Quantum suicide and many worlds

Shan Gao
Research Center for Philosophy of Science and Technology,
Shanxi University, Taiyuan 030006, P. R. China
E-mail: gaoshan2017@sxu.edu.cn.

July 17, 2022

Abstract

Quantum suicide experiment is an interesting and brave idea to test the many-worlds interpretation of quantum mechanics. However, there have been debates on whether the idea is valid. In this paper, I present a new analysis of the quantum suicide experiment. It is argued that the experiment is not different from usual quantum experiments, and it fails to provide a feasible way to test the many-worlds interpretation of quantum mechanics.

Quantum suicide experiment or quantum Russion roulette is an interesting and brave idea to test the many-worlds interpretation of quantum mechanics (MWI) (Squires, 1986; Tegmark, 1998). However, there have been debates on whether the idea is valid (Peter Lewis, 2000; Papineau, 2003, 2004; David Lewis, 2004; Tappenden, 2004; Wallace, 2012). In this paper, I will present a new analysis of the quantum suicide experiment. I will argue that the experiment is not different from usual quantum experiments, and it fails to provide a feasible way to test MWI.

Consider a typical quantum suicide experiment in which there is an observer O. In the experiment, a device M measures the z-spin of a spin one-half system S which is in a superposition of two different z-spins. When the result is z-spin up, the device will leave the observer O alive, while when the result is z-spin down, the device will make the observer O dead rapidly without pain. According to the linear Schrödinger equation, the state of the composite system after the experiment will be the superposition of S being z-spin up and M recording z-spin up and O being alive and S being z-spin down and M recording z-spin down and O being dead:

$$\alpha \left|up\right\rangle_S \left|up\right\rangle_M \left|alive\right\rangle_O + \beta \left|down\right\rangle_S \left|down\right\rangle_M \left|dead\right\rangle_O , \qquad (1)$$

where α and β are not zero and satisfy the normalization condition $|\alpha|^2 + |\beta|^2 = 1$.

According to MWI, there will be two (sets of) worlds after this experiment, in each of which there is a successor of the original observer, either alive or dead, and the probabilities for the observer to be in the alive and dead worlds are $|\alpha|^2$ and $|\beta|^2$, respectively. According to some authors (Tegmark, 1998; Peter Lewis, 2000), however, from the point of view of the observer, he will survive from the experiment and see the z-spin up outcome with certainty. The reason is that there is exactly one observer who has conscious perceptions before and after the experiment (Tegmark, 1998). Concretely speaking, since the observer only has one successor who sees the outcome, the measure of the subjective probability relative to the observer covers only this outcome, and thus the probability of surviving and seeing this outcome is one for the observer (Peter Lewis, 2000).[1] Then when $|\alpha|^2$ is small enough, the experiment will provide a feasible way for the observer to test MWI; single-world quantum theories predict that the observer will almost surely die after the experiment, while MWI predicts that the observer will find that he will survive with certainty after the experiment according to the above authors.

This idea of quantum suicide test seems to be plausible. In the following, I will argue that it is problematic. Consider a variant of the above quantum suicide experiment. Suppose when the result of the device is z-spin down, the device makes the observer not dead but be in deep coma without conscious perceptions. Then according to the above argument, the observer will still survive unharmed from the experiment and see the z-spin up outcome with certainty. Now suppose that the observer wakes up later from the deep coma and sees the z-spin down outcome in the z-spin down branch. Then, since the observer has a nonzero probability of surviving harmed from the experiment and seeing the z-spin down outcome, the total probability will be not one but larger than one. This is impossible.

The issue is more obvious when we adjust the amplitudes of the two branches of the above superposition. When $|\alpha|^2 \to 0$, the probability of surviving is always one for the observer, no matter how small $|\alpha|^2$ is. But when $|\alpha|^2 = 0$, the probability of surviving will be zero for the observer. This violation of continuity is in want of a reasonable explanation. It seems that since the change of the state of reality is continuous, the change of

[1]According to Peter Lewis (2000), "if the observer only has successors for some of the potential outcomes, then the relevant probability measure covers only those outcomes; the usual quantum mechanical probabilities for those outcomes need to be renormalized so that they sum to 1." By comparison, in a usual quantum experiment, since an observer has successors who see each potential outcome of the experiment, the usual quantum mechanical probabilities are the ones which are relevant for the observer. This also means that if an outsider watches the experiment, there is a probability $|\alpha|^2$ that he will see the observer alive and a probability $|\beta|^2$ that he will see the observer dead, since the outsider has successors for both outcomes (Peter Lewis, 2000).

the probability, which is determined by the state of reality, should be also continuous.

