X International Workshop on Quantum Mechanics and Quantum Information:

PHILOSOPHY AND PHENOMENOLOGY OF QUANTUM INTERPRETATIONS

BOOK OF ABSTRACTS

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X International Workshop on Quantum Mechanics and Quantum Information

Philosophy and Phenomenology of Quantum Interpretations

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Abstracts

Meta-metaphysical fictionalism (and quantum mechanics)

Raoni Arroyo* Matteo Morganti†

Metaphysics is traditionally conceived as i) aiming at the truth—indeed, the most fundamental truths about the most general features of reality—and ii) being detached from the empirical domain since it employs an essentially a priori methodology. Naturalism and the corresponding conception of metaphysics of science solve the problem that is allegedly constituted by the latter fact. The scientific realist and the metaphysician of science join forces to seek descriptions of reality as it actually is. However, according to some sceptics about metaphysics, a problem remains with the former feature. As the argument goes, metaphysics lacks testability, so it can only have recourse to non-empirical virtues to break the empirical underdetermination that inevitably affects our hypotheses about reality. Since non-empirical virtues are allegedly not truth-conducive, and since only scientific theories can be (at least partly) assessed in terms of empirical success, this leads directly to eliminativism about metaphysics. Hence the need for the naturalist non-eliminativist about metaphysics to find other ways to characterise the discipline.

In the present talk, we'll unpack the above statements, and suggest a way to revise assumption i) so as to make naturalised metaphysics acceptable. This will lead us to a fictionalist approach to metaphysics that, we will argue, remains perfectly compatible with naturalistic methodology as well as scientific realism.

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Is there any place for spacetime functionalism in the quantum-to-classical transition?

Emilia Margoni*

The broad goal of quantum gravity projects is to formulate a theory of the microscopic structure of spacetime. An increasingly popular perspective is the so-called emergent gravity paradigm, in which low-energy spatiotemporal phenomena, as described by general relativity, are conceived as emerging from an underlying, more fundamental, and arguably different background. In the context of this endeavour, a theory of quantum gravity is expected to encounter different levels of spacetime emergence. Recently, it has been argued that spacetime functionalism is the proper way to deal with the recovery of spacetime. In the present context, I will discuss the usefulness of such a conceptual programme, with a particular focus on the quantum-to-classical transition that a theory of quantum gravity is expected to scrutinise.

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Dubitable and Indubitable Aspects of Quantum Physics

Carl Hoefer*

I have in recent years defended a selective form of scientific realism, "Tautological Scientific Realism" (TSR). The point of TSR is that since the mid-20th century, some basic bits of scientific lore have become literally *indubitable*: there is no way to seriously imagine how they might turn out to be false, unless we contemplate radical skeptical scenarios (brains in vats, the universe as a computer simulation, etc.). Most of *fundamental* physics, however, lies on the still-dubitable side of this dividing line, and this certainly includes the theorertical cores of all quantum theories. But some facts about the microscopic constitution of matter and its coarse-grained behavior is by now entirely indubitable, e.g., the fact that atomic matter is composed mostly of protons, neutrons and electrons, with two of these bearing charge and the third not, the electrons being separable from atomic nuclei in certain circumstances, etc.

TSR has many advantages over earlier forms of SR, but as with all selective SRs, it can be argued that "the devil is in the details". A number of philosophers have pressed me about the details of how to draw the dividing line between the indubitable parts of physics lore and the still-dubitable parts, and what lies on which side. In this talk I will look at the case of *spin*, which is both highly theoretical and far from observable experience, and yet also embedded in a large number of experimental and technological phenomena. Is the existence of *spin* now on the indubitable side? I will make some suggestions concerning the *project* of clarifying where the dividing line lies, using *spin* and *neutrinos* as example cases.

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Why is there no consensus on the foundations of quantum mechanics?

