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Research Article

Unity as an Indicator of Theory Choice

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Abstract

While choosing scientific theories scientists often show natural biases, such as regarding unity, identity, simplicity, and novelty as indicators of theory choice. Unity is determined by the heterogeneous conceptual and empirical scope directly involved in theory through a logical intermediary. In physics, the pursuit of unity is one of the unremitting motives for scientific innovation and progress. Maxwell's Electromagnetic theory unifies electricity, magnetism, and light. Einstein unified not only time and space but also matter and energy. Einstein failed to complete the unified field theory in his lifetime, but his pursuit of unification was not wrong. Quantum mechanics is a theory of describing nuclear forces in mathematical language, which successfully unifies three forces except for gravity. In today's view, string theory is not generally acceptable to most people, but it has some strong local advantages, so it can be pursued.

Keywords: Unity; Indicator; Theory choice; Rationality

Introduction

Unity is determined by the heterogeneous conceptual and empirical scope directly involved in theory through a logical intermediary. In physics, the pursuit of unity is one of the unremitting motives for scientific innovation and progress. In the 17th century, Galileo and Newton's work greatly enhanced people's confidence in building a unified world vision [1]. The development of the unified field theory shows that scientists always hope to construct a unified theory, like Laplacian demons, to grasp the expanding scope of heterogeneous experience and the scope of heterogeneous concepts. Newton unified the force of heaven and the force of earth with the law of universal gravitation but excluded the force between atoms, so Newton's theory could not grasp the time and space when atoms passed through. In the second half of the 19th century, Maxwell supplemented Newton's theory of mechanics and gravity with electromagnetic theory. Electromagnetic theory unifies electricity, magnetism, and light [2]. For example, Maxwell believes that light is a kind of visible electromagnetic wave. He deduced from the wave equation that the speed of electromagnetic wave propagation is exactly equal to the speed of light. At that time, people ignored the existence of atoms and thought that electromagnetic force or gravity could explain all natural forces. The problem of unification was solved [3]. The following work was just to pursue accuracy.

The Combination of Space-time and Mass-energy

In terms of conceptual unity, it is unsatisfactory to assume two basic forces, i.e., gravity and electromagnetic force. In particular, gravity theory and electromagnetic theory have different descriptions of time and space, and there are fundamental contradictions between them. Electromagnetic theory necessarily requires a singular distortion of time and distance, and Maxwell's equation predicts that clocks will slow down in some cases. But to Newton's theory of gravity, time has a uniform rhythm in the universe, and clocks on the earth run at the same speed as clocks on the moon [4-7].

In 1905, on account of a profound understanding of Maxwell's electromagnetic equation, Einstein proposed special relativity.

This theory subverts Newton's absolute space-time view with a relative space-time view. It predicts that for high-speed moving objects, time will slow down and distance will shorten. In this way, time and space are just different manifestations of the same entity. Einstein unified not only time and space but also matter and energy [8]. He saw the transformation between matter and energy. Under certain conditions, a stone (uranium) could turn into a beam of light (a nuclear explosion), and the fission of atoms would release enormous energy in the nucleus. Although special relativity has achieved great success, Einstein believes that it is not complete enough because it does not involve gravity. Newton's theory of gravity seems to violate the basic principles of special relativity [9-11]. According to Newton's theory, if the sun suddenly disappears, the earth will immediately escape from its orbit, because the "force" between the sun and the earth suddenly disappears. However, in Einstein's view, this is impossible, because gravity cannot run faster than light, the speed of light is the ultimate speed of the universe.

Einstein put forward the general theory of relativity in 1915, which interpreted gravity as a combination of space-time and mass-energy. Gravity is no longer a force, but a space-time bend caused by the existence of mass-energy (the sun). According to this theory, the path of the earth is determined by the curved space-time caused by the sun; if the sun suddenly disappears, gravitational waves propagating at the speed of light take eight minutes to reach the earth. General relativity predicts that the path of a beam will bend as it passes through the sun [12]. On May 29, 1915, this prediction was dramatically verified during a total solar eclipse in Africa and Brazil.

