Working Group on Philosophy of Physics
Arbeitsgruppe Philosophie der Physik (AGPhil)

Meinard Kuhlmann
Abteilung Philosophie
Universität Bielefeld
Universitätsstr. 25
33615 Bielefeld
mkuhlmann@uni-bielefeld.de

Dennis Lehmkuhl
Faculty of Philosophy
University of Oxford
Woodstock Road
Oxford OX26GG, UK
dennis.lehmkuhl@philosophy.ox.ac.uk

Wolfgang Pietsch
Munich Center for Technology in Society
Technische Universität München
Arcisstr. 21
80333 München
pietsch@cvl-a.tum.de

Overview of Invited Talks and Sessions

(Lecture room: SPA SR22)

Plenary Talks most notable for AGPhil

PV VI	Wed	8:30– 9:15	Audimax	**Sharp versions of Heisenberg's error-disturbance trade-off** — •Reinhard Werner
PV IX	Wed	20:00–21:00	Audimax	**Wege durch die Quantenwelt – neue Experimente zur Welle-Teilchen Dualität massiver Materie** — •Markus Arndt
PV XIV	Fri	9:15–10:00	Audimax	**Quantum networks based on diamond spins: from long-distance teleportation to a loophole-free Bell test** — •Ronald Hanson

Invited Talks

AGPhil 2.4	Wed	18:00–18:45	SPA SR22	**Properties Are ...** — •Antigone Nounou, Harris Anastopoulos
AGPhil 4.1	Thu	14:00–14:45	SPA SR22	**Quantum Flesh on Classical Bones: Semiclassical Bridges across the Quantum-Classical Divide** — •Alisa Bokulich
AGPhil 5.1	Thu	16:15–17:00	SPA SR22	**Entropy, entanglement and utility** — •Jos Uffink
AGPhil 5.2	Thu	17:00–17:45	SPA SR22	**Collapsing to classicality: on the ontology of dynamical collapse theories** — •Wayne C. Myrvold
AGPhil 6.1	Fri	10:15–11:00	SPA SR22	**Asymptotic theory reduction, spontaneous symmetry breaking, and the measurement problem** — •Klaas Landsman

Invited talks of the joint symposium SYQC

See SYQC for the full program of the symposium.

SYQC 1.1	Thu	10:30–11:00	Audimax	**Experimental tests of quantum macroscopicity** — •Markus Arndt
SYQC 1.2	Thu	11:00–11:30	Audimax	**From classical instruments to quantum mechanics and back** — •Reinhard F. Werner
SYQC 1.3	Thu	11:30–12:00	Audimax	**Correlations and the quantum-classical border** — •Dagmar Bruss, Alexander Streltsov, Hermann Kampermann
SYQC 1.4	Thu	12:00–12:30	Audimax	**Why Physics Needs a Classical World...and How It Can Get One** — •Tim Maudlin

Sessions

AGPhil 1.1–1.4	Wed	14:00–16:00	SPA SR22	**Wissenschaftstheoretische Perspektiven**
AGPhil 2.1–2.4	Wed	16:30–18:45	SPA SR22	**Quantum-Classical Divide I**
AGPhil 3.1–3.4	Thu	10:30–12:30	Audimax	**Symposium Quantum-Classical Divide**
AGPhil 4.1–4.3	Thu	14:00–15:45	SPA SR22	**Quantum-Classical Divide II**
AGPhil 5.1–5.4	Thu	16:15–19:00	SPA SR22	**Quantum-Classical Divide III**
AGPhil 6.1–6.5	Fri	10:15–13:15	SPA SR22	**Quantum-Classical Divide IV**
AGPhil 7.1–7.6	Fri	14:15–17:30	SPA SR22	**Quantum-Classical Divide V**
AGPhil 8.1–8.2	Fri	17:30–18:30	SPA SR22	**Classical Electrodynamics**

AGPhil 9.1–9.4	Tue	14:00–16:00	SPA SR22	**Alternative Ansätze I**
AGPhil 10.1–10.3	Tue	16:30–18:00	SPA SR22	**Alternative Ansätze II**
AGPhil 11.1–11.1	Tue	18:00–18:15	SPA SR22	**Poster**

Mitgliederversammlung der Arbeitsgruppe Philosophie der Physik

Donnerstag 19:15–20:00 SPA SR22

- Bericht
- Wahl
- Planung 2014/15
- Verschiedenes

AGPhil 1: Wissenschaftstheoretische Perspektiven

Time: Wednesday 14:00–16:00 Location: SPA SR22

AGPhil 1.1 Wed 14:00 SPA SR22

Die physikalische Welt und mögliche Welten — •Hans Jürgen Pirner — Institut für Theoretische Physik, Universität Heidelberg

Welche Rolle spielen mögliche Welten in der Physik? In der klassischen Mechanik erscheinen mögliche Welten als mögliche Wege eines massiven Objekts unter dem Einfluss äußerer Kräfte. Das Prinzip der kleinsten Wirkung selektiert aus diesen möglichen Welten einen optimalen Weg, entlang dem sich der Körper wirklich bewegt. Leibniz* Idee von unserer Welt als der besten aller möglichen Welten entspricht diesem Variationsprinzip der klassischen Mechanik. Die statistische Mechanik beruht auf der Annahme, dass jeder mögliche Mikrozustand gleich wahrscheinlich ist. Trotzdem besteht ein Unterschied zwischen wahrscheinlich und möglich. Möglichkeiten genügen anderen Axiomen als Wahrscheinlichkeiten. Die Wahrscheinlichkeitsamplitude ergibt sich aus der gewichteten Summe über alle möglichen Wege eines Teilchens, sie betrachtet nicht nur den klassisch *besten* Weg. In der modernen Kosmologie werden mögliche Welten diskutiert, die kontinuierlich entstehen und ohne kausalen Kontakt mit der unsrigen existieren. Sind die möglichen Welten, von denen D. Lewis spricht, um seine modale Logik verständlich zu machen, mit diesen Welten vergleichbar? Bis jetzt verstehen wir nicht das Massen Spektrum der Quarks, Leptonen und Bosonen. Vielleicht ist es hilfreich alle möglichen Welten zu betrachten, die ähnliche Strukturen, wie das Standardmodell enthalten. Man könnte dann mit Hilfe eines Wahrscheinlichkeitsgesetzes den Wert der Massen aus ihrer Rangfolge abschätzen?

