Physics & Philosophy

The Fourth Conference
Time, Space and Space-Time

Split, 6–7 July 2015

Organizing and Program Committee

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2015

Program

The time schedule will be flexible and it will be adapted the length of the discussions.

Monday (July 6 2015)		
8:45–9:15		Opening
9:15–10:45	Jean-Marc Lévy-Leblond	From relativity to chronogeometry. The twin paradox (re)^{n}visited and (finally?) tamed
10:45–11:15		Coffee break
11:15–12:00	Tomislav Živković	How experimentally to detect quantum transformations in space and time
12:00–12:30	Zvonimir Šikić	There is only one speed
12:30–13:00		Coffee break
13:00–13:30	Dragan Poljak and Mirko Jakić	Nature of time asymmetry in modelling of physical systems
13:30–14:00	Tonći Kokić	Presocratic concept of time
14:00–16:00…		Lunch
16:00–16:45	Aurelien Perera	Should simulation — as a computer experiment — guide theory or the opposite? A liquid state physicist point of view
16:45–17:30	Jadran Vrabec	Simulation, theory and experiment in thermodynamics from an engineer's point of view
17:30–18:00	Tomaž Urbič	What is anomalous in liquids and is there liquid-liquid phase transition?
18:00–18:30		Coffee break
18:30–19:15	*Physics and Philosophy*: book presentation.	Presenters: Filip Grgić, Dragan Poljak

Tuesday (July 7 2015)		
9:00–9:45	Scott Walter	Radio telemetry and the birth of spacetime conventionalism
9:45–10:30	Nevenko Bilić	Space and time in modern cosmology
10:30–11:00		Coffee break
11:00–11:45	Marko Uršič	The enigma of the existence of time
11:45–12:15	Dubravko Horvat, Zoran Narančić and Saša Ilijić	Wormhole geometries and exotic matter
12:15–12:45	Ivana Skuhala Karasman and Filip Grgć	Time of death
12:45–13:00		Coffee break
13:00–13:30	Vasil Penchev	Beyond and across space: entanglement
13:30–14:00	Luka Boršić	The concepts of time and space just before the emergence of modern science
14:00–16:00...		Lunch
16:00–16:30	Kristina Šekrst	The cosmological theory of inflation: problems, possible answers, and computational complexities
16:30–17:00	Domagoj Kuić	What is probability and what is then statistical mechanics?
17:00–17:30	Peter Lukan	Time and probability
17:30–17:50	Jadran Beganović	Some remarks on Reichenbach's philosophy of space and time
17:50–18:00	Closing of the conference: Franjo Sokolić and Berislav Žarnić	

Abstracts

Some remarks on Reichenbach's philosophy of space and time

Jadran Beganović

We shall undertake roughly assessment of Reichenbach views of space and time. Reichenbach was highly influenced by Poincaré and Einstein to point out grounds for his philosophical work. His analysis of themes concerning space and time are rather wide and complex therefore we're going to extract two problems that evoked strong reaction in scientific community. First we address the problem of „coordinative definitions" which is a Reichenbach form of correspondence rules. Term used in empiricist philosophy of science to connect non-observable theoretical terms with observable terms. Second we mention the Reichenbach attempt to clarify the notion of time offering theory of anisotrophy of time based on a factual asymmetries in actual order of events. Then we meet some critics of Reichenbach. Finally we indicate some methodological and theoretical values of Reichenbach views.

Space and time in modern cosmology

Nevenko Bilić
Institute Ruđer Bošković, Zagreb

After an introduction to theoretical and observational cosmology a few basic concepts will be discussed. Special attention will be devoted to the concepts of time and space in the context of creation, inflation, and current universe expansion. In that regard some recent ideas will be discussed such the *braneworld* cosmology and its relation to the so called **AdS/CFT** correspondence.

