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The Limits of Atomism, the Bohm Way of a New Ontology

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Abstract: In this paper, we survey a developed outline of atomism. The paper clarifies that this leading principle of modern physics faces a limitation. This limitation is a limit of ontology. We are unable to recognize a concrete ontology; we have only epistemology. Therefore, we discuss this issue from a philosophical viewpoint by referring to Cassirer's philosophy. These arguments will clarify that there is a need for a new ontology that will be able to make a consistent understanding from the microscopic to the macroscopic level. To do this we argue the case of the new ontology that was introduced by Bohm. Also, we will see the mathematical formalism of cyclic ontology as a new ontology for the process. Then we will see that this formalism is able to obtain the Heisenberg equation as well as the Bohm equation.

Keywords: Atomism, Cyclic ontology, The implicate & explicate order, Bohm
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Brief History of Atomism

The primary ideas of atomism were developed by Demokritos and Leukippos. They were philosophers of the atomist school of pluralists in ancient Greece in the late fifth century BC. Demokritos and Leukippos thought that the whole of any given physical object consisted of atoms and void. According to the theory, these two aspects are never generated and never ending. Demokritos and Leukippos thought these two elements were the elements of all physical objects. However, their ideas in atomism were not developed further. Then, replacing their idea, the 'four elements theory' became the mainstream of the next generation of philosophers.

Thales thought that water was the source of creation and named it 'arkhe'. There were other thinkers that thought fire was the 'arkhe', air is 'arkhe' or the Earth is the 'arkhe'. On the other hand, Empedocles thought all four of these were the 'arkhe'. He called these four elements 'rizomata', that means the 'root' or 'foundation of all creation'. Empedocles believed that the four rizomata constantly join together and rupture, thus

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creating all things in the universe. Also, he suggests that the total amount of these four rizomata will never increase or decrease like in the idea of atomism. This was later called the 'four elements theory'.

These two ideas seem childish and poor to our eyes but the fundamental concepts are not different from our own atomism of modern physics, since they also search for the fundamental being of the universe. Ancient atomism calls this the 'atom', and the four elements theory calls this the 'rizomata'. Modern physics calls this 'elementary particles' though it is not considered to be elementary at present. The similar aspect in these three ideas is that all of them suggest that there is some kind of fundamental object.

The 'four elements theory' eventually succeeded the scholasticism that was established by clergyman and priests in Europe in the eleventh century. The ideas of modern atomism were developed by Lavoisier, Dalton and Boltzmann. This in turn led to modern particle physics.

Necessity of the New Ontology

At the end of the eighteen century, we found that there are subsystems within the atom. That is, the atom is not the most fundamental layer. There is an internal structure within the atom that is made up of electrons and nucleuses. Thus, it follows the ideas of quantum theory and modern particle physics. However, we are then forced to ask, is the nucleus made from quarks? Moreover, is the quark made from strings? Nobody knows the answer to this! Let us assume however, that the quark is an elementary object; then we are faced with a difficult question —– what is a quark? Is this 'the fundamental and elementary substance'? We are faced with the same problems concerning strings too. If a quark (string) is a substantial object, then we must be able to create a macroscopic object by combining and uniting them. However, nobody knows the mechanism that will combine and unite quarks (strings). That is, we are unable to make a macroscopic object in this way. And moreover, we also know that the expression of 'combining' (or 'uniting') quarks (or strings) is an improper use of the word.

Quarks and strings are concepts that come from the simple and primitive ideas of atomism. Modern physics arrived at the concepts of quarks and strings from the ancient ideas of atomism but it faces a serious difficulty. We do not have an ontological consistency between classical and modern matter, or between the microscopic object and macroscopic object. We ought to call this a 'Limit of Atomism'. In order to bridge the two worlds properly we need a new ontology.

Philosophical Viewpoint——from Substance to Function——

It is obvious that there is a serious chasm between the two worlds, the microscopic and the macroscopic world. This chasm can be attributed to a lack of ontology in the modern physics theory. Here, we will discuss this from a philosophical viewpoint referring to Cassirer's philosophy [1].

When we look at the developing history of scientific atomism we realize that this is a history of how we make an epistemological understanding about nature. Cassirer's point of view is that humans recognize the world using metaphors (or simply we should say fable) initially. These metaphors are accomplished by using symbols. The world can be understood by the connection and the relationship between these symbols. However, this is a comparatively primitive way of developing an understanding, since these symbols appear to have a mysterious and magical power. Conceptualization is achieved by fixation of change that is a fluctuation. Therefore, when we use symbols for understanding the world there is a risk that our understanding will regress to its ancient and mythical stage every time. This stage is the initial fluctuation.

