Physics & Philosophy

The Fifth Conference

Basic Concepts of Physics

Split, 7–8 July 2016

Organizing and Program Committee

Gabriela Bašić · Luka Boršić · Ljudevit Hanžek · Dragan Poljak
Ivana Skuhala Karasman · **Franjo Sokolić** (chair) · Berislav Žarnić

University of Split, Croatia
Faculty of Science
Faculty of Humanities and Social Sciences
Faculty of Electric Engineering, Mechanical Engineering and Naval Architecture

***

Institute of Philosophy, Zagreb, Croatia

2016

Program

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

Thursday (July 7 2016)		
9:00–9:30		Opening
9:30–11:00	Gérard Berry	The Informatics of Time and Events
11:00–11:30		Coffee break
11:30–12:30	Tomislav Živković	Double Slit Experiment: Through which slit did the particle go?
12:30–13:30	Neven Bilić	Multiverse and Braneworlds Inspired by String Theory
13:30–15:00		Lunch
15:00–15:30	Dragan Poljak and Mirko Jakić	On the Time Domain Solution Methods in Classical Electromagnetics
15:30–16:00	Dubravko Horvat	Time-evolution and Quantum Computing
16:00–16:30	Tomaž Urbič	Philosophical Problems in Statistical Physics
16:30–17:00	Kristina Šekrst	Nothingness
17:00–17:30		Coffee break
17:30–18:00	Peter Lukan	Physical Probability *vs.* Probability in Physics
18:00–18:30	Domagoj Kuić	Probabilities and Statistical Mechanics of Large and Small Systems

Friday (July 8 2016)		
9:00–10:30	Tim Maudlin	Topology and the Structure of Space-Time
10:30–11:15		Coffee break
11:15–12:00	Marc Ch. Dupuis	On the Likelihood of Likeness
12:00–12:45	Ivan Dadić	Causality and Renormalization in Finite-Time-Path Out-of-Equilibrium ϕ^3 QFT
12:45–13:30	Zoran Primorac	The Ontology of Space Geometry Choice in Physical Theories
13:30–15:00		Lunch
15:00–15:30	Jadran Beganović	Reichenbach on Physical Theory
15:30–16:00	Berislav Žarnić	On the Evolution of the Concept of Time
16:00–16:30	Franjo Sokolić	Space, Time, and Space-Time

Abstracts

Reichenbach on Physical Theory

Jadran Beganović

Can we determine empirically only the relations of material objects with one another, or can we have direct empirical access to the structure of the space itself? Those are some of the questions that were invoked by Einstein and Poincaré theories which both had immense impact on tought of Hans Reichenbach. In this lecture we examinate Reichenbach's answers to those questions. Reichenbach's theory lies on the ground of positivistic observable/theoretical terms division, but specialized for problems of space. This scheme is convenient for scrutinize grounds of physical theory, but also for eneral philosophy of science.

The Informatics of Time and Events

Gèrard Berry
Collège de France, Paris

Time has always been a mystery, both in current life and in Physics. It took a very long time to build accurate clocks telling what time it is and making it possible to precisely measure durations, a problem that has been only recently solved by Physics thanks to atomic clocks. This is reflected in our everyday language, which is largely unable to talk precisely about time. The same holds for classical computer programming languages that basically ignore time and keep the handling of external events outside their instruction core. However, correctly handling time- and event-related issues has become crucial in many domains: electronics circuits driven by multiple clocks, network-based distributed systems, cyber-physical systems that embed computers to control physical objects, time-aware data bases, computer music, etc. The talk discusses the recent ways to deal with time and events using specific formalisms and programming languages. We demonstrate that the standard real-number based "time arrow" is too limited and discuss much more elaborate models that generalize the basic notion of time to the repetition of arbitrary and possibly irregular events, deal with actions that look timeless and atomic at one level of observation but timeful at a lower abstraction level, etc. We present the programming formalisms and languages that implement this richer view, and discuss applications in fields as diverse as electronic circuits design, critical software in avionics, and computer music.