AGPhil 1.2 Wed 14:30 SPA SR22

Die Reduktion physikalischer Theorien nach Erhard Scheibe an einem Beispiel aus der Astroteilchenphysik — •Raphael Bolinger — TU Dortmund

In seiner in zwei Bänden erschienenen Arbeit zur Reduktion physikalischer Theorien (1997 bzw. 1999) stellt Erhard Scheibe eine umfassende Taxonomie von intertheoretischen Beziehungen vor, die sich weitestgehend mit den aus der philosophischen Diskussion des 20ten Jahrhunderts erwachsenen Reduktionskonzepten identifizieren lassen. Im Rahmen des Vortrags werden einige dieser Beziehungen vorgestellt und es wird aufgezeigt, wie sie sich auf ein Fallbeispiel aus der Astroteilchenphysik anwenden lassen. Es wird sich herausstellen, dass bei der Modellierung eine Vielzahl unterschiedlicher Theorien zur Anwendung kommt, deren Zusammenhalt sich sinnvoll mit den Reduktionsarten nach Scheibe beschreiben lässt.

AGPhil 1.3 Wed 15:00 SPA SR22

Newton and Leibniz on the absolute space — •Dieter Suisky — Humboldt University Berlin, dsuisky@physik.hu-berlin.de

The idea of the absolute space had been introduced by Newton in the 1680s to combat Cartesian relativism and to establish the laws of mechanics. The complete theory was eventually published in the *Principia* by 1687. Already in the 1670s, Leibniz discussed, however, independently just the same model of the absolute space and absolute motion, but used it as a counterexample in order to *confirm* and *improve* Cartesian relativism and to demonstrate that "space and motion are really relations". Newton started from the position that "the nature of the body is to fill the place which is considered as a part of the space", i.e. the absolute space. In Leibniz's anticipated reply from 1677 it is demonstrated that "space is not such a thing and motion is not something absolute", an assertion which he renewed and underlined later in his correspondence with Clarke in 1716. Leibniz's earlier interpretation had been only published in the 20th century. It follows that the elaboration of the model of the absolute space is a decisive intermediate step towards a relational theory of space and motion.

Thus, it can be concluded that Einstein's summary from 1953 is in conformity with the historical development: "It required a severe struggle to arrive at the concept of independent and absolute space, indispensable for the development of theory. It has required no less strenuous exertions subsequently to overcome this concept – a process which is probably by no means as yet completed."

AGPhil 1.4 Wed 15:30 SPA SR22

Information und Photonen — •Rudolf Germer — ITPeV — TU-Berlin — germer@physik.tu-berlin.de

In Bildern können wir Information sehen, die von Photonen übertragen wird. Damit werden physikalische Probleme für eins unserer wichtigsten Sinnesorgane anschaulich darstellbar. Während das einzelne Photon u.a. dadurch charakterisiert ist, daß es an einem Ort eines Detektors zu einer bestimmten Zeit registriert wird, liefern mehrere Photonen und ihr Bezug zueinander Information über Helligkeit oder geometrische Strukturen. Beim Klassifizieren von Helligkeitsstufen ist die Genauigkeit durch das Schrotrauschen begrenzt. Offensichtlich tragen daher die einzelnen Photonen unterschiedlich zur Information "Helligkeit" bei, für die ersten 10 Graustufen benötigt man 100 Photonen, für die nächsten 10 weitere 300. Durch das Rauschen geht aber keine Information, die die Photonen übermitteln, verloren, es ergibt sich die Frage des Verteilens davon auf unterschiedliche physikalische Größen. Dies Problem löst sich einfach, wenn man den Zusammenhang einer Messung mit der Art der Informationsauswahl analysiert, die damit verbunden ist. Die Ergebnisse beim Betrachten von Photonen lassen sich leicht auf das allgemeine Problem bei physikalischen Messungen übertragen.

AGPhil 2: Quantum-Classical Divide I

Time: Wednesday 16:30–18:45 Location: SPA SR22

AGPhil 2.1 Wed 16:30 SPA SR22

Convergence in theories of quantum gravity? — •Johannes Thürigen — Albert Einstein Institute, Potsdam, Germany

Theories in (empirical) science can be considered epistemically justified not only by empirical content but also by systematization power and uniformity. In the light of these concepts we present an analysis of the basic structure and intertheoretic relations of some approaches to quantum gravity each starting from quite different assumptions. These are Loop quantum gravity, Spin foams, Causal dynamical triangulations, Regge calculus and Group field theory. The aim of this analysis is to critically discuss an argument of physicists working on quantum gravity, stating that there is some kind of convergence of the mentioned approaches which (at least partially) justifies them.

Such an argument would be of high relevance since neither the precise relation to the established theories (and thus the phenomena described by those) nor the derivation of original phenomena might be achievable in the foreseeable future, leaving uniformity as the only epistemological criterion in favor for them.

We find that intertheoretic relations can be found mainly at the level of the conceptual framework of the theories, rather than regarding the actual dynamical laws. Therefore a weaker notion of theory relation is needed. The recent concept of theory crystallization is a good candidate and we analyze to what extent the approaches to quantum gravity meet its conditions.

