Physics & Philosophy

Split, 8–9 July 2013

Program Committee

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Faculty of Mathematics and Natural Sciences
Faculty of Electric Engineering, Mechanical Engineering and Naval Architecture
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Program

The Second Meeting PHYSICS & PHILOSOPHY takes place at the Faculty of Mathematics and Natural Sciences University of Split, Teslina 12, Split.

	Monday (July 8 2013)	
8:30–9:00		Opening
9:00–10:00	Tim Maudlin	What is it to Interpret Quantum Mechanics Anyway? Part 1
10:00–11:00	Detlef Dürr	What is it to Interpret Quantum Mechanics Anyway? Part 2
11:00–11:15		Coffee break
11:15–12:00	Tomislav Živković	Maxwell's Demon and Quantum
12:00–12:45	Slobodan Bosanac	Unsolved Problems in Quantum Dynamics
12:45–15:00		Lunch break
15:00–15:40	Dubravko Horvat & Zoran Narančić	Quantum Mechanics and Reality
15:40–16:20	Nikola Godinović	Nothingness in Physics and Philosophy
16:20–16:40		Coffee break
16:40–17:20	Luka Boršić	Some Remarks on the Origins of Modern Science
17:20–18:00	Luca Malatesti	Conceivability Arguments for Dualism: the Cartesian Legacy
18:00–19:00	Round table, Pavel Gregorić (moderator)	Physics versus Philosophy

Tuesday (July 9 2013)		
9:00–10:00	Marko Uršič	Multiverse or Universe?
10:00–10:40	Mile Dželalija	Philosophical Challenges in High-energy Physics
10:40–11:20	Dragan Poljak, Franjo Sokolić & Mirko Jakić	On the Physical versus Philosophical View to the Nature of Time
11:20–11:40		Coffee break
11:40–12:20	Lovre Grisogono	Quantum Logic vs. Classical Logic
12:20–13:00	Mate Jagnjić	Time Measurement in Quantum Mechanics
13:00–13:40	Berislav Žarnić	Quantum Logic and the Question of the Empirical Nature of Logic
13:40–14:20	Franjo Sokolić	Space, Time and Space-time: Substantivalism and Relationism
14:20–14:30		Closing
14:30–...		Lunch

Abstracts

What is it to Interpret Quantum Mechanics Anyway? Part 1

Tim Maudlin
New York University

Any testable physical theory must somehow have implications about the outcomes of experiments and observations. In the early 20th century, this gave rise to the idea that at least some of the language of the theory must be connected—as a matter of meaning—to claims about experience or "sense data". But no actual physical theory in history has taken this form. John Bell offered a very different account of how the language of physical theory connects to the language of experimental data by means of the "local beables" postulated by the theory. I will sketch how this connection goes, then describe several archetypical "quantum mechanical" experiments that any acceptable physical theory must account for.

What is it to Interpret Quantum Mechanics Anyway? Part 2

Detlef Dürr
Ludwig-Maximilians-Universität München

I shall explain how the quantum theory Bohmian Mechanics accounts for the archetypical "quantum mechanical" experiments Prof. Maudlin decribes in his talk and I shall address common misconceptions about Bohmian mechanics, which arise from ignoring what the theory actually is.

Maxwell's Demon and Quantum

Tomislav Živković
Institute Ruđer Bošković, Zagreb

Maxwell's demon is a thought experiment created by James Clerk Maxwell in order to show that the second law of thermodynamics has only a statistical certainty. It describes hypothetically how to violate the second Law: a container of gas molecules which are initially at equilibrium, is divided into two parts. Those parts are connected by a door that can be opened and closed by the "demon". He opens the door to allow only the faster than average molecules to flow through this door in one direction, and only the slower than average molecules to flow through this door in the opposite direction. In this way one side of the container becomes gradually hotter and another becomes cooler, thus violating the second Law and decreasing entropy. In classical theory it is shown how Maxwell's demon is unable to perform this task. However, quantum theory opens new hypothetical possibilities to violate the second Law. This requires more subtle analyze of the idea of Maxwell's demon. Can one beat the second Law? In spite of all subtleties of the quantum theory, the answer is "No".