For example, a number is a typical symbol. We know there is no essential difference between each of the numbers. There is no 'special number'. However, historically we can say that humans recognize numbers to be dressed in some kind of mysterious robe. The irrational numbers are typical good examples of this. People thought such numbers has mythical and magical power.

The next step is that, humans use substance for their understanding of the world. These substances are also one type of the symbols but these symbols have no longer magical tendency. However, from Cassirer's viewpoint this is still only on the way to discovering a final form of epistemology. Cassirer claims that we do not need to assume there is a substance when we attempt to perceive nature. For him, substance is like Kant's 'Ding an Sich' as 'Ding an Sich' was a mistake of Kant's in Cassirer's view[2]. Cassirer insists that we do not need substance for our epistemology; the important point is the relationship between phenomena[A].

Cassirer claims that our method of understanding, that is epistemology, has changed from being a substantial method to one of recognizing the relationship between phenomena. He describes this change as being a change 'from substance-concept to function-concept'—from Substanzbegriff to Funktionsbegriff. That is to say, a developed way of epistemology is to recognize the world by functional relationship between phenomena. We do not have to assume any substances for each phenomenon in a modern way of epistemology.

This epistemological change of philosophy can be paralleled with the epistemology of science. It seems that there are no serious problems and it seems that this change supports the standard interpretation of quantum theory. However, it also strongly justifies that modern physics has lost its ontological object. In fact, we are unable to find any ontological object and substance in quantum theory (within the microscopic world). There is no concept of ontology in standard quantum theory. Therefore, we can say that Cassirer's viewpoint is also correct in this case. It also follows the change of the epistemology

[A] This expression reassembles Bohr's claim about his research attitude toward quantum mechanics. Bohr is very careful to avoid using the term 'substance' when he considers quantum physics and when he develops his theories in physics. This is very similar to his interpretation of quantum mechanics that follows the Copenhagen interpretation. We are able to say that the Copenhagen interpretation abandons the idea of referencing to the real objective world.

of science while it exposes the fact that we have lost the idea of any form of substance making up the world. That is, we cannot develop any consistent understanding from the quantum to the classical world ——from the microscopic to the macroscopic world.

As we argued in the above paragraphs, we could not find any ontology in quantum theory. The main problem is that the modern physics has lost ontology. Therefore, we are unable to explain the stability of a general object, for example, a desk, pen, cup, and so on using standard quantum theory. The several quantum paradoxes are caused by this lack of ontology.

We will argue for a new ontology in order to construct a new way of thinking in the following sections. This new form of ontology can be called 'cyclic ontology'. And this helps us to make a consistent understanding the world from the microscopic to the macroscopic way without to take false stapes of the several quantum paradoxes.

Process and the Cyclic Ontology

In the above arguments we saw that a few serious and fundamental difficulties arise due to the lack of ontology. It is said that physicists imagine a picture when they think about their problems in physics, but strictly these images are fundamentally mistaken. All of these images are classical. That is, a mind of the physicist is also split seriously. This is not beneficial to our thought too. We must cover the chasm between these two worlds as soon as possible. What is the best way to do this? Now, we know this chasm is caused by the limitation of ontology that we have, that is atomism. Such being the case, we must look for a new ontology for an alternative way of thinking.

David Bohm[3] introduced the idea of process. The concept of process was mainly thought by Whitehead in the modern era. In the ancient era, Herakleitos also thought of this idea. Herakleitos said "all things flow". However, this idea has not been considered particularly in philosophical thought in Asia. This is considered to be 'commonsense', a part of daily human life in Japan; it is particular to the Japanese way of life. Bohm's idea is also similar to this way of thinking. In Japan, it is believed that all things in the universe are mutable, and this should not be limited to the islands of East Asia but adaptable all over the world[B].

Hojoki is a famous old essay in Japan (it was completed at 1212). The author of this essay is KamoNoCyomei. The beginning of this essay has a deep philosophical implication. KamoNoCyomei describes a river that the river is the flow but not the water, the flow is a change[C]. That is to say, the water is not an essence of the river. He

[B] For further information about the eastern (mostly old Japan's) natural thought, see 'Limit of the Cartesian Order'(References number four), ANPA Cambridge(2003), Ryo Morikawa.

[C] The beginning of this essay is that —— "Though the river's current never fails, the water passing, moment by moment, is never the same. Where the current pools, bubbles form on the surface, bursting and disappearing as others rise to replace them, none lasting long. In this world, people and their dwelling places are like that, always changing". —— Quotation from the website of Robert N Lawson,

was not a philosopher but he expressed the river very frankly. We ought to think that he could write this because he had no knowledge of the western philosophy.

