# Do We Live in the Multiverse?

***The Exploration of Future Universe and Human Intelligence***

Castaly Fan

05/16/2016

## INTRODUCTION

Owing to the Industrial Revolution, technology and human population are illustrated as the amazingly exponential growth. Nowadays, the brand-new development of physics implies the greater obligation for all human beings.

Modern physics are based on general relativity and quantum mechanics. The most attractive part of quantum physics is that it describes microscopic as a more profound structure. Today, scientists have found the importance of quantum technology, for instance quantum computer, quantum information – or – more abstract fields such as the existence of wormholes and parallel universe.

Are we able to accomplish time travel? Can we control the spacetime arbitrarily? Dose the multiverse exist?... All of these questions have certain explanations in quantum theory. The more feasibility we find, must imply the more significant mission we have.

## 1. SCHRÖDINGER'S CAT

According to the uncertainty principle of quantum mechanics, we cannot detect the displacement and the momentum at the same time. It defines the property of "random" in microscopic scale.

### 1.1 Experiment

In Erwin Schrödinger's Cat Experiment, there's a cat be put in a box. Inside the box, there's a device can activate the toxic gas. Once the particles decay, the toxic gas might be activated, and then the cat would die. In quantum mechanics, the cat at the moment of decay is in the situation of "superposition". More accurately, the possibility wave after being observed will immediately collapsed and turn into the particle, namely, the result of observation.

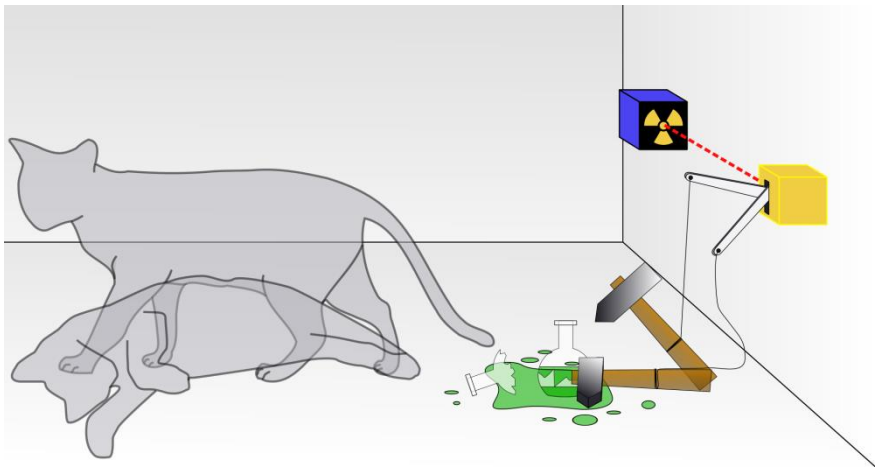

Fig.1 Schrödinger's Cat Experiment (source from *Wikipedia*).

### 1.2 Many-World Interpretation (MWI)

By analyzing above experiment, Hugh Everett III suggests the "many-worlds interpretation" (MWI). We can assume our universe full of wave functions, then, MWI implies that each choice of observer would lead the universe separate as two universes. In Schrödinger's Cat experiment, MWI suggests that the world would be separated as two at the moment we open the box and observe if the cat has died or not. In other words, each event can be regarded as a branch point. Our daily choices generate infinite universes. Thus, MWI indicates there are infinite parallel universes exist.

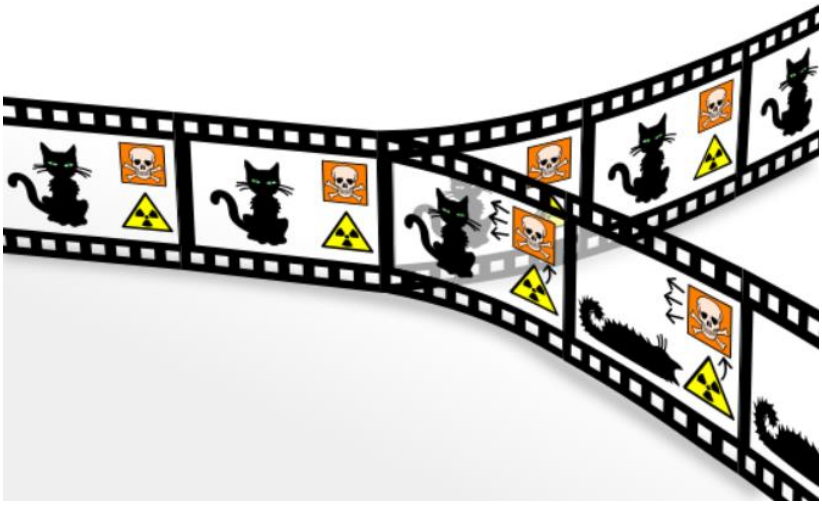

Fig.2 MWI implies Schrödinger's Cat may live in another parallel universe (source from *Wikipedia*).

