

*Chapter 7*

**WHERE IS THE OS OF THE BRAIN?:  
PHYSICAL CONSCIOUSNESS OUTSIDE  
THE BRAIN**

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**ABSTRACT**

Consider the rehabilitation. Local functions of the brain can be complemented by other parts by training, even if they were lost by an accident such as external injury and internal bleeding. This is the dynamical redistribution of functions inside the brain. It can be regarded as a result of the Operating System (OS) function of the brain, on the analogy of computers. On the other hand, the passive consciousness hypothesis is known to be a powerful hypothesis in the sense that it figures out the difficult problems concerning consciousness such as the frame problem, binding problem, etc. Intrinsic problem of the hypothesis, however, lies in the dubious mechanism by which collective opinions are decided by “majority vote” in the unconscious system and are collected to the local conscious system in a bottom-up manner. No one has elucidated, so far, how the unconscious system and the conscious one are connected in the neural network. The Parasite Fermion Model is a physical model that solves those problems. The Model asserts that, only by assuming the multi-dimensional universe that is nowadays commonly discussed in the modern physics and two types of fermions (material particles), there exists the materialistic subject, called Parasite Fermion Object (PFO), in the extra-dimensional space. One can avoid above-mentioned difficulties, by assuming that the PFO plays a significant role in the OS function and decision process of the unconscious system. It is shown that the Model gives us an insight into the possibility of “life after death.”

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## INTRODUCTION

### Monism and Dualism

Take, for example, a political discussion. Those who are convinced try to justify their statements through discussions. It is a collision between the “reasoning of one’s arguments” or “justifiable grounds.” The world of natural science, however, is a bit different. In general, it is possible to argue that, “Although it is not clear yet at this point if it is justifiable, we could say blah blah blah as a possibility.” This is a “presentation of a hypothesis.” Everyone has the right to present their own hypothesis, so long as it remains to be a hypothesis. The hypotheses will be theoretically and experimentally examined afterwards, resulting in some of them fading away at an early stage with their lies quickly being exposed, and others gaining publicity and going through a relatively long period of examination. Just a small portion of them will be considered valid and gain a status as an accepted notion, and may appear in the textbooks. Even in that case, however, experiments for the purpose of review will be continued to examine the limit of application of the theory. No matter how reasonably the theoretical observation is made on the hypothesis at the time of its presentation, its corollary still remains at a hypothesis level. A hypothesis in the area of the natural science must be examined by “nature” through experiments and observations. An argument without the proven grounds shall be taken as one merely implying a possibility. This is the very reason that differentiates the quality of the science from that of the religion where “the truth” is conveyed in a top-down manner.

There are generally two points of view that you could take when you think about the mind-body problem; namely, the monism and the dualism. In short, the monism argues that the “mind” and the “body” relevant to the mind-body problem are consisted of a single substance, whereas the dualism argues that each of them are consisted of something which cannot be the source of the other. In the world of modern physics, the predominant study policy is based on the materialism, that is, a perception that the materials are the source of everything in this world, and the mind, consciousness, and personalities of the human beings are a phenomenon that accompanies the functions of the brain comprised of the materials. It is not just predominant; rather, it is the only study policy publicly accepted. According to the religious interpretation of the world, on the other hand, the existence of the inner world which is not based on the materials is generally presumed. In this sense, the materialism and the religions are inconsistent in their interpretation of the world. Needless to say, there are some individual scientists who are publicly based on the materialism but have different thoughts in their mind. Dr. Hideki Yukawa, who is the Nobel Prize laureate in physics, who later believed in the Buddhism, is a good example. Mind-body problem are rare in that, a perception which has reached a consensus to a significant extent in the academic community has only reached a consensus so low as this in the world. In reality, there are many other categories, and it is not just an either-or between the monism and the dualism. Various arguments are being made based on each of such standpoints. This being said, setting aside how the individual researchers perceive inside their mind, the fact is that, the materialism is indeed firmly maintained by the modern physics studies. What, then, are we able to argue within this scope about the mind-body problem? For instance, are we able to presume “a mind which is independent from the brain” within the meaning of the materialism?

## **Re-Examine the Basis—What Else Do We Need?**

Which functions of the brain bring us about our mind? No established theory is available by the modern science as an answer to the question that has been posed through the ages. The improvements in the measurement technology, including the functional magnetic resonance imaging (fMRI), have allowed the hemodynamics in the brain to be visualized. As a result, a relationship between the state of consciousness, such as emotions, feelings and thoughts, and the state of the brain activities are beginning to be revealed. However, this will not be of any evidence to indicate that the brain activities generate the mental states. Although it implies the linkage or the relationship between the brain activities and the mental states, it does not indicate in any sense the causal association between them, that is, a linkage between the cause and effect, such as “This activity of the brain generates that psychological state.” On the other hand, the reports are made on some cases where people remembered the happenings that had occurred around them and the flush of emotions that had arisen while their brain activities stopped, and reported about such experiences after they restored consciousness. Some scientists even argue the possibility of the perpetuity of the afterworld mind, consciousness and personalities. A study on the “reincarnation” is one of such examples. In the study of Dr. Ian Stevenson and Dr. Jim Tucker, the University of Virginia, more than 2,500 cases were collected all over the world (Tucker 2008, XIV). A tendency is shown that they start talking about what they call their previous lives around the age of three and stop talking about them closer to six or seven. While some researchers try to explain this phenomenon through a memory mechanism particular to the childhood, such as the childhood amnesia, Tucker conducted a detailed investigation on the cases where he could identify who those people were in their previous lives based on their evidence on the memories of their previous lives, and argues that the “reincarnation” is a phenomenon that truly exists. If this is true, the next required step would be to explore a scientific theory that accepts the reincarnation phenomenon. As a matter of course, the relevant modification in the relevant academic area, including the modern brain science and the physics, would be required. On the contrary, if one denies the existence of the “reincarnation,” one would have to be able to explain the background of a number of cases suggesting the memories of previous lives without using the “reincarnation” as a reason. In this sense, the direction of the abovementioned research attributing the causes of the evidence on the memories of previous lives to the childhood amnesia is naturally acceptable. On the other hand, if you argue that the reincarnation does not exist by denying the very existence of over 2,500 cases evidencing the memories of the previous lives, saying that “it is inexplicable by the modern science,” such attitude is inappropriate as a scientist.

I would like to hereby cite the words of the two other people who accept the perpetuity into the afterworld. Dr. Eben Alexander, a neurosurgeon, states as follows: “Without knowledge of the larger geography of where we came from and where we are going again when our physical bodies die, we are lost.” (Alexander 2014, XXXIII) Dr. Naoki Yahagi, the head of the Emergency Department and the Intensive Care Department of the University of Tokyo Hospital, states as follows: “Death is not the end. Our soul is perpetual. The essence of our being, in the first place, is not the body but the soul. Therefore, there is actually no reason for us to fear the disease and aging.” (Yahagi 2014, 162) Given these statements, is it not unjust to exclude from the start the potential existence of the mental activities independent

from the brain activities? As a matter of course, however, it is difficult to think that, given the fMRI example as mentioned earlier, the brain activities and the mind are totally independent and irrelevant. Inside our brain, there may be the phenomena, be it the source of our mind or not, that are yet unknown but are related to the mental states. If any physical grounds could exist independently from our brain as a subject that engages in the mental activities called consciousness and personalities, and if, further, they are the causes of the brain activities observed by the abovementioned visualizing technology, the next question to come would be in what form do such materials exist, and how do they interact with the brain. Moreover, a question must also be posed as to how they could escape the medical and biological observation until now. In the latter half of this discussion, I would like to stick to the materialist perspective to look into the pattern that the soul dwells in the body, based on the latest outcome of the research concerning the new patterns of existence of the material particles. It is a hypothesis to challenge the statement that says “A materialist must explain the consciousness as part of the brain functions dwelling in this cranium. If you accept a consciousness independent from the brain, the monism would not work.”

To date, the entire outcome of the experiments of the elementary particle physics can be explained by what is called the “Standard Model.” Now that the Higgs boson, the lastly discovered particle among the particles anticipated in the Standard Model, was discovered, the firm footing of the Standard Model has been made furthermore solid. Could we then totally leave all physical phenomena in the world to the Standard Model? The answer is no. The Standard Model has been successful in describing three out of the four physically known interactions—that is, all except the gravity. However, it has not been able to quantize the gravity, leaving the gravity outside of its theoretical scope. In short, it is a “defective” theory. It is the general theory of relativity that describes the gravity. The two theories are concomitant but play in the different fields—should we call only one of them “standard”? Would there not be the true “standard” model in charge of all forces that we have not yet discovered? There are a number of physicists who are feeling ashamed. However, except for those limited number of theorists who make living by exploring the “true standard model,” the reality is that we can live without being distracted by this issue—which is not surprising, as all experimental outcomes and observations that we see these days can be explained by either of the two theories.

Should there be a pitfall, it may be somewhere around here. When we try to deal with the mind-body problem physically, some theoretical defect may be deceiving our eyes to lead us to a conclusion different from the truth. In the modern physics, two unintegrable—that is, two incompatible theories, namely, the Standard Model and the relativity co-exist, which means that the fundamental theories of the physics are not being integrated without inconsistency. As such, the modern physics is blatantly defective, and it is obvious what actually the defect is. It implies the future development of the physics, where the two theories are integrated without inconsistency and the next-generation standard model will be completed. Generally speaking, no person would agree to a statement such as to say, for example, that “The science has now reached its highest point of development, thus leaving no room for a further progress.” However, on a more specific basis, rarely do we encounter a case where the current situation is understood that the two incompatible theories co-exist and its meaning and the direction of the future development are examined particularly in relation to the mind-body problem. We may be in a situation where, with an incomplete interpretation of the world drawn from the incomplete physics, we are unable to get out of the circumstance of being

forced to perceive things in a narrow scope even with respect to the matter of our current interest, which is the mind-body problem, and we do not even have the slightest chance of recognizing the situation. At least, it may be worthwhile examining the possibility. I would like to take time to look into this issue in the following discussion.

The two principal pillars of the modern physics, the quantum theory, which is the basis of the Standard Model, and the relativity, have both presented in their respective initial periods an outlook on nature which is drastically challenging to the people's common sense. The substantial changes to the outlook on nature occurred intensely at the beginning of the 20th century which significantly undermined the traditional outlook on nature, including the perceptions that the position and the momentum cannot be precisely determined at the same time, that the "existence probability" is the only measure to properly formulate the variation corresponding to the lapse of time using the equations, and not the positions of the particles or the velocity, that the wave-particle duality exists, that the time can be regarded in the same light as the space (the concept of the "space-time") and it gets distorted due to the existence of the mass (= energy), and that such distortion is the gravity itself, etc. Tremendous efforts were made by the forerunners who established the new theories based on the observational consequences that are inexplicable by the traditional theories and the crackbrained ideas beyond the common sense that had existed. Undoubtedly, a similar theoretical breakthrough can be achieved any time in the future. It is more natural to think that, although it is hard to anticipate the timing, the next breakthrough will surely be made before too long. A highly probable expectation is that the upcoming breakthrough would be something that would be "unconventional," defying our existing knowledge, as the substantial changes had been at the beginning of the 20th century.

With respect to the mind-body problem, the current mainstream from the scientific perspective is that the mind is generated as a result of biological and chemical action of the brain. Our inner experiences, such as emotions, memories and senses, are said to be the manifestation of the functions of the brain as a material. However, nothing has been revealed in relation to the cause and effect between the specific individual functions and the experiences. Given this circumstance, it may be reasonable to some extent to assume that the source of the mind may not be the brain. The upcoming next breakthrough in the physics may be decisive in bringing an end to this disarrayed mind-body problem. If this is not absolutely impossible, it would be worthwhile to hope for it, and your life would be more blessed with that thought. Before we go on to examine the matters related to the mind-body problem, I would like to talk a little bit about some related issues in the following Section, namely, the theoretical study beyond the Standard Model of the physics.