AGPhil 2.2 Wed 17:00 SPA SR22

On the Significance of the Gottesman-Knill Theorem — •Michael Cuffaro — Ludwig-Maximilians-Universität München, Munich Center for Mathematical Philosophy, München, Deutschland

This paper addresses the question of the quantum-classical divide from the perspective of quantum computation, as well as the relevance of this for our understanding of the limitations of local hidden variables theories, and thus for our understanding of the quantum-classical divide more generally. According to the Gottesman-Knill theorem, quantum algorithms utilising operations chosen from a particular restricted set are efficiently simulable classically. Since some of these algorithms involve entangled states, it is commonly concluded that entanglement is not sufficient to enable quantum computers to outperform classical computers. It is argued in this paper, however, that what the Gottesman-Knill theorem shows us is only that if we limit ourselves to the Gottesman-Knill operations, we will not have used the entanglement with which we have been provided to its full potential, for all of the Gottesman-Knill operations are such that their associated statistics (even when they involve entangled states) are reproducible in a local hidden variables theory. It is further argued that considering the Gottesman-Knill theorem is illuminating, not only for our understanding of quantum computation, but also for our understanding of what we take to be a plausible local hidden variables theory, as well as for our understanding of the relationship between all-or-nothing inequalities such as GHZ, and statistical inequalities such as CHSH.

AGPhil 2.3 Wed 17:30 SPA SR22

Quantum and Classical Computation: Foundational Issues besides the Speed-up — •Filippo Annovi — Department of Philosophy, University of Bologna, Italy

The divide between quantum and classical computation does not concern which tasks can be performed, but the amount of resources necessary to achieve them. Does this entail that the computational divide is only relevant from a practical point of view, but not from a foundational one? No, because both the formal structure of quantum computers (based on the properties of Hilbert spaces) and the physical tools used by them (e.g. entangled states) are not classically available, thus the differences between quantum and classical computation go beyond complexity questions: the divide would remain in place even in the extremely unlikely case that the discovery of new classical algorithms were to nullify the quantum speed-up.

Moreover, there exist alternative equivalent models of quantum computation, some of which, like the cluster-state model, make an essential use of classical resources. Then, while the "where does the quantum speed-up come from?" question can satisfyingly receive a different answer for each model, the "where does the quantum-classical computational divide lie?" question requires an unified answer. This could be the first step towards a "representation theorem" for quantum computation, which would turn out to be very fruitful for the debate over the foundations of quantum mechanics.

Invited Talk AGPhil 2.4 Wed 18:00 SPA SR22

Properties Are ... — •Antigone Nounou[1] and Harris Anastopoulos[2] — [1]University of Athens, Athens, Greece — [2]University of Patras, Patras, Greece

The object of this paper is the notion of property and its objective is to study the different nuances that manifest as we transition from the classical to the quantum. Of the many questions that might -in our view need- be addressed, only one has been discussed thus far, namely whether properties in non-relativistic QM can be viewed as categorical or dispositional but the answers have been given in the context of particular interpretations only. The dispositional-categorical distinction constitutes the backdrop of the present discourse also as it bears on a more comprehensive discussion of the metaphysics of quantum physics and the question whether QM is amenable to a Humean construal or not. Given the nature of quantum probabilities and the possibility of entangled states, we acknowledge that in order to be able to talk about properties of microscopic systems (presumed determinate and single-valued) additional elements are required, such as the Copenhagen inspired mechanisms for wavefunction collapse, Bohmian pilot waves or GRW spontaneous localizations. Committing to any one of them implicates the adoption of a certain interpretation or rendition of the QM formalism and this has an effect on how properties can be understood. But by offering as exhaustive an analysis as we possibly can, we attempt to propose a satisfactory general account of how quantum properties may be understood in the context of non-relativistic QM.

AGPhil 3: Symposium Quantum-Classical Divide

Time: Thursday 10:30–12:30 Location: Audimax

Invited Talk AGPhil 3.1 Thu 10:30 Audimax

Experimental tests of quantum macroscopicity — •Markus Arndt — Faculty of Physics, VCQ, University of Vienna, Boltzmanngasse 5, A-1090 Vienna, Austria

Quantum physics is often said to be the theory of the microscopic world, whereas classical physics is associated with our macroscopic experience. But what is actually the criterion for an experiment to be microscopic or macroscopic [1]? Are quantum superposition and coherence limited to small systems, in size, particle number, mass, state separation in real or phase space? We suggest that experimental matter-wave interferometry with high-mass (10^4-10^7amu) and ultrahigh-mass particles (10^8-10^{10}amu) can settle some of these questions, in the future. State of the art molecule interferometers [2, 3] are expected to corroborate or falsify spontaneous localization models[5]. Recent progress in optical cooling of nanoparticles [6,7] also gives hope for quantum experiments in the ultra-high mass range.

[1]S. Nimmrichter et al., Phys. Rev. Lett. 110, 160403 (2013). [2]S. Eibenberger et al., Phys. Chem. Chem. Phys. 15, 14696 (2013). [4]P. Haslinger et al., Nature Physics 9, 144 (2013). [5]S. Nimmrichter et al., Phys. Rev. A 83, 043621 (2011). [6]P. Asenbaum et al., Nat Commun 4, 2743 (2013). [7]N. Kiesel et al., Proc. Natl. Acad. Sci. USA 110, 14180 (2013).

Invited Talk AGPhil 3.2 Thu 11:00 Audimax

From classical instruments to quantum mechanics and back — •Reinhard F. Werner — Leibniz Universität Hannover

In the early days of quantum mechanics Bohr and Heisenberg often referred to the indispensability of classical concepts for the quantum object. But increasingly this was applied only to the classical description of the measuring devices, emphasizing the rather obvious need for classical language to communicate the result of experiments. This is the starting point of the quantum axiomatics of Günther Ludwig, the operational approach to quantum physics, and, more recently, quantum information theory. It comes with a choice of "fundamental" concepts (states, observables and channels) in terms of which the whole theory is set up. With regard to Bell's theorem(s) I will show how this leads to a theory which automatically respects no-signalling locality, but gives up "classicality".