Unsolved Problems in Quantum Dynamics

Slobodan Bosanac
Institute Ruđer Bošković, Zagreb

Both in classical and quantum dynamics there are problems that cannot be solved, or that are not yet solved. For example, in classical relativistic dynamics the two particle problem is not solved. The fact that there are tens of interpretations of quantum mechanics indicates that its formulation is not a solved problem. At the root is that many of these interpretations do not take evidence as the basic criterion to distinguish them. Connection with classical dynamics is evidence and another is why the concept of the photon is necessary to formulate? Most of the difficulties are encountered in relativistic quantum dynamics, and one is the interpretation of the solutions for Klein-Gordon and Dirac equations. Is the connection between spin and magnetic moment of the electron real or accidental? Why harmonic oscillator does not have bound state solutions? These and a number of other problems that need answering shall be briefly described in the talk.

Quantum Mechanics and Reality

Dubravko Horvat & Zoran Narančić
University of Zagreb

A recent paper by M. F. Pusey, J. Barrett, and T. Rudolph with the title "On the reality of the quantum state," *Nature Physics* 8, 475–478 (2012) has produced different reactions within the physics community, from appraisals to serious criticism. Here we present the PBR theorem, give a simple non-mathematical proof and hint on some further developments.

Main references:

Matthew F. Pusey, Jonathan Barrett, and Terry Rudolph, On the reality of the quantum state, *Nature Physics* **8**, 475–478 (2012)

Nicholas Harrigan and Robert W. Spekkens, Einstein, Incompleteness, and the Epistemic View of Quantum States, *Found. Phys.* **40**, 125–157 (2010)

Jon Cartwright, The life of psi, *Physics World* **26**, 26–31 (2013)

Nothingness in Physics and Philosophy

Nikola Godinović
University of Split

Nothingness/void is one of the most intriguing questions, if not the most intriguing one in philosophy and physics too. Already in ancient Greece the existence of vacuum (void) was debated. The teaching of "horror vacui" was advocated by Aristotle, that nature can not contain void since surrounding material will immediately fill it. Void by definition is nothing and according to Plato, nothing cannot rightly be said to exist, it is featureless, it could neither be encountered by the senses. Even Galileo Galilei was in favor of "horror vacui" and restated it in the early 17th century as *resintenza del vacuo*. However, Galileis pupil Evangelsita Torricceli and Blaise Pascal, experimentally showed that vacuum could exist and they were teaching that perfect vacuum in principle could be achieved.

But, according to modern physics, the quantum field theory, the vacuum exists but it is populated by virtual particles, which produce measurable effect on the well known physical process (Lamb shift). The most precise scientific theory (quantum filed theory) allows us to calculate the interaction between real particles and virtual particles (void) with unprecedented precision of one in billion. That is not all, vacuum, empty space/void posses energy, so dark energy seats in vacuum, and it is the dominant component of the Universe, in the amount of 75%. The latest results of LHC experiments (CMS and ATLAS) showed that Higgs boson exists. Experimental detection of the Higgs boson in fact is experimental confirmation of the Higgs field which exist everywhere and even in vacuum. Higgs field is omnipresent and has constant value in every single point of the universe. In our universe, the vacuum "empty" space with no Higgs field would have energy than when the Higgs field is present. Our universe is such that adding a Higgs field to the void and the overall energy is reduced.

Some Remarks on the Origins of Modern Science

Luka Boršić
Institute of Philosophy, Zagreb

The main question is how modern science emerged. The self-perception in the West, the relationship towards its own history and directedness towards its future have undergone an essential change when new cognitive values started forming around new value of science. The new science did not import new — scientific — values in already existing attempts to understand the world and our position in it; more than that it has totally transformed this endeavour, redefining its methods and goals of research. How this colossal and all-encompassing change of paradigm was possible?

Among different reasons of this change, I will be discussing just one aspect of this quintessential event: Renaissance critique of Aristotle and Aristotelianism. Truncation and subsequent rejection of some main Aristotelian topics prepared the ground for thinkers such as Galileo, Bacon and Newton. The most vigorous rejection of Aristotle occurred in the second half of the 16th century and I will be analysing the most prominent anti-Aristotelian of the time: F. Petrić (F. Patrizi). I will contextualize his critique of Aristotle in the line of previous and following thinkers (M. Nizolio and J. Mazzoni), displaying the line of influence. Then I will show on concrete texts how the truncation of Aristotle was performed. I will display Nizolio's critique of demonstrative science, Petrić' critique of substance and Mazzoni's approach to mathematics.