## **SECTION 1. MULTIDIMENSIONAL UNIVERSE – OUR UNIVERSE IS NOT THE ONLY UNIVERSE!**

### **Dissatisfaction with Status Quo Is the "Steppingstone to the Development"**

"An artificial black hole can be made possible." In the early 2000's, such a controversial news was reported. This was about an experiment performed at an experimental facility for the high-energy physics, "Large Hadron Collider" (LHC), located near the national border of

Switzerland and France in Europe. “Hadron” is a collective term given to the particles comprised of 2 to 3 quarks that are a kind of the elementary particle. The constituent particles of the atomic nucleus, the neutron and the proton that you learn at school, are among the hadron. The meson, the existence of which was predicted by Dr. Yukawa, and the existence of which was later confirmed, is also included. In the experiment using the LHC, the protons are accelerated inside the giant circular vacuum tube the total circumference of which reaches about 27 km, the protons that are rotating in nearly the speed of light are collided with each other, and the broken pieces that are generated (the new particles) are observed and analyzed to sort out the physical phenomena that have happened. The collider is in a circular shape to allow the protons to continue to accelerate until they collide, and the facility is huge so that a high energy can be obtained with a higher efficiency. As for the black hole, everyone seems to have some kind of an image. It is something in the cosmic space that absorbs everything. If it could be made artificially and on the ground, it might not only be “fantastic and interesting,” but also eerie to some people. In fact, a certain researcher who is engaged in the physical experiments of the atomic nucleus bothered to explain in his press conference that there would be no such effect whatsoever of “the entire globe being swallowed” as generally concerned. This mere fact suggests that the public opinion was concerned to a considerable extent, and that at the same time, people were relatively interested. A black hole, if in fact generated by this LHC, would be minimum. In addition, it would cease to exist after releasing the energy in an extremely short period of time in accordance with a mechanism called the Hawking radiation. As such, there is no risk of damage at a macroscopic level. In any event, it is good if a lot of people were driven to pay attention to the science through a high-profile topic.

Meanwhile, what is the purpose of colliding the protons, and with the energy as high as possible? Think about when you boil water with a kettle. As the temperature rises, the water vapor jets out. By heating, the water molecules that had been intertwined with each other to constitute the liquid water get energy, and cut off the connection among themselves to independently move and evaporate. What will happen if we raise the temperature of this water vapor? This time, the individual molecules will be further decomposed, and the atoms of the oxygen and the hydrogen will be separated. If we further raise the temperature, the decomposition will be further advanced, and the atoms are decomposed into the electrons and the positive ions that comprise the atoms to enter an ionized stage called plasma. The higher the temperature of the materials are, the more fragmented they become and turn into the more minuscule constituent particles. The physicists try to decompose the materials into as smaller parts as possible to see their interior in order to find out the basic particles that comprise the materials and clarify the forces acting amongst them. How then, do we “decompose” the materials? “To heat” means to give energy. By putting the materials in a higher energy state, we are able to observe the physics of a more microscopic world. A colliding accelerator is, in short, a device that decomposes the particles by placing energy from the exterior through acceleration of the particles (by giving a kinetic energy) and their collision. When you have a proton collide with another proton, various kinds of particles will be generated depending on the quantity of the energy. The larger amount of energy you put in, the more particles you will see that could not be seen before and you would be able to expect an interaction that you have never observed or the physics that you have never seen. For this purpose, we construct a giant accelerator that could create as large amount of energy as possible with a huge budget.

A black hole can be made through an experiment—this, in itself, is extremely interesting as well as impressing in a sense that it is somewhat SFish. Putting that aside, let us reconsider what it implies. The Standard Model is a tentatively “complete” physics theory which is able to thoroughly describe the experiments and the observational consequences of the modern physics. I say “complete” because currently, we have in fact no problem interpreting the experimental outcomes and observational consequences using this model. I also say “tentatively,” because the observations are beginning to be made on the phenomena deviating from the traditional frame of the Standard Model, as can be seen in the observation of the neutrino oscillations (the phenomenon where the neutrinos coming to the earth transform into different types; it suggests that the neutrinos have mass, whereas the mass of the neutrinos is considered to be zero in the Standard Model). It is expected that the progress in such observations, with the accumulated new discoveries, will lead to an establishment of a new theory beyond the Standard Model. There are reasons to why, despite the current Standard Model being able to consistently describe the observational experiments, people are making such expectation. The types of the particles that comprise the materials are one of such reasons. The quarks that comprise the protons, mesons and the like inside the atomic nucleus are classified into generations called the first, second and third generations. The Standard Model predicted the existence of two types of particles in each generation, with a total of six types of particles, and all of them have in fact been discovered. It is unknown as to why the number of the generations is three—the fourth and the fifth generations could potentially exist as well. However, no experimental outcome to date indicates such possibility. The most significant issue is that, among what is called the quarks, only the particles in the first generation, namely, the up quarks and down quarks, exist spontaneously in this universe. What, then, are the *raison d'être* of the second and thereafter generations? This is yet to be known to date. In addition, with respect to the interactions that exist in this universe (the forces that act among the particles), 4 of them are known today. They are the electromagnetic force and gravity (that are familiar to us), as well as the “strong force” and the “weak force.” What makes it difficult for us to understand is that only the gravity from among the 4 forces is extremely small. It is so small that it is only approximately  $1/10^{34}$  (that is, 1/10 billionth of 1/trillionth of 1/trillionth) of the smallest of the remaining 3 forces, which is the “weak force.” The ratio of power of the 3 remaining forces stay within the range of  $1 : 10^6$ . That is, only the gravity is extremely small in strength compared to the other forces. The Standard Model does not provide us with any persuasive explanation on this apparent unnaturalness. This issue is particularly called the “hierarchy problem.” I will talk about this in the Sections that follow. Another issue of the current Standard Model is that there are too many parameters that have to be given manually by human, such as the strength of the forces. However, the fundamental theory that we are looking for has to start from a guiding principle which is as simple as possible, and has to be something that allows us to obtain various physical constants as a natural consequence.

### **Does Superstring Theory Save Physics?**

Given the abovementioned circumstance, the physicists have an expectation for an updating of the Standard Model. Above all, the more significant issue of the modern physics

is the fact that the quantum mechanics and the theory of relativity, each of which are extremely successful, have not been integrated into one unified theory without inconsistency. This is a huge problem. The two main pillars of the modern physics are incompatible with each other. A circumstance where each of them is successful is where, in an aspect where you can disregard the effect of either of the quantum mechanics and the theory of relativity, you can rely on the other theory to well describe and predict the relevant phenomenon. This means that in an aspect where the effects of both theories are prominent and cannot be disregarded, it cannot be appropriately described by the language of the current physics. Such aspects include, for instance, the initial period of the universe when the level of the energy was extremely high and the curvature of the universe's space-time was extremely high, or, the dynamics of a black hole. The theory in relation to which a research is under progress with an expectation to resolve this issue is the string theory. Under the existing Standard Model, the elementary particle, which is much smaller than the atomic nuclei and are the basis comprising the materials, and the gauge particle, such as the photon, which mediates forces, is considered to be one very point which does not have a spatial extent. The string theory considers this to be a one-dimensional string-like object, and attributes the diversity of the types of particles to the difference in the vibrational state of this string. The string theory is currently considered to be the prime candidate for the theory that integrates the quantum mechanics and the theory of relativity.

There is a by-product to the string theory, which is the dimension number. Both the quantum mechanics and the theory of relativity view the world as being comprised of a total of 4 dimensions, 3 of which are for a space and one for the time, while the string theory delineates the world as being comprised of multiple dimensions larger than four. Rather, in order for the theory to keep consistency, the world cannot be four-dimensional. The reason that the Standard Model and the theory of relativity have not been integrated may be because the number of their dimensions had been wrong. The string theory which is able to describe not only the particles that mediates the forces but also the material particles is called, in particular, the superstring theory, the number of dimensions of which is ten. It is difficult to imagine the dimensions so many as this, as it is far from our common sense. However, on top of the surprisingly large number of dimensions proposed thereunder, the impression given by the superstring theory as an ultimate candidate theory which will be the standard model of the next-generation is quite strong. On the other hand, there are still some issues that need to be solved with respect to this superstring theory that has captivated a lot of physicists. First of all, if the world is in fact comprised of multiple dimensions, why are we only able to see 4 dimensions, namely, the space and the time? The Standard Theory that we currently have at hand is a 4-dimension theory, and we are able to explain all experiments on elementary particles based on this theory. If we are unable to detect the extra-dimension space, that is, the dimensions other than the 4 dimensions, due to the reason that the energy level of the experiment is too low, we need to explain the reason why it is invisible in the low energy region. The dimensions that exist but that are invisible. What is it that is hiding the extra dimensions?

A mechanism that has been worked out as one of the answers to this issue is the "compactification." This is a relatively simple concept where it is perceived that, although the extra dimensions exist, their extent is too small to be visible or observable. The high-energy experiments to date have succeeded to observe a space in the scale of  $10^{-16}$  cm (1/10,000 of 1 trillionth). This means that, if the concept of the compactification is accurate, the size of the

extra dimensions are smaller than this size. If the extra dimensions exist in the compactified size so small as to be unobservable, it is effectively the same as living in the 4-dimension world from the beginning.

## Brane Model

Apart from the compactification, there is another mechanism called the brane model, which makes the extra dimensions invisible. The “brane” is a term which has derived from a word “membrane.” Although originally, it means the “membrane,” in the string theory, it refers to the low-dimensional space-time integrated into the high-dimensional universe (Figure 1).

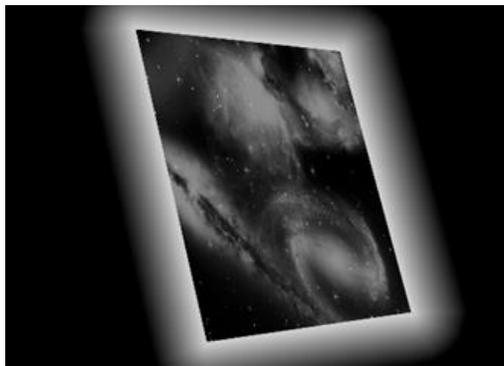


Figure 1. Brane universe.

A term which forms a counterpart is “bulk,” which refers to the entire high-dimensional universe that includes the brane. The brane is an object which is integrated into this bulk or which forms the boundary with the bulk. Very conveniently, in fact, a cosmic view which suggests that the (3+1) brane is integrated into the high-dimensional bulk space-time sheds a light on the various issues in the modern physics. Such issues include the hierarchy problem, unravelling of the dark matter, and the exploration on the cause of the cosmic expansion. Now then, why is it called the “brane”? When we say brane, we imagine something that is thin. Why is this expansive universe called the “brane”? Normally, when we call something a “brane,” it is indeed something thin, be it the bubble brane in the wire hoop, the oil membrane in the puddle, or whatever. Precisely speaking, even a bubble brane has a definite thickness as thick as several microns, and in this sense, it is 3-dimensional. However, I would like to glamourize and disregard the thickness of these branes here. As a result, a brane can be considered as a 2-dimensional object when we observe it from the 3-dimensional space where we live. Normally, we call a 2-dimensional object a brane. In a more general sense, an object with a certain number of dimensions can be described to be a brane when observed from the world with a larger number of dimensions. The 4-dimensional space-time where we live is a brane when observed from the 10-dimensional space-time. Interestingly, the brane on which the universe where we live exists is not necessarily the only brane that exists in the bulk. There may be multiple other branes. They may be intersecting, colliding, or located or interacting in various ways. Its depth is immeasurable, such that a theory has been submitted

arguing that the famous Big Bang can be explained based on the dynamics of the brane. Further, the number of the dimensions of the brane itself may not necessarily be four; various numbers of the dimensions can be perceived.

### Path to Solution for “Hierarchy Problem” – ADD Model

One of the effects of an extra dimension expected of the LHC is the aforementioned generation of a black hole. Before I look into how it is structured, I would like to get off the point for a while (it is however a still important point). In establishing a model using a brane, a challenging point is the hierarchy problem, which is too unnatural in its difference in strength of the interactions that I mentioned earlier. Something that paved the way to resolving this issue is the “large extra dimensions model.” I would like to call this the ADD Model after the three persons who devised the model, namely, Arkani-Hamed, Dimopoulos, and Dvali (Arkani-Hamed, Dimopoulos, and Dvali 1998). In this model, the abnormal weakness of the gravity is resolved by the magnitude of the extra-dimensional space. In the superstring theory, the material particles and the particles which mediate interactions between them are described as a “string”. There are two types of strings—an open string which is a one-dimensional object with two end points and a closed string which is an elastic band-like loop with no end points. The gravitons which mediate the gravity can be described by a closed string, whereas all the rest of the particles are described by an open string (Figure 2). Although the two ends of an open string can move around on the brane, they do not deviate from the brane. As such, an open string is bound down on the brane. On the other hand, solely the gravitons, which are described by the closed string, can break loose from the brane. When you look at the physical four “forces,” while the three forces, namely, the electromagnetic force, the “strong force,” and the “weak force” can only exist inside the brane where we live, only the gravity is able to act on outside of the brane. Looking it from our side which is trapped inside the brane, the gravity appears to have been “thinned down,” as it were, and have weakened, compared to the former three forces that are similarly trapped inside the brane. More particularly, it would be that in the multi-dimensional picture such as this, the gravitational constant that we feel is in fact a deceptive figure, and the true gravitational constant is indeed much larger. The true gravity is not particularly weak; it is merely that it is structured so that we feel that it is extremely weak. Accordingly, the ADD Model has paved a path to the resolution of the hierarchy problem.