The success of space-time theory and gravity theory inspired Einstein to pursue a greater goal: to integrate the geometric theory of gravity with Maxwell's electromagnetic theory. Einstein fought alone in the last 30 years of his life and failed. Most people focus on the study of atomic physics and nuclear physics and have no time to consider the unity of light and gravity [13]. They temporarily abandoned the pursuit of unity and explored other aspects of coordination. In the 1930s and 1940s, physicists focused on quantum mechanics, describing atomic and nuclear phenomena in mathematical language. Although Einstein eventually accepted quantum mechanics, he thought it was incomplete. He believes that the characteristics of quantum mechanics would become by-products of his unified field theory and that subatomic particles and atoms would emerge as solutions of the unified field theory[14]. Einstein failed to complete the unified field theory in his lifetime, but his pursuit of unification was not wrong. Einstein may have made mistakes in two ways. One is the lack of new physical principles and physical images, plagued by simple mathematical concepts and structures. Of course, there are objective reasons. Of the four forces, people had the weakest understanding of nuclear force at that time. Second, gravity and electromagnetic force (light) are chosen to be unified, ignoring nuclear force (including strong and weak).

The Unity of Wave Theory and Particle Theory

Quantum mechanics is a theory of describing nuclear forces in mathematical language, which successfully unifies three forces except for gravity. Quantum theory began with Planck's solution to the problem of "blackbody radiation" or "ultraviolet catastrophe" (ultraviolet or high-frequency radiation). If the light is a pure wave and can vibrate at any frequency, the radiation will have infinite high-frequency energy, but this is impossible. In 1900, Planck not only used mathematical techniques to deduce an equation that accords with the experimental data of Rubens blackbody radiation but also put forward the particle nature of energy, that is, radiation is not entirely a wave, and energy transfer is accomplished by some definite discontinuous packets. The "size" of each packet is determined by the "Planck constant." According to this logic, light can be divided into granular "light quantum." In 1905, Einstein put forward the theory of the photoelectric effect based on Planck's quantum theory of light. According to this theory, when a light particle strikes a metal, it can knock out electrons from the metal atoms and generate electricity. The energy of the electrons can be calculated by the Planck constant [15].

In 1909, Einstein predicted at an academic conference that a new theory of light would emerge in the next stage of theoretical physics, which would integrate the theory of light fluctuation with the theory of light particles. This work was later completed by the French physicist L. V. De Broglie. In 1924 De Broglie intended to make a bold assumption that all physical particles, including electrons, are also volatile. He believes that under general macroscopic conditions, the wavelength of physical particles is very short, so its fluctuation cannot be clearly shown, and it can be treated by classical mechanics; however, in the microscopic field, because the mass of microparticles is very small, the momentum is also very small, then its wavelength may be observed, and its fluctuation may be clearly shown. De Broglie gives the basic relationship that the "matter-wave" obeys, and describes the determined frequency and wavelength of electrons. In this way, De Broglie unified the two concepts which were considered to be opposite in the past and integrated them into wave-particle duality. He successfully extended the wave-particle duality first proposed by Einstein to all matter particles. In 1926, Owen Schrodinger wrote the basic equation (Schrodinger wave equation) for the wave. In principle, the Schrodinger wave equation can make complex calculations of molecules and atoms and deduce the properties of all chemicals. In 1927, Werner Heisenberg put forward the principle of uncertainty [16]. The measurement of an atomic system will change the state of the system. Therefore, we can never know the position and velocity of a single electron at the same time. This principle is also a direct corollary of Schrodinger's wave equation, which shows that we can never accurately predict the behavior of a single atom, let alone the behavior of the universe.

The combination of Relativity and Quantum theory

Relativity and quantum theory seems to be antagonistic. The former concerns the macroscopic motion of galaxies and the universe, while the latter concerns the microscopic motion of the subatomic world. The force field of relativity fills the whole space continuously, while the force field of the quantum world is a discontinuous unit, which is quantized. Relativity and quantum theory are both successful, but they are not suitable for the foundation of unified field theory [17]. Relativity cannot calculate the behavior of atoms, and quantum theory cannot describe the motion of galaxies. Now physicists realize that the key to unified field theory is to combine relativity with quantum theory.

Over the past half-century, theoretical physicists have made tremendous efforts for this ideal. So far, string theory can be said to be the best solution for this effort. Some physicists combine gravitational theory with quantum theory to get an expression of quantum gravity, but from a mathematical point of view, such an expression is meaningless because it always contains infinity. For example, when an electron is treated as a point particle to calculate its electric and gravitational fields, infinite energy can be found in both electric and gravitational fields. However, in superstring theory, electrons are no longer point particles, but a small string that vibrates only 110^{-33} centimeters in size. The additional degree of freedom of the vibrating string enables us to explain its gravitational field [18].