I will then briefly describe how one employs symmetries and other structures to fix some basic observables of the theory. As an illustration I will describe the salient formulation of the classical limit. A detailed description of the measurement process then requires the application of quantum theory to (parts of) the measuring instruments. I will briefly describe what one can hope to get out of this theory of measuring processes. One aim is a consistency statement, justifying the initial classicality assumptions about instruments, like the possibility of stable records, from quantum mechanics itself. The core of this problem is the emergence of classicality in much the same way as it is targeted by statistical mechanics.

Invited Talk AGPhil 3.3 Thu 11:30 Audimax

Correlations and the quantum-classical border — •Dagmar Bruss[1], Alexander Streltsov[2], and Hermann Kampermann[1] — [1]Institut für Theoretische Physik III, Universität Düsseldorf, Germany — [2]ICFO, Castelldefels (Barcelona), Spain

There are several options to define the quantum-classical border for states of composite systems: First, classicality can be viewed as locality in the sense that all Bell-type inequalities are fulfilled; second, it can be defined via the possibility to create the state with local operations and classical communication; and third, via the existence of a local Hamiltonian that leaves the state invariant. Once we agree on where to draw the quantum-classical border, some counterintuitive phenomena near this border will be illustrated.

Invited Talk AGPhil 3.4 Thu 12:00 Audimax

Why Physics Needs a Classical World...and How It Can Get One — •Tim Maudlin — New York University, Department of Philosophy

One basic question about a proposed fundamental physical theory is how it makes contact with empirical data. If a theory does not provide empirically testable predictions then it cannot be part of empirical science, and if the theory is supposed to be a fundamental physical theory then those predictions should be derivable from the account of the world provided by the theory itself. It has never been clear how quantum theory is supposed to meet this demand. Bohr's presentation of the theory had a "two-worlds" character: the microscopic world is represented by a mathematical quantum state, but the laboratory had to be described in "classical language". Bohr's approach provided (somewhat vague) rules for how to derive probabilistic predictions about the latter given a mathematical representation of the former, but did not even aspire to show how the laboratory equipment itself could be understood as a fundamentally quantum-mechanical system. John Bell proposed a general solution to this problem with what he called the "Theory of Local Beables". I will review Bell's general program and discuss several quite different concrete ways it can be realized.

AGPhil 4: Quantum-Classical Divide II

Time: Thursday 14:00–15:45 Location: SPA SR22

Invited Talk AGPhil 4.1 Thu 14:00 SPA SR22
Quantum Flesh on Classical Bones: Semiclassical Bridges across the Quantum-Classical Divide — •Alisa Bokulich — Center for Philosophy and History of Science, Boston University, Boston, MA, USA

Traditionally quantum mechanics is viewed as having made a sharp break from classical mechanics, and the concepts and methods of these two theories are viewed as incommensurable with one another. A closer examination of the history of quantum mechanics, however, reveals that there is a strong sense in which quantum mechanics was built on the backbone of classical mechanics. As a result, there is a considerable structural continuity between these two theories, despite their important differences. These structural continuities provide a ground for semiclassical methods in which classical structures, such as trajectories, are used to investigate and model quantum phenomena. After briefly tracing the history of semiclassical approaches, I will show how current research in semiclassical mechanics is revealing new bridges across the quantum-classical divide.

AGPhil 4.2 Thu 14:45 SPA SR22
***Umdeutung:* The Development of Quantum Mechanics as a Process of Reinterpretation.** — •Christoph Lehner — Max-Planck-Institut für Wissenschaftsgeschichte, Berlin

In 1925, Werner Heisenberg famously entitled his first paper on what was soon to be known as matrix mechanics "On the quantum theoretical reinterpretation (*Umdeutung*) of kinematic and mechanical relations." In my talk, I will analyze the centrality of this reinterpretation for the development of the new theory and for understanding the relation of matrix to classical mechanics. I will also consider the development of wave mechanics by Erwin Schrödinger in 1926 and analyze it as a parallel process of reinterpretation.

I will argue that this model offers a more realistic picture of the change of foundational theories than Kuhn's model of paradigm change.

AGPhil 4.3 Thu 15:15 SPA SR22
Experimental tests of the quantum superposition principle — •Hendrik Ulbricht — Physics and Astronomy, University of Southampton, Southampton SO17 1BJ, United Kingdom

New technological developments allow to explore the quantum properties of very complex systems, bringing the question of whether also macroscopic systems share such features, within experimental reach. The interest in this question is increased by the fact that, on the theory side, many suggest that the quantum superposition principle is not exact, departures from it being the larger, the more macroscopic the system. Testing the superposition principle intrinsically also means to test suggested extensions of quantum theory, so-called collapse models. We will report on three new proposals to experimentally test the superposition principle with nanoparticle interferometry, optomechanical devices and by high resolution spectroscopy.

AGPhil 5: Quantum-Classical Divide III

Time: Thursday 16:15–19:00 Location: SPA SR22

Invited Talk AGPhil 5.1 Thu 16:15 SPA SR22
Entropy, entanglement and utility — •Jos Uffink — Department of Philosophy, University of Minnesota, Minneapolis, MN, USA

This talk explores a formal analogy between the study of entanglement in quantum theory, entropy in classical thermodynamics, and utility in decision theory. Roughly speaking, I will argue that in all three cases, the mathematical problem arises of finding and characterizing those functions that respect a given pre-ordering relation, subject to certain auxilliary conditions. Moreover, theorems have been obtained in these three separate areas that might be applied to them in common. It is my main purpose to draw attention to these analogies, and argue how they might be useful in thermodynamics and quantum theory.