Multiverse and braneworlds inspired by string theory

Neven Bilić
Institute Ruđer Bošković, Zagreb

String theory, which has been the main candidate for a fundamental theory of the universe for more than 20 years, is believed to be a unique theory that unifies all the particles and forces in nature – including gravity. But even if the theory is unique, the number of different universes that appear as solutions to its equations is enormous. One interpretation of this unpleasant feature is that we live in one of many worlds comprising the so called *multiverse*. Besides, consistency of string theory requires existence of multidimensional objects — D-branes, which opens a possibility that our universe is a $3+1$ dimensional brane — the so called "braneworld" — moving in a $4+1$ dimensional bulk. Astrophysical and cosmological implications of the string-theory multiverse and braneworlds will be discussed.

Causality and Renormalization in Finite-Time-Path Out-of-Equilibrium ϕ^3 QFT

Ivan Dadić
Institute Ruđer Bošković, Zagreb

We formulate the perturbative renormalization for the out-of-equilibrium $g\phi^3$ quantum field theory in the formalism with the finite time path.[1] We use the retarded/advanced basis of out-of-equilibrium Green functions. We use the dimensional regularization method and find the correspondence of diverging contributions in the Feynman diagrams and their counterparts in R/A basis.

1. The tadpole contributions are only partially eliminated by renormalization condition. But, finite tadpole contributions are vanishing as $t \to \infty$, in a good agreement with the renormalization condition $< 0|\phi|0 >= 0$ of the S-Matrix theory.

2. Renormalized finite part of retarded (advanced) self-energy $\Sigma_{\infty,R(A)}(p_0)$ is not retarded (i.e. not causal), as it is not vanishing when $|p_0| \to \infty$. The same happens in S-matrix theory, where $\Sigma_{\infty,F}(p_0)$ cannot be split into it's retarded and advanced component. The problem is "avoided" by considering self-energy with legs $G_F(p_0)\Sigma_{\infty,F}(p_0)G_F(p_0)$, which can be split to R and A components. The same works in the Glaser-Epstein renormalisation approach. In the finite-time-path approach $G_R * \Sigma_R * G_R$ should be calculated at $D \neq 4$.

3. We find the causality problem to be more severe in S-matrix theory, where the accausal information is possible (i.e. information from future).

[1]This talk is based on work with Prof. Dr. D. Klabucar.

On the Likelihood of Likeness

Marc Ch. Dupuis
SURFnet, Utrecht

From a philosophical point of view the different ways in which different languages can express similar types of meaningful messages is a real challenge as the differences raise the question as to whether speakers and listeners of different languages contemplate the world differently, or even think differently. For example, many if not most languages possess means to indicate time and space and, in particular, action and movement in time and space from the perspective of the main subject, in its semantical and grammatical senses. It is interesting, however, to consider how even within one language family the various descendants of the original protolanguage have developed along different paths to indicate such phenomena. Some language use different grammatical structures to express subtle differences which may even be hard to make in related languages spoken relatively nearby. The presentation will address possible differences of mindset among speakers of different languages, illustrating them using examples of different Germanic and Slavonic languages relating to time and space.

Time-evolution and Quantum Computing

Dubravko Horvat
Faculty of Electrical Engineering and Computing (FER), University of Zagreb

Quantum circuits are one possibility to implement quantum computation. Stemming from the adiabatic theorem in quantum mechanics where a time-changing Hamiltonian will remain in the same energy level over time as long as the evolution time, the adiabatic computing opens another possibility to implement time-dependent quantum computation. In this way time evolution is introduced in a formal way in quantum computation. Here the basic ideas of quantum computation will be given and the mimicking of the time evolution within a quantum ground state will be introduced. Some features of the adiabatic quantum computers will be given and open questions will be posed.

