NeuroQuantology | December 2016 | Volume 14 | Issue 4 | Page 708-717 | doi: 10.14704/nq.2016.14.4.927
Li J., Directly facing up to the hard problem of consciousness

Directly Facing up to the Hard Problem of Consciousness with a Fundamental Theory of Consciousness

Jianfeng Li

ABSTRACT

In this article, a pre-spacetime quantum theory of consciousness is presented, which reveals the structural position of consciousness to the rest of universe. We focus on extracting as many structural ingredients as possible from the conscious experience and try to identify its possible theoretical correspondence in theory. Based on this fundamental theory of consciousness, it is found that the entity that produces the consciousness must be an elementary particle with an extraordinarily large inner freedom. We further propose that this conscious particle originally comes from among the dark-matter particles (like Wimpzillas) and can be possibly stabilized by the indistinguishable principle of temporarily identical particles. This proposition has, actually, provided a physical model of our brain beyond the neurological science, which explains how our brains capture and stabilize the dark-matter particles and use them to produce conscious experiences together with the precursor particles of consciousness. In other words, our brain might be just a Nature-made collider which is much smaller but much more powerful than that of Large Hardron Collider. The model indicates that during the dying of the consciousness, the brain will lose some weight which is a testable prediction.

Key Words: quantum entanglement, conscious machine, dark matter, timeless and spaceless

DOI Number: 10.14704/nq.2016.14.4.927 **NeuroQuantology 2016; 4:708-717**

1. Introduction

In D. Chalmers's (1995) famous article "facing up to the problem of consciousness", he has drawn a clear line between the easy problem and the hard problem of consciousness and this work might become as the first milestone in the history of the science of consciousness. But it might indicates that philosophical thinking is not as helpful as before for the science of consciousness since it seems all problems that can be answered by philosophers have been already resolved by philosophers after that; and the remaining problems should be handed over to people who are familiar with modern physics but fully respect those philosopher's works. It is because modern physics not only provides necessary theoretical tools for the study of consciousness but, more importantly, it also provides important hints about how Nature works, that all candidate theories of consciousness should respect. Therefore, many people are trying to propose a

Corresponding author: Jianfeng Li
Address: The State Key Laboratory of Molecular Engineering of Polymers, Key Laboratory for Computational Physical Sciences (Ministry of Education), Shanghai 200433, China.
Phone: +862165642125 **e-mail** ✉ lijf@fudan.edu.cn
Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 23 March2016; **Accepted:** 2 August 2016
***e*ISSN** 1303-5150

scientific theory of consciousness that can present an integrated picture about our consciousness and explain how our brains work in the fundamental level. Over two decades past, several theories (Smith 2006; 2009; Borm, 1980; 1990; De Sousa, 2013) have been proposed but none has received wide acceptance and none has directly faced up to the hard problem of consciousness.

For example, Penrose and Hameroff (1995, 2003, 2007) have proposed an objective reduction theory to explain the phenomena of consciousness. But it immediately received many critiques that point out that the brain is just too wet and warm for the scenario described by the theory to really take place. D. Chalmers simply ignored this theory because the theory did not touch the hard side of problems of consciousness; these theories might be useful but they would not draw attentions of people who really care about the hard problem of consciousness. Even though, in this paper we show that the quantum effect can be maintain in the wet and warm environment by introducing a dark-matter particle, the quantum effect itself as physical phenomena cannot produce conscious experience. Tononi (1994) and his coworkers proposed an integrative information theory about consciousness (or awareness more precisely). They asserted that for a system to be conscious it has to satisfy some conditions and above all its integrity characterized by some parameter should be over some threshold; more importantly, they further declaimed that any system that has a high integrity and big complexity is actually conscious. The author agrees with the first part of the assertion but totally disagrees with the second part because of the two reasons. First, the high integrity of the physical properties of the system (composed of particles) does not imply the high integrity of the phenomenal properties of the system. Second, it is very reasonable to assume that the phenomenal properties of one type of simple elementary particles (e.g. electrons) correspond to one special type of conscious experience (such as vision experience) and it is possible that a system composed of one type of simple particles can have high complexity and integrity; nevertheless, it is highly impossible that this system is conscious because it can only experience one type of conscious experience which is obviously not enough to form any meaningful picture of our world not even time (even if the phenomenal properties can automatically form a series of integrated experiences).