Now, let us consider an object A (or phenomenon A) while referring to the beginning of this old Japanese essay. A will change to B. B will change to C. C will change to D..... Then D will return to being A sooner or later. Paper is made from wood. Wood grows on the Earth. Paper will return to the Earth sooner or later. Creation, in this way, is in a constant state of flux, and everything is constantly changing. Thus we are able to call this cyclic ontology[4]. A phenomenon comes into the world but this phenomenon then disappears and changes back into the form of phenomenon it was in the first place.

We are unable to indicate whether one particular phenomenon is fundamental in this cycle. The fundamental thing is not the phenomenon itself but the cycle. Therefore, we can say that the cycle is the most fundamental stage. Let us recall the idea "the river is the flow but not the water, the flow is a change". A change is an essential thing in our world.

Now, we can depart from atomic ontology and come to terms with cyclic ontology[5].

Mathematical Formalism of Cyclic Ontology

It is possible to form cyclic ontology in mathematics. We will see a brief explanation of this formalism in this section. This formalism was developed by R. Morikawa in 2003 from Bohm's idea[6].

Here, we consider the implicate order and the explicate order that are introduced by Bohm[7]. Now, phenomenon A will appear in the explicate order from the implicate order. A will change the variation on the explicate order (for example A will change to B, B will change to C.....) and it will return to the background, that is the implicate order, sooner or later. Let us consider this movement[D].

This is a mapping from the implicate order to the explicate order and vice versa. For example, Ψ will be mapped from the implicate order to the explicate order.

Let us consider Green's function as a propagator. We can determine the form of the wave function at the region 'y' according to the sum of the contributions from {x} where this {x} means a set of points in a volume at a given time t_1 (see Figure-1). Thus:

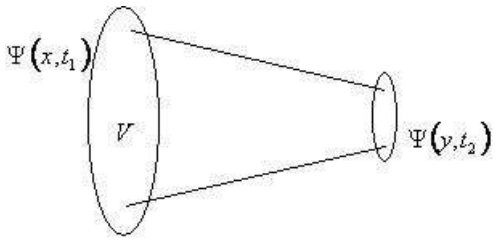

Fig. 1

Washburn University, Kansas USA, http://www.washburn.edu/reference/bridge24/Hojoki.html.

[D] This movement was named 'holomovement' by Bohm.

$$\Psi(y,t_2)=\int_V M(x,t_1;y,t_2)\,\Psi(x,t_1)\,dx \tag{1}$$

where $M(x,t_1;y,t_2)$ is Green's function. The wave function at all points of the volume V contributes to the wave function at 'y'. We interpret that $\Psi(x,t_1)$ is an order in the implicate order and $\Psi(y,t_2)$ is an order in the explicate order. So that, $\Psi(y,t_2)$ is in the visible layer. According to Bohm, the implicate order is a sea of information. So we are able to interpret $\Psi(y,t_2)$—— the appearing order is an accumulation of the information coming from the implicate order. This means that the information enfolds as a wave function $\Psi(y,t_2)$. In turn $\Psi(y,t_2)$ itself unfolds into a series of points on a later volume $V^{'}$ (see Figure-2). We can say $\Psi(y,t_2)$ is enfolded into the implicate order as well. That is, the accumulated information diffuses to the implicate order again. Or, we can say that information from $\Psi(y,t_2)$ makes an order in the implicate order too. So $V^{'}$ can be interpreted as an accumulation from $\Psi(y,t_2)$.

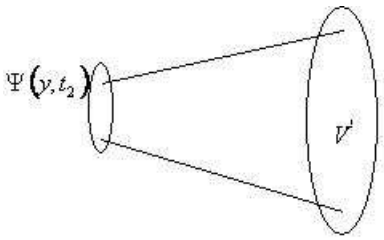

Fig. 2

$$\Psi\left(z,t^{'}\right)=\int_V M\left(y,t_2;z,t^{'}\right)\Psi(y,t_2)\,dx \tag{2}$$

This can also be described as an order in the explicate order enfolding (going back, returning) into the implicate order. This also demonstrates both a mapping from the implicate order to the explicate order as well as a mapping from the explicate order to the implicate order.

The Heisenberg Equation

We can deduce the Heisenberg equation of motion using the above idea. This means that we construct a consistent ontology and a consistent theory from the microscopic to the macroscopic world.