Valia Allori*

Quantum mechanics is regarded by many as problematic for the scientific realist (among other things) because it looks like the prototypical example of underdetermination of theory by data: there are so many quantum theories which are (effectively) empirically equivalent, so how could the realist choose which one to believe? In this paper, I argue that the disagreement about theory choice in the quantum domain can be tracked down to specific features a fundamental physical theory should have in order to be satisfactory. People disagree about these desiderata because they disagree about which explanatory schema one should look for in a theory. This is, I argue, what leads different people to favor different theories. First, I show that the proponents of the information-theoretic approach, since they focus on empirical adequacy, are naturally led to look for an explanation in terms of principles, which is provided by standard quantum theory. In contrast, primitive ontologists favor a constructive understanding, which requires a spatiotemporal microscopic fundamental ontology, which guides them towards favoring the pilot-wave theory. Instead, Everettian approaches, which center around physical practice, conceive of quantum theory as a framework, and this makes them prefer the many-worlds theory. Finally, I argue that the wave function realists' requirement of a local and separable ontology leads them to think of quantum theories as interaction theories, which describe how the fundamental ontology, provided by the non-spatiotemporal wavefunction, behaves. Thus, if this reconstruction is correct, it is unlikely that the realist community will find an agreement on which is the best quantum theory.

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Measurements in Quantum Field Theory

Emanuele Rossanese*

The aim of my talk is to present and discuss some recent results in the explanation of measurement in Quantum Field Theory (QFT). The measurement problem is one of the most discussed interpretative issues of non-relativistic quantum mechanics, and has led to different proposals to interpret the theory in order to solve it. However, even if there is not yet a solution to this problem, non-relativistic quantum mechanics provides nonetheless a measurement theory that has a remarkable success in predicting the statistical results of experiments. The measurement problem is even worse in the context of QFT. On the one hand, there is not a solution to this problem yet, exactly as in the case of non-relativistic quantum mechanics. On the other hand, it is not possible to generalize the non-relativistic quantum mechanics measurement theory to QFT. For, it is possible to show that such generalization would lead to what Sorkin (1956) calls "impossible measurements", that is, to measurements that would entail superluminal signalling. Following Papageorgiou and Fraser (2023), the aim of my talk is then to present and discuss some recent interesting attempts to solve at least the pragmatical aspect of the measurement problem in the context of QFT, namely the formulation of a measurement theory that would not be undermined by Sorkin's analysis (and in particular the proposals of Fewster and Verch (2020) and of Polo-Gómez, Garay, and Martín-Martínez (2022)).

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Cassirer, Reichenbach and Causality

Samuele Fasol*

Over the past two decades, the interest in Ernst Cassirer's approach to Quantum Mechanics in his *Determinism and Indeterminism* (1956) has grown increasingly. The aim of the present talk is twofold: firstly, I expose the last parts of Cassirer (1956), which have been neglected by the commentators. Secondly, I compare Cassirer's and Reichenbach's conflicting accounts of "causality". Indeed, Cassirer regards causality as stating the general lawfulness of nature and therefore as a principle employed to *constitute* (in a sense to be clarified) the objects of our physical theories. Reichenbach (1944) describes causality as a notion involving only strict and deterministic laws and, as a consequence of the probabilistic laws of Quantum Mechanics, regards such a notion as outdated. Cassirer's and Reichenbach's opposite views of "causality" raise more than a mere terminological issue. An investigation of their conflicting views will prove of decisive importance also to shed light on the differences between their broader philosophical frameworks.

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Relational Quantum States: Ontology or Epistemology?

Andrea Oldofredi*

Relational Quantum Mechanics (RQM) is an interpretation of quantum theory in which different observers generally assign diverse states of affairs to a given physical situation. Notably such descriptions are equally correct and do not generate contradictions. For instance, taking into account the Wigner-friend scenario, the physicist within the lab will find a definite measurement outcome for their measurement, whereas Wigner - who is outside the lab - will describe the experimental setup into the room with a superposition of states. Remarkably, RQM claims that both representations are valid, thereby reality is relational and observer dependent. Recent works in this interpretation, however, reshape the axioms of the theory and suggest that measurement outcomes are observer independent facts. In this talk we discuss such a new version of RQM, in particular it will be studied whether such a theory still makes ontological claims or whether it is only about epistemic states of individual observers. Moreover, a comparison with Quantum Bayesianism is drawn.

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Quantum origin of time's arrow

Davide Romano*

Time's arrow is a constant feature of the macroscopic world, but why and how does it emerge from fundamental physics? The standard answer is based on the second law of thermodynamics, as the entropy increase for isolated systems defines a privileged evolution for those systems, even though the underlying Newtonian mechanics is time-symmetric. However, thermodynamics can hardly be considered the final answer, as the arrow of time looks like a fundamental feature of reality rather than a (higher-level) emergent phenomenon. Moreover, many features appearing at the macroscopic level (from the solidity of a table to the dynamics of classical systems) are concretely derived from the underlying quantum regime. It is then legitimate to ask: "can the thermodynamic time's arrow also be derived from quantum mechanics?"