The concepts of time and space just before the emergence of modern science

Luka Boršić
Institute of Philosophy, Zagreb

Francesco Patrizi (1529–1597) was one of the most important pre-modern scientific thinker whose overall criticism and rebuttal of contemporary dominant Aristotelian philosophy prepared the ground for the emergence of modern science. In this respect his ideas about space and time are of a special interest, as he developed them in the section "Pancosmia" of his opus magnum, *Nova de universis philosophia* (1591). The most important and influential point of Patrizi's approach to space is his distinction between physical and mathematical space. Mathematical space presents a sort of a Platonic pure reality, more prior and ontologically higher than physical space; physical space, besides residing in three dimensions, possesses also resistance, which can be understood in a relation to Leibniz's notion of force and Descartes' concept of bodies as geometrically definable (Kristeller). On the other hand, Patrizi's concept of time, which is argued for less systematically than space and contained primarily in the "Panarchia" part of his *Nova de universis philosophia*, is based on the notion that the highest genus, under which time falls, is duration (*manentia*). The implications of this notion of time are far-reaching: e. g. not only that it questions the traditional relationship between time and eternity, but also when applied to physical bodies, duration implies a certain relationship of bodies to the space they occupy.

Wormhole geometries and exotic matter

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Wormholes are exotic solutions of Einstein field equations of General Theory of Relativity. They are tunnel-like space-time structures connecting different universes or separated regions of one universe provided the wormhole throat remains open. The exotic matter for such traversable wormholes is required. Recent science-fiction movie "Interstellar" was made with the active participation of one of the authors of the seminal scientific paper which triggered recent wormhole research. Aspects of physics and science-fiction of wormholes are discussed.

What is probability and what is then statistical mechanics?

DOMAGOJ KUIĆ
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From the point of view of predictive statistical mechanics, with the exception of quantum mechanical probabilities, there is no reason to consider any probability distribution as the only correct distribution. Such a view is in a marked contrast to the interpretation that defines probabilites only in terms of frequencies as the objective property of the observed system. In the frequentist interpretation the probabilities are experimentaly verifiable, and consequently, the foundational problem of statistical mechanics would be to derive them and to justify them in the sense of frequencies. Jaynes presented the opposite view, that if we the choose to represent the degree of our knowledge about the individual system, then there can not be anything physically real in the frequencies of the ensemble of a large number of systems, nor there is any sense in asking which ensemble is the only correct one. What we call different ensembles in reality corresponds to the different degrees of knowledge about the individual system, or about certain physical situation. In the argumentation of this viewpoint, Jaynes referred to the statement by Gibbs, according to which the ensembles are chosen to illustrate the probabilites of events in the real word.

The simplest interpretation of Gibbs formalism follows from the fact that by maximizing the information entropy, which is also known as uncertainty, subject to given constraints, one predicts just the macroscopic behaviour that can happen in the greatest number of ways compatible with those constraints. Without going deeper into the problem of interpretation of probabilites, which is even more pronounced in the case of non-equilibrium states, it is important that the distributions that follow from the application of the principle of maximum information entropy depend only on the available information. If one referres only to predictions, from the same viewpoint one can speak about the objectivity only in the extent in which the incompleteness of information is taken into account. Consistent with this way of thinking, by applying the principle of maximum information entropy, we come to the relevant statistical distributions.

Concepts of time in Presocratics

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The first question of the nature of time remains inaccessible somewhere in deep and shady past of human history. On the West, ancient Greek philosophy in Presocratics period and in the closest previous pre-philosophical thoughts, already offers the possibility of insight in the continuous tradition of investigation of time problem. Based on three selected points: (1) Hesiod consideration on time in *Theogony*; (2) reports about Thales studies in astronomy; and (3) Parmenides theoretical consideration in *On nature*; it is possible to speak about three very different ideas and swift 'development' of time concepts. One interpretation can find three stages in 'development' of time concept in Presocratics, as follows: (1) the mythical concept of Hesiod's time marked by indirect connection with χάος; (2) Thales measurement of astronomical phenomena (κρόνος) marked by practical or technological (τέχνη) purpose; and (3) Parmenides highly theoretical notion of time narrowly links time with being, so it is necessary to speak 'Now being in time' — because being had no beginning in time and will no end in time. When focusing on 'development' of time concepts through these three stages, it is possible to loosely interpret change in meaning of time concepts as a shift from χάος and κρόνος to κόσμος, from irregular world in which it is impossible to orient towards highly defined and regularly ordered world.