We believe that the future fundamental theory of consciousness should explicitly include the consciousness and the external world at the same time, and directly face up to the hard problem of consciousness. On the one hand, the theory should be consistent with the nowadays physics or in other words nowadays physics should be seen as a constraint for the construction of the theory of consciousness. On the other hand, the theory should face up to the hard problem of consciousness and try to explain what kind of system can be conscious. It is not to employ nowadays physics to explain the phenomena of consciousness; instead, it is to construct a new theory that can simultaneously explain both physics and consciousness even though the new theory should respect modern physics.

This paper is trying to directly face up to the hard problem of consciousness and to present a relatively integrated picture of consciousness in terms of a pre-spacetime quantum theory proposed by me in 2013 but with some modifications (Li, 2013). We try to answer the follow questions in the present work. (1) What is the physical position of consciousness to the rest of the world? (2) What is the role of time in the theory of consciousness? (3) What corresponds to the conscious experience in the theory? (4) Why consciousness has to be produced by an elementary particle with an extraordinarily large inner freedom? (5) What is the role of our brain in producing the consciousness? (6) How does our brain work?

2. Philosophical Bases

The most important philosophical principle of this work is (Li, 2015): The properties of a system can be only described by the relations of the system with other systems; and they cannot be described by the relations among the different parts inside the system. This principle is basically derived from Russell's philosophical insight about physics (Barbour, 1974; 1999; 2003; 2009).

Some might be not comfortable about the assertion “they cannot be described by the relations among the different parts inside the system" in the above principle. If the properties of a system are defined as the relations among the different parts inside the system, then these properties will depend on how to divide the system into different parts and it will be a disaster for a big system since there are almost infinite

ways to divide it. Therefore, the properties defined in this way is not well-defined. Instead the relations among the different subsystems inside the system should be seen as the properties of the subsystems. Based on this discussion, we can also see the above principle as an axiom or a definition of the properties of a system.

Based on the above principle, we conclude that if a system contains everything then it has no properties and thus cannot be described. Because if this system can be described it has to be described as some relations with other systems but there are no other systems since it contains everything. For simplicity, we call this system as the wholeness D. Although the system that contains everything is not describable, we can still manage to study it by dividing it in some way. For example, we can divide it into two parts A and B in some way and study the relations between A and B. Obviously, relations between A and B completely define the properties of A as well as the properties of B. If some of the relations can be mapped to some mathematical structure, we define this mathematical as the original physical properties of A as well as those of B (Note the difference between the original physical properties and the physical properties defined below). We define the paring (A,B) (more precisely the parings of $\{(a_i,b_j)\}$ with $\{a_i\}$ and $\{b_j\}$ possible states of A and B) as the intrinsic properties or the phenomenal properties. Or more generally, the system A's phenomenal properties are defined as the paring (A,B) with $B=D-A$ the rest of the wholeness with respect to A.

If the system A is complicated enough and the parings $\{(a_i,b_j)\}$ have some demanding structures, then we might be able to define such as time and space in these structures and in this sense a subset of the parings will effectively form a consciousness. Therefore, we can say the parings $\{(a_i,b_j)\}$ actually correspond to a series of conscious experiences. We can further divide the rest of the wholeness into different parts and the relations between different parts of $D-A$ specify the physical properties of the different parts in the world of the consciousness A.

Actually, the original physical properties (A and D-A) reflect the inner structures of the phenomenal properties of A where the consciousness need not to be specified while the physical properties can be only defined when the consciousness has already been defined. Actually, only the physical properties are physical while original physical properties are not physical.

The type-F monism proposed by D. Chalmers (2003) and others can be derived or understood from the above principle. In the view of type-F monism, everything has both phenomenal properties and physical properties, where the physical properties specify its relations to the rest of the world; and the consciousness might be a kind of combination of phenomenal properties of some matter or a group of matters. Obviously, just as indicated by the above principle the conscious experiences and the phenomenal properties are almost the same thing in the type-F monism. But the above principle further asserts that the physical properties can be only defined when some consciousness is already presented while the phenomenal properties of a system can be defined even if there is no other consciousness is presented because the studied system can be now seen as some kind of consciousness (even though its structure might be too simple to be able to experience the time flowing).

In this work, we will further define induced phenomenal properties of particles (in section 3.5) as the conscious experiences of consciousness when those particles (precursor particles) are directly interacting with the 'core' system of consciousness; Actually, the induced phenomenal properties is the phenomenal properties of the consciousness. Nevertheless, for ordinary matter, only its induced phenomenal properties are meaningful for us while we will never know its phenomenal properties even though there are relations between two types of properties. Most of the time the phenomenal properties of ordinary matter correspond to the wholeness D.

