not zero (like a field vacuum fluctuations).





$$\vec{W} = \tfrac{1}{2}\vec{W}_L + \tfrac{1}{2}\vec{W}_C\,; \quad \vec{W}_C = \vec{W}_{L*}\exp i\pi$$

$$\overline{W} = \begin{bmatrix} (1/\sqrt{2})^2 & (1/\sqrt{2})^*(1/\sqrt{2})_* \exp(-i\pi) \\ (1/\sqrt{2})^*(1/\sqrt{2})_* \exp i\pi & (1/\sqrt{2})^2 \end{bmatrix}$$

Figure 4. Superposed state of non-quantum system

If we wrote the density matrix for our classical system energy, we saw the non-diagonal terms corresponding to the energy streams from one circuit element to another one.

Finally, when we inspect the tension and the current with an oscilloscope ("non-destroy" inspection), we reach the maximally possible strong correlation between the instant values of them. Let us now perform a "destroy" type of inspection after the key interrupting at the *especial* time moment *when the circuit current is equal to zero* (else an arc may appear and summary energy would not conserve). As result, we can determine with the equal probability ½ that the complete circuit energy may be accumulated in the capacitor or in the inductance. Such irreversible "destroy" detection is just the same that we have for the quantum systems.

4. More complicate superposed classical system

So, an electrical oscillator can be used as example of dynamical state, in other words – of the superposition state. In order to consider a system with the many states superposition let us make a source state model the more primitive. We will now talk about light bulb that may be turned-on or turned-off. More precisely, we will consider an ensemble of such bulbs, that the state ("on" or "off") can vary.

If the state of each bulb is fixed forever and does not change with time, then an analysis of such static ensemble does not need any analogy with QM. However, if the individual bulbs change its state (from "on" to "off" and vice versa), then the ensemble common state requires a dynamical description and seems to be similar of the QM's one (we will not here consider the questions due to the particle identity).

In fact, if the working duration and pauses are short, we can from the “bird's eye view” (i.e., for a long time) say that our bulbs ensemble presents *the superposition* of the all possible “basic” states of the system, where we consider each possible bulb state distribution (turned-on – turned-off) as basic. Note, the similar approach is used in QM to describe the identical particles ensemble. Particularly, if our ensemble contains only two bulbs, each of them at any time moment is randomly turned-on or turned-off, then we have the superposition that is called “Shrodinger cat” in QM.

It is easy to understand that $N = 2^n$ different basic states are possible for an ensemble containing n bulbs. This result is very important for the quantum computations. On the other hand, we should note that if the probabilities for a bulb to be turned-on are *independent*, then the transition rates between N states would be *completely* determined by a relatively small number n of these probabilities. This explains some doubt like “where does Nature save an information about an enormous amount N of quantum freedoms for the system containing n particles?”

Let us now suppose that several bulb pair states are strongly *correlated* because of some reasons – they can turn-on or turn-off synchronously only. From the physical point of view that is a good analogy for the entangled EPR-pairs. From the mathematical point of view we have to replace the independent single transition probabilities by these ones for pairs. Note, every such pair two times reduces the amount N of the bulb ensemble basic states.

References:

[Feynman et al., 1963] Feynman R., Leighton R., Sands M. *The Feynman lectures on physics*. Addison Wesley publishing company, inc., 1963.

[Zurek, 2002] Zurek H. Woitech. *Decoherence and the Transition from Quantum to Classical*. Los Alamos Science, Number 27, 2002