Probabilities and Statistical Mechanics of Large and Small Systems

Domagoj Kuić
Faculty of Science, University of Split

It is known that statistical mechanics reproduces the thermodynamic properties of large systems in equilibrium. Standard examples are thermodynamic potentials derived in statistical mechanics for systems described by microcanonical, canonical or grand canonical ensemble. However, use of these ensembles is generally based on the assumption that the interaction of the system with its environment is weak, and therefore, the correlations existing between the degrees of freedom of the two can be neglected. This effectively means the statistical independence of the system and environment microscopic degrees of freedom. On the other hand, for "very small" systems driven out of thermodynamic equilibrium by external forcing, the assumption of weak interaction between the system and its environment compared to the bare system Hamiltonian is not always justified. By following the approach of [1], which extends the validity of the Crooks fluctuation theorem [2] and the Jarzynski nonequilibrium work relation [3] to the quantum systems strongly coupled with their environments, we explain how that leads to a reformulation of the standard statistical mechanics expressions for thermodynamic quantities like free energy and entropy. This raises also interesting questions about the additivity and extensivity of these quantities.

[1] M. Campisi, P. Talkner, P. Hanggi, *Phys. Rev. Lett.* 102, 210401 (2009)
[2] G.E. Crooks, *Phys. Rev. E* 60, 2721 (1999)
[3] C. Jarzynski, *Phys. Rev. Lett.* 78, 2690 (1997)
[4] D. Kuić, *Eur. Phys. J. B* 89,124 (2016)

Physical Probability vs. Probability in Physics

Peter Lukan
Faculty of Arts, University of Ljubljana

In my presentation I discuss the differences between different concepts of probability used in physics. I first focus is on the difference between classical (combinatorial), frequentist and measure-theoretic concepts of probability. Then I try to define how we can regard probability in the most physical (or physicalist) sense. I proceed to single out conditional probability as one of the central problematic concepts in this regard and discuss its status. This concept is most often used and introduced in so called subjective probability theories. In frequentist probability its role is to denote non-homogenous subpopulations, which is a concept that physical models generally try to avoid. This approach may present part of the problem in interpretations of quantum mechanics. I end with an evaluation of the concept of physical probability and argue for the need for a broader understanding of probability in physics.

Topology and the Structure of Space-Time

Tim Maudlin
Department of Philosophy, New York University

Mathematical representations of physical entities are shaped by the mathematical tools used to create them. Space, time, and space-time have traditionally been represented by topological spaces: sets of points that are knit together, at the most fundamental level, by a structure of open sets that satisfies the axioms of standard topology. Notions such as the connectedness of a space, the boundary of a set, and the continuity of a function are defined by reference to these open sets. Additional geometrical structure (such as metrical or affine structure) can be added to a topological space, but the mathematical representation typically begins with a topological manifold.

I will argue that standard topology is wrong mathematical tool to use for representing the structure of space and time (or space-time). I will present an alternative mathematical tool, the Theory of Linear Structures, whose primitive notion is the line rather than the open set. The Theory of Linear Structures has a wider field of useful application than topology in that it can be used to capture the geometry of discrete spaces as well as continua. It provides alternative, non-equivalent definitions of, e.g., connectedness, boundaries, and the continuity of a function. And it offers a more detailed account of the sub-metrical geometry of a space: every Linear Structure induces a topology on a space, but many different Linear Structures give rise to the same topology.

Using the Theory of Linear Structures rather than standard topology to describe space-time has a powerful ontological payoff: one can show that the basic organizing principle of a Relativistic space-time (but not a classical space-time) is time. Contrary to common belief, Relativity does not *spatialize time*, it rather *temporalizes space*.

On the Time Domain Solution Methods in Classical Electromagnetics

Dragan Poljak[1] **& Mirko Jakić**[2]

[1] *Faculty of Electric Engineering, Mechanical Engineering and Naval Architecture, University of Split*

[2] *Department of Philosophy, Faculty of Humanities and Social Sciences, University of Split*

The paper deals with the time domain techniques used within the framework of the classical field theory for the solution of electromagnetic phenomena. Direct time domain solution methods based on differential and integral equation formulations are considered. Illustrative computational examples are related to transient analysis of grounding systems and penetration of the transient electric field from dipole antennas used in ground penetrating radar (GPR) applications.

A particular emphasis is given to the solutions of the wave equations (derived from Maxwell's equations) represented by particular integrals often referred to as the retarded potentials and the advanced potentials. The retarded potentials are related to the electromagnetic waves detected at an observation point once they are emitted from a source. The advanced solutions, on the other hand represent the waves reaching the detector before they leave the source.