3. A Pre-Spacetime Quantum Theory of Consciousness

3.1 Wholeness Contains Everything But Tells Nothing

In the following context, we will try to mathematically formulate the above principle in terms of quantum entanglement. It is a quantum theory of consciousness without background spacetime, which is an updated version of the theory I proposed in 2013 (Li, 2013).

Why there is no background space time? If there is background space time then there is more

than physical properties about the space time. Otherwise, it has only relations then it can be completely described by the relations of matters and, effectively, it does not exist. On the other hand, if the spacetime has phenomenal properties, what can they be? They might be the phenomenal properties of some matter or some matter with the name spacetime. It is unimaginable there exists a thing with the name spacetime which has both phenomenal properties and physical properties. Therefore, it is reasonable to assume that there is no background spacetime.

First, consider a system that contains everything including all observers. According to the above principle, this system as a whole does not have any physical properties because we cannot define any relations between this system and other systems since there are no other systems. Therefore, it also has no time and space. We denote this system using a state $|D\rangle$.

Assume that the state $|D\rangle$ can be spanned in some basis $|D_k\rangle$ in order that $|D\rangle=\sum_{k=1}^{N_d}C_k|D_k\rangle$ with C_k the complex numbers. Some may wonder how to choose the basis $|D_k\rangle$. In principle, you can choose any basis you like to denote the state $|D\rangle$ but the rule of choosing basis should make the following decomposition convenient.

Now the system D is boring. But we can separate or decompose it into several systems. For example, we can decompose D into two systems M and W by assigning C_k to C_{kj} and rewrite $|D\rangle$ as

$$|D\rangle=\sum_{k=1}^{N_m}\sum_{j=1}^{N_w}C_{kj}|M_k\rangle\otimes|W_j\rangle \tag{1}$$

with $N_d=N_mN_w$. Obviously, this decomposition is an inverse manipulation of the direct product of states.

Consider a permutation $P=\{M_{I_1},M_{I_2}...M_{I_n}\}$ with $I_i\in\{1,2...N_m\}$ and $I_i\neq I_j$ if $i\neq j$. For simplicity, we may just write $\{M_1,M_2...M_n\}$. We call this permutation as an observer of D based on the system M. Note that, this observer might not be able to experience time and space at the moment.

3.2 Maximum Information Principle and Definition of Time

Rewrite eq. (1) as

$$|D_P\rangle=\sum_{k=1}^{n}|M_k\rangle\otimes\sum_{j=1}^{N_w}C_{kj}|W_j\rangle \tag{2}$$

For an instant now k, it is just two pure states $|M_k\rangle$ and $\sum_{j=1}^{N_w}C_{kj}|W_j\rangle$, and quantum entropy between M and W is zero for k; therefore, M cannot have any information about W for an instant now. Now consider $k=k_1$ to $k_1+\Delta k$ with $\Delta k>0$ an integer. Then

$$|D_P(k_1,\Delta k)\rangle\equiv\sum_{k=k_1}^{k_1+\Delta k}|M_k\rangle\otimes\sum_{j=1}^{N_W}C_{kj}|W_j\rangle \tag{3}$$

Now the quantum entropy is not vanished and depends on Δk, which can be expressed as $S_{k1}(\Delta k)$. If for all k_1, $S_{k1}(\Delta k)$ has a maximum at some $1\ll\Delta k^*\ll n$, then we can define time as follow,

$$dt(k_1+\Delta k/2)=\frac{1}{S^*\Delta k^*} \tag{4}$$

or

$$t(k_1+\Delta k/2)=t_0+\sum_{k=0}^{k_1}\frac{1}{S^*\Delta k^*} \tag{5}$$

with $dt(k_1+\Delta k/2)$ the time step at the instant now $k=k_1+\Delta k/2$. Note that, if $S(\Delta k)$ is a monotonic ascending function of Δk, then the observer would tend to include all $k>k_1$ to obtain the maximum information about the outside world; and this is obviously a disaster because time has effectively disappeared for $k>k_1$.

Roughly speaking, the order of k in $k_1\to k_1+\Delta k^*$ is not important for the consciousness.

