Two Days Workshop: Philosophical Perspectives on Understanding Quantum Mechanics

8-9 October, 2009, CLEA, Vrije Universiteit Brussels, Brussels

Pleinlaan 2 · B-1050 Brussel

PROGRAM

Thursday 8 October from 16.00 to 19.00 in the Promotiezaal D.2.01

16.00 – 17.00 **The SCOP-formalism: an operational approach to quantum mechanics**
Bart D'Hooghe
Center Leo Apostel (CLEA) and Foundations of the Exact Sciences (FUND)
Vrije Universiteit Brussel

17.00 – 18.00 **Quantum Mechanics, Contextuality and Correlations as Actual Elements of Physical Reality**
Christian de Ronde
Center Leo Apostel (CLEA) and Foundations of the Exact Sciences (FUND)
Vrije Universiteit Brussel

18.00 – 19.00 **The whisper and the rage. An essay in humanism**
Wim Christiaens
Center Leo Apostel

Friday 9 October from 13.00 to 19.00 in the lokaal E.0.06 and D.0

13.00 – 14.00 **Who understands the turtle that stands under the quantum world?**
Sven Aerts
Center Leo Apostel (CLEA) and Foundations of the Exact Sciences (FUND)
Vrije Universiteit Brussel

14.00 – 15.00 **Analyzing passion at a distance: progress in experimental metaphysics?**
Michiel Seevinck
Center for History and Foundations of Science, Utrecht University

15.00 – 16.00 **Reverse Epistemology and Quantum Measurement: an Outline of the Approach**
Karin Verelst
Center Leo Apostel (CLEA) and Foundations of the Exact Sciences (FUND)
Vrije Universiteit Brussel

16.00 – 17.00 Coffee break

17.00 – 18.00 **Reflective Metaphysics : Understanding Quantum Mechanics from a Kantian Standpoint**
Michel Bitbol
Centre de Recherche en Épistémologie Appliquée
CNRS/Ecole Polytechnique, Paris, France

18.00 – 19.00 **The world according to quantum mechanics: a matter of perspective**
Dennis Dieks
Center for History and Foundations of Science, Utrecht University

Organized by: Christian de Ronde, Sven Aerts and Diederik Aerts
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Abstracts

Who understands the turtle that stands under the quantum world?

Sven Aerts

Center Leo Apostel (CLEA) and Foundations of the Exact Sciences (FUND)
Vrije Universiteit Brussel

If a theory claims verifiable prediction of a very large variety of phenomena, the question of its relationship to the world becomes notoriously difficult to ignore. We hope to increase our understanding of the universe by having a better understanding of the theory. Such is the case with quantum theory and yet it is often said we don't understand quantum theory. After almost a century of intense debate and research we still find it difficult to agree upon an acceptable ontology that is consistent with quantum theory. We do seem to agree however on how to apply the theory and famous physicists like Fermi and Feynman argue one should stop wondering why quantum mechanics is the way it is. It seems however beyond dispute that research into the foundations of quantum theory has provided us with a better understanding, if not of acceptable solutions, then at least of the types of problems we encounter. Much of the debate on the interpretation of quantum theory seems centred around two main problems. The first is the so-called measurement problem. We will argue that understanding the measurement problem is not so much a matter of exploring the consequences of the measurement problem for our worldview, but rather that the consistency and completeness of the theory are at stake. We argue that any theory that includes in its description the process of observation of the very values that are observed, is liable to some form of measurement problem. The question then shifts from “why do outcomes in a quantum universe behave as classical quantities” to: “is it necessary to include the process of observation in the description of quantum phenomena?” This directly leads us to the second main obstacle in our attempt to understand quantum theory: contextuality. Contextuality in particular seems to stand in the way for a direct interpretation of the correspondence between the theory and the world. The inclusion of an active process of observation limits the set of experimental setups and hence of the possible actualizations of reality. In performing an experiment, we get to decide among which options nature has to choose. And in doing so we deny forever not only the knowledge of the values of the observables we didn't care to measure, but even the mere possibility of attributing values to them in a unique way. We will give a completely transparent but surprisingly persistent example of contextuality in visual perception and explore in what respect it can serve as a metaphor for its quantum analogue.