Invited Talk AGPhil 5.2 Thu 17:00 SPA SR22
Collapsing to classicality: on the ontology of dynamical collapse theories — •Wayne C. Myrvold — Department of Philosophy, University of Western Ontario, London, ON, Canada

Dynamical collapse theories are intended to yield, at the macroscopic level, a world of objects that act appropriately like classical objects. There has been extensive discussion of late about the ontology appropriate to collapse theories, much of it focused on the question of whether the wave function needs to be supplemented by primitive ontology that goes above and beyond the wav function. This paper will examine the question: "What does it take to be an object?" and will argue for the claim that collapse theories can yield a world of classical objects, with nothing other than wave functions, properly construed.

15 min. break

AGPhil 5.3 Thu 18:00 SPA SR22
Physical Reality, Explanation and the Nomological Interpretation of the Wave Function — •Federico Laudisa — Department of Human Sciences, University of Milan-Bicocca, Piazza Ateneo Nuovo 1, 20126 Milan, Italy

One of the most controversial issues in the area of the foundations of quantum mechanics is the status of the wave function. According to a recent result, denying the wave function a certain degree of reality leads to contradictions with quantum predictions (Pusey, Barrett, Rudolph 2012); the PBR result, however, gives no hint as to what a wave function is supposed to mean as 'part of reality'. In the present talk, I will turn to the nomological interpretation of the wave function according to the Bohmian mechanics (Goldstein, Zanghì 2013). In order to investigate its status and to see whether it can make justice to the role of the wave function in quantum mechanics, I will rely on two points: 1) the reading of the 'nomological' according to the primitivist approach to laws (Maudlin 2007); 2) the defense of the claim according to which a nomological entity can be part of the natural world even if it is not a concrete and causally efficacious entity (Psillos 2011). Finally, on the basis of the above reading of the nomological role of the wave function, we will see whether this claim can also bring to bear on its explanatory virtue (Lange 2013).

AGPhil 5.4 Thu 18:30 SPA SR22
The Role of the Wave Function in the GRW Matter Density Theory — •Matthias Egg — University of Lausanne, Switzerland

Every approach to quantum mechanics postulating some kind of *primitive ontology* (e.g., Bohmian particles, a mass density field or flash-like collapse events) faces the challenge of clarifying the ontological status of the wave function. More precisely, one needs to spell out in what sense the wave function "governs" the behaviour of the primitive ontology, such that the empirical predictions of standard quantum mechanics are recovered. For Bohmian mechanics, this challenge has been addressed in recent papers by Belot (Eur. J. Phil. Sci. **2** (2012), 67-83) and Esfeld et al. (Brit. J. Phil. Sci. forthcoming, doi:10.1093/bjps/axt019). In my talk, I attempt to do the same for the matter density version of the Ghirardi-Rimini-Weber theory

(GRWm). Doing so will highlight relevant similarities and differences between Bohmian mechanics and GRWm. The differences are a crucial element in the evaluation of the relative strengths and weaknesses of the two approaches, while the similarities can shed light on general characteristics of the primitive ontology approach, as opposed to other interpretative approaches to quantum mechanics.

AGPhil 6: Quantum-Classical Divide IV

Time: Friday 10:15–13:15 Location: SPA SR22

Invited Talk AGPhil 6.1 Fri 10:15 SPA SR22

Asymptotic theory reduction, spontaneous symmetry breaking, and the measurement problem — •Klaas Landsman — Radboud Universiteit Nijmegen

The issue of the classical/quantum divide is (re)formulated as a problem in asymptotic theory reduction. On this formulation, the measurement problem and the closely related problem of spontaneous symmetry breaking assume a particularly clear form and become well posed as mathematical problems. As such, we propose a mathematical mechanism for their solution within the confines of standard quantum mechanics. References: arXiv:1210.2353 (with R. Reuvers) and arXiv: 1305.4473.

AGPhil 6.2 Fri 11:00 SPA SR22

In search of a primitive ontology for relativistic quantum field theory — •Vincent Lam — University of Lausanne, CH-1015 Lausanne, Switzerland

There is a recently much discussed approach to the ontology of quantum mechanics according to which the theory is ultimately about entities in 3-dimensional space and their temporal evolution. Such an ontology postulating from the start matter localized in usual physical space or spacetime, by contrast to an abstract high-dimensional space such as the configuration space of wave function realism, is called primitive ontology in the recent literature on the topic and finds its roots in Bell's notion of local beables. The main motivation for a primitive ontology lies in its explanatory power: the primitive ontology allows for a direct account of the behaviour and properties of familiar macroscopic objects. In this context, it is natural to look for a primitive ontology for relativistic quantum field theory (RQFT).

The aim of this talk is to critically discuss this interpretative move within RQFT, in particular with respect to the foundational issue of the existence of unitarily inequivalent representations. Indeed the proposed primitive ontologies for RQFT rely either on a Fock space representation or a wave functional representation, which are strictly speaking only unambiguously available for free systems in flat spacetime. As a consequence, it is argued that these primitive ontologies constitute only effective ontologies and are hardly satisfying as a fundamental ontology for RQFT.

15 min. break

AGPhil 6.3 Fri 11:45 SPA SR22

Symmetries and the philosophy of language — •Neil Dewar — University of Oxford, Oxford, UK

This paper looks at how ideas from the philosophy of language can shed light upon the conceptual significance of symmetries in physics.

I begin by reviewing and summarising the case in the literature for believing that unless a quantity is invariant under such symmetries, it is epistemically undetectable. Then, I consider a novel adaptation of the permutation arguments of Quine and Putnam to raise concerns about how we could come to express the physical differences those quantities supposedly signify. This argument also helps to clarify the structure of those permutation arguments, and plausibly provides a clearer example than those considered by Quine and Putnam.

Finally, I turn to the question of what we should say instead. I reject the consensus view that we must seek an alternative theory in which those quantities do not figure; rather, I claim, it is appropriate simply to stipulate that the theory is to be interpreted so that such models are taken to represent the same physical state of affairs. The remainder of the paper is given over to a defence of this claim against objections; and in particular, to exploring an intriguing analogy between models related by a symmetry transformation and synonymous sets of sentences.