## 2. THE MULTIVERSE

## 2.1 Categories of the Multiverse

Despite the fact that MWI hadn't been valued in early age, however, in 1970s, the theory has been valued in physics field, that is, "multiverse" theory. In 2003, Max Tegmark, a professor of MIT, formally categorized different types of multiverse:

(1) **Level I**: Due to the inflation after the moment of the Big Bang, the actual size of universe should be much huger than the observable universe. In other words, this type of parallel is not the real "multiverse" but the extension of our observable universe which exists outside of cosmological horizon. The physics principles of this type of universe are basically same as ours, but particles may have different configuration. According to an estimation, the object with the same configuration should appear approximately $10^{10^{112}}$ kilometers far away from us. Interestingly, the number represents the possible distance from us to "another us".

(2) **Level II**: According to the inflation theory, the inflations in early universe were random and happened everywhere. This means the inflation should create various universes which have different physical constants.

(3) **Level III**: Same as the many-world interpretation (MWI) in quantum mechanics. Dominated by probability, this type of multiverse implies that each choice will lead to the splits of universe, and the physical constants should be same us Level I multiverse.

(4) **Level IV**: This type of multiverse is based on all possible mathematical hypotheses in physics, for instance, string theory suggests that there are at least $10^{500}$ multiverses exist, and the physical constants of Level IV should be different from our universe.

## 2.2 Multiverse in String Theory

In a nutshell, string theory is a hypothesis since 1970s which describes a point-like particle as a 1-dimensional string. By introducing the supersymmetry into the string theory, there are five types of "superstring theory", which suggests our spacetime has 10 dimensions. In 1995, Edward Witten unified five types of superstring theories by dualities. In other words, all of these types of theories can be viewed as the different forms of "M-theory", which involving in 11-dimensional spacetime.

In effect, according to the string theory, we can view the vacuum energy as a "landscape" full of peaks and valleys. Our universe is located in a valley, namely, a

stable vacuum. The most important thing is that landscape theory describes the multiverse with various physical parameters, and there are $10^{500}$ possible solutions, that is, there are at least $10^{500}$ multiverses exist. [1]

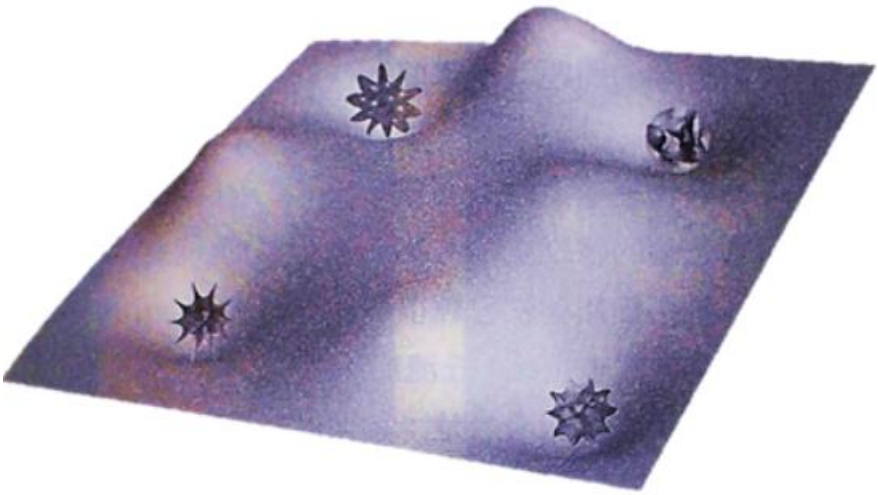

Fig. 3 Based on the string theory landscape, our universe dominates a "valley" with stable vacuum energy and develops everything without disaster.
(Source from: Shing-Tung Yau and Steven J. Nadis, *The Shape of Inner Space*, 2010)

### 2.3 Brane Cosmology

In addition to "strings", there are several "branes" appeared in string theory. According to brane cosmology, multiverse can be regarded as several "branes" which is embedded in higher-dimensional space. Our universe is theoretically a 3-dimensional "brane" embedded in the "bulk".

Besides, there is no any interaction among the branes except for gravity. Brane cosmology supposes that the attachment of branes might generates the wormholes. If two branes collided with each other, it might be viewed as the Big Bang, namely, the origin of a new universe.

## 3. THE FATE OF OUR UNIVERSE

### 3.1 Categories of a Civilization

In 1964, Nikolai Kardashev categorized a civilization in future based on the amount of energy they controlled:

(1) **Type I civilization**: They can completely control planetary energy with the amount of $10^{16}$ W. They can control the climate, prevent from earthquakes, drill deep inside the Earth, and explore through the whole solar system.
(2) **Type II civilization**: They can utilize stellar energy, that is, the energy with $10^{26}$ W. They are going to colonize inside the stellar system.
(3) **Type III civilization**: They can harness the energy with the amount of $10^{36}$ W. They control galactic energy, and ideally, they have already comprehended Einstein's theory, even can harness spacetime arbitrarily.