Note that in applied electromagnetics the advanced potentials are always dropped out and regarded as non-physical. Nevertheless, the linear nature of the wave equation in principle allows the advanced solutions to represent radiation phenomena accurately.

On the basis of the fact that convergent waves represented by the advanced potentials, though mathematically possible, are never observed in nature (Water waves in a pond do not converge ejecting a stone…) they are eliminated by prescribing certain set of boundary and initial conditions, or even invoking the principle of causality of natural phenomena. Finally, the problem of a back-reaction force (radiation reaction force, radiation resistance) experienced by an accelerated charge (in the process of losing energy by radiation) is discussed in the paper, as well.

Ontology of Geometry Space Selection in Physical Theories

Zoran Primorac
Faculty of Science and Education, University of Mostar

Relation between geometry of space selection and the space itself or extensiveness is given at the ontological level, i.e. between the space and geometry as a logical-mathematical form which draws its intrinsic value from that relation.

The analysis of area concept in western philosophical tradition implies a dual appearance of the concept of space, namely as an immanent characteristic (of the body, field, etc.) and space as an independent entity. These two concepts are dichotomic, they define two different paradigms which are mutually irreducible. But, the fact is that both concepts will exist in some theories, but for a damage of theoretical coherence or an eclectic approach to physical reality.

The full meaning of the term "space", which gets its geometrical structure through analytical Euclidean geometry, appears with Newton and the concept of space as immanent characteristic gets its philosophical rounding in Descartes' definitions of space. All modern philosophical attitudes or scientific attitudes on physical reality have derived their conceptual formulations from Newton and Descartes' approaches. It is important to point out: both philosophers started with their constructions or explanations of the physical reality and their ontological approaches, as well as their concepts of geometry, heavily depended on their conception of the space. The fact is also that the concept of space or extensiveness appears in physical theories as paradigm both in implicit or explicit form.

Accepting the concept of space as an independent entity, geometry appears as science of that entity structure. Geometrical objects such as point, direction, etc. represent some elements or parts of the space and do not belong to the set of physical objects. They can be approximated from physical objects but not identified.

Then space enables spreading of physical objects, but it does not define them and that is the only difference between the pure spatial extension and the physical extension of material objects. In this case the selection of the geometry of space cannot be the consequence of experimental research. It has to be given in advance, or in such concept the intrinsic geometry of the physical space has to be given in the form of definition. In other words, the examination of the ontological truth of geometry is neither necessary nor possible, because we speak on the priory geometry of the space and not on the geometry of physical or material objects. Ontologically speaking it is the fact that the concept of space and its characteristics as well as its geometry are given in the form of definitions. Such status can bring to certain theoretical problematic situations which were manifested, e. g. in quantum mechanics.

We may also ask the question; if Euclidean geometry is given as the inherent structure of space by definition, as it was done by Newton, is it possible to assign that inherence to any other geometrical system? The answer has to be affirmative, but Euclidean geometry has certain advantages over other systems. We could call them conditionally "generic" and "logic" advantages. The "generic" advantage could be in the fact that there is a generic connection of the Euclidean geometry and the concept of space. The concept of space has its historical genesis and the Euclidean geometry had an important place in that development. On the other side the abstract concept of space as such enabled the Euclidean geometry to leave the level of the phenomenal space. The "logical" advantage of the Euclidian geometry lies in certain mathematical "simplicity" in relation to other geometrical systems.

However when we take the concept of space as an immanent characteristic of physical objects then we put the extensiveness at the level of physical properties. But, in order to make extensiveness experimentally applicable, all other physical conditions, which may change the dimensions of extensive objects, have to be eliminated. Then we hope that the behavior of the "clearly" extensive objects can give us the answer regarding the inherence of geometry and extensiveness.

For that purpose some gauge of extensiveness has to be defined, for example: "solid" bodies which do not change its dimensions under the influence of some other physical factors. The second gauge of extensiveness which is often used in physics is the ray of light, which as a physical object which characteristics mostly correspond to the concept of geometrical direction.