AGPhil 6.4 Fri 12:15 SPA SR22

On the Invariance Principle — •Thomas Moller-Nielsen — University of Oxford (graduate student), UK

Physicists and philosophers have long claimed that the symmetries of our physical theories — roughly speaking, those transformations which map solutions of the theory into solutions — can provide us with genuine insight into what the world is really like. According to this 'Invariance Principle', only those quantities which are invariant under a theory's symmetries should be taken to be physically real, while those quantities which vary under its symmetries should not. Physicists and philosophers, however, are generally divided (or, indeed, silent) when it comes to explaining how such a principle is to be justified. In this paper, I attempt to spell out some of the problems inherent in other theorists' attempts to justify this principle, and sketch my own proposed general schema for explaining how — and when — the Invariance Principle can indeed be used as a legitimate tool of metaphysical inference.

AGPhil 6.5 Fri 12:45 SPA SR22

The Internal/External Distinction in the Light of Supersymmetry — •Radin Dardashti — Munich Center for Mathematical Philosophy, Munich, Germany

Several physicists in the 1960s tried to combine internal symmetries with external or spacetime symmetries in a non-trivial way leading to many theorems culminating in the famous Coleman-Mandula theorem of 1967. The theorem proves the impossibility, under certain physical and mathematical assumptions, of combining internal and spacetime symmetries in any but the trivial way, i.e. as a direct product. However, allowing for spinorial generators one can generalize the theorem (Haag-Lopuszanski-Sohnius theorem) leading to Supersymmetry as the only possible extension of the algebra. Although the result is mathematically clear one finds many differing statements regarding the interpretation and consequence of this result for the relation between internal and external symmetries.

We will discuss both the historical and conceptual issues involved in the discussion of the internal/external distinction in the light of supersymmetry and its relevance for the philosophy of physics literature on symmetry.

AGPhil 7: Quantum-Classical Divide V

Time: Friday 14:15–17:30 Location: SPA SR22

AGPhil 7.1 Fri 14:15 SPA SR22

Big bang causality as quantum-classical transition — •Rüdiger Vaas — bild der wissenschaft, Ernst-Mey-Str. 8, D – 70771 Leinfelden

Explaining the beginning of our universe is a delicate and difficult task, not only from a cosmological point of view, but also from an epistemological, conceptual, and philosophy of science perspective. To search for a causal explanation of the big bang could even be meaningless, if causality is understood only as a kind of regularity, or in terms of counterfactuals, interventionism, or (dispositional) perturbation pragmatism, or indeed just as a feature of human cognition (cf. Schaffer 2007, Hüttemann 2013). My talk argues that a physical notion of causality – if any – associated with a transfer of conserved quantities such as energy or momentum (as proposed, e.g., by Salmon 1998, Dowe 2007, 2009) is needed for a causal big bang explanation, and that this is consistent with at least some recent big bang models in physical cosmology. This is closely related to the hypothesis of a cosmological origin of the arrow(s) of time, i.e. irreversibility. If pseudo-beginning models are correct – in contrast to models of an absolute beginning of time or a past-eternal time –, the big bang can be causally explained as a quantum fluctuation within a time-reversible quantum vacuum, creating quasi-classicality along with an arrow of time. My talk argues that such models can be interpreted in the framework of physicalistic causation mentioned above. However, there could be a paradox lurking here: If the big bang created causality and classicality in the first place, how can it itself have a causal and classical explanation? – L. Mersini-Houghton, R. Vaas (eds.): The Arrows of Time. Springer, 2012.

AGPhil 7.2 Fri 14:45 SPA SR22

The Quantum-Classical Divide and the Kochen-Specker Theorem: A Case for the Nonlocality of Time? — •Martin Schüle — IHPST, 13, rue du Four 75006 Paris

In quantum physics, the properties of two systems can exhibit long-range correlations although there is no direct contact between the systems. Bell's analysis of the situation led to his famous no-go theorem which says that it is not possible to introduce additional variables that would explain these correlations. The additional variables must thereby satisfy certain intuitive constraints such as "locality". The impossibility of such a "hidden" or additional variable theory thus firmly established the issue of nonlocality in physics and philosophy of physics, which may be seen as a central characteristic of the quantum-classical divide.

In my contribution, I will discuss the no-go theorem by Kochen and Specker and claim that it is in a certain sense more fundamental than Bell's theorem, providing some evidence that Bell's theorem is historically and conceptually based on the Kochen-Specker theorem. Interpreted this way, the Kocher-Specker theorem does not only allow for a Bell-type argument implying nonlocality in space, but possibly also "nonlocality" in time, that is, correlations between time- like separated events that cannot be causally connected. I will then discuss some experimental evidence of this "nonlocality" and its conceptual and philosophical implications.

AGPhil 7.3 Fri 15:15 SPA SR22

Decoherence and the Many Worlds Interpretation — •Carsten Thomas Weigelt — University, Bonn, Germany

The theory of decoherence gives us a good account (at least for open systems) of how classical properties emerge from the quantum world. Recent experiments based on decoherence offers strong arguments against the quantum-classical division proposed by the early Copenhagen Interpretation.

But even if decoherence may support the view that quantum mechanics can be considered as fundamental theory the question remains if this sheds new light to the question of how a realistic interpretation of quantum theory can be achieved? In the last years proponents of decoherence pointed out that the theory fits perfectly into the framework of many worlds interpretations (Zurek 2003, Wallace 2012).

The question that I will address is, in what sense these interpretations can be considered as realistic interpretations? To answer this question I will argue that in the context of decoherence we have strong reasons to interpret quantum states in a realistic sense. A problem for many worlds interpretations arises when the meaning of Everett's relative states is considered since these interpretations strongly dependent on the interpretation of relative states. I will show that einselection proposed by the decoherence theory will determine Everett's relative states in an objective sense but these states must be interpreted as epistemic states. I will conclude that this ambiguity between realistic interpreted quantum states and epistemic relative states limits the strict realistic character of many worlds interpretation.

