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REALISM QUANTUM

Arts & Humanities Research Council

SCIENTIFIC REALISM AND THE QUANTUM – R&Q2017

School of Philosophy, Religion, and History of Science
University of Leeds

Keynotes: Doreen Fraser, Carl Hoefer, George Musser, Adrian Kent, Alyssa Ney, David Wallace

12. September 2017

Workshop for Science Communicators

10am	Launch
10:05 – 11:00	**George Musser** keynote
	Coffee
11:15 – 12:15	Mini-talks
	Juha Saatsi (Leeds)
	Alyssa Ney (UC Davis)
	Doreen Fraser (Waterloo)
	David Wallace (USC)
12:15 – 13:00	Q&A and panel discussion

Conference Starts

13:00 – 14:00	Lunch
14:00 – 15:15	**Alyssa Ney** (UC Davis) *The Fundamentality of Quantum Theories*
	Coffee
15:30 – 16:45	**David Wallace** (USC) *Quantum Mechanics as a Theory Framework*
	Tea
17:00 – 18:15	**Adrian Kent** (Cambridge) Testing the Bell Nonlocality of the Gravitational Field
19:00 –	Drinks and Dinner

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09:30 – 10:45	**Carl Hoefer** (Barcelona) *Quantum natural kinds: like atoms, or phlogiston?*
	Coffee
11:00 – 11:45	**Raffael Krismer** (Vienna) *Pragmatism, Realism, and Quantum Mechanics*
11:45 – 12:30	**Mauro Dorato** (Roma Tre) *Is Healey's pragmatist approach compatible with physicalism?*
	Lunch
13:30 – 14:15	**Matthias Egg** (Bern) *Metaphysical Underdetermination in QM and QFT*
14:20 – 15:05	**Joshua Rosaler** (RWTH Aachen) *Branching, Scientific Realism, and the Set Selection Problem*
15:10 – 15:55	**Diego Romero Maltrana** and **Pablo Acuna** (PUCV) *Quantum Mechanics as a Framework Theory*
	Tea
16:15 – 17:30	**Doreen Fraser** (Waterloo) *The non-miraculous success of formal analogies in quantum theories*
17:30 – 17:45	**George Musser**: Concluding thoughts
18:00 –	Close. Drinks.

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Abstracts:

Mauro Dorato (Roma Tre) – Contributed paper
Is Healey's pragmatist approach compatible with physicalism?

I discuss some crucial aspect of Healey's agent-centered approach to quantum theory (QT) with the aim of inquiring whether it is compatible with physicalism. Since the truth of the view that in principle physics ought to able to explain the mental should not depend on controversial interpretations of QT, it is important to focus on two problems raised by Healey's approach that have significant repercussions on physicalism: the possibility of interpreting the notion of "user" in physicalistic terms and the classical-quantum distinction. In particular, I argue that the epistemic states of users of physical theories can play an epistemic role in two very different ways: either they are needed (trivially) to describe any physical, mind-independent situation as in classical physics – which I label weak epistemic dependence – or they are "conditions of possibility" to frame legitimate questions about a particular physical domain, in our case the quantum world – which I label strong epistemic dependence. Since Healey's pragmatist and agent-centered approach seems to be committed to the latter option, agents' epistemic states cannot be explained by physics, as physicalism requires, because any such explanation presupposes them.

Doreen Fraser (Waterloo) – Keynote
The non-miraculous success of formal analogies in quantum theories

The development of quantum theories and models over the past century has relied on the heuristic strategy of drawing formal analogies to theories and models for different domains. For example, the Higgs model for the electroweak interaction in particle physics was inspired by analogies to the Bardeen-Cooper-Schrieffer model of superconductivity, and renormalization group methods in particle physics and statistical mechanics were based on a series of analogies between models for a variety of systems. These are cases in which the mathematical structures of the analogue models are given entirely different physical interpretations, indicating that the analogies are purely formal. The successful employment of formal analogies is in tension with a core intuition of scientific realism, captured by the 'no miracles' argument: that success in science is explained by getting something right about the world. I will argue that the success of formal analogies in quantum theories is explicable and is not underwritten by approximately capturing substantive facts about the world, which tempers this realist intuition.

Matthias Egg (Bern) – Contributed paper
Metaphysical Underdetermination in QM and QFT

The existence of ontologically different but empirically indistinguishable versions of non-relativistic quantum mechanics is one of the most serious cases of metaphysical underdetermination. I argue that this problem is unlikely to disappear when we turn to the next more fundamental theory, namely relativistic quantum field theory. The problem is merely overshadowed by yet another interpretational controversy (the one between conventional and axiomatic approaches to quantum field theory), but it persists regardless of the outcome of this latter debate. I discuss different ways of dealing with this situation,

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with a critical focus on ontic structural realism and its underlying idea of seeking common structure.

Carl Hoefer (Barcelona) – Keynote
Quantum natural kinds: like atoms, or phlogiston?