Then what is the crux of the problem? It may be related to the calculation of conditional probability. The probability of an observer obtaining a result is equal to the probability of the observer being alive multiplied by the probability of the alive observer obtaining the result. Although the probability of the alive observer obtaining the result is one, the probability of the observer being alive is not one in the quantum suicide experiment, and thus the probability of the observer obtaining a result is not one. Note that in usual quantum experiments where there are no life and death branching, the probability of the observer being alive is always one, and thus it can be omitted in calculating the probability of the observer obtaining a result.

There is another somewhat different argument supporting the idea of quantum suicide test (David Lewis, 2004). Since the observer cannot experience death or there is no experience of being dead, from the point of view of the observer, his experience must continue to exist through the alive branch with certainty. It seems that this also provides an explanation of why a dead observer should be not regarded as a successor of the original observer from the point of view of the observer. However, this argument is also problematic. The key is to see that why an observer cannot experience death is because he has no function of experiencing something and his experience terminates after death. Although an observer cannot experience death, death or the termination of his experience is still a possible outcome for him; otherwise in a classical Russian roulette, the observer will also live with certainty. But this is not true.

Again, the probability of an observer having an experience of a result is equal to the probability of the observer having the function of experiencing something multiplied by the probability of the observer having an experience of the result. Since the probability of the observer having the function of experiencing something is not one in the quantum suicide experiment, the probability of the observer having an experience of a result is not one either in the experiment.

In my view, a dead observer after the quantum suicide experiment is still a successor of the original observer. That a dead observer obtains no result is also a possible outcome for the original observer, and it should be also included in the calculation of the sum of probabilities of all possible outcomes for the original observer. By physicalism (which is widely accepted by the proponents of MWI), if only the particles of which the observer is composed exist after the experiment, the system should be regarded as a successor of the original observer. In this case, the Born rule is not violated.

Finally, it is worth noting that there is a sense in which the idea of quantum suicide test is intuitively plausible. If assuming a certain form of dualism, e.g. mind is something different from body and always exists somewhere in the world, this idea seems to be justified. In this case, since the dead branch cannot accommodate mind and mind only exists in the alive branch, the mind of the original observer will continue to exist in the alive branch with certainty in the quantum suicide experiment. However, most proponents of MWI are not dualists, let alone this kind of dualists. Moreover, this form of dualism can hardly explain where the minds are after death in single-world theories.

To sum up, I have argued that the quantum suicide experiment is not different from usual quantum experiments, and it fails to provide a feasible way to test the many-worlds interpretation of quantum mechanics. Therefore, even if you are a staunch proponent of the theory, you should not do this dangerous experiment.

References

[1] Lewis, D. (2004). How Many Lives Has Schrödinger's Cat? Australasian Journal of Philosophy 82, 3-22.

[2] Lewis, P. J. (2000). What is it Like to be Schrödinger's Cat?, Analysis 60, 22-29.

[3] Papineau, D. (2003). Why you don't want to get in the box with Schrödinger's cat. Analysis 63, 51-58.

[4] Papineau, D. (2004). David Lewis and Schrödinger's Cat. Australasian Journals of Philosophy 82, 153-169.

[5] Squires, E. (1986). The Mystery of the Quantum World. Bristol: Institute of Physics Publishing. pp.72-73.

[6] Tappenden, P. (2004). The ins and outs of Schrödinger's cat box: a response to Papineau. Analysis 64, 157-164.

[7] Tegmark, M. (1998). The Interpretation of Quantum Mechanics: Many Worlds or Many Words? Fortsch. Phys. 46, 855-862.

[8] Wallace, D. (2012). The Emergent Multiverse: Quantum Theory according to the Everett Interpretation. Oxford: Oxford University Press. pp.369-372.