The problem of such concept of extensiveness and the geometry belonging to it is particularity, i.e. determination of a physical entity or a process as the carriers of extensiveness in relation to other qualitatively different physical entities. For example Einstein's General theory of relativity favors the gravity field as the carrier of extensiveness, i.e. it considers extensiveness as the immanent characteristic of the gravity field. Empirically set Riemann's type of geometry is considered as intrinsic to the gravity field, but there arises a question of relation to other physical realities, for example in the case of quantum objects and processes, etc.

Here we have to point out that two concepts of the space have different approach to selection of intrinsic geometry, but they are put at the same level of conceptual formulation, which means that any of them doesn't have any logical advantage in relation to the need of introducing the given definition in physics. As we already said, intrinsic geometry is given by definition in the concept of space as the independent entity, and in the concept of space as an intrinsic characteristic of physical entities we have the possibility of experimental fixing of the intrinsic geometry, but with the help of a gauge of extensiveness which has to be given by definition.

Space, Time, and Space-Time

Franjo Sokolić
Faculty of Science, University of Split

Space, Time and Space-Time Franjo Sokolić, PMF Split There are phrases and questions about space and time which have problematic meaning. For instance:

Do space and time exist?
If they do, in what sense they exist? Do they have a limit?
Are they finite or infinite?

For Greek philosophers, for example Aristotle, Cosmos is finite, and beyond its limits there is nothing, not even empty space. On the other hand, for him, the world is eternal, time is limitless. If we supose the limits of space and time, then we may ask what is beyond those limits.

What would it mean to be beyond space and time; particularly, if existing means to be in space and time?

Modern physics says that the world started by Big Bang at a certain moment, and there is no point to ask what was before. Space is probably finite, but without boundaries, like a sphere.

Does it have sense to speak about empty space?
Is there time if there is no change?
Is there a distinction between mathematical and physical sense of this concepts?
What is the empirical foundation of the concepts of space and time?
Is any experience possible without the a priori concepts of space and time?
Are they the a priori forms of perception?
Does it have sense to speak about without the notions of space and time?
Do they have onthological or merely epistemological sense?
What change brings in all that the theory of relativity and the notion of space-time?

Nothingness

Kristina Šekrst
Croatian Studies, University of Zagreb
Faculty of Humanities and Social Sciences, University of Zagreb

Why is there something rather than nothing? seems like the most fundamental philosophical and physical question. Since proving that there is only nothing would be contradictory since we would be the ones observing it, the problem of explaining why there is not nothing remains, not only as a (meta)physical, but as a mathematical and a computational issue. Absence has been used in logic not only as a negation or as a certain modal concept of an empty world, but as an existential issue as well, where several non-classical logics have tried to raise and solve this issue. Along with the notion of nothing in mathematics and philosophy, the notion of infinity as its conceptual counterpart raised lots of issues as well, which can be seen in cosmological models in which the universe is an endless cycle of universes in collision with other ones, where time and space seem to be infinite.

In physics, and especially in cosmology, the question falls back to the issue of the symmetry of matter and anti-matter, where these should have annihilated each other, and since there was a billionth more matter than anti-matter, something—the 5%-matter universe we live in—was possible. Physical vacuum may not contain any matter, and in that sense it usually counts as "nothing", even though it may contain physical fields. However, if we it were possible to create a spatial region without matter or fields, we would still have quantum fluctuations with a sea of virtual particles that come in and out of existence, and at any given instant the vacuum is full of such virtual pairs which cannot be directly observed but create measurable effects.

The goal is to go through certain quantum tunneling models from total empty geometries—a version of "nothingness", while bearing in mind the fact that quantum particle generation requires pre-existing energy, so a speculation remains whether quantum mechanics could spontaneously create a universe (or multiple ones) from this pre-existing energy. This "nothingness" would still include laws of physics, which should be there even prior to the universe itself, which invokes philosophical issues of their independent reality. Eternal cosmological scenarios do not bother with nothingness and seem like a more elegant solution with great philosophical appeal, and in these the whole universe could pop into existence as well. The most fundamental question, therefore, seems not the question of the notion of somethingness and nothingness, but the question of the independent reality of physical laws, which could give us a strong insight into quantum computing and its possible computational success.