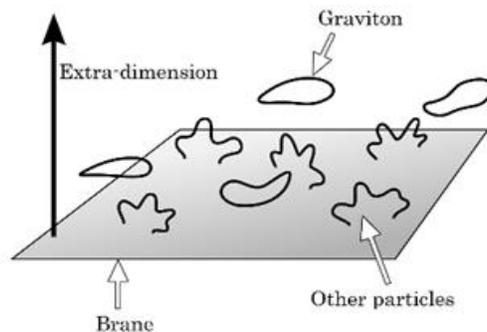


Figure 2. Various types of strings.

The photons are the particles that mediate the electromagnetic force. It is an open string trapped in the brane. More particularly, it is in principle impossible to capture the extra dimensions through an observation by light no matter how. What measures can we think of then, to capture the extra dimensions experimentally? In this respect, the sole particles that are not trapped in the brane are the gravitons. The gravity could be a keyword. One of such efforts is the generation of a black hole through a high-energy experiment. Why then, is a black hole generated when the high-energy particles are collided in the LHC? The quantity which is proportional to the inverse of the square root of the gravitational constant ( $G$ ) is called the Planck mass ( $M_P$ ).

$$\frac{1}{\sqrt{G}} \propto M_P$$

When the particles are accelerated and collide, if the energy amounts to approximately this Planck mass, a black hole is generated. Based on the perception to date that the gravity is extremely small compared to the other three forces, that is,  $G$  is very small, the Planck mass is on the contrary extremely large as you can see from the formula above, and it has been believed that it is virtually impossible to reach that area through an experiment. However, the different circumstances apply when you use the ADD Model. It is a misperception to feel that the gravitational constant is small. It is actually larger than what you actually feel. The true Planck mass may not be as large as it had been perceived, making it possible for the LHC to achieve the Planck mass and generate a black hole. If a generation of a black hole is confirmed in the LHC, it could be a piece of evidence which suggests the multidimensionality of this universe!

The study on the multi-dimensional universe per se was inspired by the study at the beginning of the previous century at the latest, where the integration of the theory of relativity and the electromagnetics had been sought. Although it has been over a century since then, it is only very recently that the possibility of the observation has come under close scrutiny. As a matter of course, it is totally different to point out that there is a theoretical possibility of existence and to prove the existence. For instance, at the beginning of the 20th century, the general theory of relativity suggested the theoretical existence of a black hole. However, for half a century since then until a black hole was actually observed in the universe, many of the physicists thought that it was purely a theoretical product, and few thought that it actually existed. Nowadays, a lot of observational results have been obtained that indicate the existence of a black hole, and very few people doubt its existence (although it is not completely zero). Although as a corollary of the string theory, it is considered that our universe is multi-dimensional, the string theory per se is far from being accepted as a standard theory at the moment. Indeed, there are numerous issues that need to be resolved, including a necessity to verify a mechanism which allows the extra dimensions to be invisible for having low energy (such as the abovementioned compactification), a theoretical resolution on a huge gap extending to 16 digits between the energy scale of the string theory and the energy scale of the current Standard Model which takes care of the phenomena of the low-energy elementary particles, the explanations on the initial inflation and the accelerating expansion of the universe. On top of that lies the fact as a more fundamental issue that the guiding principle for the string theory is yet to be unraveled. On the other hand, it is also true that the string

theory is positioned on the far right wing with a potential of being a standard theory of the next generation which integrates the theory of relativity and the current Standard Model. If multidimensionality is indicated as a result of an experiment, it would certainly be a material breakthrough out of the paradigm. It is difficult even just to imagine what theoretical predictions we are able to get as a corollary of the new multi-dimensional physics theory. I am sure that the nature will reveal an amazing fact that we would never be able to imagine no matter how much we struggle to conjecture this and that now. Those phenomena that are said to be psychic and are currently ineligible for a scientific examination—even they could be a subject of science. Dr. Randall, who is a researcher of a brane world model, when she revealed to her co-worker that she was considering installing a new space dimension and was asked that “It is about the world where you will have a spiritual experience or the afterworld, no?” is said to have responded, “No way.” Although I do fully understand why she would want to swear, as one researcher who has dipped into the modern physics world, I would like to bother to point out that it may not be the case.

### **Warped Universe – RS Model**

In the ADD Model which has large extra dimensions, there are extra dimensions as large as several millimeters. From the view of energy, this is about  $10^{-4}$  eV, and conversely, is 15 digits far to the smaller side compared to the energy scale of the Standard Model. With this size of the scale, it could be said that the hierarchy problem has not yet been resolved but has rather been rehashed. Is it possible then, to establish a model where the energy scales do not vary as much as this? Dr. Randall and Dr. Sundrum (RS) have overcome this problem by devising a model where the extra dimensions are warped (Randall and Sundrum 1999).

In this RS Model, two branes of the 4-dimensional space-time are placed in the 5-dimensional space-time across each other with the fifth space dimension in the middle (the Initial RS Model) (Figure 3). That is, there will be just one extra dimension. The Standard Model particles are trapped in one of the branes. This is the brane where we live in and is called the weak brane. As a matter of course, the Standard Model particles include not only the fermions that constitute the materials but also the bosons that mediate the electromagnetic forces, strong forces, and the weak forces. Similarly with the ADD Model, only the gravity is not trapped in this brane and is able to propagate through the bulk. On the weak brane, the fermions interact with each other through the bosons, and only the bosons called the gravitons that mediate the gravity are able to exist anywhere in the 5-dimensional space-time. The important consequence of the RS Model is that the gravitons are not distributed evenly in the bulk. In the general theory of relativity, a gravitational field is literally a distortion of the space-time. Any object that has mass distorts the surrounding space-time. It is famous that, in 1919, as an embodiment of this prediction provided by the general theory of relativity, the space-time near the sun was distorted due to the gravity of the sun, and as a result, the distorted light path coming from the fixed star at the back of the sun was observed (the gravitational lens effect). The distortion of the space-time propagates to the surroundings as an object which has mass moves, forming a gravitational wave. On 2016, this wave was firstly observed.

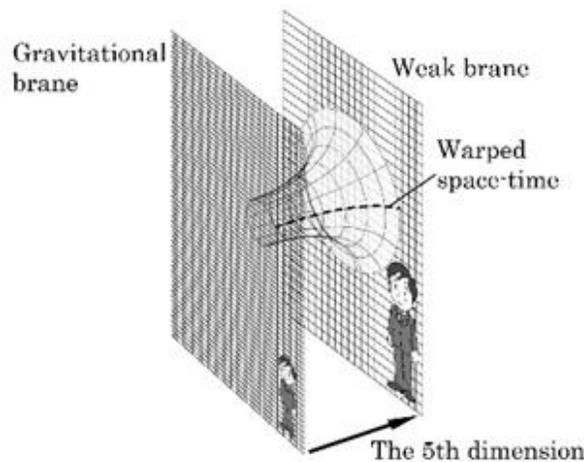


Figure 3. RS model.

RS paid attention to the fact that the brane itself has mass, and solved the Einstein' equation, which links the distribution of the energy (=mass) in the space-time and the distortion of the space-time with respect to the 5-dimensional space-time where the two branes with different mass exist. They then clarified the warp of the extra-dimensional space. According to them, when you set  $(x^0, x^1, x^2, x^3)$  as the coordinates in the space-time inside the brane (with  $x^0$  being the time axis and the rest being the space axes) and  $x^5$  as the extra-dimensional coordinate, the gravitational field in the 5-dimensional space-time varies as a function of  $x^5$  only. The gravitational field in the brane is multiplied by the constant in correspondence with the position  $x^5$  of the brane in the extra-dimensional space, and the constant is expressed by the exponential function of  $x^5$ . It is presumed that the brane itself is flat and there is no gravitational field inside it. However, the gravitational field in the brane varies in correspondence with its position within the extra dimension, and, as shown in the figure, the pitches of the time and the space of the space-time inside the brane vary. The fact that the space is warped in the direction of the fifth dimension means that, as a matter of course, the gravity works differently depending on the location within the space. From the perspective of the gravitons, which propagates the gravity, it means that it shows a distribution in accordance with the distribution function which is solely dependent on  $x^5$ , rather than  $(x^0, x^1, x^2, x^3)$ . Naturally, this distribution function reflects the features of the warped space-time, and exponentially varies between the maximum on one brane and the minimum on the other brane. The brane where the distribution function is minimum is the weak brane, which is where we live, and the distribution function will be the maximum on the other brane. This brane is called the gravitational brane. On the gravitational brane, the gravitons exist densely. As you leave this brane to enter the extra dimensions and approach the weak brane, the density of the gravitons which exist in the surroundings becomes exponentially lower in a rapid pace, reaching the minimum on the weak brane. Naturally, the higher the density of the gravitons is, the stronger the gravity is, and the lower the density of the gravitons is, the weaker the gravity will be. The reason why we feel that the gravity is particularly weak is that the density of the gravitons on the weak brane is extremely low. On the contrary, the gravity is extremely strong on the gravitational brane due to the distribution density of the gravitons. If you perceive this as the true strength of the gravity, the hierarchy

problem is solved. The point in this model is that the strength of the gravitational field is expressed by the exponential function on the coordinate of the extra dimensions. By virtue of this, we do not have to attribute the extreme smallness of the gravity on the weak brane to the hugeness of the extra-dimensional space. The moment we leave the gravitational brane, the distribution density of the gravitons become lower in accordance with the distance therefrom and the exponential function, which is a rapidly changing function. For this reason, it is not necessary to have so large extra-dimensional space as is required under the ADD Model, regardless of how small we feel the gravity is. The distribution function of the gravitons become sufficiently small, keeping the extra-dimensional space as small as it is, thereby requiring no large extra-dimensional space such as is required under the ADD Model. The difference in the gravity strengths on the gravitational brane and the weak brane can be described with a distance which is not so much different from the length of Planck, if you take a look at the distance between the branes.

## **SECTION 2. ADVANCE MODEL OF “CONSCIOUSNESS INDEPENDENT FROM BRAIN”**

### **What Is Non-Computability of Intellect?**

Our consideration aims at pursuing the horizon to see to what extent we are able to press hard on the mind-body problem taking advantage of the modern physics, particularly, to what extent it is physically possible to examine the substance of the consciousness which exists independently from the brain. From this point, I would like to consider the specific possibility of the existence of the consciousness which is independent from the brain. It could be called our personalities, or our mind. Let me say that such thing exists separately from our body, and independently. I would, however, like to stick here to the point that it is something that has material grounds, as does our body, rather than something ideological. That is, this has to be something which could be a subject of research of the modern physics—I will ensure this. Based on this, I would like to say that it is comprised of a material particle, which is fermion. Where do we seek the whereabouts of the consciousness? A physicalistic aspect based on the monism which seeks the whereabouts in the brain functions, and the aspect of dualism which assumes the existence separate from the materials, accepting the existence of consciousness as a substance apart from the brain. It is not simple, as each aspect has their various details as a matter of course. I would like to ask myself if, as the third alternative, something like a “monism where the consciousness exists separately from the brain.” First of all, I will look into the current status of the researches on “the consciousness which is independent from the brain.” A consciousness as a substance which exists not as a result of the brain activities but independently from the brain—is such a thing possible? How much have the researches progressed?

Dr. Stuart Hameroff, an American anesthesiologist, advocates in his unique study something ultramicro called “Proto-conscious,” which is independent from the brain. According to him, the Proto-conscious continues to be even after the perishing of the brain, and gains an opportunity to dwell in another brain to “be born” again in this world. Underlying in his study of the mind-body problem is the “Orch – OR Model” which he

proposed with Dr. Roger Penrose, a theoretical physicist. “Orch” is an abbreviation for “Orchestrated,” and “OR” is that of an “Objective Reduction.” What is this model? What is going to be orchestrated and what is going to reduce?