Conceivability arguments for dualism: the Cartesian legacy

Luca Malatesti
University of Rijeka

Contemporary philosophers of mind debate the issue whether or not conscious experiences can have a place within the natural world that is described and explained by physics and the other natural sciences. So, for instance, philosophers discuss the issue whether the specific way in which a blue object is given to us, when we are visually aware of it, can be reduced or explained in terms of the physical properties of the brain and its physical relations to the environment.

Contemporary dualists argue, against contemporary materialists or physicalists, that our conscious experiences involve properties that are ontologically or explanatorily irreducible to the properties that are posited by the natural sciences. Specifically, a family of influential contemporary dualist arguments are based on the intuition that it is conceivable a situation that satisfies a complete physical description of reality and, nonetheless, fail to instantiate any conscious experience. Central in these conceivability arguments for dualism are two assumptions. First, the conceivability of such a situation leads to its metaphysical possibility. Second, this possibility creates problems for physicalism. The first assumption, that bridges conceivability to metaphysical possibility, belongs to a set of interconnected theses that usually is indicated as the Cartesian legacy to contemporary philosophy of mind.

The preliminary aim of this talk is to enucleate the core of the Cartesian legacy as operating in the conceivability arguments mentioned above. To achieve this task, although the aim of this contribution is not exegetical, I will also rely on some recent scholarship that aims at elucidating the relationship between René Descartes and the Cartesian legacy. I will maintain that the core tenets of the Cartesian legacy are two epistemic transparency theses. The first thesis states that we have a transparent epistemic access to the essence of certain properties of conscious experiences. The second thesis is that we have a similar access to the essence of physical properties.

The second aim of the paper is to evaluate the two theses of the Cartesian legacy and their consequences for the debate about the nature of conscious experiences. I will argue that the physicalist who opposes the conceivability arguments might have some resources, coming both from the analytic and the continental philosophical traditions, for rejecting convincingly the first epistemic transparency thesis. However, I will maintain that the second transparency thesis is more problematic. In particular, this problem opens up a challenge both for the dualist who endorses the conceivability arguments and the physicalists that resist them. This is the challenge of specifying the nature of physical properties.

Multiverse or Universe, after all?

On some epistemological issues of the concept of multiverse

Marko Uršič,
University of Ljubljana

In this paper the concept of multiverse is philosophically discussed, starting from two points: 1. the controversy between metaphysical "modal realism" (David Lewis) and "actualism" (Saul Kripke); 2. the four-level hierarchy of multiverses, proposed by the cosmologist Max Tegmark (2003). Here we take into account especially Tegmarks "Level-III", i.e. quantum multiverse(s), and "Level-IV", the "complete mathematical democracy", his putative universal isomorphism between mathematical and physical structures.

In the first main part of this paper, a typical example of Tegmarks Level-III multiverses is analyzed from the philosophical point of view: David Deutschs quantum multiverse as "the fabric of reality" (1997). Deutschs principal argument for the reality of quantum "parallel universes" is the existence of "shadow particles", which he proposed in order to explain quantum interference phenomena in slit-experiments. But parallel universes entail heavy questions concerning identity: personal identity (doppelgngers) and identity of objects, of entities in general. It is interesting to note that in Deutschs updated version of his quantum multiverse (2011), the *meta*-physical background is rather shifted from "shadow particles" in parallel universes to "multiversal object(s)" in the unique multiverse which has its "measure" in the laws of quantum mechanics. However, in this updated picture and in spite of the key role of quantum decoherence, *other* universes of this still quite "baroque" multiverse *remain* "out there" (*where* indeed?)—and so the (un)famous problem of Schrödingers cat remains open as well.

