Journal Homepage: -www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI:10.21474/IJAR01/ 9450
DOI URL: http://dx.doi.org/10.21474/IJAR01/9450

RESEARCH ARTICLE

REALISM IN SPACE-TIME THEORY.

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Manuscript Info

Manuscript History
Received: 24 May 2019
Final Accepted: 26 June 2019
Published: July 2019

Abstract

The quantum space is both an important part of quantum mechanics and the core problem in the philosophy of quantum mechanics. Because the quantum objects, such as electron and photon, always moves at the speed close to that of light, it is inevitable to involve the inseparability between space and time and discuss the 4-dimensional space-time. In order to investigate the essence of space-time, we must approach to the realm of physical philosophy and discuss the core problem, i.e. the realism in the space-time theories. In this paper, we, combined the semantic and contextual analysis, analyze the development of realism in the development of quantum space-time theory.

Introduction:-

The study of space-time realism is subject to intertwist between the metaphysics and scientific rationality, which resulting from the speciality of space-time. According to the view of absolute space-time in Newtonian mechanics [1, 2], the space and time are independent with each other and play the roles either of background and the frame of reference in the motions and interactions of matter. Therefore, the space and time, in the realm of classical physics, behave like a container, and their existence is independent of the matter. In the realm of philosophy, the absolute space-time becomes the foundation of space-time substantialism, i.e. absoluteness, reality, and independence. However, the geometry of space-time, describing in Einstein's general relativity [3, 4, 5], transforms from the Euclidean to the non-Euclidean and from the discrete space and time to the space-time reality. Accordingly, the geometry of space-time becomes a dynamical factor combined the changeable characteristics, and the structure of space-time varies with the motion and distribution of matter, according to Mach's concepts, whose philosophical foundation is the relationalism, i.e. relativeness, relation, and indivisibility. We just need to investigate the relation between geometry and structure of space-time and physical world, in the epistemology of space-time. With the development of general relativity, the semantic analysis [6] of space-time pushes us to inquiry the nature of space-time, which plays a methodological importance in the development of space-time realism. Then it moves to the quantum gravity [7, 8], whose theoretical form relates closely to the concepts of general relativity and underlines the function of metaphysics, scientific analysis, and intentionality in the development of space-time reality. Since then both substantialism and relationalism have been eliminated [9, 10] and replaced by structuralism [11]. In the context of quantum gravity based on structuralism, the space-time realism finally realizes the transformation from the inquiry for the nature of space-time to the understanding for space-time reality.

The space-time realism bases on the semantic analysis of space-time, which includes two factors [6]. One is the space-time and its geometrical structure, which are the primary objects and used to define observable entities. The other is the matter field, such as distributions of masses and charges, which characterize the physical process and

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events occurring in the space-time. In this paper, we use the space-time structural realism and space-time contextual realism to discuss the space-time quantization in the context of quantum gravity.

Space-time Realism and Quantum Gravity:-

The quantum gravity was proposed in 1980s [8], which introduces the general relativity into the framework of quantum theory and is the quantization of space-time in essence. The development of quantum gravity was integrated into the thought of space-time ontology, which inevitably has significant influence on the space-time realism. Because of the singularity in general relativity and the semi-classical space-time background in quantum theory, the theory of quantum gravity requires the quantization of space-time and thus involves the investigation for the discrete micro-structures of space-time structure on Planck scale. However, the choice for space-time background highlights the intentionality of physicists, and we need to consider the contextual factors.

In quantum gravity, the geometry language describing the space-time becomes quantized one, instead of the traditional continuous language. According to uncertainty principle, we cannot measure the coordinate of a quantum object with accuracy, even without the consideration of momentum. Because we need to improve the wavelength of measuring photon in order to get more accurate results, which leads to a higher frequency and energy. If the energy of photon reaches an upper limit, the interactions between measuring photon and measured particle will produce new particle. Therefore, the accuracy has an upper limit, and the smaller space than the limit is unobservable in principle. The special quanta correspond to the shortest interval in the space.

The contradiction between the background-dependence of quantum mechanics and the background-independence of general relativity results in different concepts and attitudes about the quantum gravity. Therefore, the process of constructing quantum gravity potentially implies the consideration of space-time ontology, which unifies the disputations between substantialism and relationalism. Anyway, the "space-time" and "matter" are distinguished obviously in the theory of quantum gravity. In order to supply the defects of both attitudes, the quantum gravity met the space-time structuralism [12], which successfully resorts to the background-independence and keeps the space-time realism. According to the space-time structuralism, the local observables are eliminated by the general covariance of general relativity, we should forget the individual matter field and consider the structures described by metrics.