One thesis that constitutes a foundation of Penrose’ study on the consciousness is an argument that the “Thoughts of the human beings are non-computational.” Artificial intelligence, which is a popular topic among the researchers, is an example. It is an effort to imitate human’s intelligence using a computer. Some researchers consider as follows: With the progress in the study on the artificial intelligence, it will eventually evolve into something which can be called an artificial consciousness. It will have a desire and appetite, and will be able to apply the information obtained through perception to the actions in line with its own desire based on the “cognizance.” It will be able to predict the future events to some extent (it does not have to be able to predict everything, as it is not possible even for the human beings), and it will have the thought patterns and emotions unique to itself as the human beings do, eventually possessing “personality.” However, those who believe that the thoughts are non-computational argue that there is no possibility that the artificial intelligence will make such a development. They say this is because the current artificial intelligence is as computational as one can be. Being “computational” means that each individual problem can be reduced to a computation which will be made in line with a program that gives an algorithm to solve that problem. An algorithm is a set of rules utilized for the computation to solve the problems, and is a computational process. Penrose and Hameroff believe that the thinking ability of the human beings cannot be reduced to something like this, and that it is non-computational. To be non-computational means that there is no algorithm for the computing. More particularly, a certain status of consciousness cannot be derived from a status at a preceding point in terms of time through a process of algorithm. They first reached this conclusion, and then set up a mechanism that supports such process.

Which of the materials and the mind is primordial? This is a question that the mankind has pursued since several thousands of years ago. It is the materialism that requires materialistic support for the mental activities, and it is also called the reductionism and the physicalism. An opposing concept is the idealism, which considers that the spiritual existence constitutes those things that are considered material. Regardless of which concept you will have your basis on, an important theme will be how you consider the qualia. The qualia is a subjective experience that appear in the image. Such experience includes, for example, the “redness” or the “rose-likeness” that you feel when you look at a red rose, or the hurt you feel when you touch the thorns. “What is the source of such qualia?” This is an enormous challenge. The modern brain science and neuroscience reveal the association between the parts in the brains and the perceptions and emotions, such as a phenomenon where a specific part of the brain makes some kind of reaction when a person obtains some visual information. It is already evident that the qualia and the brain activities are not irrelevant. However, what causes the qualia to occur is totally unknown at the moment. It is sufficiently presumed that the brain functions are involved. However, how they get involved and which certain function of the brain causes the qualia to occur under what mechanism is in an area which is intact, rather than just remaining unsolved. Reflecting the status quo of the scientific research as mentioned above, there is an argument which can be viewed as an escape way on the side of the philosophical conception of nature, which is the neutral monism (I am not saying that the neutral monists are aiming at evading the abovementioned difficult problem). They do not believe that the fundamental entity of the world should be chosen from either of the material

or the spirit; rather, their argument is that a certain kind of neutral existence, which is neither of the material nor the spirit, is the very entity which is the source of the materials and the spirits. Based on this argument, it is possible to say that a qualia itself is the source. If this is the case, there is no need to think about the source of the qualia.

A similar argument is the panpsychism, which argues that all materials have the attribution to constitute the consciousness. Even the elementary particles such as the electrons have a primary consciousness, if not on the same level as that of the human beings. This concept belongs to the neutral monism, and similarly, does not require an exploration into how a qualia is generated based on what material grounds. This is because they consider that a qualia also exists based on the consciousness as a fundamental entity on an elementary particle level. The views of Penrose and Hameroff are largely a part of the panpsychism. Having said this, their argument is characterized by the point that the consciousness is affected by the quantum effect within the material. If it is revealed that the human intelligence contains the non-computable factors, the inconsistency of the neural network model to date will be brought to light, as it is considered that the neural network works purely classically. If it is classical, it should be computable. If it is non-computable, there should be a quantum mechanics involved—which is the only area among the natural laws known today that contains (that could contain) the non-computability. The non-computability of the thought is the manifestation of the quantum effect. In the quantum mechanics, the state of the materials is described by the wave function. Unlike the image of the particles in the classical mechanics, in the quantum mechanics, we are only able to express the certain positions or a particular momentum of the particles stochastically. This is an attribute of the quantum mechanics inherent in the natural world, rather than the lack of our measuring ability or the cognitive ability. The wave function quantifies the distribution of this probability. The probability means that a certain physical quantity does not necessarily have a specific value but forms a ranging probability distribution. When you specifically observe, however, the observer discovers a specific measured value. You do not obtain the scattering measured values with a certain range through an observation of just one time. A measured value is just one. The wave function is originally devised to describe the non-classical movements of the particles (the wave nature). Although you can only obtain one measured value through an observation of just one time, a group of measured values will be distributed relatively sparsely if you measure multiple times, showing as a result the nature as a wave (including the interference or diffraction). Then, does the wave function, which has been introduced to theoretically take care of the nature of the wave, exist in the natural world? Alternatively, is it only meaningful for the purpose of computation and not an entity, with the cause of the coexisting relationship between the nature of the particle and the nature of the wave arising from another mechanism which is yet to be known? No common grounds have been reached definitively in this relation. The interpretations thereof include various theories including, among others, the parallel universe theory as well as those which doubt the existence of the wave function itself. A historically main stream among such theories is what is called the “Copenhagen Interpretation.” Needless to say, “Copenhagen” is the capital city of Denmark. The interpretation is called as such, as it was devised at the famous Niels Bohr Institute in Copenhagen. According to this Interpretation, the wave function indeed exists. Under the Copenhagen Interpretation, the process where something which existed with a range prior to the observation indicates a specific value at the time of measurement is described as the “collapse of the wave function.” More particularly, the particles the measured values of which

range (such as a wave) and which also have the nature of the wave actually collapse through the process of observation to form one state that indicates their measured values. If the wave function exists, so does the process of this collapse, which occurs in the natural world. As a matter of course, this process of collapse, as well as the states preceding the observation, are not directly observed (although it is fundamentally impossible to “observe the states preceding the observation,” because if you observe the states preceding the observation, it would already be “observed”). The wave function within the meaning of the quantum mechanics is a concept obtained in an effort to establish a theory which can predict the measured outcome to the maximum extent possible and give an “interpretation” to the natural phenomena that show both the nature of the particles and the nature of the wave. To date, however, as mentioned earlier, it is not at all evident as to if the wave function itself exists, or if it is something that is not perceivable and is quite different from the real world but is only convenient for the purpose of the computation. Based on the Copenhagen Interpretation, which is one of the various possible interpretations, the wave function itself and the collapse thereof indeed actually exist in the natural world.

Penrose and Hameroff seek the factor of the non-computability, which is the intrinsic attribute of the human thoughts, exactly within this collapse of the wave function. A system which can be described by the classical physical laws is computable, that is, an algorithm exists for it and physically it can be reconstructed by a computer. However, if an intelligence is featured by the non-computability, it is impossible to think that the intelligence will emerge from such system. They have understood that the true value of the quantum mechanics is that it includes the non-computability, and that its source is nothing other than the collapse of the wave function. At the moment, there is no other way than to depend on the quantum mechanics, if you want to seek the non-computability within the source of the consciousness. Meanwhile, for the quantum system, an observational act from the exterior which causes the collapse of the wave function and a disturbance from the surrounding environment (such as a thermal energy) are equivalent. The two are indistinguishable in that both of them disturb the quantum-theoretical coherence by the exterior disturbance and cause the collapse. It is possible to distinguish them through the difference in the appellations, by referring to the collapse caused by an observation by an observer who has a consciousness as the “Subjective Reduction.” In any event, the collapse occurs randomly under the circumstance where there are random effects of the environment. If, however, a system is isolated, the coherent state thereof (the quantum-superposition state) is maintained under the circumstance where it is sufficiently insulated from the environment (and the observational act of the observer), and the coherence is broken to cause the collapse to occur not randomly but autonomously (objectively), that is when the “consciousness” will be born (this collapse is called the “Objective Reduction”). That is, the autonomous collapse of the wave function is the very process which brings about the non-computable factor. Then, what does it mean that the collapse occurs autonomously rather than randomly? What causes the collapse, if it is not due to the disturbance from the environment? The answer to this problem given by Penrose and Hameroff was extraordinary. They said that it was a structural change in the space-time geometry related to the general theory of relativity.

## Theoretical Effect of General Relativity Generates the “Consciousness”!?

Under the Orch-OR Theory, it is the cell architecture in the brain that constitutes the very wave function that collapses. More specifically, it is the structure in the neuron cells which constitute the neural circuits in the brain and mediate the information processing and transmitting. Largely divided, the neuron cells are comprised of three parts, namely, the cell body which includes the cell nuclei, the multiple dendrites of the signal input parts, and one nerve fiber which is in charge of the signal output, the so-called axon. At the end of the axon, the neurotransmitters are exchanged with the other cells through the synapse. The axon transmits the information electrically toward a certain direction, from the cell body side to the end of the axon. This axon has another role. In the axon, a microtubule exists, which maintains its long form as a cell skeleton. The microtubule plays a role of a transport pipe which supports the transportation inside the cell. Instead of a signal, a protein which is necessary for the maintaining and the activity of the cells is transported. The molecules that constitute this microtubule are called the tubulins. The  $\alpha$ -tubulin and  $\beta$ -tubulin, the macromolecules each of which has a molecular weight exceeding 50,000, form a heterodimer. Those heterodimers lining up in the long axis direction form a protofilament. 13 of these protofilaments are bundled in a loop to form a microtubule with a cylindrical structure of about 25 nanometers in diameter (1 nanometer is equal to 1 over 10 million centimeters). Each of these protofilaments are used as a rail to allow a transport vesicle loaded with the protein molecules to move from a cell body to the end of the axon like a cargo vehicle with the help of the motivity of a molecular motor, carrying out an axonal transport.

The collapse of the wave function devised by Penrose and Hameroff as a source of the emergence of the consciousness. This collapsing wave function is the wave function of a tubulin dimer that constitutes this microtubule. Hameroff, who is an anesthesiologist, found out that an anesthesia gas molecule affects the molecular structure of this tubulin dimer. As is well known, anesthesia, particularly the general anesthesia causes the loss of consciousness without interfering the other brain functions necessary for the maintenance of life. Based on this fact, Hameroff got an idea that the movement of the molecular structure of the tubulin dimer directly acts on the occurrence of the consciousness. Physically, each of the dimers is in an “open” state or a “closed” state (Figure 4).

Classically, only one of the two states are possible. However, it is not the case with the quantum mechanics. A state called the quantum superposition can be perceived, where both states are stochastically possible at the same time. When the anesthesia gas molecules get through the interspace of the dimers, the quantum-superposition state will be released due to the interaction with the anesthesia gas molecules which came near (the collapse of the wave function), fixing the dimers that had been in a quantum-superposition state to either of the open or the closed state concerning their system. At this point, the consciousness is lost. Based on this fact, Hameroff gained an insight that this superposition state of the dimers in their open or closed states is deeply involved in the generation of the consciousness.

The fact that something is non-computational per se does not directly link to the issue of the whereabouts of, for instance, a qualia. However, it could be a key factor to understanding the physical activities in the background. In order for a system to be maintained in a coherent state to allow the autonomous collapse of the wave function to occur, the state has to be sufficiently remote so that there will be no disturbance from the environment. Through an

autonomous collapse, which is not random, a system will show a non-computational phenomenon. A coherent and super-positional state preceding the occurrence of OR is called a preconscious process, and a non-computational OR which occurs instantaneously is called a conscious event. Under the preconscious process, a quantum-mechanical computation will take place. Each individual OR is an irreversible process in terms of time, and thus it determines the direction of time. With the occurrence of the ORs that are discrete in terms of time, a “flow” of time and consciousness will occur. In this relation, a bridge molecule called a microtubule-related protein is connected to the microtubule, and the microtubules are physically bound together. According to Penrose and Hameroff, this binding “adjusts” the quantum oscillation of the preconscious process in the quantum states, and realizes the orchestration toward a possible result of the collapse.

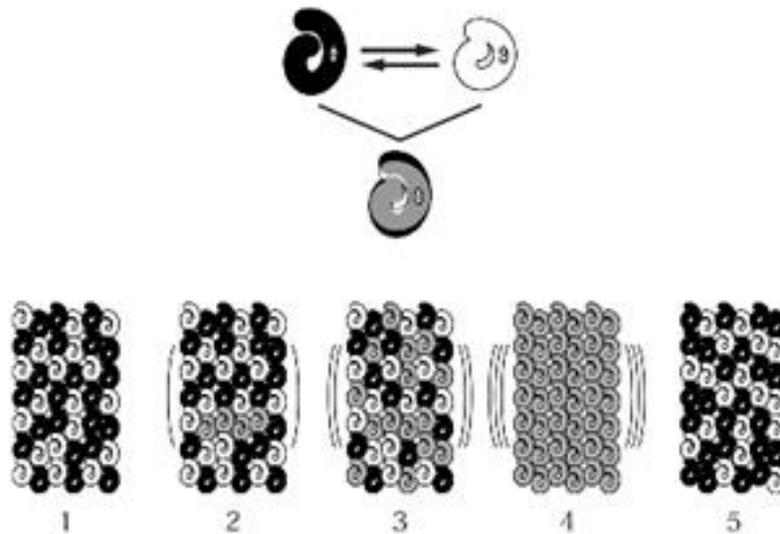


Figure 4. Time propagation of quantum mechanical tubulin.