AGPhil 7.4 Fri 15:45 SPA SR22

On the ontological emergence from quantum regime — •Damian Luty — Adam Mickiewicz University, Poznań, Poland

There are several views on the relation between quantum physics and theory of relativity (especially General Relativity, GR). A popular perspective is this: GR with its macroscopic gravitational effects will turn out to be a limit of a more fundamental theory which should consider discrete physics and not deal with continuity (like theory of relativity). Thus, GR will emerge from a more basic theory, which should be quantum-like. One could call this an epistemic emergence view towards fundamental theories. The question is, given that scientific realism is valid: should emergence be a fundamental notion in our ontological view about the evolving, physical Universe? Is there an ontological emergence fully compatible with the notion of fundamentality?

I would like to argue that if we want to defend ontological emergence (from quantum to macroscopic regime) as something fundamental, we will arrive at the position of metaphysics of dispositions (and I shall argue, why this is undesirable), or conclude, that we cannot square fully fundamental ontology with the notion of emergence, and that we have to accept an ontological pluralism relativised to a certain scale. I shall defend the latter proposition, showing, that epistemic emergence doesn't entail (logically) ontological emergence.

15 min. break

AGPhil 7.5 Fri 16:30 SPA SR22

The quantum-classical divide understood in terms of Bohm's holographic paradigm — •Vera Matarese — The University of Hong Kong, Hong Kong

This paper aims to interpret the problem of the quantum-classical divide following Bohm's holographic model and to reformulate it as an indication of a new physical order.

First of all I will briefly outline the differences between the classical world and the quantum one (such as locality against nonlocality, determinism against indeterminism and continuity against discontinuity); then I will claim that in order to understand the divide between the two domains we should start from what is common, and regard them as two abstractions and limiting cases of a general theory.

In particular, following Bohm, I will show that the central notion of this new theory is an undivided whole characterized by a general order consisting of a holomovement from an implicate order - the quantum domain - to an explicate order - in the classical domain. This part will be explained with the aid of the structure of the hologram and will be supported by a reflection on some key terms such as 'order', 'structure', 'implicate' and 'explicate'.

Finally I will propose that this movement of unfoldment and enfoldment can explain the apparent incompatibility of the two physical domains and the passage from one to the other.

AGPhil 7.6 Fri 17:00 SPA SR22

Measurement and Uncertainty in Classical Physics — •Lukas Nickel[1] and Tobias Jung[2] — [1]LMU München, Fakultät für Physik. Steinsdorfstr. 18, 80538 München — [2]TU München, Lehrstuhl für Philosophie und Wissenschaftstheorie. Forststr. 7, 82547 Eurasburg

We discuss the consequences it has for classical physics if one includes the measurement process in the theory. The terms measurement and error thereof are explained and it is argued that every measurement can be reduced to a measurement of position and/or time. The statement that every measurement carries a finite inaccuracy implies that, also in classical mechanics, only probabilistic predictions are possible. Hence we find a similarity between classical and quantum physics that is mostly misconceived: By including measurements in the theory itself, one can view the former exactly like the latter as an indeterministic theory, as well as both theories can be formulated deterministicly without inlcuding measurements.

AGPhil 8: Classical Electrodynamics

Time: Friday 17:30–18:30 Location: SPA SR22

AGPhil 8.1 Fri 17:30 SPA SR22

The Elimination of Fields in Classical Physics — •Mario Hubert — University of Lausanne, Switzerland

Newtonian Mechanics was originally formulated as an action-at-a-distance theory. With the advent of electrodynamics in the 19th century, the ontology of physics was enriched by a further entity apart from matter and forces: the electromagnetic field. The idea of fields was then used to make Newton's gravitational theory spatiotemporally local by the introduction of the gravitational field. However, I want to show that classical fields pose philosophical as well as physical problems that encourage to state that they are not entities in space-time. As a result, I want to point out that classical physics only requires substances and properties in the ontology.

AGPhil 8.2 Fri 18:00 SPA SR22

The radiation arrow of time is not a statistical arrow — •Wolfgang Pietsch[1] and Mathias Frisch[2] — [1]TU München, Germany — [2]University of Maryland, College Park, USA

We comment on the debate concerning the radiation arrow of time in classical electrodynamics starting with the Ritz-Einstein debate at the beginning of the 20th century up to more modern considerations involving among others Earman, Rohrlich, and Frisch. We first identify and distinguish several asymmetries, which have often been confused: between retarded and advanced fields, retarded and advanced potentials, converging and diverging fields, converging and diverging potentials, converging and diverging electromagnetic waves. Furthermore, a crucial issue regards whether we consider point or extended charges as sources. Some, but by no means all of these asymmetries can be shown to coincide. Various reasons are discussed for a non-statistical asymmetry concerning the way potentials or fields are generated by point charges or point charge elements. Most importantly, the main classical derivations of the radiation reaction either presuppose retarded solutions and would yield wrong results using advanced solutions or at least presuppose an asymmetric role for retarded and advanced potentials. The usual counterarguments are shown to employ other notions of symmetry that are compatible with the described non-statistical asymmetry, which by the way was already identified a century ago by Walther Ritz.