The twin paradox (re)^{n}visited and (finally?) tamed

Jean-Marc Lévy-Leblond
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After a brief historical review of the birth and development of the twin paradox in Einsteinian relativity, some of the still current misunderstandings and misinterpretations will be clarified. I will suggest that assessing (and naming) Einsteinian relativity as a chronogeometry offers a way out to many of its pseudoparadoxes, including the twin paradox. Two new scenarios will the be proposed generalizing the standard story and enabling some deeper understanding. First, Aesop's fable "The Hare and the Tortoise" is considered in the light of Einsteinian chronogeometry. It will be shown that the Hare, while arriving later than the Tortoise, may still be the winner of the race — or at least may consider itself to be. Second, the situation is considered where the twin initially left at home decides to catch up his brother during his travel. Can they meet so that they may celebrate a common anniversary and recover the same age?

On relations between the concepts of probability and time

Peter Lukan
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The relation between the concept of probability and time within physics has many faces. The so called arrow of time is usually defined with the help of entropy, the formulation of which includes probability in the microscopic picture. Probability is in this sense implicit to the concept of arrow of time. With the measure-theoretic development of the concept of probability its very definition became linked to time average behavior of particles, which turned the dependence between the two concepts the other way round. Later, quantum mechanics brought an explicit dependence between the two, the calculus of temporal development of probability distributions. I will analyze these different relations in depth from a philosophical standpoint.

Beyond and across space: entanglement

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Einstein, Podolsky, and Rosen (1935) suggested a thought experiment in order to demonstrate that quantum mechanics was ostensibly incomplete. Furthermore, they showed that the mathematical formalism of quantum mechanics had been granted as complete, it would imply some action at a distance beyond and across space, "spooky" in words of Einstein. Since that kind of action contradicted the principle of physics, quantum mechanics should be incomplete in their opinion. Edwin Schrödinger (1935) also pointed out that quantum mechanics implies some special kind of interaction between quantum systems by means of "vershränkten zustände" using his term. John Bell (1964) suggested a real experiment apt to distinguish quantitatively and observably between the classical case without that "spooky action at a distance" and the quantum one involving a special kind of correlation between physical systems, which can exceed the maximally possible limit of correlation in classical physics. The experiments of Aspect, Grangier, and Roger (1981, 1982) as well as all later ones show unambiguously that the forecast quantum correlations are observable phenomena. Thus that "spooky action at a distance" exists and quantum mechanics should be complete. The new phenomenon was called "entanglement" and a separate branch of quantum mechanics, the theory of quantum mechanics, studying that kind of phenomena has appeared and blossomed out since the 90th of the past century. The theory of quantum information showed that the phenomena of entanglement are underlain by the necessary restriction of the concept of space in relation to the coherent states in quantum mechanics. Space is a well-ordered set of points in relation to any observer or reference frame in it while coherent state in quantum mechanics is a whole of those points, which is inseparable and thus unorderable in principle. Both space and coherent state are initial elements of cognition mutually restricting their applicability. However, space refers to our everyday experience while the concept of coherent state or entanglement to scientific cognition in an area inaccessible to our senses. The concept of space should be limited to the relations between physical bodies of commeasurable mass. If a human is granted as an observer in space, the range of masses comparable with that mass (or energy) determines fussily the domain, in which the concept of space is applicable.

The way, in which the concept of space is being diluted gradually to and the beyond the limits of comparability in mass, can be visualized as follows: A de Broglie (1925) wave can be attached to any physical entity according to quantum mechanics. Its period is reciprocal to its mass (or energy). One can interpret this period as the length of the present moment specific to the corresponding physical entity of this mass (energy). If the masses (energies) of the interacting physical entities are commeasurable, they can share approximately a common enough present. If their masses (energies) are incommeasurable, what is the case in quantum mechanics studying the system of a macroscopic device, which measures one or more microscopic quantum systems, and that or those systems, the lengths of their present moments are also incommeasurable: The present of the entity of much bigger mass (energy) can be idealized as a point on the segment representing the length of the present of the entity with much less mass (energy). Furthermore, the present of the measured quantum systems being an approximately common segment will include as the past as the future rather than the present of the device. The past of the device will be represented as all points of the segment, which are before the point of the present of the device, and its future as those after this point.