How does an OR actually occur autonomously, as described by them? They argue that a quantum gravity effect contributes. An OR is not something that came from a micro-viewpoint based on the wave function of the individual tubulin. Under the preconscious process, a coherent state spreads from one tubulin to another. The flow spreads within the tubulin dimers that constitute a microtubule, from a classical “open” or “closed” state to a quantum-coherent state which is super-positional. Eventually, a considerable number—a non-negligible number of dimers in a microtubule participate in this superposition state. It is considered that each of the two extremes, namely, the state where the total count is open and the state where the total count is closed, possesses a particular geometric structure within the space-time. The more dimers there are that participate in the superposition state, the larger the discrepancy of the mass distribution in the space-time will be between these structures. The larger the level of this discrepancy will be, the more unstable the superposition state will be, eventually collapsing to become a simple state. The level of this unstableness is determined by the quantum gravity theory. It takes longer than a cosmic age for a simple system such as one electron to collapse its superposition state with the OR, whereas the larger the system is,

the shorter it will require for the OR to take place. A macro-system such as this microtubule would require a much shorter time to become destabilized. The two factors required for the generation of the consciousness are that a system is secluded from an environmental noise until the OR occurs, and that the time required for the OR to reach the threshold value for it to occur is short enough to be of advantage in the thought process. The process of selection where certain state is chosen at the time of each OR event is non-computational, and it is a process where the geometry of the space-time selects on their own. As such, the non-computational process gets involved in the process inside the brain through a microtubule. In the course of expansion of a superposition state of a tubulin where it expands from a micro-scale to a macro-scale, the superposition state transforms through the OR into a classical macro-structure released from the superposition state. A quantum wave which expressed multiple possibilities prior to the OR falls into one macro-reality. That is, one of the eigenstates that exist will be selected. The selection of an eigenstate caused by the collapse of the wave function follows an unknown and non-computational theory which cannot be deduced algorithmically. Although it is unknown, its non-computability has a substantial significance for the consciousness which includes the activity styles that cannot be reduced to the algorithm.

### **Issue on “Non-Computability = Collapse of Wave Function”**

The problem of this model is apparent. It is hard to imagine a quantum effect which actualizes in a macro-scale. In this model, a coherent state actualizes in the axon of the neuron cells inside the brain, on the rail called the microtubule which is used for the transportation of the molecules. Although the rail is only about 25 nm in diameter, some of them are as long as several dozens of  $\mu\text{m}$ —a sufficiently macroscopic system. According to the Orch-OR Theory, the coherent state lasts stably for as long as several hundreds of milliseconds. The greatest wall standing there in the way is the temperature. Generally, a quantum effect is an effect which appears in the micro world. As such, in order for the quantum effect to actualize on a macro-scale, be it superconductive or superfluid, an extremely low temperature, which cannot be experienced in our daily life, has to be prepared in the laboratory. Although the phenomena such as “a high-temperature” superconductivity has already been actualized in cuprate and the like, it is something like minus 170 degrees Celsius, which is far from the room temperature or the body temperature. The “high temperature” means that it is only higher than the temperature of the previously known superconductors (around minus 270 $^{\circ}\text{C}$ ) or that of the liquid nitrogen frequently used in a low-temperature experiment (minus 196 $^{\circ}\text{C}$ ). The superfluidity is also a phenomenon which occurs in a super-low temperature as low as around minus 270 $^{\circ}\text{C}$ . In addition, these materials, be it cuprate or liquid helium, are of a system with extremely simple compositions. Not only are there too much disturbance inside the brain due to a too-high-temperature as high as a body temperature, but they are the extremely complicated systems where the protein molecules with an extremely large molecular weight and a lot of living cells are mixed. Thus, the significant issue is if it is possible at all to stabilize a macro quantum effect. In fact, because of this reason, the Theory is not much supported, which is understandable.

## **Proto-Conscious – Consciousness Which Stays Alive After Death**

As you can see in this video site ([https://youtu.be/jjpEc98o\\_Oo](https://youtu.be/jjpEc98o_Oo)), Hameroff further talks about the “proto-conscious.” He says that the consciousness which is born in the brain is extremely small—as small as the elementary particles—and that it goes in and out of the human brain. Formerly, he has sought the cause of the generation of the consciousness in the quantum effect inside the axon of the neuron cells. He may have felt that it is difficult to explain the mechanism solely based on the phenomena inside the brain, or has come to more proactively accept the continuance of the consciousness after death taking into consideration the cases of the “reincarnation”—we are unable to presume what he had in mind. In any event, he started to advocate this proto-conscious, which is a consciousness independent from the brain. He states that the micro consciousness diffuses across the universe as a person dies. When it once again returns to the brain, it is the resuscitation, and a so-called “near-death experience” is actualized. If no resuscitation occurs, the consciousness floats around in the universe, and “reincarnates” as it gets connected to another living matter. However, such super-micro consciousness theory contains another issue. First of all, we need to pay attention to the mechanism of conjunction between the brain and the proto-conscious. It is directly linked to the association between the OR, which Hameroff himself described as being the source of generation of the consciousness, and the proto-conscious. Inside our brain, which is in the size of 10 cm, there are several dozens of billions of neuron cells. How does a “super-micro” consciousness as small as an elementary particle communicate with the phenomena within the microtubule inside these huge number of neuron cells in the macroscopic area? Hameroff takes out the “quantum entanglement” to describe this, saying that the information is exchanged among the neuron cells inside the brain, and between the neuron cells and the proto-conscious. However, this is also difficult. In principle, an exchange of information based solely on the “quantum entanglement” is not possible. What the quantum information theory tells us is that the transmission of the quantum state (quantum teleportation) and the communication of the classical information (quantum dense coding) are only made possible when accompanied by another communication route. On top of that, as a matter of course, it is impossible to instantly transmit the information beyond the light speed. As such difficulty being evident as a physicist, even his ally, Penrose, seems to be skeptical about this proto-conscious theory.

There is still another extremely significant problem. When you look at the cases of a “near-death experience,” it is reported that the patients go through various experiences prior to the resuscitation stage. A tunnel, a bright light beyond the tunnel, an encounter there and conversation with the families who preceded in death, oneself lying in a hospital room and the surrounding healthcare professionals and their conversation. They suggest that the five senses (at least the sense of vision and the sense of hearing, based solely on the examples I cited here) are working. If you want to interpret the reincarnation and the “near-death experiences” with a “super-micro consciousness,” you need to be able to reconstruct the sensory tissues such as the retina and the cochlea as well as the functions of the sensory nerves with the super-micro particles as small as an elementary particle. Naturally, the sophisticated mental activities and the intelligence such as memories and thoughts also have to be reconstructed. It is doubtful if such a thing is possible. If the super-micro particles collectively function, how do they transmit the information among themselves? I would like to reiterate that the mere sharing of the quantum entanglement does not allow the information

transmission to happen. It is presumed that the reason that he sought the substance of the consciousness independent from the brain in these super-micro materials is to keep consistency with the fact that it has not been observed to date. He had no choice other than to describe that it was extremely small—so small that it could not have been observed in any of the experiments to date, including the high-energy physics experiments. Indeed, no substance of the consciousness which exists outside of the brain has been found in the 4-dimensional space-time where we live in. It is therefore understandable to think that such substance is “super-micro” to keep consistency with this fact. This very presumption, however, has brought about further difficulties such as mentioned above.

### **Capturing of “Consciousness Independent from Brain” through Brane World – John Smythies Theory**

Assuming that a substance of the consciousness independent from the brain exists, in what form could it exist? If it is comprised of the materials similarly with the brain, why is it invisible to us? A concept that immediately comes to us is that “it is too small to be visible.” If this is the case, to what extent of the size could it be perceived as reasonable as being “sufficiently small”? Obviously, given that it has not been found to date, it is absolutely not in a level as that it is invisible with the unaided eyes. It should be smaller than  $10^{-16}$  cm, which is approximately the scale of the space which can be decomposed through today’s high-energy experiments. However, even if there were an instrument in charge of the consciousness so extremely small as such, we cannot avoid the inconsistencies arising from the very fact that it is small, as explained above. If the “smallness” is the cause of the difficulty, we should establish a model which allows the substance of the consciousness to have a macroscopic scale to avoid such difficulty. However, is such a thing possible? The substance of the consciousness exists with a macroscopic scale—several millimeters or several dozens of centimeters large—and it is still invisible to us—is such a theory model ever possible?

The development of the modern physics gives us a picture of a multi-dimensional universe. This is a theory which argues that there are more than four dimensions that are visible in the universe where we live. What kind of a model can be perceived based on this picture? If the universe is 4-dimensional, it is impossible to assume the existence of a material which is of a macroscopic size but is still invisible. It may not be the case, if there are a larger number of dimensions—the fifth dimension, the sixth dimension, and so on. The problem that we need to address from now on is to consider if we can assume such existence in the picture of a multi-dimensional universe.

In the previous Section, I have explained the outline of the brane models. Based on these models, naively, we come up with a brane model comprised of the two brane worlds. For example, supposing that we live on a brane, are we able to presume that there is another brane that exists, and the so-called “consciousness” is the existence on such brane (Figure 5)? What would be the relationship between the consciousness and the brain in that case?



Figure 5. Soul on another brane?

This is how I describe it. On one brane, this universe where we live in exists, and our Earth and the bodies of ourselves who live there exist thereon. On this brane, the world which we feel daily exists. The profoundness of the universe as well as the microscopic world which can be captured by all kinds of equipment exist there. Let us call this a visible brane. We know that our body, naturally including the brain, exists on this brane. Now, we are trying to think that the consciousness is an existence which is separate from the brain. We consider that the substance of the consciousness exists on another brane. This is why we need to have two brane worlds. We call the brane where the consciousness exists the “consciousness brane.” It is possible to consider that the substance of this consciousness is invisible from us even if it is in a macroscopic size, as it exists on another brane. It seems that it is possible, at least tentatively, to set a circumstance such as this in a multi-dimensional universe model using the brane. I would like to examine the appropriateness of this setting later. This independent brane model resolves the existence of a consciousness independent from the brain in a form which could most naively be perceived in the brane world model. The brain and the consciousness exist separately in the two branes—the visible brane and the consciousness brane. The consciousness has a will, emotion and memory, obtains the information from the body such as the sense of vision, sense of hearing and sense of pain, and conveys the will as an order to the brain to cause an action to occur. The brain plays a role of a receiver, and somehow exchanges the information with the consciousness. The model of John Smythies is an example of such model (Smythies 2003).

Smythies tried to apply the latest topics in the modern physics, such as the superstring theory and the brane universe, to the mind-body problem. He named the space-times existing in the abovementioned two independent branes—the visible brane and the consciousness brane—the physical space-time and the phenomenal space-time, respectively (Figure 6).

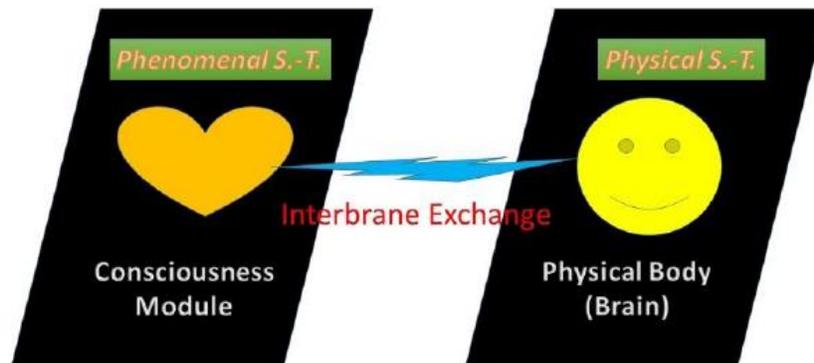


Figure 6. Schematic view of Smythies model.