It can be found that the understanding for background-independence of quantum gravity is intuitive, because of the comprehension of support for space-time relationalism. Therefore, the space-time realism in quantum gravity displays regression. However, it was noted that the disputation between substantialism and relationalism, which was confronted with the metaphysical underdetermination, must moves the way to structural realism. Therefore, the space-time realism in the context of quantum gravity shows transcendency.

Space-time Structural Realism:-

The space-time structural realism bases on the high mathematicization of the space-time theory and highlights the continuity of mathematical structure in the development of theory. By noting the reality of geometrical structure of the space-time, the space-time structural realism keeps the physical structure and distinguishes with the mathematical structure. It claims that the existence of space-time is independent of the special physical objects and events to the extent depending on the extent that the geometrical law is subject to and exceeds the corresponding physical events [13]. It admits that the space-time structure, described by mathematics, is independent of the minds and is exemplified by the physical world. Therefore, the space-time structuralism is neither the substantialism, without the admission of space-time points, nor the relationalism, but has a real structure, included in the physical world and manifesting as a well-connected network exemplified by the physical world.

Both objects and mathematical structure belong to the same ontological level and have no any ontological priority to the physical world [14]. Because the properties characterizing the objects just consists in the relations and the relations exists as the relations between objects, there is no meaning to allocate the ontological priority to both objects and relations. The objects and relations relate each other on the ontology and the concept and also keep their individual independency. Accordingly, the space-time should be considered as a well-connected network by the space-time points without any intrinsic properties, which transcends the relations between the points. The structure of space-time is expressed by the 4-dimensional differential manifold and the Lorentzian metric tensor field. All the fundamental relations between the space-time points can be understood as the physical structure in the differential homeomorphism, which are defined by the metric tensor field. Because there is no assumption for the unknown

intrinsic properties of the space-time points, the structural realism keeps the consistency between the metaphysics and epistemology.

However, the space-time structural realism introduces the mathematical structure and thus cannot avoid the ontological problem of mathematical structure and the relational problem of the relations between the related terms included in the structures and the structures characterized by the relations. In addition, the space-time structural realism resorts to the mathematical structure and conceptualize the space-time, aiming to consider the different ontological interpretations as the different metaphysical expressions for the same structure. Such method actually accepts the subjective intention. In order to overcome the methodological deflects of space-time structural realism, we should stand on the overall historical viewpoint and analyze the space-time theory according to the context, aiming to find out the intertwist relations among the mathematical forms, theoretical choices, and the semantics.

Space-time Contextual Realism:-

During the development of space-time realism, the inheritance and development of physical concepts, the formulation system of space-time characteristics, semantic interpretations, and the intentionality play significant roles. The grammatical space of the development of space-time realism determines the extent to which the physicists' concepts give expression to the formulized theoretical system. The formulation system is the unification of university of mathematical method and the semantic conventionality of physical concepts. The grammatical space of space-time realism includes the linguistic space and logical space consisting of the fundamental postulations, theorems, deductions, equations, and symbols, which are the intrinsic and latent conventionalities. Without these conventionalities, the space-time theory has no scientific significance.

Because the theory of quantum gravity is out of the experimental range, the dependence on mathematics is stronger than any other theories. It is very difficult to find out the existing quantum geometry to describe the properties of quantum space-time, and we have to construct new branches of physics and mathematics bit by bit to explain the geometrical its properties. According to quantum gravity, the wave function of gravitation or the quantum state, as the functional of gauge field, is independent of the given coordinates and the geometrical structure of space-time background, which transforms the geometrical dynamics to the connection dynamics and constitute the foundation of the space-time geometry. Therefore, the space-time metric and gravitational field are physical entities, and the theory of gravitation is the theory of space-time metrics. In order to avoid the contradiction between substantialism and relationalism, it need to the background-independent space-time theory. Therefore, the fundamental variable in the theory should just be the points or loops, and the space-time is the product of the relations between these points or loops. The whole structure of the space-time is dynamical and structures indicating these relations.

The study for space-time aims to understand the space-time structure, i.e. the geometrical structure, which leads to the proposal of space-time structural realism. However, the space-time structural realism admits the semantic realism of the space-time theory and neglects the influence of intentionality. Accordingly, we have to consider the contextual characteristics and its influence on the theory, which is the space-time contextual realism. According to the space-time contextual realism, the ontology and intentionality of physical context results in that any theory cannot give the world to absolutely objective descriptions, because of the interference of both intuition and supposition. However, in the contextual realism, the space-time becomes the contextual object. Consequently, the mathematical structure, the metaphysical interpretations, and the choice of interpretations become the elements in the context of space-time physics resulting from the metaphysical presupposition, which display continuity and inclusiveness during the dynamical development of recontextualization. The intentionality is the mental reality and shows semantic properties. Bothe the mathematical structure and semantic interpretations are put in the historical rocess, and both the mathematical continuity and mental intentionality are objective existences and are highlighted.

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