By the definition of eq. (4), we can approximately represent time in a continuous form and the Δt^* corresponding to Δk^* is the same for all t. Now eq. (3) can be rewritten as

$$|D_p(t,\Delta t)\rangle=\int_t^{t+\Delta t}C_j(t)|M_t\rangle\otimes|W_j\rangle \tag{6}$$

The quantum entanglement entropy between M and W can be expressed as

$$S(t,\Delta t) = -\mathrm{Tr}\rho(t,\Delta t)\ln\rho(t,\Delta t) \quad (7)$$

with

$$\rho_{jj'}(t,\Delta t) = \int_t^{t+\Delta t} C_j(\tau)C_{j'}(\tau)d\tau \quad (8)$$

3.3 Dynamics of the Universe

By the maximum information principle of consciousness, we should have

$$\frac{\partial S(t,\Delta t)}{\partial \Delta t}\Big|_{\Delta t=\Delta t^*} = 0 \quad (9)$$

Therefore we have

$$\sum_{i,j}\frac{\partial S(t-\Delta t^*,\Delta t^*)}{\partial \rho_{ij}}C_i(t)C_j^*(t) = 0. \quad (10)$$

This equation basically governs the dynamics of $C_i(t)$ or the dynamics of the Universe $|W(t)\rangle$. Note that this equation is more like a constraint equation on $C_i(t)$ other than the ordinary dynamic equation of $C_i(t)$.

3.4 Definition of Relative Distance and Emergence of Space

We define mass and energy of a system as follow. If a system E cannot be separated from an instant NOW $|M_k\rangle\otimes\sum_j C_{jk}|W_j\rangle = |M_k\rangle\otimes\sum_{il}C_{ilk}|W_i\rangle\otimes|E_l\rangle$, we first define the density matrix $\rho_E = \rho_{ll'} = \sum_i C_{ilk}C^*_{il'k}$. The mass of E is certainly also a relationship specified by the quantum entanglement entropy of the system to the rest of the world W', i.e. $m_E \equiv S_E = -\mathrm{Tr}\rho_E\ln\rho_E$. Obviously, by this definition the total mass of the rest of the world is the same as the mass of E, i.e. $m_E = m_{W-E}$. If the system E is separable from $|W_k\rangle$ then it has a zero mass. The total energy of a system is defined as the entropy between a system and the rest of the mixed state of M and W for the time span $k_1 \to k_1 + \Delta k^*$ or $t \to t + \Delta t^*$.

The relative distance between two systems E_1 and E_2 can only be defined as the entropy between them rescaled by their masses

$$d_{E1E2} = \frac{m_{E_1}m_{E_2}}{S_{[E_1E_2]}(t,\Delta t^*)} \quad (11)$$

with $S_{E_1E_2} = S_{E_1} + S_{E_2} - S_{E_1E_2}$. By strong subadditivity of quantum entropy, $S_{E_1E_2}$ is always positive. It is not very difficult to see that this equation also indicates Newton's law of gravitation (also see Li, 2013).

With relative distances $\{d_{E_iE_j}\}$ between systems of a time span $t \to t + \Delta t^*$, we might be able to define a space in the reference frame of the observer M at time t.

With above definitions, we might be able reconstruct the timespace and might even be able to derive the Lorentz transformation especially when it is found that in the eq. 11 the definition of distance is already mixed with the time. But because most the derivations depend on mathematics of tensor decompositions, which is only at its infant stage, so there is still much work to do to reach this stage.

3.5 Elementary Particles

If $N_w = \Pi_{i=1}^{n_m} N_i$ then we still have many ways to decompose the world into n_m systems by assign the coefficients $C_j(t)$ to $C_{j_1j_2\cdots j_{nm}}(t)$.

If for some decomposition, n_1 is a prime number and the mass of this system is always constant then we call this system an elementary particle.

For an elementary particle E, we can singular-value decompose eq. (6) into

$$|D_p(t,\Delta t^*)\rangle = \lambda_1(\sum_l e_{1l}|E_l\rangle)\otimes|\varpi_1\rangle + \lambda_2(\sum_l e_{2l}|E_l\rangle)\otimes|\varpi_2\rangle + \ldots \quad (12)$$

where $|\varpi_1\rangle$ combines M and W. Ordinarily, only some of λ's are big while most λ's are extremely small. The big λ's usually used to indicate the inner state of the elementary particle while the small ones are used to indicate the position of the particle. When there is only one big λ, we call the elementary particle is in its relatively pure state, while there are many big

ones we think of the elementary particle is deeply entangled with environment.