The second, shorter part of this paper considers the assumption that multiverses (as sets of universes) might contain *infinite*—or even *transfinite*—number of their elements. This conjecture implies similar troubles as the "naïve" theory of sets: *paradoxes of infinity and self-reference*. In the conclusion, Cantors view of "the Absolute" is outlined, and it is compared with Immanuel Kants critique of infinite "totalities"

which are just "ideas", because they "transcend all possible experience". From the point of modern cosmology, Kants critique has to be applied to the "highest" *Multiverse*, i.e. to the set of all universes and/or multiverses, which can be considered as the (new, updated) *Universe*, after all.

Main references:

Cantor, Georg (1984). *Über unendliche, lineare Punktmannigfaltigkeiten. Arbeiten zur Mengenlehre aus den Jahren 18721884*. Leipzig: BSB B. G. Teubner Verlagsgesellschaft.

Deutsch, David (1997). *The Fabric of Reality*. London: Penguin Books.

Deutsch, David (2011). *The Beginning of Infinity. Explanations that Transform the World*. New York: Viking, Penguin Books.

Kant, Immanuel (2007). *Critique of Pure Reason*, translated and edited by Paul Guyer & Allen W. Wood. Cambridge: Cambridge University Press (13th printing).

Lewis, David (1986). *On the Plurality of Worlds*. Oxford: Basil Blackwell.

Penrose, Roger (2005). *The Road to Reality. A Complete Guide to the Laws of the Universe*. New York: Vintage Books. Tegmark, Max (2003). "The multiverse hierarchy", reprinted in: *Universe or Multiverse?* (2007), ed. Bernard Carr, pp. 99–125. Cambridge: Cambridge University Press.

Uršič, Marko & Markič, Olga & Ule, Andrej (2012). *Mind in Nature. From Science to Philosophy*. New York: Nova Science Publishers, Inc.

Philosophical Challenges in High-energy Physics

Mile Dželalija
University of Split

Modern research in the high-energy physics includes complex, costly and lengthy theoretical and experimental preparation of models and theories, experiments, analysis of data collected and agreed concepts to confirm the potential discovery of new knowledge. At the present time, this includes collaboration hundred of research institutions around the world and tens of thousands of scientists working on the same topic. A special philosophical basis of such research has been developed, which continues to create an impact on the philosophy of research in other areas of science. Special features of the philosophy of high-energy physics come from the view to the reality of gauge symmetry and its spontaneous breaking; from the view to the reality of the existence of quarks; from the philosophical way of confirming the various steps of creating experimental raw data in which theoretical concepts potentially burdening experimental steps, and vice versa; from the criteria for the development of new theories; from the concept of naturalness of systems investigated, and more. Modern research in high-energy physics and the history of physics create a good basis for the development of more precise philosophical concepts.

On the Physical versus Philosophical View to the Nature of Time

Dragan Poljak, Franjo Sokolić & Mirko Jakić
University of Split

Heat transfer never occurs from an object at lower temperature to an object at higher temperature provided that the external energy sources are absent. Thus, broken eggs do not reassemble spontaneously, coffee does not get hotter and people do not get younger. In other words, there is a general tendency for any closed system to become more dissipated, less and less ordered and consequently less and less able to do useful work. A measure of this disorder is called *entropy* and the 2nd law of thermodynamics states that the entropy of a closed system either increases or remains constant. Nevertheless, all mentioned processes are not strictly forbidden by principles of particle motion mechanics. Instead, they are rather highly improbable phenomena and are not likely to be observed in the age of universe. As these phenomena are in principle possible the second law of thermodynamics is not deterministic law, but rather statistical in nature.

The asymmetry of time, or the famous arrow of time, is then determined by the direction of increasing disorder. The processes occurring in the direction from lower disorder to higher disorder mean that the processes are always directed from lower probable to higher probable events, respectively. In 1927 Arthur Eddington proposed a term arrows of time for the classes of phenomena which characterize direction in time. Among the most important time arrows are: arrow of radiation (diverging and not converging waves are observed in nature), thermodynamics arrow (entropy never decreases), evolution arrow (dynamical self-organization of matter, cosmological arrow (due to expanding universe), quantum arrow (wave function collapses but never uncollapses), etc.