String theory can deal well with the infinite problem of all elementary particles and interactions. Just as different overtones of a violin are different harmonics of the same string, electrons, gravitons, photons, neutrinos, and all other particles are different vibrations of the same basic string. Physicists hope to find a more basic framework for string theory and get a set of equations whose approximate solutions are the different theories we have at present. In this way, we can get a unified theory of the basic interaction in nature, which unifies the gravitation of planets rotating around the sun, the electromagnetic force of electrons rotating around the nucleus, the strong interaction or nuclear force that keeps the nucleus intact, and the weak interaction related to many radiative decays. At present, this goal has been partially achieved.

How to Treat with Superstring Theory

The scientific value of string theory cannot be ignored. String theory pursues direct conceptual unity, which not only has an obvious effect but also promotes the rise of other standards of string theory. The concept clarity of string theory is enhanced by eliminating the opposite solutions of relativity and quantum theory, which are the two cornerstones of contemporary physics. From the point of view of being a superior solution to the paradox, string theory can also be established as a scientific hypothesis. String theory can provide a logically self-consistent framework to accommodate gravity and quantum mechanics, that is, string theory can simultaneously derive relativity and quantum theory, all experimental support for relativity and quantum theory, logically also support string theory itself. String theory tries to give a quantitative description of all particles in nature and their interactions, which is the pursuit of harmony and accuracy of the theory, and has made positive progress.

String theory also has some conceptual novelty. Many string theory models predict the existence of non-trapped particles with fractional charge, whose mass almost falls in the Planck energy region, and it is possible to find them in cosmic rays [19]. The conceptual certainty of string theory has also inspired some scientists. There are infinite possibilities in traditional quantum field theory. In contrast, the current string theory is much better. According to a particular algorithm, scientists have reduced the infinite string theory to four or five, or six current string theories. In terms of certainty, this cannot but be said to be major progress.

Of course, string theory has not been fully accepted or even strongly criticized at present, which is caused by other criteria of the theory. The strength of string theory is conceptual but weak in experience, experiment, and application. The novel conclusions predicted by string theory cannot be observed directly and can hardly be verified by experiments. Although in principle we can invent a sufficiently advanced instrument to directly detect small rings of strings, it is extremely difficult to do so in practice. To see the ring structure inside the particle, we must use experiments to detect the energy region below the Planck energy (10^{19}Gev), which is about 100 million times the energy of the current particle accelerator. The construction of such a high-speed accelerator is not only inconceivable in cost but also does not have the necessary time and technical conditions. Some scientists believe that it will take at least 10 light-years to design and build such accelerators. Therefore, it is impossible to test any superstring theory above 10^{7}Gev directly. Logically speaking, the experimental support for relativity and quantum theory is also the support for superstring theory itself, but so far, superstring theory has not added new empirical evidence, so it cannot reflect the progress of experience. Superstring theory cannot be directly verified in an experiment, let alone applied in technology. The understanding of superstring theory relies more on mathematical self-appropriateness, and its 10- or 26-dimensional images are difficult to grasp intuitively and psychologically. String theory cannot bring direct economic benefits, and its investment is quite limited. In today's view, superstring theory is not generally acceptable to most people, but it has some strong local advantages, so it can be pursued [20].

Conclusion

Historically, the reduction of stubborn concepts of ambiguity and contradiction and the reconciliation of inconsistent physical theories are likely to lead to significant progress in theoretical exploration. This is how some advances in physics were made in the 20th century. Special relativity originates from the harmonization of Maxwell's and Newton's mechanics, general relativity originates from the harmonization of special relativity and Newton's gravitational theory, and quantum field theory is the harmonization of non-relativistic quantum mechanics and special relativity.

Quantum theory pursues not only unity but also accuracy. The principle of uncertainty does not mean that quantum theory has no bias for precise. It can accurately predict the probability that a large number of atoms will move in some way, and can calculate the proportion of atoms that will decay into billions of uranium atoms with astonishing accuracy [21].

It shows that the expansion of the conceptual scope of heterogeneity is likely to lead to the expansion of the empirical scope of heterogeneity. Physics without mathematics is vague and mathematics without physics is empty. Scientific success is often the result of the synergistic rise of various scientific criteria. It is dangerous to rely too much on one criterion.

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Conflict of Interest

No conflict of interest.

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