Now we will consider two successive orders: $e(\tau_1)$ and $e'(\tau_2)$. We assume that $e'(\tau_2)$ is a result of the unfolding movement. Then we describe the enfolding process as M_1 and the unfolding process as M_2. Order $e(\tau_1)$ is enfolded; thus we write $e(\tau_1)M_1$. Order $e'(\tau_2)$ is unfolded; thus we write $M_2e'(\tau_2)$. Order $e(\tau_1)$ and $e'(\tau_2)$ are successive orders, so $e'(\tau_2)$ is similar to $e(\tau_1)$. Indeed, the differences of these two orders are very small, that is to say the differences are infinitesimally small. Therefore we are able to equate these two expressions as;

$$e(\tau_1)M_1=M_2e'(\tau_2) \tag{3}$$

These two process are the reverse side and the obverse side, if $e(\tau_1)M_1$ is the reverse side then $M_2 e'(\tau_2)$ is the obverse side. One order $(e'(\tau_2))$ generates from the implicate order to the explicate order and is equal to an infinitesimally closed order $(e(\tau_1))$, which disappears from the explicate order to the implicate order. Equation (3) expresses this.

Let us now assume for simplicity $M_1 = M_2 = M$, where $M = \exp[iH\tau]$. So that we can obtain,

$$e' = M^{-1} e M \tag{4}$$

If τ is very small, then we can write,

$$e' = (1 - iH\tau)\, e\, (1 + iH\tau) \tag{5}$$

So that we can obtain,

$$i\tfrac{(e'-e)}{\tau} = [H, e] \tag{6}$$

from the equation (5).

Therefore we obtain the Heisenberg equation,

$$i\frac{de}{d\tau} = [H, e] \tag{7}$$

The notable point is that we can deduce the Heisenberg equation using cyclic ontology.

The Bohm Equation

Let us substitute $e = AB$ for equation (7). Then we have,

$$i\left(\frac{dA}{d\tau}\right) = HA \quad \text{and} \quad -i\left(\frac{dB}{d\tau}\right) = BH \tag{8}$$

Now we can get two forms of the Schrödinger equation,

$$i\partial_t|\Psi\rangle = H|\Psi\rangle \quad \text{and} \quad -i\partial_t\langle\Psi| = \langle\Psi|H \tag{9}$$

We consider a pure state $\rho = |\Psi\rangle\langle\Psi|$ for simplicity. Then we will have,

$$i\partial_t|\Psi\rangle\langle\Psi| = i\left[(\partial_t|\Psi\rangle)\langle\Psi| + |\Psi\rangle(\partial_t\langle\Psi|)\right] \tag{10}$$

So we have,

$$i\partial_t\rho + [\rho, H]_- = 0 \tag{11}$$

Moreover, we can get

$$i\bar{\partial}_t\rho + [\rho, H]_+ = 0 \tag{12}$$

from the Brown-Hiley[8] notation that,

$$i\bar{\partial}_t|\Psi\rangle\langle\Psi| = -i\left[(\partial_t|\Psi\rangle)\langle\Psi| - |\Psi\rangle(\partial_t\langle\Psi|)\right] \tag{13}$$

Here $[\rho, H]_+$ is an anti-commutator that $[\rho, H]_+ = \rho H + H\rho$.

Put equation (10) into $\langle r|$ and $|r\rangle$ and use the form $H = \frac{P^2}{2m} + V$ for the result. Also, here we define that P is a probability density $P(r,t) = \Psi^*(r,t)\,\Psi(r,t) = \langle r|\rho|r\rangle$. Then we obtain,

$$\partial_t \rho + \nabla \cdot j = 0 \tag{14}$$

Here j is the probability current. Moreover, we put equation (13) into $\langle r|$ and $|r\rangle$. Then, if we write the wave function as a polar form $\Psi = R\exp[iS]$ we thus obtain,

$$P(r,t)\,\partial_t S(r,t) + \frac{1}{2}\langle r|\,[\rho, H]_+\,|r\rangle = 0 \tag{15}$$

Substitute $H = \frac{P^2}{2m} + V$ for (15) then we can get the quantum Hamilton-Jacobi equation that,

$$\partial_t S + \frac{(\nabla \cdot S)^2}{2m} - \frac{(\nabla^2 R)}{2mR} + V(r) = 0 \tag{16}$$

The third term on the left side is the quantum potential that Bohm introduced in 1952.

Conclusion

We see that the fundamental equations, the Heisenberg equation of motion and the Bohm equation, can be deduced from the new methods of ontology. Therefore, we are able to say that our new ontology is by no means ad hoc because we do not have to take choice of tools, classical and quantum mechanics. Now we have a new tool.

The next step is that we must consider how the world can be seen when we use this ontology in all of the modern physics fields. Bohm's formalism of the quantum mechanics leads to the same result as ordinary quantum theory. This means that we are able to see the world from a different point of view when we use the Bohm theory. Looking from the different view will be a powerful method for revising our view of the world. It provides the potential for us to find a new aspect of the world. This view will then help to create a new world.

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