The elementary particle can be only observed when it transforms from the relatively pure to entangled state or from entangled to relatively pure. Because if it is always relatively pure or entangled then the changes on the quantum entropy $S(t,\Delta t^*)$ due to this elementary particle would be totally negligible which means the consciousness cannot aware the existence of this particle at all.

By this insight, some type of dark matters can be some elementary particle with extraordinarily large inner freedom always deeply entangled with environment and all singular values λ of the dark matter can be extremely small which means this type of dark matters mainly act as 'the builders' of the spacetime. Because of these builders of the spacetime, the spacetime looks quite 'stable' and people mistake them as the background spacetime. In the following context, you will be shown that these dark-matter particles can be possibly captured by our brains to produce consciousness.

3.6 Conscious Experience and Phenomenal Properties

In terms of the theory described above, the state $|D_p(t,\Delta t^*)\rangle$ in eq. (6) actually corresponds to a conscious experience while the density matrix $\rho_{jj'}(t,\Delta t^*)$ depicts the structure of this conscious experience or the information contained in this conscious experience. The phenomenal properties of an entity E can be similarly defined in this way.

As you can see, this definition is not very useful because we can still not able to answer when and why we can experience some typical kind of perception. In order to answer this question, the concept precursor particles of consciousness is introduced. Assume that there exists a decomposition as

$$|D_p(t,\Delta t^*)\rangle = \lambda_1(\sum_{kl} f_{1kl}\,|M_k\rangle\otimes|E_l\rangle)\otimes(|W_1'\rangle)$$

$$+\lambda_2(\sum_{kl} f_{2kl}\,|M_k\rangle\otimes|E_l\rangle)\otimes(|W_2'\rangle)+\ldots$$

where only the first leading term is big while all other terms are extremely small. We include as much as systems (particles) into the system E but keep the decomposition with only one big leading term until we can include no more. Then we call the particles contained in the system E are the precursor particles of consciousness M at time t.

In this picture, the state $\sum_{kl} f_{1kl}\,|M_k\rangle\otimes|E_l\rangle$ *in the first blanket corresponds to a conscious experience while the structural information of this experience contains in the density matrix* $\rho_{ll'}=\sum_k f_{1kl}f_{1kl}^*$. As time goes by, some particles will be moved in the first bracket which might corresponds to some kind of input signal from the external world, while some particles will be moved out of the bracket which can be seen as some reactions of consciousness to the external world. The concept of the precursor particles will be re-examined in the next section using an indistinguishable principle of temporarily identical particles.

Now let's define the phenomenal properties of an ordinary system E with inner freedom N_e in W. If $|D\rangle=\sum_{kij} C_{kij}\,|M_k\rangle\otimes|E_i\rangle\otimes|W_j'\rangle$ we rewrite it as $|D\rangle=\sum_{il} C_{il}\,|E_i\rangle\otimes|\varpi_l\rangle$ with $|\varpi_l\rangle=|M_k\rangle\otimes|W_j'\rangle$ for $l=(k-1)*N_m+j$. If there exists an permutation of $\{E_i\}$ and a similar maximum information expression as eq. (9) then we can define conscious experiences of E as that for M. But if there is no such permutation then its conscious experience actually correspond to $|D\rangle$ and it is just wholeness which means it experience nothing! Although it experiences nothing, we can define the set $\{\sum_{m=1}^{n} C'_{ml}\,|E_{i_m}\rangle\otimes|\varpi_l\rangle\,|\,i_m\in(1,2,3\ldots N_E)\wedge n\le N_E\}$ as the phenomenal properties of the system E.

We can also define the induced phenomenal properties of a system E when it becomes precursor particles of the consciousness or it is in the bracket of eq.(13). The way of defining the induced phenomenal properties is similar to that of defining the phenomenal properties except for replacing $|D\rangle$ with the state in the bracket. Actually, we have seen the state in the bracket as a small wholeness. In this picture, what the consciousness M experiences are the induced phenomenal properties of the precursor particles induced by the consciousness M.

There might be some connections between the induced phenomenal properties of some particle with its phenomenal properties, but we still do not know much about it at the current stage. It is reasonable to propose that the same kind of elementary particles should have basically the same or at least the same type of induced phenomenal properties otherwise it will be difficult to explain why when the photons come into the eyes they always cause the vision experience (note that photons are not the precursor particles for vision experience). But we need to prove this proposal and specify how different types of precursor particles correspond to different modes of conscious experience in the future; and this should be the central mission for the scientists in the field of the consciousness.