Our body exists in the former, whereas the phenomenal consciousness is a separate and independent substance which belongs to the latter. Based on his unique psychophysical experiment, he believes in the representational theory, driving out the direct realism which argues that the world exists just as perceived by the human beings through the sense of vision. Under this theory, the information obtained through the sense of vision is computed by our brain as something that should be, and it is not capturing the world as is. When we capture a chair with our sense of vision, the chair as a phenomenal object which we recognized through our sense of vision exists in the “phenomenal space-time,” independently from the external object which exists in this physical world. Under the representational theory, it is argued that the direct appearance of the chair as an exterior object which exists in the physical space-time and the phenomenal object which exists in the phenomenal space-time do not have to be the same, and may be totally different. For instance, a chair that we recognize when we are looking at the chair is a final product obtained through a process in the bodily physical organization such as the eyes, skin, and nerve which is separate from the chair as an exterior object. The phenomenal space-time is allocated as a unique real space against our consciousness. Through his consideration on the sensory abnormalities such as visual agnosia, vision disorder and phantom limb, Smythies argues the existence of a phenomenal space-time. More particularly, he says that it is not that one of the phenomenal space-time and the physical space-time is the real world and the other is ideological. Rather, he says that both are equally positioned in the real world. It is a parallel world, if you will. Smythies displays his unique cosmic view, applying here the brane world picture which is the leading concept of the modern physics. They exist on the independent branes, and a physical body exists and acts in the physical space-time, whereas a bodily image exists and acts in the phenomenal space-time. The physical events and the psychological events occur in the different space-times which do not share the same dimension. He points out that the reason that we are only able to see the physical space-time and are not able to see the phenomenal space-time is because the light cannot be exchanged between the parallel worlds. He considers that there is a sense that can be experienced directly without the light mediating, believing that the counterpart of the object in the physical space-time is generated in the phenomenal space-time through the senses. He took the sense of vision as an example to marshal the process of perception as “object – photon – retina – brain – intersection with different branes – field of vision sense,” thereby naming this process the causal chain. He also stated that a hallucination is caused in

the latter half of this chain, that is, “brain – intersection – field of vision sense.” The point in this model is the existence of intersection of information between the branes that bridge the physical space-time and the phenomenal one. Smythies argues that the concept arguing that the consciousness lies in a unique brane in a separate dimension outside of the physical world is extremely in line with the trend of the modern physics. However, precisely speaking from a physical perspective, it is not an issue so simple as such to actualize an intersection of information between the branes in the chain of cause and effect. I would like to talk about this later. Smythies calls the combination of these various senses, image fields and subjective self, which exist in the phenomenal space-time beyond the physical body, a “consciousness module.”

As mentioned earlier, there was a significant problem in the super-micro consciousness theory. That is, it is not possible for a particle so small as an elementary particle to equip the sensory tissues and sensory nerves. On the contrary, the Smythies Theory, which has in mind the brane model, still has a potential in this sense. In this model, it is argued that our body including our brain exists on one brane, and a “consciousness module” as a substance of the consciousness exists on another brane. The difficulty of the super-micro consciousness theory lies where it considers the substance of the consciousness super micro. In the background of this difficulty, there is a fact that we have not been able to find the substance of the consciousness existing independently from the brain. For the purpose of rationalizing this fact, it had to be “super-micro.” In this relation, the Smythies Theory argues that this substance of the consciousness exists in another brane universe, and thus it is “invisible” from the beginning. Because it is invisible, it does not have to be “super-micro.” It can be large. This is a huge advantage over the super-micro consciousness theory.

What we need to pay attention to is the point that, as a fundamental position, Smythies fundamentally adheres to the position of Dr. Andrei Linde, who is a theoretical physicist who argues that there are three independent basic configuration bodies in this world, namely, the space-time, materials, and consciousness. This is qualitatively different from the monism in that it considers that each of the consciousness and the materials is an elementary entity which does not consider the other as its own source (in this sense, Andrei Linde himself is somewhat peculiar as a physicist). He bothers to propose a hypothesis which presumes an existence of the consciousness independent from the brain based on the picture of a brane universe, which is the latest concept in the modern physics. Given this situation, it is worth examining if there are any problems hiding somewhere in the path through an achievement of the modern physics. Smythies is not an expert in the area of physics. It is an interesting idea to assume an existence of the parallel world in a multi-dimensional universe as a concept, to assume some kind of interactions with that and our universe, to assume something called a consciousness module, thereby commenting on the existence of our consciousness independent from the brain. However, if we want to treat this as part of the scientific topics, the steps are definitely required to examine what kind of difficulties lie ahead at this stage and if there are any problems. The physical challenges hiding in the Smythies Theory are, simply put, what can be described as a “hierarchy problem.” Let us take a look at this hierarchy problem, which appeared again at this point.

## Trap in Simple Application of Brane Model

I would like to examine the appropriateness of the Smythies Theory based on the ADD Model and the RS Model. Is it possible to apply the concept of the information communication between the branes to a mind-body problem, that is, the idea of “the consciousness as a substance independent from the brain,” as Smythies says? Is it reasonable to think that the “mind” and the “body” exist on the different branes and implement a communication between themselves—that is, exchange information through information intersection between the branes as described in the Smythies Theory? On what mechanism is the intersection between the branes based on, if it exists at all? How much credible in terms of physics is the idea that the “consciousness module” which is the subject of the consciousness and our body (particularly the brain which lies in our skeleton) exist on the separate branes, and that they are somehow communicating the information?

First of all, under the ADD Model, the gravitons are the only thing that are considered to move back and forth between the branes. In this Model, even if the parallel world existed, it is possible for only the gravity among the four interactions to walk back and forth among two worlds, and interaction using, for example, the light is impossible. The information intersection between the branes, if it ever exists, has to rely on the gravitons within the meaning of this Model. What happens if, for instance, the photons can also jump out of the brane into the extra-dimensional space? In this Model, the energy of these photons have to be proportionately small because the extra-dimensional space is large in this model. In that case, we have to have already found through the experiments the dimensions in the number larger than four. If we say something extreme, if the level of the energy of the photons that can move to and from the extra-dimensional space is in the area same as the energy of the electromagnetic force that we handle regularly, our understanding and the skills that are dependent on the formulation at the 4-dimensional space-time would not be valid. More particularly, if the number of the extra-dimensions is two and the millimeter-order extra-dimensions truly existed, something such as the Coulomb’s law would already be invalid in such space scale. This would rock the foundation of the architecture of the semiconductor device based on the electronic engineering to date—which, however, has not yet occurred. Given this situation, we can say that, even if the model that proposes a large extra-dimensions such as the ADD Model were true, the light cannot move to and from the extra-dimensional space based on this Model. Is the information intersection between the branes possible, then, if the gravity is used? The general theory of relativity describes the gravity as a distortion of the space-time. As such, when some disturbance is caused in the gravitational field in the cases of, for instance, a binary star system where the two fixed stars go around each other, or a supernova explosion, this distortion is propagated. An effort to detect this “gravitational wave” has been made for a long time. On February 2016, a successful detection was eventually reported by the gravitational wave observatory LIGO (Laser Interferometer Gravitational-wave Observatory) in USA. A detection range required for the detection of a distortion in the space-time is so sensitive that it has to be able to detect, for example, the change in the size of a hydrogen molecule against the distance between the sun and the Earth. For example, in Japan, an experimental facility for the detection called the LCGT (which goes by KAGRA) is under construction, aiming at a full-fledged operation in 2017. This is a huge Michelson interferometer with the length of the base line as long as 3,000 m. The reason that such a huge experimental facility as this is required is that, as a matter of course, the

gravitational wave is extremely weak. In order to secure the required accuracy, the length of the base line of the interferometer has to be enormous, because the gravitational wave is so weak. Even after the completion of this facility, the expected observational events will be only several times a year. That is, the gravitational wave is so weak that, even with such an enormous observational equipment as this, it can only be observed in rare occasions. Should the consciousness module and the brain be exchanging the information via this gravitational wave, it would be that the brain as large as 10 square centimeters large at the most has a sensitivity that supersedes the observational facility with the length of the base line as long as 3 km in detecting the gravitational wave. This is plainly impossible. It cannot be considered that the information intersection between the branes is carried out through the exchanges of the graviton signals so extremely subtle as this. There is another point. When we say the information intersection between the branes, it should not only include the brain's receiving of the gravitational wave but also the transmitting. For the purpose of simulating the brain "generating the gravitational wave," the equipment has to be made that generates the gravitational wave in the scale the same as the brain. This is also desperately impossible. As it is difficult to detect the gravitational wave coming from the universe, which was caused by a supernova explosion or the like, it is even more difficult and impossible to artificially create a gravitational wave on the ground which is detectable.

If we need to depend on such an unreliable technique for a gravitational wave to communicate with the other brane, it is effectively impossible to do such a communication, even if there was another brane world and there were the residents who have a consciousness module or an intelligence. Although the existence of the brane per se can be indirectly presumed from the string theory required to keep consistency in the physical theories, at this point where it is impossible for the branes to interact, it makes no difference on our perception basis whether there were another brane or not. However, we do not need to jump to the conclusion. At this stage when the brane world model itself has not yet become an accepted view and there are a variety of opinions relating thereto, we do not have to despair and give up, thinking that "there is no other communication tool than the gravitational wave." There is a possibility that in the future, other forms of brane interaction is discovered. In fact, a model which enables the propagation of the photons within the extra-dimensional space already exists at this point—the RS Model.

## **Second Hierarchy Problem**

The RS Model has brought about a new insight relating to the hierarchy problem. While the ADD Model seeks the cause of the tremendous weakness of the gravity in the gravitational diffusion into the huge extra-dimensional space, the RS Model seeks it in the warp of the extra-dimensional space. Separately from the brane where we live in, there is a gravitational brane which generates the gravity, and the gravitational brane exists across the bulk from our brane. Similarly with the extraordinary distortion of the space-time around the black hole which has an enormous mass, the fifth-dimensional space between the gravitational brane and our brane is warped in accordance with the general theory of relativity, and the gravitons are distributed disproportionately closer to the side of the gravitational brane which has a larger energy. The mechanism was that because the fewer gravitons are distributed near our brane, we feel the gravity extremely weakly. In this Model,

the extra-dimensional space need not be enormous, as it does not consider the gravitational diffusion into the large extra-dimensional space as a solution to the hierarchy problem. The ADD Model drew a high attention, arguing that in some cases, the invisible extra-dimensional space may have the size as large as several millimeters. However, in this Model, it can be extremely small, as small as the Planck scale. The large extra-dimension in the ADD Model increased the impact of the model itself, but was at the same time the weak point. It shows a certain solution to the hierarchy problem arising from the weakness of the gravity, but contains an issue in that the millimeter-order extra-dimension is too small in energy scale. In this respect, the RS Model is able to explain the weakness of the gravity without invoking a new unnatural energy gap, because the extra-dimensions are small. Further, because the extra-dimensional space is small, even if the photons, in addition to the gravitons, propagate through the extra-dimensional space and move to and from the other brane, it is consistent with the observed facts. It opens the possibility of the communication with the other brane using the photons.

Is the information intersection between the branes possible, then, under the RS Model? In this Model, the exchanges of the light between the branes are indeed permitted, which is plainly different from the circumstance under the ADD Model where it is only permitted to the gravitons. Is this a good news? Actually, not necessarily. In this Model, if you want to exchange the light with the other brane, the light has to have an ultra-high energy. The high-energy light (electromagnetic wave) is the gamma ray. Although there is a considerable range in the energy value of the gamma ray, typically, it is around  $10^6$  eV. However, the light energy which traverses the extra-dimensional space in this Model has to be, in theory, at least 6 digits higher than that in energy. If not, we should already have found the trace of the extra-dimensions through the high-energy physics experiments. What makes it worse is that we do not yet have the skill of freely generating and detecting such ultra-high energy beams with an experimental equipment in a size as small as about a laboratory, much less a function in our brain which is able to receive and transmit such ultra-high energy electromagnetic wave. Therefore, it cannot be that an information intersection between the branes is conducted through an exchange of such ultra-high energy photons. When we try to explain the “mind independent from the brain” by the RS Model, we cannot avoid running into this wall of huge energy gap. This significant issue can be addressed as the second hierarchy problem. If we want to perceive our mind-body problem as a physical phenomenon and interpret it through the brane world model, it is inevitable that we solve this second hierarchy problem.