Some Analogies between Quantum Mechanics and Descriptions of Consciousness

Andrej Ule
Faculty of Arts, University of Ljubljana

Cancelled talk.

I present some structural analogies between quantum mechanics and experiential (phenomenal) consciousness. I see the fundamental analogy between them in the fact that both can be described as the fields of potentiality for actualizing some possibilities of physical or mental occurrences. Human experiential consciousness can be thus taken as a quantum-like field of mental potentiality of an individual which under the impact of the individual's attendance constantly "jumps" into its actual experiences. Human experiential consciousness indicates some important quantum-like traits but it does not indicate some real quantum traits. I assume the very taking the individual experiential perspective in humans stays outside the quantum-like system of their experiential potentialities. In humans we have further to consider their knowledge of their individual and generic presence in the world and the realm(s) of generalized meaning/senses ('objective spirit') which give(s) recognizable meaning to actual human experiences. They too remain non-similar to quantum world.

Philosophical Problems in Statistical Physics

Tomaž Urbič
Faculty of Chemistry and Chemical Technology, Chair of Physical Chemistry, University of Ljubljana

Statistical mechanics is one of the crucial fundamental theories of physics. The philosophy of statistical mechanics is a very chaotic discipline — much more so than, for instance, philosophy of quantum mechanics. Among the topics mentioned in the talk are probability and statistical explanation, the basic issues in both equilibrium and non-equilibrium statistical mechanics, the role of cosmology, the reduction of thermodynamics to statistical mechanics, and the alleged foundation of the very notion of time asymmetry in the entropic asymmetry of systems in time.

On the Evolution of the Concept of Time

Berislav Žarnić
Faculty of Humanities and Social Sciences, University of Split

Within a simplified model time can be understood as a temporal relation of "precedence or simultaneity" on the domain of events. A pluralistic theory of time admits existence of at least two temporal relations; monistic theory admits exactly one temporal relation; nihilistic theory denies the existence of temporal relation. Temporal relation can be understood either as connected or not. The four interesting types of time theories can be defined using these conditions:

- strong temporal monism: exactly one connected temporal relation;
- weak temporal monism: exactly one not-connected (i.e., with temporal gaps) temporal relation;
- strong temporal pluralism: at least two connected temporal relations;
- weak temporal pluralism: at least two not-connected temporal relations.

In the history of science firstly the theory of temporal monism has been introduced, by F. Petris and I. Newton. Much later the theory of weak temporal pluralism has been developed by A. Einstein. The research of J. Piaget has revealed the fact that in the intellectual development of human mind the implicit theory of weak temporal monism comes before the implicit theory of strong temporal monism. The comparison between the historical development of explicit time theories and the psychological development of implicit theories shows that there is a structural dissimilarity between the two process. This fact, it will be argued, has important consequences for the philosophy of science education.

Double Slit Experiment
Through which slit did the particle go?

Tomislav Živković
Institute Ruđer Bošković, Zagreb

Double slit experiment demonstrates a paradoxical nature of quantum behavior as interpreted within a classical notion of space: a solid particle going simultaneously through two separate slits. A standard formulation of quantum theory provides an exact mathematical prediction of the resulting interference pattern behind those slits. However, this formulation is ultimately unable to provide a satisfactory interpretation of this effect since in a classical picture no solid particle can be simultaneously situated at two different positions in space. From a point of view of a quantum notion of space this effect is explained in a most natural way. In one reference frame this particle is delocalized and it is going simultaneously through those two separate slits. However, there is another (non-classical) reference frame in which the particle is relatively well localized while those two slits are delocalized and they partially overlap each other. Both reference frames are equivalent and the laws of physics are the same in those reference frames. In one reference frame the particle is delocalized while the slits are localized, while in another reference frame the particle is localized while those two slits are delocalized. The existence of such non-classical reference frames requires a substantial modification of a standard notion of space. The same applies to a standard notion of time.

Notes

Notes

Notes

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