Consequently, the concept of coherent state in quantum mechanics refers both to the future and past as well as to the present of the investigated system while that of space only to the present, because of which the condition for the present of all discussed entities to be commeasurable is necessary in the latter case. Indeed the future of any entity is unorderable in principle and just this property of it is rigorously represented by the concept of coherent state. However, the past of any entity is always well-ordered as the series of all past moments in time. Therefor the description in quantum mechanics has to provide the invariance both to the unorderable future and to the well-ordered past. In mathematical terms, this means that the so-called well-ordering theorem equivalent to the axiom of choice is necessarily involved. Furthermore, the present always situating and intermediating between the past and the future is just what any choice transforming future into past shares. Space makes possible choice and thus the transformation of future into past. Entanglement transcending space should be defined as temporal interaction involving the future and past of the macroscopic devices displaying quantum correlations. While any classical correlation should refer only to the present of the correlating entities and thus to the space, in which they are and which they share, any quantum correlation transcends the present and space involving the future and past in order to be able to exceed the maximal possible bound of all classical correlations. Furthermore, the entanglement involves the concept of quantum information. It is a generalization of the classical concept of information in relation to the choice among an infinite set of alternatives.

All those studies in quantum mechanics and the theory of quantum information reflect on the philosophy of space and its cognition. Space should be discussed as a "transcendental screen" (a necessary condition of visualization or objectification), on which all phenomena are represented by masses comparable with those of observers granted as human beings. Our sensual experience as well as classical physics observes and studies only phenomena within the framework of space and therefore it cannot transcend it. However, quantum theories can do this allowing of interpreting space newly as the domain of interaction of bodies of commeasurable mass or of physical entities of commeasurable energy and thus as that area of choice, which is able to transform future into past.

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Should simulation—as a computer experiment—guide theory or the opposite? A liquid state physicist point of view

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About a decade ago, computer simulations of complex liquids mixtures, such as water mixed with alcohols for example, posed seemingly formidable problems, that were predicted by many experts to be resolved in the future by the brute force increase of raw computational power. These problems were thought to be posed by the different force field representation of water and various solutes molecules as well as system sizes and length of statistics. It turned out that these problems were posed by a physical manifestation of these complex liquids, namely micro-heterogeneous distribution of species. This type of distribution poses fundamental problems about matter in general, principally about its homogeneity. The organiser of the *Physics and Philosophy*, Franjo Sokolić, and myself, were active actors in the change of paradigms that allowed to solve this problem at the modest level of the physics of liquids. The various steps of this exciting adventure are revisited, in connection to the many key concepts in Statistical Physics.

Nature of Time (A)symmetry in Modeling of Physical Systems

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The paper deals with the concept of the (a)symmetry of time (time arrow) in modeling of realistic physical systems with particular emphasis to electromagnetic phenomena. Contrary to the fact that the Maxwell's equations of electromagnetism are time invariant, (there is no preference regarding the direction of time), the usual solutions of the wave equations derived from Maxwell's equations are related to *the retarded potentials*, thus dropping out the *advanced potentials* as non-physical. The *retarded potentials* represent the electromagnetic waves detected at an observation point once they left the source. The *advanced solutions* are related to the waves arriving at the detector before they leave the source, though mathematically possible, which are never observed in nature. These waves are eliminated through prescribing certain set of boundary and initial condition, respectively. However, one can mathematically construct the time reversal version of electromagnetics which has been successfully applied in some engineering

applications. Time reversal or T-symmetry is related to the symmetry of physical laws under a time reversal transformation: $t \rightarrow -t$. Thus, this paper discusses the notion of time *reversal invariance* of physical theories, the character of such *time reversal operators*, and how physical properties change under time reversal. Finally, a recent disagreement among philosophers of science if classical electromagnetics is *time-reversal invariant* is discussed. Namely, it is stated by some authors that Maxwell's equations are not time reversal invariant and the sign change of the magnetic field is just a mathematical trick to keep the time reversal invariance. This statement is not found to be correct, as there is a clear physical reason for the current density to change the sign under time reversal. As a matter of fact, the time direction reversal causes the charge velocity to change sign, thus requiring the associated current density to change sign too. Finally, a change of sign of the current density causes a sign change in the related magnetic field. Therefore, Maxwell's equations appear to be invariant under time reversal. However, it is important to emphasize that the electromagnetic propagation in a lossy medium is time reversal invariant only if an inverted-loss medium is considered for the reverse times.