For example, the Maxwells equations of electromagnetism are time invariant, i.e. there is no preference regarding the time direction. Nevertheless, the usual solutions of Maxwells equations, the ones considered as physical are related to so called *retarded* pertaining to the electromagnetic waves detected at an observation point after they left the source. In other words the time these waves reached a receiver is delayed with respect to the time measured at the source. On the other hand, advanced solutions related to the waves that would propagate in a way to arrive at the detector before they leave the source are mathematically also possible. However, due to the fact that they are never observed in nature, they are eliminated by specifying certain set of boundary and initial condition, respectively. Thus, the time asymmetry is injected into the solutions of the equation of physics representing the laws of nature through the initial and boundary conditions, respectively. Moreover, one concludes that the physical laws themselves expressing mathematically in terms of differential equations, are not sufficient to describe the natural phenomena. What is required is to include the initial conditions, as well.

As a matter of fact, it could be shown that all time arrows could be reduced to thermodynamic arrow which is stated to be the master one, the fundamental arrow. The question of low entropy initial condition in the beginning of the universe still remains to be resolved. One of the widely used concepts in the philosophy, or it can be posed, metaphysics of time deals with McTaggart and his famous *A-theory of time*, or *A-series*, and *B-theory of time*, or *B-series*. According to the Mc Taggart *A-theory* the passage of time is compatible with our experience and time flow is considered to be real, i.e. within this scheme there is a flowing now constantly shifting the border between *Past* and *Future*. On the contrary, in the *B-Theory* of time only *temporal relations*, such as *earlier than* and *later than* without a *moving now* exist. It is worth noting that *A-series* implies *change* while *B-series* does not. From the theoretical physics point of view both *classical* (Newton) and *relativistic* (Einstein) concept of time is related to the B-theory of time.

Furthermore, referring to the Gödel cosmological proposal whose work on Einstein theory of relativity allows the existence of closed time-like curves (time loops), i.e. time travel to the past, as physical possibility, the very concept of linear ordering of time is seriously attacked. One can also discuss the four-dimensional essentially static space-time picture of time in relativistic sense (block universe) which means that objective world simply is and actually does not happen. Philosophically, it could be regarded as a version of *eternalism* where all times; past, present and future do exist, but in a tensless sense.

Quantum Logic vs. Classical Logic

LOVRE GRISOGONO
University of Zagreb

To be able to compare classical logic and quantum logic, the first step would be to define what kind of logic is classical logic. Without going into too many details, the most important properties of classical logic for this topic are: binarity, commutativity, distributivity, principle of excluded middle, principle of non-contradiction. The second step would be an explanation of different meanings of 'quantum logic'. There is not only one quantum logic, but there are different approaches to the idea of a logic which is appropriate to quantum mechanics. In this presentation two approaches to quantum logic will be examined. The first approach is the algebraic Birkhoff-von Neumann quantum logic, while the second is the Fuzzy quantum logic which also has some different types. In this presentation, a major accent shall be set on comparing classical and fuzzy logic on the basis of above presented properties of classical logic.

Arrival time measurement in quantum mechanics

Detlef Dürr[1], **Mate Jagnjić**[2] & **Nicola Vona**[1]
[1] *Ludwig-Maximilians-Universität München*, [2] *University of Split*

Time in quantum mechanics is subject of debate since the early days of the theory; see for example [1]. Usually, arrival time measurements are described by a semi-classical approximation, where one takes the formula $t = x/v$ and uses for x simply the distance between the source and the detector. In this way, the arrival time distribution is derived from the velocity distribution. Although very effective, this is of course just an approximation, and it is still unclear what should be the correct distribution. One possibility is suggested by Bohmian mechanics, and is based on the probability current [2, 3]. We propose an experiment to show the limit of the semi-classical approach. The difference between these two time distributions is already visible for the superposition of two free Gaussian wave packets in one dimension. We are also considering the case of the superposition of two wave packets in two dimensions as a candidate for a realistic experiment.