### SECTION 3. PARASITE FERMION MODEL

#### Formulation by Quantum Field Theory

One challenge in the brane world picture is to find a probable scenario by which the movement of the particles are restricted within the brane. We live in the 4-dimensional world (at least, it appears that we do). For this purpose, the fermions (the matter particles) and the bosons (the particles which mediate interactions such as the electromagnetic forces, and the Higgs boson) inside the high-dimensional bulk have to be bound down on the brane with dimensions as low as just four. Otherwise, even the Newton’s law would not be valid. The

low-dimensional standard model particles are trapped on the brane. Then, what would be the probable scenario by which the movement of the particles are bound on the brane, that is, on the membrane of the low-dimensional space-time? The physicists have provided some insights. Under the D brane Model in the string theory, the standard model particles are described by the open-end string (open string), and describe that the both ends move only on the D brane. For this reason, the binding of this particle movement is just natural. The D brane was rather devised in the beginning as an object on which the both ends of an open string are fixed. On the other hand, in the quantum field theory, the mechanisms which localize each of the low-energy 4-dimensional vector (gauge) field, scalar, and fermion field has been proposed individually. Based on the quantum field theory, I would like to talk about the “Parasite Fermion Model,” which is a new type of the fermion restricting mechanism (Taneichi 2013). We refer to the 4-dimensional brane where we live in and the fermions trapped in the brane. To this point, it is the same as the theories that have already existed. Now, I would like to newly consider another type of fermion which actualizes the localization into the brane via this existing fermion field. The former fermion is called the host fermion and the latter is called the parasite fermion. The parasite fermion gets connected with the host fermion by a fermion interaction, an interaction between those two types of fermion, feels the potential energy created by the host fermion, and localizes around the brane. It is literally “parasitic” on the host fermion and is indirectly bound down on the brane through the fermion interaction.

I would like to mention here the 5-dimensional bulk and one brane therein. Let us assume that both the bulk and the brane are flat; that is, its space-time is not distorted, and it is a Minkowski space. In reality, a brane has stars and black holes as you can see in our universe, and because of their mass, it is naturally not flat but is a space-time with a structure. In this model, however, I would like to disregard such structure inside the brane and assume the flatness inclusive of the extra-dimensions. The scalar field here is a type of 1-dimensional soliton which is called a kink solution. A soliton is a form of wave where an energy is localized. In the case at hand, if we take a look at the coordinate axis in the fifth dimension, the potential energy of the scalar field is localized on the position where there is a brane. A brane is described by something called the scalar field in the quantum field theory. On the other hand, the matter particles are a “matter field” but are described by something called the fermion field (or the Dirac field). Among the fermion fields, there are two types—namely, the abovementioned host fermion field and the parasite fermion field. The host fermion is a previously known matter field. Any and all materials in our environment including our body itself, as well as all materials confirmed through the experiments are included here. This couples to the abovementioned scalar field, namely the brane, through the Yukawa Interaction. This means that it is directly coupled to the brane. This is what is meant by the explanation that “the materials are trapped on the brane” (Figure 7). A host fermion field coupled to a scalar field is expressed in a formula as follows:

$$\lambda \bar{\Psi}_1 \Phi \Psi_1 \tag{1}$$

$\Psi_1$  is the host fermion field, and  $\Phi$  is the scalar field.  $\lambda$  is the coupling coefficient, indicating the degree of coupling of the two fields. This is an extraction of the relevant part from the quantity called the “lagrangian.” In the physics, there is a quantity called the action integral. All movements of an object in the world stay in an orbit where this quantity will be

minimized. This is called the least-action principle. Although lagrangian is indeed relatively unfamiliar compared to the energy and the momentum, it is extremely important in terms of the physics, as it is a component of the action integral which appear in this principle. Such is the image of binding of the host fermion field and the scalar field.

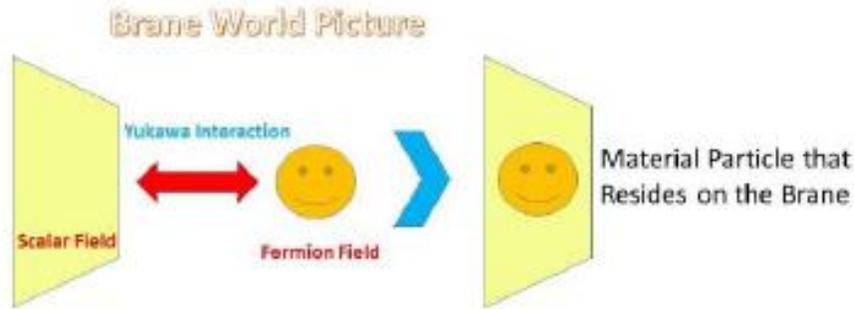


Figure 7. Particle on a brane expressed by the quantum field theory.

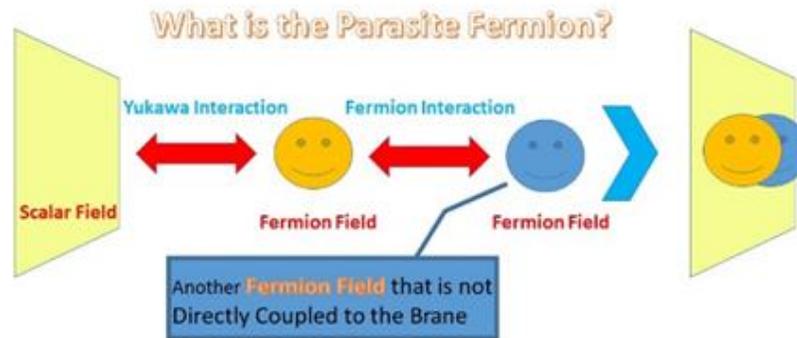


Figure 8. Parasite fermion indirectly trapped on the brane.

On the other hand, the parasite fermion couples to the host fermion field through the fermion interaction. An expression of “parasite” would fit this image (Figure 8). This fermion does not have a channel to directly couple to the scalar field. A formula to express this would be as follows:

$$\kappa \bar{\Psi}_2 \bar{\Psi}_1 \Phi \Psi_1 \Psi_2 \quad (2)$$

$\Psi_2$  is the parasite fermion field,  $\kappa$  is a coupling constant. It is not a pure fermion interaction as there is a scalar field in it. However, it is natural to think that the scalar field has an effect somehow since the host fermion is involved. In addition, when calculated without a scalar field, only unstable tachyon solutions have been obtained. As such, a scalar field is necessary in this term also for the purpose of obtaining a stable solution. Accordingly, a localization of a parasite fermion field on the brane will be carried out indirectly through a coupling to the host fermion. Secondly, let us divide the parasite fermion field into a

coordinate component within the brane (4 dimensions) and the coordinate component within the extra-dimensions (1 dimension), and assume that the field is indicated by their product.

$$\Psi_2(x, z) = f_{2L}(z)\psi_{2L}(x) + f_{2R}(z)\psi_{2R}(x) \quad (3)$$

$x$  is the coordinate component within the brane,  $z$  is the coordinate component within the extra-dimensions, and  $\psi$  and  $f$  are the components in the parasite fermion field corresponding to each of these coordinates. The two added letters L and R are the signs related to a property called “chirality” of the particles, meaning the left and the right (their details shall be omitted here). Anyway, by doing this, an equation of motion relating to the bulk coordinate component

$$-\partial_{zz}f_{2L} + W_L f_{2L} = m_2^2 f_{2L} \quad (4a)$$

and

$$-\partial_{zz}f_{2R} + W_R f_{2R} = m_2^2 f_{2R} \quad (4b)$$

can be obtained.  $m_2$  is a pseudo-mass of a parasite fermion on the brane (4D mass). In this equation of motion, a kinetic energy term, potential energy term ( $W_{L/R}$ ), and eigenvalue (the square of  $m_2$ ) are included, and the solution is an energy conservation solution, that is, eigenstates. The potential is expressed by a term which contains the product of a scalar field and the host fermion field.

$$W_L = \kappa[\kappa(\bar{\Psi}_1\Phi\Psi_1)^2 - \partial_z(\bar{\Psi}_1\Phi\Psi_1)] \quad (5)$$

The steady solution in the bulk coordinate component  $f_{2L/R}$  indicates the localized probability distribution of the parasite fermion in this potential. Setting the position of the brane as an origin of the extra-dimensional coordinate, the potential energy curve is illustrated.

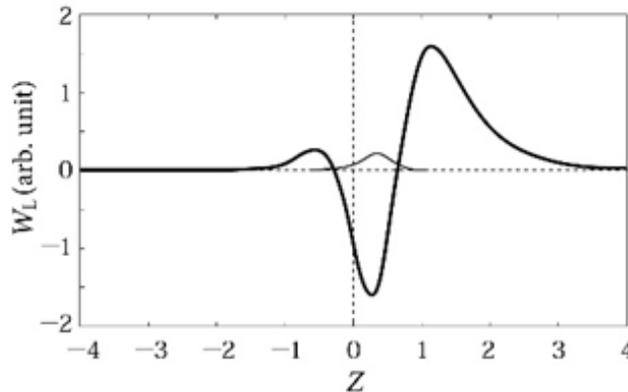


Figure 9. Potential curve that parasite fermion feels (thick solid line) and its presumable existence probability (thin solid line).

As mentioned earlier, the eigenvalue of the parasite fermion is a square of the 4D mass. If this is negative, it means that the mass is a pure imaginary number, meaning that it is a superluminal particle tachyon which is hypothetical. Therefore, I would like to exclude this for now. The potential well where the parasite fermion stabilizes is located in a position about a brane thickness off the position of the brane (Figure 9). This indicates that the parasite fermion stabilizes not on the brane but in a position off to the direction of the extra-dimensions. A stable parasite fermion solution is a solution where the energy eigenvalue is 0, that is, where the mass is 0, which is indicated with a thin solid line in the illustration. In order to allow the solution to have a mass, other mechanism such as the Higgs mechanism may be needed to be considered. The fermion interaction with the host fermion may function as another type of 4D mass. Further consideration is needed for this issue.

In any event, a parasite fermion exists in a totally different form from a host fermion which localizes on the brane. If we are comprised of the host fermions bound on the brane, the difference of the form of existence between the host fermion and the parasite fermion should certainly be reflected in the difference of how they are viewed from and captured by us who are on the brane. The two fermions interact with each other through the fermion interaction. The strength of such interaction depends on how much distant each of them are in the direction of the extra-dimensions, that is, how much distant the potential dent and the brane are, how much localized the host fermions are on the brane, how much localized the parasite fermions are in the potential dent, and the coupling constant of the fermion interaction.

## OUTLOOK ON PARASITE FERMION MODEL

The possible solution to the second hierarchy problem is the parasite fermion model which is introduced here. The center of the existence of the parasite fermion is outside of the 4-dimension world where we live in, in the extra-dimension. However, as it is coupled to the host fermion through the fermion interaction, it is able to have an influence over our world. Although it is not evident as to how much the influence would be, it could be partially visible, or could interact with the particles in this world. The interaction is not something too weak to be controlled or detected like a gravity; rather, it can be possible through an electromagnetic force. It is neither required to be a super-high energy. This is because the parasite fermions “partially” exists, as it were, in the brane universe where we are. It could either be that they interact but are not visible, or they are visible but their interaction is of a degree that can be disregarded. It could be that the force of the interaction varies timewise and spacewise.

In this model, I have formulated the combination of a substance inside the extra-dimensions as a material (parasite fermion) with a substance inside the brane as a material (host fermion) based on the quantum field theory. If we assume the former as being the grounds of the “consciousness” which has a material basis, the latter as being our brain, we are able to express the binding between the brain and the consciousness existing independently from the brain. To put it simply, it is a “wired method,” rather than a “wireless method” as is in the Smythies Model. That is, it is not a Wi-Fi but an Ethernet method. In this way, we are able to avoid the second hierarchy problem. This is because the communication between the brain which is comprised of the host fermions and the “consciousness” which is

comprised of the parasite fermions is carried out through a communication media which is similarly comprised of the parasite fermion, and it is consistent with our daily sense and the experimental outcome, even without assuming that they are carried out by the gravitons or a super-high energy photons.

“Passive Consciousness Model” is an example of totally materialistic cognitive model in which our mind is assumed to be comprised of material particles (Maeno 2005). This is a hypothesis that assumes that there are a conscious part and an unconscious part inside our brain, and that the unconscious part plays a main role in the activity of mind. Mind activities such as perception, representation of knowledge, emotion, willpower, and memory (learning) are not what the conscious part independently performs, but they are established via unconscious autonomous distributed and parallel recursive processing. The conscious part plays only a small role, accepts outcomes of the unconscious part, misunderstands that it is independently responsible for them, and pass them to the “episode memory” part. According to Maeno’s metaphor, there are lots of dwarfs (they are actually neurons or collection of neurons), and they show various function such as, for instance, being struck by the beauty, feel a bit sad, have a will to prepare for dinner, as seeing the sunset. They decide one outcome by majority. If the collective opinion is to feel beauty, the conscious part accept the outcome passively, it asserts that it was independently moved by the beauty, and pass the outcome to the episode memory. In this way, one wrongly recognizes that his/her consciousness was moved by the beauty of the sunset on its own initiative. Maeno asserts that many difficult problems concerning cognitive models, such as how to establish qualia sensitivity in the neural network, the binding problem, and frame problem, are solved by his model.