In this talk I suggest an affirmative answer to this question, tracing back the origin of time's arrow to the irreversible behavior and dynamics of open quantum systems. Partial results are presented, much more is to be done.

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Scientifically-informed metaphysics for the EPRB-quantum correlations: why there is no room for radical metaphysical hypotheses

Vera Matarese*

Emery (2022) has argued that radical metaphysical hypotheses provide better explanations of the EPRB-quantum correlations compared to those provided by standard interpretations of quantum mechanics, as they are less novel than their rivals. This raises questions on whether we should indeed consider them when doing any scientifically-informed metaphysics. After examining the relationship between novelty and explanatory power, I will argue that radical metaphysical hypotheses involve a kind of novelty that undermines and even precludes explanatory power. In conclusion, I will argue that there is no room for radical metaphysical hypotheses in any scientifically informed metaphysics of the EPRB-quantum correlations.

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In Defense of Speculation: Quantum Ontology without Textbooks. Nor Overlapping[†]

Cristian Lopez[*]

In this paper, I critically assess two recent proposals for an interpretation-independent understanding of non-relativistic quantum mechanics: the overlap strategy (FRASER; VICKERS, 2022) and the textbook account (EGG, 2021). My argument has three steps. I first argue that they presume a Quinean-Carnapian meta-ontological framework that yields flat, structureless ontologies. Second, such ontologies are unable to solve the problems that quantum ontologists want to solve. Finally, only structured ontologies are capable of solving the problems that quantum ontologists want to solve. But they require some dose of speculation. In the end, I defend the conservative way to do quantum ontology, which is (and must be) speculative and non-neutral.

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Strange Metals, Holography, and Philosophy of Physics[†]

Enrico Cinti[*]

In recent years, the philosophy of dualities has seen a rapid growth both in depth and breadth of topic. In this context, an especially important role has been played by the study of gauge/gravity dualities, or holography, i.e. dualities which relate a theory of quantum gravity in n+1 dimensions to a field theory without gravity in n dimensions. The goal of this talk is to discuss some interesting philosophical issues raised by the application of holography to certain condensed matter systems, in particular to strange metals. Since these systems can be studied in the lab, and moreover for features which are only modelled via the use of holographic means, this application of holography promises interesting new insights into the possibility of experimentally testing quantum gravity hypotheses.

In particular, I will provide a simple introduction to the theoretical framework used to model strange metals within holography, i.e. so-called semi-holography, and I will discuss some interesting philosophical questions it gives rise to; in particular, I will focus on the relation between semi-holography and full holography, the meaning of explanation in the semi-holographic context, the prospect for emergence within a duality relation in semi-holography, and the possibility of taking a realist stance towards the gravity dual of the field theory in semi-holography. Throughout, the goal will be to introduce these questions as interesting and worthy of further philosophical analysis, rather than on providing direct solutions to these issues.

[†]Joint work with S. De Haro, M. Golden, U. Gursoy, S. Mukherjee, and H. Stoof.

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Niels Bohr: quantum mechanics as a theory of principle

Mauro Dorato†

In this paper, I show why Bohr's stress on the epistemic primacy of the classical image ought to be framed in terms of Einstein's distinction between principle theories and constructive theories. Bohr's approach to quantum mechanics belongs to the first category. In particular, I will argue that his refusal to give a quantum description of the measurement process was explicitly motivated by Einstein's formulation of the special theory of relativity as a theory of principle.

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Identity and Individuality: Quantum Scales and Beyond

Otávio Bueno*

It is tempting to think that a distinguishing feature of the quantum scale is the fact that, on that scale, objects lack identity (FRENCH; KRAUSE, 2006), whereas in larger scales this is not the case. I argue that the situation is not so simple. The apparent lack of identity of quantum objects crucially relies on a particular interpretation of quantum theory, and there are ways of making sense of quantum experiments that preserve the identity of quantum objects (VAN FRAASSEN, 1991). By distinguishing identity and individuality, it becomes clear that quantum objects, despite not being individuals, still have identity. The same considerations extend beyond the quantum scale, such as at the nanoscale, in which alleged failures of identity turn out to be failures of individuality instead. Thus, it is possible to preserve classical identity in these contexts, provided that a metaphysical theory of individuality is not added as an extra metaphysical gloss.

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