Time of death

Ivana Skuhala Karasman[1] & Filip Grgić[2]
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The ancient Epicureans famously proposed several arguments to the effect that death is not an evil for the person who dies. We will consider two of them: Epicurus' argument that neither the living nor the dead can be the recipient of the evil of death since for the former the death is not while the latter is no more, and Lucretius' argument based on the symmetry between our pre-natal and posthumous nonexistence. We will discuss the ways in which these arguments depend on certain metaphysical views on the nature of time. In particular, we will consider whether adopting a four-dimensional framework can provide a satisfactory response to Epicurus' argument, and whether Lucretius' symmetry argument presupposes a different conception of time than the presentist position which is apparently assumed by Epicurus. In addition, we will discuss some psychological considerations related to our attitudes towards the future and the past. Dependence of Epicurean arguments on the nature of time implies that our attitude toward a supposed evil of death depends on our understanding of time. This further implies that our attitudes and psychological states, e.g. fears and desires, depend on our other psychological states, e.g. beliefs. From this (Epicurean) perspective we are supposed to organize our life according to rational principles, i.e. the rational attitude should control upon the irrational one if they are in conflict. This is particularly important in our relationship towards death — rationally we should not be afraid of death whereas irrationally hardly anyone can get rid of this fear. By analyzing our relationship towards the time of death we will try to shed some light on this particular paradox of our lives.

The cosmological theory of inflation

Problems, possible answers, and computational complexities

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The cosmological principle states that at each epoch, the universe is the same at all locations and all directions, besides the local irregularities, i. e. globally the universe is assumed to be homogeneous and isotropic at given time: on a large scale usually greater than 100 Mpc, but it is not on scales up to that limit. In modern cosmology there are three puzzles. The first one is why is the universe so uniform on large scales (the horizon problem), the second one is why is the geometry of the universe almost flat (the flatness problem), and the third one is where do fluctuations in large-scale structure come from, as a source of future stars, galaxies and clusters, along with the monopole problem regarding magnetic monopoles predicted to exist in Big Bang cosmology.

The inflation theory, as the exponential expansion of space, with a less accelerated rate after the period of inflation, tries to give some answers to these puzzles since the early 1980s. It implies a much bigger universe than the observable one: the inflation never ends in the universe, and the central role is given to the concept of false vacuum — a metastable state characterized by higher energy than the rest, negative pressure and strong repulsive gravitational field — which, as a probabilistic process, drives the accelerated cosmic expansion, for the universe undergoes a phase transition from false vacuum to a ground state with a great amount of energy released.

The goal of this talk it to shed some light on the philosophical consequences of this theory: to compare the inflational models with some ancient and modern philosophical ones as possible equivalents or alternatives; to see the possible problems — such as fine tuning and creation problems — which seem to arise; and to observe the notion of causality, all along with the possible computational complexity observations regarding key moments and concepts.

There is only one speed

Zvonimir Šikić
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Minkowski developed the four-dimensional physical space by combining three space coordinates and a time coordinate into a four-dimensional event and hereby: "Space by itself and time by itself are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality." Einstein joked that he no longer understood the special relativity (since the mathematicians took it up) but it is clear that the new geometric perspective was a great advance. It enabled Epstein to conclude that everything moves with the speed of light in this four-dimensional space-time: "The reason you can't go faster than the speed of light is that you can't go slower. *There is only one speed*. Everything, including you, is always moving at the speed of light." We will explain the philosophy of these extraordinary assertions.

What is anomalous in liquids and is there liquid-liquid phase transition?

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The most known anomaly of water is that density of ice is lower than density of liquid. This is why ice in beverage is floating on liquid and beverage is ice cold on top. There are many other water anomalies; number depends on reference state we are choosing. Question remains why should water be treated as anomalous liquid being the most abundant liquid on earth. Why shouldn't we say water is normal and other liquids anormal?

The existence of a liquid-liquid first order phase transition in supercooled water has been one of the most heavily debated questions. The liquid-liquid critical point (LLCP) hypothesis was put forward in 1992 after simulations of the ST2 water model showed a putative phase transition in the supercooled range. Much of the subsequent research was focused on proving or disproving the existence of LLCP and results to this day remain mixed. There is limited experimental evidence to back these claims up because the supposed LLCP is well below the homogenous nucleation temperature of water.

The enigma of the existence of time

Marko Uršič
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Aristotle, at the beginning of his famous analysis of time in *Physics*, discusses the question whether time exists or not, since the past no longer exists, the future does not exist yet, and the present is just like a moving "point" without extension. St. Augustine, following in his *Confessions* the Platonic definition of time as the "moving image of eternity", tries to resolve the enigma of time by conceiving time as *distentio animae*, i.e. as stretching-apart of the soul from the attention of the present to past by memory and to future by anticipation.