4. A Physical Model of our Brain

This section mainly discusses how the consciousness is embedded in our brain. In this course, we will inevitably address the physical properties of the consciousness. But as discussed in the section 2, physical properties can be only definable when some consciousness is already presented. Therefore, we can only study the physical properties of the consciousness M in the eyes of some other consciousness M' (also see Li, 2013).

4.1 Why Consciousness has to be an Elementary Particle

If someone tell you that your consciousness is actually produced by an elementary particle, you will feel quite boring because most people expect that consciousness should be generated by some super complicated composite-particle system which has a cool fashion features such as non-linear, self-organized and so on. But unfortunately, the system that produces consciousness has to be an elementary particle with an extraordinarily large inner freedom for the following reasons.

(i) If type-F monism is true, then everything have both phenomenal properties and physical properties at the same time. It is expected that the conscious experience is a properly organized collect of phenomenal properties of some particle (or some particles). Many people think that when the physical properties of some particles are well organized then the phenomenal properties of these particles will spontaneously organized in the same structure. But we can easily prove that this cannot happen. For instance, in nowadays computers, we organize the physical properties of photons (electromagnetic wave) to realize all kinds of functions. But the inner properties of photons should be basically the same or the same type to generate the same version of experience (for example, the acoustic experience). It is hardly possible that the collect of the same kind of the experiences has the same structure as those functions or in other words it is impossible that these photons will aware what human want them to realize. Besides, to make a consciousness with many particles, one should first able to connect the phenomenal properties of these particles together to form an integrated conscious experience. It is now still very hard to see how to connect phenomenal properties of different particles.

(ii) It is an easiest way to solve the combination problem of consciousness by assuming that the consciouness is produced by the phenomenal properties of an unbreakable particle. Chalmers and many others (Chalmers 2013) argued it is impossible for the consciousness to be a single particle since it is highly impossible that it can be stabilized for such a long time in our brain. But I show that ,in the sections 4.2 and 4.3, the indistinguishable principle of temporarily identical particles proposed by me (Li 2016) can solve this problem gracefully.

(iii) If the consciousness M is not an elementary particle, then we can write it as $|M_A\rangle\otimes|M_B\rangle$, put, for example, $|M_B\rangle$ into the W side and you will find that a consciousness M_A is 'contained' in the consciousness M which is quite impossible. On the other hand, M_A or M_B might be just the precursor particles defined in eq. (13) or we can say we always 'define away' some systems that are not lying in the 'core' of the consciousness. In other words, if M is separable, then one can always separate the unimportant parts into the environment until it is not separable. One might think that maybe we can put all of M into environment; however, according to the discussion about the philosophical bases if all of M is placed in the environment, then there is only the wholeness $|D\rangle$ which contains everything but tells nothing.

(iv) Certainly, if now M is consciousness and an elementary particle and E stays in the bracket as the precursor particle of M through

the whole life of M, then we can say that now this consciousness should be seen as composed at least two elementary particle M and E. It is extremely impossible this can happen although we can still not be able to rule out the existence of this life-long-lived precursor particle.

4.2 Indistinguishability of Temporarily Identical Particles

In one of my previous work (Li, 2016), I propose the indistinguishability of temporarily identical particles which states that two particles with almost same inner freedom might have the same effective inner freedom during a short time period Δt_c and they can exchange with each other without causing any observable physical effects. In that work, I show that it is possible to capture a kind of dark matter particle D with an extraordinarily inner freedom N_D by trading a composite particle system with n_c deeply entangled ordinary particles each with an inner freedom of N_p. If it happens that there are exactly $m = N_D - n^{N_p}$ almost vanishing terms in the singular-value decomposition of D with environment then the dark-matter particle and the composite system share the same effective inner freedom and they exchange with each other. In the following discussion we will use the two numbers (N_D, m) to denote one consciousness, i.e. we hypothesis (N_D, m) with N_D a large prime number will uniquely determine a consciousness. In other words, there are no two consciousness's share the same (N_D, m), otherwise they are temporarily identical and will exchange with each other or in other words they are the same consciousness with the same conscious experiences. Obviously, this is not true in reality.

