The Sleeping Beauty Paradox from the Perspective of Multi World Explanation in Quantum Mechanics

Xiaolong Wang
Shanghai Arts and Crafts Vocational College

Abstract: The Sleeping Beauty Paradox is an unavoidable issue in probability philosophy. According to this paradox, the basic assumptions of probability philosophy will lead to conclusions that are highly inconsistent with intuition. Analyzing the two different viewpoints held by scholars on this issue, it can be found that they have a fundamental misunderstanding of each other in understanding the setting of this paradox, that is, they have not made appropriate distinctions between relative frequency and probability tendency. The multi world interpretation provides a new theoretical framework for describing probabilistic events, that is, describing the different consequences of a probabilistic event as a split world branch structure. By using this description, different types of probabilities can be clearly distinguished, misunderstandings can be avoided, and the Sleeping Beauty paradox can be eliminated.

Keywords: philosophy of probability; The Sleeping Beauty Paradox; Philosophy of quantum mechanics; Multi world interpretation

1.Sleeping Beauty Problem and Quantum Sleeping Beauty Approach

Firstly, we will use Elgar's own statement to illustrate the experimental setup of the Sleeping Beauty Paradox:

"Some researchers will make you fall asleep. During the two days that your sleep will last, they will briefly wake you up once or twice, depending on the number of times a uniform coin is thrown (front: once; back: twice). Every time you wake up, they will make you take a medication that makes you forget you have woken up before. So, when you first wake up, how much confidence do you have in the coin being positive?"

The special feature of this experiment is that taking memory loss medication makes it difficult for Sleeping Beauty to distinguish which wake-up call each time it is. Elgar believes that when Sleeping Beauty wakes up for the first time, her confidence in the coin being positive should clearly be 1/3. Before entering the experiment, that is, before falling asleep, the confidence level of the Sleeping Beauty in the positive result of throwing this coin should obviously be 1/2, because it is a uniform coin. However, according to the principle of reflection, if a subject can determine that their confidence in a certain proposition r will be x tomorrow, then they should have confidence in proposition r now. Before the Sleeping Beauty falls asleep, if she knows the setting of this experiment, she can calculate through a series of probability calculations that her confidence in the coin toss result being positive when awakened tomorrow is 1/3; So her current confidence level in this proposition should also be 1/3, but this is unreasonable. This poses a threat to the consistency of probability philosophy itself.

In the face of this issue, scholars represented by Elgar believe that there are abnormal changes in confidence that conflict with the principle of reflection, and they are generally referred to as the "third"; Scholars represented by David Lewis believe that there is no such change in confidence, and the principle of reflection has not been violated. They are generally referred to as the "half faction". The quantum sleeping beauty approach has stood out in this fierce debate and received widespread attention and discussion, precisely because this approach itself has its unique and noteworthy aspects.

2.Elgar's one-third argument

Elgar's derivation of the result of 1/3 is as follows:

Firstly, it is stipulated that P is the confidence function of the Sleeping Beauty when she is first awakened. Assuming that the first wake-up occurs on the first day, and the second wake-up (if the coin is thrown on the opposite side) occurs on the second day. P (H1) is her confidence in throwing a coin with a positive side and now on the first day, P (T1) is her confidence in throwing a coin with a negative side and now on the first day, P (T2) is her confidence in throwing a coin with a negative side and now on the second day.

So, suppose you wake her up on the first day and tell her that the result of the coin toss is the opposite. At this moment, she didn't know whether it was the first day or the second, because she didn't know how many times she had been awakened. And because every wake-up is indistinguishable for her, based on a principle of indifference with high limitations, she will definitely believe that the probability of whether it is the first day or the second day is the same. So it can be concluded that P (T1)=P (T2).

Then, suppose you wake her up on the first day and tell her that today is the first day. Since the experiment did not specify when the coin should be thrown, and regardless of the outcome of the coin being thrown, the Sleeping Beauty would be awakened on the first day, it can be assumed that the coin was thrown after waking the Sleeping Beauty on the first day. So, what is the confidence level of Sleeping Beauty that the coin toss result is positive at this time? Obviously, it should be a confidence level of 1/2 that a uniform coin is thrown with a positive result. And at this point, what should be the confidence level of P (H1) that the Sleeping Beauty's coin toss result is positive and now is the first day? Since she already knows that it is the first day, this confidence level should be equal to her confidence level that the coin toss result is positive, which is 1/2. Similarly, P (T1) is also 1/2, so P (H1)=P (T1).

Therefore, it can be obtained that P (H1)=P (T1)=P (T2). Due to the exhaustion of these three possibilities for Sleeping Beauty at this point, their sum is 1, and therefore their respective values are 1/3.