In this model, however, a problem can be found as to how the majority decision of the unconscious can be achieved in the neural network in which each signal transmitted through synapse has no record on which neuron it had passed up to that point. To establish the majority decision, we may need to assume that some object plays a role as supervisor that cannot be in neural network. An object comprised of the parasite fermion (PFO: Parasite Fermion Object) is a strong candidate for that, because it exists outside the brain although it is surely connected to the brain and exchanges information. This supervisor manages the “meeting” of dwarfs and extracts one result of majority. The supervisor also can perform a maintenance and even medical treatment, in a sense, to the network, which are realized in the rehabilitation. This is actually the “Operating System” of the neural network!

Assuming that the parasite fermion particles exist, it is totally unknown as to how they are organized and compose a “consciousness” that has five senses and intelligence. For now, there is no other way than to put off the issue, but such a cognitive model serves as a very useful reference. The difficulty seems to be much smaller than when it has to be reduced to a super-micro particle such as an elementary particle. I would like to reiterate that, because the “consciousness” existing in the extra-dimensional space and which is comprised of the parasite fermions may be in a macro-scale size, it is able to avoid the difficulty that the super-micro consciousness theory has. In addition, it is possible to take in the Orch-OR Theory which focuses on the non-computability of the consciousness. The original Orch-OR Theory has been criticized of its difficulty to keep the quantum coherence in a macroscopic scale at room temperature for a long period of time. However, we do not necessarily think that the PFO, which resides in the extra-dimensional space, is at room temperature. Rather, it is difficult to imagine that it is in an environment where the temperature is about the same level as our body temperature. If this is the case, we need to assume some kind of heat source

inside the extra-dimensional space. It is natural to think that it is in an extremely low temperature as close as the absolute zero. In such environment, a non-computational process may be actualized by a macro quantum coherence and its collapse inside the “consciousness” comprised of these parasite fermions as perceived by Hameroff. Although it is difficult to prove it as it has been to prove the parasite fermion itself, at least, it looks more hopeful than assuming a quantum coherence with the neuron cells inside the brain.

Historically, we have tended to sense something unscientific, religious, or of an occult in a phrase such as an “inhabitation of a soul.” However, we can say that such a thing has been formulated now. The consciousness is perceived as a substance comprised of the materials, existing in the extra-dimensions—the dimensions that we normally do not recognize—based on the perspective of a multi-dimensional universe. The inhabitation of mind in the brain is, so to say, modeled by a fermion interaction between the matter particles. This idea may somehow contribute to the future studies which seek to find the forms of existence of mind as a substance interacting with but existing independently from the brain. The circumstances where a parasite fermion couples to a host fermion through a fermion interaction matches with an image where the “soul” inhabits in the “body,” at least in so far as the appearance goes. Naturally, it is not sufficient just to say that it matches the image. Although it is certain that the host fermions comprise our body, it is essential as a next step that we obtain solid evidence that the “mind” existing separately from the brain is comprised of the parasite fermions, and clarify the mechanism where such mind inhabits in the body (brain) through the fermion interaction as the fetus grows and releases itself from the coupled body along with an event called death. Through what kind of an experiment, are we able to prove the existence of a parasite fermion and that it comprises the consciousness separately existing from the brain? Even if the Parasite Fermion Model were expressing the truth, it would require quite a lot of time and effort for the human beings today, who have no experience of having observed any phenomenon clearly involving the extra-dimensions, to obtain and fully understand these new forms of existence of the materials. This being said, the science progresses without doubt. It is understandable that we helter-skelter searching for the whereabouts of the mind, as we have not yet sensed the extra-dimensions. However, it is egoistic, indiscreet, and arrogant to write off all studies going around concerning the continuance after death as being unrelated to the science, trivial and a sheer nonsense even to dispute about. The models have been proposed that solve, respectively, the first hierarchy problem which has haunted the physicists for long, and the issues arising from the ADD Model which has been devised to solve the first hierarchy problem. On top of these is the Parasite Fermion Model, which is a model that solves the second hierarchy problem which surfaces when handling the consciousness outside of the brain from a scientific perspective. Some other different solutions may be further proposed, and the experimental examinations will certainly proceed. We are neither able to make a hasty prediction on the future development nor allowed any unfounded prejudgement. A scientific optimism would be what is required of us now. It is wrong to think that there is nothing there just because it cannot be justified at this point. Such an attitude would make the scientific researches too boring.

## CONCLUSION

### Rationality Judgment and Trap

We often see the words perceiving that it is rational (or irrational) not to believe (or to believe) in spirits. Those who believe in the existence of a spirit, continuance after death, after-world, and spiritual phenomena are determined to be irrational. How do we perceive this rationality, then? A rational theory is not equivalent to a theory to which the entire world agrees. Otherwise, there will be almost no rationality in the world. Perhaps, we can list two methods of judgment—an aided judgment on rationality and a self-judgment on rationality. The former is a judgment based on the thoughts supported by the theories and the knowledge systems established and examined based on the objectively existing natural phenomena or the reproducible experimental outcome. On the other hand, the latter is an examination of the appropriateness through a judgment criterion based on the subject or instinct of the individuals. If the objective of the physics is to clarify the mechanism of the universe, and if the so-called spiritual phenomena are an emergence of an unrevealed structure of the universe that accompanies the reproducible natural phenomena, they all have to undergo an examination through the physical studies. If, after excluding the mental actions, misconceptions and fakes, there is still a possibility of the phenomena objectively being generated, this is a scientific agenda. If we call an attitude unscientific that unnecessarily attributes something to a spiritual thing that has no material basis, the waver of an effort to clarify would also be considered unscientific. When you make a judgment based on the aided judgment on rationality, it is important that you refrain from absolutizing the existing knowledge. A true scientific attitude would be to understand that the scientific knowledge shall always be updated, and recognize that it is yourself who update the knowledge.

What makes it confusing is that people tend to be influenced by a self-judgment on rationality which is strongly dependent on the instinct. A succeeding outcome of the aided rationality judgment which took more time and is based on a hardheaded insight is easily changed by an outcome of a self-judgment on rationality previously conducted, although the situation may vary depending on the insight of the former. Judging someone from an appearance is a good example. Although the appearance shows the personality of a person to some extent, we cannot fully evaluate the person's inner surface merely based on the appearance. The cases are not rare where we are surprised by the unpredicted quality of a person. However, the first impression has a strong influence on the evaluation of the person. In the training of a sales person or a seminar on communication, a significant emphasis is put on the importance of the first impression. This first impression directly acts on the self-judgment on rationality, that is, a rationality judgment after your style which is strongly based on your instinct. The TV shows and solicits to a religious group exactly make use of the feature of this rationality judgment of the people. In a TV show, an audience is easily transported to the terminal station on the rail through the performance effects such as an impression from the appearance, acts of the entertainers making a fuss, and intentional cheers of the studio viewers. These are all a result of a self-judgment on rationality.

Why do the spirits that were witnessed or taken by a photo have clothes on (though, of course, I would not want them to come out naked)? Where did they procure their clothes? Do changes similar to those which occur to the appearance of us living in this world caused by

aging also occur after death? How do they occur and proceed? If they do not occur, what is the reason therefor? What is the mechanism by which the “death,” that is, the transition of a spirit from this world to the after-world is invoked by the damage to the body? How much lower forms of animals have their own spirit? It is intuitively possible for anyone to raise any number of questions. It is easy to cut off the possibility of the continuance after death with these questions. However, this is the very opportunity where an aided rationality judgment, that is, a lucid judgment based on the modern science and the investigational activities toward the development of science will be required.

In reality, there are extremely few fields where the spirits and the continuance after death are considered as a scientific agenda. A predominant number of cases are just being ignored, the reason being that it is considered unscientific, rather than not attracting any interest. What does “unscientific” mean? Should it mean that “it is not yet explained by the modern science,” the whole world would be full of unscientific stuff. An important factor which makes them being considered unscientific is the lack of reproducibility of the observational cases which indicate their existence (i.e., the spiritual experiences). Although a spirit photo or a movie can never be the pieces of evidence or a subject of study and thus should be excluded, a so-called spiritual experience cannot be any more than an unexpected and transient experience for the very person who had the experience. It is nothing other than an experience to be talked about in a past tense. In the process of examining and generalizing the hypothesis or a theory that have been made based on the natural phenomena, it is imperative that the observations and the experimental outcomes are accumulated in a reproducible manner. Under the same conditions, any person is able to obtain the same result through an experiment within the margin of error. That is what the natural phenomena should be. Needless to say, the difficulty of procuring these “same conditions” varies depending on the experiments, and there are indeed cases where it is extremely difficult to examine or to do a replication study. Having said this, the “difficulty” and the “impossibility” are evidently different. Even if it is indeed impossible, it is not a fair approach to the science to exclude it from the scope of scientific studies for such reason. The possibility of an “orthodox” observation is a different issue from whether something is true or not.

The scientists whom I raised in the outset who argue that the mind continues to exist after death have, among good company, reached their respective conclusions through their past actual and personal experiences such as their own near-death experiences or experiences of being present at some other persons’ deaths. Although these conclusions have been reached based on their own rationality through a number of their individual experiences, they are not reproducible, and the experiments for examination are impossible. It is far from being recognized as a scientific truth if it cannot be examined, no matter how certain they are about their conclusion spun out through their separate and individual experiences. If a deductive method does not work, what about the opposite? Historically, there has been extremely few theories in the field of physics which support the continuance after death. There are cases where a would-be spiritual master uses a jargon, wearing a clothes of rationality, commentates on the phenomena through the mass media. They may refer to the terms such as an out-of-body experience, transition to an astral world, or “the evil spirits have been gathered through an accumulation of the negative energy.” Such statements are vague in the definition of the used terms, and nobody talks about how they are related to the interpretations in terms of the natural science. If we are unable to understand them without standing on an equal footing with them, such “interpretation” would mean nothing. Even if the issue of the

definition of the terms are cleared, if it cannot be examined by public, it is merely a straw man argument in that it would only be that the spiritual master's statement would be questioned.

Having said this, now we have with us a theory which indicates the forms of existence of a matter particle which is different from those in the existing theory based on the Parasite Fermion Model. In this circumstance, our future step would be the examination process of the theory, including the examination of the appropriateness of the theory and the scope of application thereof, and running of the predicted outcome against the observed facts. Particularly with respect to the theory of continuance after death, it means that we are going to step into a new stage of examination of a general theory, which is essentially different from an accumulation of the individual experiences that are unverifiable. This is a part of the studies of the theoretical physics, and thus, it is a new aspect which had never occurred in terms of the studies on the continuance after death. The significant point is that a new study on the continuance after death based on an inductive method has been made possible due to this Model.

The new forms of existence of the fermions, if revealed that it is true, will lead to a modification of the traditional viewpoints in various fields of science. One of such fields is the mind-body problem. Historically, from a materialistic perspective, efforts have been made to deduce the forms of existence of mind to a group of chemical or biological reactions inside the brain. The modern scientists who try to explain the mechanism under which the mind is generated seek the source of mind in the phenomena inside the brain such as the firing of the neurons. The best evidence of this theory would be to make an artificial device equipped with the firing of neurons, and display how they perform the movements of the mind including the thoughts, senses and emotions. This is because generally, a reproducibility must be guaranteed in the field of the natural science. However, as a matter of course, no such device exist at the moment. The very scientists who engage in the neuroscience honestly admit that the mechanism under which an image is generated and extinguishes inside the brain which is purely comprised of the materials and the mechanism by which the mind is generated as a result of the brain functions remain unknown. On one hand, they say that it is undoubtedly true that our mind arises from the firing of the neurons, but on the other hand, they admit that the studies have just begun to reveal the association between the factor and the mind generated as a result thereof. Some researchers seek the factors in something other than the firing of the neurons. All of these circumstances put together, we are not in a stage where we can determine that we have obtained some kind of conclusion regardless of the form thereof, based on the studies on the source of mind to date. Under the circumstance where we are still unable to identify the relationship between the neural activities and the generation of the mind, although it is the essence of the problem, and further where we have not even obtained any circumstantial evidence, it is too early to determine that the mind is generated through the neural network activities.

As such, the concept of the parasite fermion may release us from our search of the source of mind in the neural network right in front of us or in the brain. If we are in the first stage of the studies of mind from a natural scientific approach, we should not exclude any possibility from our study on this mind-body problem. The non-traditional and multi-dimensional forms of existence of the matter particles may be among such possibilities.

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