Generally, the dark-matter particle is deeply entangled with environment and cannot be observed according to discussion in the section 3. After exchange, the dark-matter particle is instantly moved to the place or container of the composite system while the particles will be instantly dispersed into the environment. Gradually, the dark-matter particle will penetrate the container and become deeply entangled with environment again because its originally vanishing terms will gradually come into play.

So effectively, we will observe the n_c particles disappear and the container becomes empty which is obviously a testable prediction.

In experiment, one can first prepare a series of 'boxes' containing with 1,2,3,... n particles, respectively. If n is bigger than some n_c then at least the n_c'th box will become empty if particles in it is deeply entangled with each other. Hopefully, this phenomenon can be observed in experiments in the near future.

4.3 Our Brain as a New Type of Collider

As discussed above, the consciousness has to be an elementary particle. But for the consciousness to be able to experience the time flowing, it must have a complex inner structure and, therefore, we believe it should have an extraordinarily large inner freedom and some kind of dark-matter particle (like Wimpzillas, Kolb, 1998) would satisfy this requirement. Luckily, the above mechanism based on the indistinguishability of temporarily identical particles enables our brain to be able to capture some dark-matter particle.

However, the brain also needs to stabilize the dark-matter particle. Actually, it can employ one more such composite entangled particles system to stabilize the captured dark-matter particle.

For example, (i) we prepare two boxes A and B both with $n_c - 1$ entangled particles at $t = 0$. (ii) At $t = \Delta t_c$, we input one more particle in the box A and let it entangled with other particles; by the indistinguishability of temporarily identical particles these n_c particles will help capture a dark-matter particle D. If there is no other measure to keep D in the box it will disappear. (iii) So at $t = 2\Delta t_c$, we input another particle into the box B this time, then D in box A will be moved to the box B instantly since now number of particles in the box B is n_c now; at the same time, the particles in box B will be moved to near box A (some of them will be outside box A because D might be expanded a little bit during the time period Δt_c). (iv) At $t = 3\Delta t_c$ we pump into the box A a small amount of particles to compensate the particles that leak out of the box A because of the expansion of the dark-matter D in order to make

the total number of particles in the box A to recover n_c. Then the the dark-matter D will be moved from the box B back to the box A again. By alternatively pumping into these two boxes proper numbers of particles in this way, the dark-matter particle D can be possibly stabilized in our brain.

Although, it seems that we know which box the dark-matter particle is in, it is more probably that D is in the superpositional state, which means at time t, D can be in A and B at the same time, and certainly the n_c particles are also in A and B at the same time. Here, we might safely call these n_c particles the precursor particles of the consciousness M (M is actually a dark-matter particle D).

In the above discussion, pumping into boxes particles corresponds to the input of some kind of signal from the external world while the leaking-out of particles from the boxes corresponds to a response of the consciousness to the outside world.

One may wonder what biologically correspond to the boxes A and B in our brain. It is possible that all neurons in some special regions in our brain have one such box and the dark-matter particle D is actually stabilized by all these auxiallary systems other than just two systems. Only when all these boxes are destroyed, then the consciousness will eventually die (or as long as two of them are working, the consciousness is officially alive). This picture may explain why the consciousness is so stable in our brain.

Physically, the dark-matter particle and the n_c particles together determine the conscious experiences of the consciousness. But more specifically, the n_c particles determine the structures of the conscious experiences while the dark-matter particle eventually feels these experiences by forcing its 'shape' to fitting into the physical structure of these n_c particles in order that they share the same observable physical properties.

When the brain cannot maintain the stability of the dark-matter particle, the dark-matter particle will gradually expand and finally become deeply entangled with environment, which actually corresponds to the dying of consciousness.

From the perspective of particle physics, a life of consciousness is actually just one single particle colliding process: many precursor particles come and go and there is one virtual particle D involved in. This collision lasts for a life-long time of consciousness. One testable phenomenon of this collision is that when the consciousness is dying, the brain will lose some tiny weight even if the brain were in a well sealed container because in this process the dark-matter particle will expand and go out of the brain to become deeply entangled with environment since the DM particle will not interact with any ordinary matter in this process. Therefore, the brain will lose the mass of this DM particle when the consciousness is dying. But experimentally, it will be quite difficult to detect the mass changing. Maybe we will be lucky if the precursor particles have non-zero net charges then the DM matter has to be charged too since they share the same physical properties and it would be much easier to detect the charges lost.