Reflective Metaphysics : Understanding Quantum Mechanics from a Kantian Standpoint

Michel Bitbol

Centre de Recherche en Épistémologie Appliquée,
CNRS/Ecole Polytechnique, Paris, France

Instead of either formulating new metaphysical images (as realists would do) or rejecting any metaphysical attempt (as empiricists would do), the case of quantum mechanics might well require from us a complete redefinition of the nature and task of metaphysics. The sought redefinition can be performed in the spirit of Kant, according to whom metaphysics is the disciplin of the boundaries of human knowledge. This can be called a "reflective" conception of metaphysics. In this paper, each one of the most popular "interpretations" of quantum mechanics is shown to be naturally associated with a variety of Kant-like reflective metaphysics. Then, two well-known "paradoxes" of quantum mechanics (the measurement problem and the EPR correlations) are reformulated by way of this reflective attitude, and they are thereby "dissolved". Along with this perspective, quantum mechanics becomes one of the most elegant and understandable theories of the history of physics in addition of being one of the most efficient. The only point that must be clarified is why it looks culturally so difficult to accept a reflective and non-ontological standpoint on physical theories.

The whisper and the rage. An essay in humanism

Wim Christiaens

Center Leo Apostel

The history of Europe is the history of the logos. The relationship with the logos has been one of love and hate, especially for the people closest to it, the philosophers. Most recently, a number of them, *irrationalists* like Heidegger, Deleuze, Derrida..., tried to substract themselves from the logos: the logos trying to substract itself from the logos, a real acrobatics of thought. More *rationally* inclined collegues reacted by locking themselves within the formalism of their reasoning.

Both options are privileges of "the beautiful soul": they are not rooted in a situation of hardship and need. Which is why we will call both irrationalism (or post-modernism) and rationalism (or analytical philosophy) *irrational rationalisms*.

A number of socio-ideological and socio-economical crises like 1973, 1989, 2009 ... (not to mention the European civil war of 1914-1945) are undermining the material basis for these privileges. Today we see that for the first time since around 1900, as Europeans we are more and more required to think from within a situation of real need and hardship again.

To lift the veil, to find a project, a goal, a praxis, we will have to bite the bullet: we will need a proper understanding of the logos. Praxis requires rationality. Rationality cannot found itself: there is no rational foundation for rationality (here post-modernism and analytical philosophy of science agree). Nevertheless praxis requires rationality. Let us then provide an irrational foundation for rationality. This we call *rational rationality* or *humanism.*

In my presentation I will develop some of the concepts required to let rationality rise from the irrational. Two such concepts are the whisper and the rage.

The world according to quantum mechanics: a matter of perspective

Dennis Dieks

Center for History and Foundations of Science
Utrecht University

One of the main areas of the present-day philosophy of physics is concerned with what might be called “scientific metaphysics”: the attempt to come up with a coherent picture of what the world could be like, given the results of modern scientific theories. Quantum mechanics is notorious for the difficulties it presents for this project. In this talk we shall argue that part of these difficulties derives from the fact that the world picture suggested by quantum mechanics is very different from what we are used to in classical physics. Indeed, there are good reasons to believe that quantum theory is trying to tell us that descriptions of the world should be fundamentally *perspectival*. That is, the properties of physical systems should always be defined with respect to a “point of view”. This perspectivalism should be understood, however, in an objective way, without the introduction of subjective elements. Pursuing this idea leads to a new notion of objectivity, according to which properties are basically relational.