[1] G. Muga, R. S. Mayato, I. Egusquiza, Time in Quantum Mechanics Vol. 1, *Lect. Notes Phys.* **734** (Springer, Berlin Heidelberg), DOI10.1007/978-3-540-73473-4 (2008)

[2] M. Daumer, D. Dürr, S. Goldstein, N. Zanghi, On the Quantum Probability Flux Through Surfaces, *Journal of Statistical Physics* **88**, 967–977 (1997)

[3] C. R. Levans, Time of arrival in quantum and Bohmian mechanics, *Phys. Rev. A* **58**, 840–847 (1998)

Quantum Logic and the Question of the Empirical Nature of Logic

Berislav Žarnić
University of Split

Quantum theory presents numerous challenges to philosophy. Instead of physics being asked by philosophy, e.g. about the reference of its terms, the interrogation changes direction: it is philosophy and not physics that ought to reflect on the logico-ontological foundations of quantum mechanics. A "case study" of Wittgenstein's *Tractatus* shows how radical the revisions might be after the reflection. According to the *Tractatus* postulates: atomic states of affairs are mutually independent, molecular states of affairs emerge only from "conjunctive composition" of atomic ones, and it is not impossible to obtain a complete description of reality. Neither of those postulates is consistent with quantum theory: observable atomic states of affairs are not mutually independent due to the uncertainty principle, unobservable or theoretically postulated molecular states of affairs can emerge also from "disjunctive composition" that corresponds to the quantum-theoretical superposition of states, consequently a complete description of the reality is not possible since it will either be indeterminate if it is observable or indefinite if unobservable. The revision affects logic which seems to be forced to distinguish between quantum-logic connectives used in describing unobservable from those used in describing observable reality. Taking the type of disjunctive connective as an example, its quantum-logic definition does not make the classical one expendable (Maudlin). Rather, as recent dynamic turn in quantum logic (Baltag, Smets) shows, both types of logic ought to be reconciled within a common framework: quantum logic as the one that is sensitive to the empirical considerations of physical theory, and "classical" as the one imposed by the structure of language.

Space, Time and Space-time: Substantivalism and Relationism

Franjo Sokolić
University of Split

Space and time, do they really exist or do they represent only some relations between material bodies? These are the questions appearing in the famous Clarke Leibniz correspondence, where Clark represented Newtons positions. Although this dispute had its revival with Mach and Einstein, and again in the end of the XX century, it does not have a definitive answer. Is it a physical or philosophical problem?

Epilogue

Why $\langle\Phi|\&|\Phi\rangle$?

This Meeting is organized with the aim to develop the dialogue between natural sciences and philosophy. Unfortunately, there is generally a lack of contacts in this sense, and in our country particularly. This has negative consequences on the general attitude of both, natural scientists and philosophers. They do not see what would be the benefit of their acquaintance with the other discipline. Scientists and the students of science perceive philosophy as of no bearing on their own work and interests. On the other side, philosophers and those interested in philosophy perceive natural science as too technical, and of no importance for their general worldview. This is in contradiction with a long tradition in which sciences emanated from philosophy. The effort of specialisation in this reductionist paradigm has as a side product the loss of the global view.

There is an immense progress in science in the last century, which was not followed by an adequate development in philosophy. Some modern philosophers developed even an antiscientific attitude, which is quite common among philosophy students. This situation may be changed by proposing curricula which combines humanistic and scientific subjects. Probably the educational system in USA is the one which goes further in that sense than those in Europe.

After a century of self-confidence in physical science it is the moment when its critical analysis is needed, and the judgement of its achievements and drawbacks. This is particularly true for its most outstanding theory, quantum mechanics, to which is principally dedicated this Meeting.

Philosophical thinking emanated from an effort to understand the world and the position of the man in that world. It was grounded on the belief that humans are able, by their rationality to capture the essence of it. The following step was based on the conviction that only by observing the world and experimenting on it, we may understand its functioning. This approach was the basis of the modern science. It was founded on the idea of causality. The singular event in that development is the appearance of the quantum theory. Although existing for already more than hundred years it is still to find its right place in the human adventure of understanding the world. The whole construction of the classical science, based on causality, has fallen apart under the attack of the quantum theory. Most of the physicists agree with the statement that they do not understand the quantum world, and that the intellectual adventure is far from being finished. On the other hand, the interest of philosophers for it was quite limited, probably due to the intrinsic difficulties of the whole field. One of the principal obstacles was its high degree of mathematisation. Mathematics is playing the principal role in physics and it may be said that it is the only language in which the quantum theory may be correctly expressed, because any expression in an ordinary language is not more than a metaphor.

Could a common effort of physicists and philosophers help to do some progress in this domain?

—Franjo Sokolić