In this sense, a brain is a Nature-made collider, which is much smaller than that of LHC (Large-Hardron Collider) but much more powerful. Further, the above strategy might also provide completely new way to study elementary particles.

Some comments about this section: (i) n_c particles need not to be the same type of particles and actually there should be several types of them otherwise the consciousness can feel only one mode of conscious experience. (ii) Maybe some of these n_c precursor particles are also dark-matter particles. If this is true, then the brain contains many 'small' colliders each using two or more small boxes to capture and stabilize the small-size dark-matter particles. We might see a brain as a set of colliders with hierarchies. The participation of these small-size DM particles would benefits in two ways: first it is possible to generate more types of conscious experience even using the same type of ordinary elementary particles; second some input signals pre-organized in these small-size DM particles would be much easier to be processed when they come to the consciousness. (iii) Note that this section has actually already presented a strategy to make a conscious machine. The key to make a conscious machine is, in the first place, to capture and stabilize the DM particles. This can be accomplished if we know how to make a cluster of particles entangled for more than the

time span Δt_c which can be very small. Because Δt_c is small so it is possible to entangle these particles even in a wet and warm environment like our brains. Second, we should study the mapping of the type of precursor particles to the type of conscious experience. To obtain this mapping, we might need to know how to inject the precursor particles to the consciousness in a controllable way and see what we experience after injecting, which might not be able to realize. Third, one also need to learn to organize the induced phenomenal properties of these precursor particles by using the nervous systems in order that the consciousness is able to sense the structural conscious experiences. (iv) In my previous theory (Li, 2013), it predicts the consciousness has a negative mass. This work corrects this prediction by re-stating that during the formation of consciousness the brain's mass remains constant while during the dying of the consciousness the brain's mass will decrease a little.

Acknowledgement

We thank the financial supports from NSFC (No. 21534002, 21474021).

References

Barbour J. Relative-distance Machian theories. Nature 1974; 249: 2.
Barbour J. The end of time: the next revolution in physics. Oxford: Oxford University Press, 1999.
Barbour J. The deep and suggestive principles of Leibnizian philosophy. The Harvard Review of Philosophy 2003; 11: 45-58.
Barbour, J. The nature of time. 2009. arXiv:0903.3489.
Bohm D. A new theory of the relationship of mind to matter. Philosophical Psychology 1990; 3: 271-286.
Bohm D. Wholeness and the implicate order. Routledge, 1980.
Chalmers DJ. Facing up to the problem of consciousness. J Conscious Stud 1995;2:200-218.
Chalmers DJ. Consciousness and its Place in Nature. Philpapers, 2003.
Chalmers DJ. The Combination Problem for Panpsychism. Forth Coming in: Bruntrup G, Jaskolla L, eds. Panpsychism. Oxford University Press. 2013
De Sousa A. Towards an integrative theory of consciousness-part 1 (neurobiological and cognitive models). Mens sana monographs 2013; 11: 100-150.
De Sousa A. Towards an integrative theory of consciousness-part 2 (an anthology of various other models). Mens sana monographs 2013; 11: 151-209.
Hameroff SR and Penrose R. Orchestrated reduction of quantum coherence in brain microtubules: A model for consciousness. Neural Network World 1995; 5: 793-804.
Hameroff SR. The brain is both neurocomputer and quantum computer. Cognitive Sci 2007; 31: 1035-1045.
Kolb EW, Chung DJ and Riotto A. Proceedings of the 2nd International Conference on Dark Matter in Astro and Particle Physics, Heidelberg, Germany, 1998.
Li JF. A timeless and spaceless quantum theory of consciousness, Neuroquantology 2013; 11: 431.
Li JF. Comments on Russell's the Analysis of Matter, 2015 (not published).
Li JF. Indistinguishable Hypothesis for Temporarily Identical Particles and Its Possible Implications, 2016 (to be published).
Mensky MB. Everett interpretation and quantum concept of consciousness. NeuroQuantology 2013; 1: 85-96.
Smith CUM. The 'hard problem' and the quantum physicists. Part 1: The first generation. Brain Cogn 2006; 61: 181-188.
Smith CUM. The 'hard problem' and the quantum physicists. Part 2: Modern times. Brain Cogn 2009; 71: 54-63.
Tononi G, Sporns O and Edelman GM. A measure for brain complexity: relating functional segregation and integration in the nervous system. PNAS 1994; 91: 5033.