In recent years I have defended the thesis that scientific realism can best be defended if we exclude fundamental physics — GR and most quantum theories — from the ambit of the proverbial "best current theories". As part of this project, I look at how reference to scientific natural kinds falling (partly or wholly) outside the scope of fundamental physics is now stable across theory change, both past theory changes and potential future ones. Some of these kinds that once were exclusively in the domain of fundamental physics — e.g. atoms or electrons — are now stabilised by their roles in a host of theories, models, and technologies, both inside and outside physics. By contrast, many natural kinds found in the most fundamental quantum theories, such as quarks or the Higgs particle (or field), do not have anything like the same empirical credentials. These hypothetical entities might, for all we know, be more like *phlogiston* than like *atoms*.

Adrian Kent (Cambridge) – Keynote
Testing the Bell Nonlocality of the Gravitational Field

Quantum theory predicts Bell nonlocal correlations of matter in Minkowski space and -- in so far as the theory is defined -- in general background spacetimes. General relativity predicts Bell locality for both matter and gravitational degrees of freedom. Most physicists' intuitions strongly suggest that the quantum prediction should prevail in this conflict. However, we have no direct experimental evidence for this, and the indirect evidence has other logically possible explanations. I review the state of our current understanding and some remaining loopholes, and discuss how future experiments could resolve the question.

Raffael Krismer (Vienna) – Contributed paper
Pragmatism, Realism, and Quantum Mechanics

In recent years, Richard Healey has proposed a pragmatist interpretation of quantum mechanics. While this interpretation shares some features with familiar interpretations (e.g., the claim that quantum states are observer-relative), Healey's pragmatism appears to be the most radical anti-realist option conceivable: "A theory may further the goals of physics without itself offering novel representations or descriptions of physical reality." (Healey 2011, 1) Or: quantum mechanics doesn't even *try* to describe the world. Clearly, this is puzzling. I will offer a defense of such a pragmatist interpretation, which, for the main part, involves telling the story about how to understand it.

Diego Romero Maltrana and Pablo Acuna (PUCV) – Contributed paper
Quantum Mechanics as a Framework Theory

This work explore the usefulness of a methodological development meant to evaluate the ontological import of scientific theories on the paradigmatic case of Quantum Mechanics.

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Such methodological approach is based on a particular way of classifying scientific theories inspired by the original distinction made by Einstein and later improved by Flores in terms of 'framework' and 'interaction' theories. The methodological potential of the framework/interaction distinction guiding the assessment of the ontological import of scientific theories is discussed. Then we draw on Muller and Ruetsche to analyse what amounts to an interpretation/version of Quantum mechanics, and evaluate the viability of the most renown interpretations/versions of QM based on its framework nature.

Alyssa Ney (UC Davis) – Keynote
The Fundamentality of Quantum Theories

Many believe that at least some physical theories enjoy a special status vis-a-vis other theories, a form of fundamentality. In this paper, I will argue that traditional conceptions of fundamentality in terms of dynamical or ontic completeness rest on mistaken assumptions about the nature and scope of real physical explanations and thus do not apply to actual physical theories. I propose an alternative conception of fundamentality that applies to actual physical theories, including quantum theories and reflect on the consequences this reconstruction has for issues in the interpretation of quantum mechanics, especially the psi-ontic/psi-epistemic debate.

Joshua Rosaler (RWTH Aachen) – Contributed paper
Branching, Scientific Realism, and the Set Selection Problem

Kent and Dowker have shown through numerous examples that multiple incompatible branching structures can be associated with the unitary evolution of a single quantum state. Here, I offer a systematic characterization of this non-uniqueness in order to further underscore the extent of the problem. While analyses of environmental decoherence help to alleviate this non-uniqueness via the identification of pointer states, they fall short of a full solution in assuming, rather than deriving, the system-environment split on which the identification of pointer states is grounded. I offer some preliminary suggestions as to how such splittings might be justified.

David Wallace (USC) – Keynote
Quantum Mechanics as a Theory Framework

"Quantum mechanics" is not a single theory that can be true or false but, like classical mechanics, is a framework in which are formulated a wide variety of concrete theories that do not fit into a neat hierarchy and which are used to model a range of different phenomena. I argue that this has two significant consequences for the interpretation of quantum theory. Firstly, the traditional interpretative question – "what would the world be like if quantum theory were true" – becomes ill-posed for most quantum theories (some of the quantum field theories of particle physics are *possibly* exceptions), and would be better replaced by the more modest question, "what would this system be like, on these scales, if it is correctly described on these scales by this quantum theory''. Secondly,

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”interpretations” can be divided into interpretations of specific quantum theories (like the Bohm and GRW theories), interpretations of the abstract framework of quantum theory (like Fuchs’ and Schack’s QBism, and Healey’s pragmatism), and recipes to interpret any given quantum theory (like the Everett interpretation); I argue that only the third kind of interpretation can really hope to solve the quantum measurement problem in general.