In fact, human is type 0 civilization currently. Based on astrophysicist Carl Sagan's A to Z categories, we possess information with the amount of $10^{13}$ bits which corresponds to the 0.7 H civilization. However, technology develops day after day, it's possible that we can turn into type I civilization within few centuries. [2]

### 3.2 The Ultimate Fate of Universe

Astrophysics heralds the end of our universe. Once the density of substance exceeds the critical density, the universe would end up expanding, then, the temperature would increase and everything in the space would pull back. This situation is called the "Big Crunch". On the other hand, if the density of substance less than the critical density, the universe would expand forever. Once the negative pressure exceeds, each galaxy, star, and even the atom would be pulled back, and then be destroyed. This extreme situation is called the "Big Rip". Another theoretical result called "Big Bounce", which suggests universe is cyclic everlastingly, namely, the origin of our universe should be the end of the last universe.

If the end of universe is incoming, that is, the gravity of substance would end up the expansion of universe. Meanwhile, all galaxies would be closer and closer, and the temperature would increase. Water on the surface of Earth will evaporate, so that we have no choice but to escape to outer space. Yet, atoms will be unstable under the overheated situation, electrons will turn into plasma out of atomic nucleus, and finally, protons and neutrons will out of nuclear strong interaction and be decomposed into quarks. As a black hole, the Big Crunch will destroy everything.

The only way to prevent from the catastrophe of Big Crunch is to escape away our universe via wormhole. Theoretically, at the moment of our 4-dimiensional universe born, the extra 6-dimensional universe should be collapsed simultaneously. Likewise, when our 4-dimensional spacetime collapsing, the 6-dimensional universe should

expand gradually. If our descendants in far future can realize spacetime structure and harness the wormholes, it might be a chance to last human intelligence.

### 3.3 The Ultimate Fate of Universe

It's possible that universe will be destroyed by either fire or ice. According to Michio Kaku's assumptions [3], there are several steps that our descendants can escape away our universe:

(1) **Propose the Theory of Everything (ToE)**: If an advanced civilization find the theory of everything, that is, an unique theory which unifies four natural interactions. Then, they may find the answers of the stability of wormholes and the feasibility of negative energy.

(2) **Find the natural wormholes or white holes**: Opposing to black hole, white hole can radiate the substance which helps escaping away the universe.

(3) **Explore the inside of black hole**: An advanced civilization should look for a black hole and launch a craft to explore the inside of black holes, and then bring back some precious information.

(4) **Create a black hole with slow motion**: An advanced civilization should have a capability to control the velocity and the radius of substance. Then, they can create a black hole with slower speed and stabilize.

(5) **Create a microscopic universe**: If the black hole we discussed above is extreme unstable, then, we should try to create a microscopic universe. Theoretically, if we want to create a universe similar to our universe, we have to have $10^{89}$ photons, electrons, positrons, neutrinos, anti-neutrinos, protons, and neutrons.

(6) **Build a particle accelerator**: An advanced civilization should find the deeper spacetime structure by a huge particle accelerator.

(7) **Negative energy**: The second device is based on the laser. We can imagine type III civilization establish the large laser storage on several asteroids and natural satellites of stellar systems. Then let those lasers emit at the same time to a point which create a high temperature enable to make spacetime be unstable. They can build a spherical board with $10^{-35}$ meters as a device of generating negative mass, and it might form a wormhole at the center of the shell which connect our dying universe with a young universe.

(8) **Build the warp drives**: A hyper-developed civilization may build the warp drives among the stars for passing the interstellar space shifts. Although it cannot be used to escape from our universe, the significant part is that it might

reverse spacetime and bring the civilization back to the past, a warmer age.

(9) **Utilize the negative energy**: A great number of lasers can create a state for generating negative energy, and then stabilize the wormholes.

(10) **Wait for quantum leap**: When the universe is dying, the process may last for trillions and trillions of years. This period is enough to let quantum events happened. In this way, human intelligence can wait for the appearing of wormholes or the happening of quantum leap though these events are unpredictable.

If, unfortunately, all of above are infeasible, then we remain have the last choice: input enough information into the new universe and recreate our civilization on the other side of the wormhole.

## CONCLUSION

Technology develops as a rate beyond human imagination. All plots in each sci-fi story are able to be realized in future, for instance, time travel, wormholes, or multiverse. These theories are not absolutely feasible in physics.

In nature, when the lives face an unfriendly environment, they would protect themselves in a subtle way. Some mammals can hibernate, some fish can generate the chemical substance for avoiding being freeze. Likewise, human should find a way to drill into another universe without being destroyed. For the endangered type III civilization, the most significant point is that: although universe will die sooner or later, it does not imply the intelligence should be withered.

Engaged in 21$^{st}$ century, human has significant missions for science. It seems that lots of idea are fictional, however, they would probably offer a blueprint and keep the human intelligence in our universe last everlastingly.

## REFERENCE


[1] Shing-Tung Yau and Steven J. Nadis, *The Shape of Inner Space*, 2010, US: Basic Books.

[2] Michio Kaku, *Hyperspace*, 1995, US: Anchor.

[3] Michio Kaku, *Parallel Worlds*, 2006, US: Anchor.