The SCOP-formalism: an operational approach to quantum mechanics

Bart D’Hooghe

Center Leo Apostel (CLEA) and Foundations of the Exact Sciences (FUND)
Vrije Universiteit Brussel

We present the SCOP-formalism, an operational approach to quantum mechanics in which a physical entity is defined by the structure of its set of states, set of properties and the (measurement) contexts which can be applied to this entity. If the corresponding State-COntext-Property-System (SCOP) satisfies a specific set of ‘quantum axioms’, it fits in a quantum mechanical representation in Hilbert space. We present a model in which the maximal change of state of the system due to interaction with the measurement context is controlled by a parameter N, representing the number of possible outcomes. In the case N=2 the system reduces to a model for the spin measurements on a quantum spin-1/2 particle. In the limit $N \rightarrow \infty$ the system is classical. Surprisingly, for the intermediate cases it is impossible to define an orthocomplementation on the set of properties. Another interesting feature is that the probability of a state transition also depends on the context which induces it. This contrasts sharply with standard quantum mechanics, where Gleason's theorem states the uniqueness of the state transition probability and independent of measurement context. We show that if the state transition probabilities satisfy a Gleason-like condition, i.e. transition probability is independent of which measurement context induces the change of state, then the lattice of properties is orthocomplemented.

Analyzing passion at a distance: progress in experimental metaphysics?

Michiel Seevinck

Center for History and Foundations of Science
Utrecht University

Violations of the well-known Clauser-Horne-Shimony-Holt (CHSH) inequality have been frequently analyzed in terms of the well-known conditions of Parameter Independence (PI) and Outcome Independence (OI), introduced by Jarrett and Shimony in the mid-1980ties. These

conditions jointly imply the factorisability (Bell's local causality) needed to derive this inequality. In the doctrine of Experimental Metaphysics it is violation of the latter condition (i.e. OI) that is supposed to be responsible for the violation of the CHSH inequality, and it has been extensively argued by many philosophers of this school that this is not an instance of action at a distance but of some innocent 'passion at a distance': one passively comes to know the faraway outcome, but one cannot actively change it. It is therefore concluded that there is peaceful coexistence of quantum non-locality and special relativity. This reasoning has been criticized by many, but it will be here criticized differently by arguing that the very starting point of this debate is flawed.

Upon closer scrutiny, both PI and OI are in fact conditions about obtaining the *local* outcome and do not address the possibility of 'coming to know' the *non-local* outcomes or settings. More technically, the conditions are not about an increase in non-local predictability because of the availability of non-local information. Therefore, they do not deal with passion at a distance at all, and in fact, there has not been a satisfactory analysis of it anywhere. Such an analysis will be given here.

It will be shown, based on the work of Pawlowski et al. (arXiv:0903.5042), that within the framework of non-local realistic theories, where it is assumed that the settings can be freely chosen, it is impossible to model a violation of the CHSH inequality without having information in one laboratory about *both* the setting and the outcome at the distant one. Thus, the passion at a distance (the increase in non-local predictability) displayed by models that violate the CHSH inequality is necessarily about *both* the non-local settings and the outcomes, despite the fact that it is *not* necessary that the models are both setting dependent (not PI) and outcome dependent (not OI) in the Jarrett/Shimony sense.

I will argue that this finally allows for progress in the field after some 20+ years of fruitless Experimental Metaphysics. For the non-philosophically inclined, it can be noted that these results are also relevant for quantifying the classical resources needed to simulate quantum communication and computation protocols.

Quantum Mechanics, Contextuality and Correlations as Elements of Physical Reality

Christian de Ronde

Center Leo Apostel (CLEA) and Foundations of the Exact Sciences (FUND)
Vrije Universiteit Brussel

Several years ago David Mermin presented what he called the Ithaca interpretation of quantum mechanics (IIQM) which focuses on the possible development of a relational account of physical reality. The IIQM founds its solid ground on the so called SSC theorem which states that subsystem correlations (for any resolution of the system into subsystems) are enough to determine the state of the entire system uniquely. There are however two no go theorems, namely, Cabello’s theorem and Seevinck’s theorem which block the possibility of interpreting correlations as actual elements of (local) physical reality. In this presentation we will address the tension which appears from the mutual co-existence of the SSC theorem on the one hand, and Cabello’s and Seevinck’s theorems on the other. We will show that there is a valuable lesson to be learn in relation to correlations and their meaning in terms of elements of physical reality.

Reverse Epistemology and Quantum Measurement: an Outline of the Approach

Karin Verelst

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