Many centuries later, by McTaggart's distinction between temporal A- and B-series of events, the classical dispute between intrinsic vs. extrinsic (or subjective vs. objective) definition of time comes back in conceptual frames of modern analytic philosophy. Einstein's theory of relativity endorses the B-concept of time as "timeless" ordering of events. From the philosophical point of view, the relativistic space-time as a metrical concept follows in its essence Aristotle's definition of time as the number of some motion/change "in respect of the before and after" — however, the relativistic time is paradoxically "timeless", since there is no absolute simultaneity of events, and there are only relative sets of "time-slices" in the 4D "block universe" (or in the universal "timescape"), which is only an abstract concept, since following "the Principle of Relativity", the actual/real absolute reference frame does not exist.

Contemporary discussions in the field of the analytic metaphysics of time generally occur among "eternalists", "possibilists" and "presentists", and they take into account especially the discoveries concerning time in modern physics. However, the old master Aristotle has already known that *somebody* has to count "the number of motion," and that some *hypokeimenon* (substratum) has to exist for the experience of "now". — So the main point of my presentation is the statement that *time and consciousness are essentially connected*, maybe not in physics itself, if we consider it as a set of theoretical models of the natural world, but surely in our phenomenological, conscious experience. We have to "take consciousness earnestly" (as David Chalmers has pointed out), if we want at least to understand the enigma of time.

Simulation, theory and experiment in thermodynamics from an engineer's point of view

Jadran Vrabec
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Thermodynamics is a subject that was founded on experimental observations. One of the most notable early goals was to understand and further develop heat engines that are (still) powering our modern world. These observations have steered theory, where the first (energy conservation) and second law (direction of processes) of thermodynamics were major breakthroughs. In conjunction with these, numerous properties of matter, like enthalpy or entropy, were postulated. This, in turn, triggered systematic experimental investigations of such properties, because they are indispensable for practical applications. The according experiments are being carried out since the inception of thermodynamics until today. Based of Boltzmann's understanding of the connection between molecules and thermodynamic properties, the advent of computing allowed for the development of molecular modelling and simulation as an alternative route, which is neither theory nor experiment. Given that Schrödinger's ab initio approach has substantially strengthened the numerical ansatz, with ever more powerful computers the balance is shifting. In this paper, it is reported on the current interplay of simulation, theory and experiment in engineering thermodynamics.

Radio telemetry and the birth of spacetime conventionalism

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Albert Einstein's notion of light-sphere invariance (1905) became, in the space of six years, a fundamental tenet of his theory of relativity. The notion was challenged by Henri Poincaré, for whom the apparent form of a lightwave depended on frame velocity. Poincaré's view was in turn challenged (implicitly) by Minkowski's theory of spacetime, and also by advances in wireless radio communication technology. These revolutionary innovations in theory and practice led Poincaré in 1909 to revise his earlier view of space and time, and to devise and promote a new philosophy that I call spacetime conventionalism. According to Poincaré's argument (1912), scientists may freely choose between Galilei spacetime and Minkowski spacetime, as this choice is indifferent for observable phenomena.

Space and Time in Quantum Theory

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Quantum space $\tilde{E}_3$ associated with the classical three-dimensional space E_3 is much larger than this classical space. However, under normal conditions all subsystems S_i of some large system S assume to a very good approximation relative to each other classical relations. Therefore, from the point of view of each of those subsystems, all other subsystems have classical appearance. This applies to the case when mutual interactions between those subsystems are velocity independent and when the energies of those subsystems are relatively small. Those are usually the conditions of the systems in our vicinity. In particular, gravitational interactions between celestial bodies are mainly velocity independent. Explicit quantum transformations of macroscopic bodies are hence to be expected in the systems relatively far from our solar system. In particular, since magnetic interactions are velocity dependent, the systems subject to strong magnetic fields could provide evidence for such quantum transformations. An experiment is suggested how those effects could be detected. This experiment is based on a new spectroscopic method which may detect some spectral properties which are not detected by currently standard spectroscopic methods. Therefore this method could be used as a new spectroscopic tool to provide a more detailed information about far celestial bodies.

Notes

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Conference website `http://www.pmfst.unist.hr/~sokolic`

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