AGPhil 9: Alternative Ansätze I

Time: Tuesday 14:00–16:00 Location: SPA SR22

AGPhil 9.1 Tue 14:00 SPA SR22

Grenzen menschlicher Erkenntnis — •Professor Dr. Klaus Hofer — Uni Bielefeld

Trotz unseres hohen Wissensstands über die evolutionäre Verwebung von Energie, Masse und Information zu Materie und Leben kommen unsere Vorstellungen zum Mikro- und Makrokosmos über Theorien und Spekulationen nicht hinaus. Dies gilt bei der Erforschung des Weltalls mit riesigen Teleskopen und Raumsonden ebenso wie bei der Spaltung von Nukleonen mit überdimensionalen Teilchenbeschleunigern. Ein Grund dafür liegt in den gewaltigen technischen und finanziellen Anstrengungen, die heutzutage schon für den kleinsten Erkenntniszuwachs erforderlich sind. Und darum wird unsere aufwändige Suche nach hypothetischen Gottesteilchen und galaktischen Außerirdischen auch weiterhin Unsummen verschlingen, ohne tiefere Erkenntnisse hervorzubringen. Dieser Beitrag will die Grenzen menschlicher Erkenntnisfähigkeit mittels der Relativität alles Stofflichen aufzeigen. Denn aus evolutionärer Sicht sind wir Menschen codierte Massehaufen aus ca. 10hoch27 Atomen, die von einer übergeordneten Schwarmintelligenz formatiert und gesteuert werden. Aus dieser begrenzten Codierungshöhe des Menschen folgt, dass unsere Beobachtung der Galaxien ebenso ungenau ist wie die Beschreibung von Gegenständen aus der Wahrnehmungsebene eines Atoms. In beiden Fällen ist der Beobachter ca. 10hoch23-mal kleiner als das Objekt und kann dieses lediglich als einen ungeordneten und chaotischen Massenhimmel wahrnehmen. Sämtliche Zusammenhänge darüber hinaus sind für den Betrachter nicht erkennbar.

AGPhil 9.2 Tue 14:30 SPA SR22

Physik in Literaturform — •Helmut Hille — Fritz-Haber-Straße 34, 74081 Heilbronn

Dicke Wälzer in einer schwer verständlichen Sprache sind wenig geeignet, das Anliegen der Physik nicht nur den Laien verständlich zu machen. Ich mache den Versuch, meine Überlegungen dem Publikum in ihm vertrauter Literaturform und Sprache mitzuteilen. So veranschauliche ich im Feuilletonstil und auf einer Seite, was unter Verschränkung und Emergenz zu verstehen ist, wodurch vieles Geschehen vom Mikro- bis zum Makrokosmos verständlich wird. In einem 2. Beispiel lasse ich in einer Szene Faust/Newton letzteren Fausts Frage, was die Welt im Innersten zusammenhält, in von Goethe geliehener Gedichtform kurz und bündig beantworten. Dann zeige ich in einer Notiz, dass es gerade die Quantenphysik ist, die uns die Gravitation und den Kosmos verständlich macht.

AGPhil 9.3 Tue 15:00 SPA SR22

Die Rolle von Prinzipien und Symmetrien in der Physik — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

Die heutige theoretische Physik ist bestimmt von Prinzipien und Symmetrien.

Diese Vorgehensweise ist jedoch nicht wirklich neu, sondern wurde im Grundsatz vom Philosophen Plato entwickelt. Sie wurde später von Newton ersetzt durch Bezug auf tiefer liegende Gesetze. Die Verallgemeinerung dieser Vorgehensweise ist das reduktionistische Weltbild, welches allgemein die Grundlage des heutigen Wissenschaftsverständnisses ist.

Vor etwa einem Jahrhundert, in der Zeit der Neuorientierung durch Relativitätstheorie und Quantenmechanik, entstand daneben eine Rückbesinnung auf den platonischen Ansatz, der - vor allem gefördert durch Heisenberg - bis heute die sog. "moderne Physik" beherrscht.

Es ist die Frage zu stellen, ob dieser ausschließliche Bezug auf Prinzipien und Symmetrien hilfreich ist und ob er notwendig ist. Dazu werden Beispiele aus Relativitätstheorie und Quantenmechanik vorgestellt, die an diesem Weg zweifeln lassen.

Further info: www.ag-physics.org

AGPhil 9.4 Tue 15:30 SPA SR22

Prinzipienbasiertes Modell der Quantenphysik — •Klaus Fröhlich — ALS, Paracelsusweg 12, 30655 Hannover

- Definition des Begriffes "real"
  - Symbiosemodell der Quantentheorie
  - Elementarsysteme besitzen die Eigenschaften von Funktionsmodellen
  - Wechselwirkungen zwischen Informationen und Quanteninformationen
  - Ad-hoc-Modell der Bewegung
  - Einheitliche Beschreibung der Natur

Prüfbare Folgerung: Elementarsysteme enthalten ihre Eigenschaften im Rahmen eines Innovationsprozesses nach dem Mechanismus der Wissenschaften. Objekte, die nach diesem Mechanismus entstehen (wie z.B. Elektronen) besitzen zwangsläufig und damit nachprüfbar bestimmte Eigenschaften.

Ein vom Mechanismus der Wissenschaften hervorgebrachtes Objekt
- besitzt die Eigenschaften einer Information.
- besitzt die Eigenschaften eines symbiotischen Systems.
- besitzt die Eigenschaften eines Funktionsmodells.

Diese Eigenschaften müssen nicht als gegeben hingenommen werden, sondern ergeben sich.

AGPhil 10: Alternative Ansätze II

Time: Tuesday 16:30–18:00 Location: SPA SR22

AGPhil 10.1 Tue 16:30 SPA SR22

Beyond Quantum Gravity and Its GUT Extension: Problems Still Open in Comprehending Our World — •Claus Birkholz — D-10117 Berlin, Seydelstr. 7

QG opens totally new horizons. Its group-theoretical approach is triggering the theoretician to reconsider his aged arguments having led into the current state of stagnation in fumdamental physics. A "New Physics" is avoiding the short-cuts of the old one.

The current string models "beyond" the "standard" model are blamed to be "irrelevant" for physics. QG/GUT are shown to represent "string" models as well. but working ones, in accord with experiment. Their "exotic" force type is suspected to trigger the creation of black holes and, possibly, new organic structures.

The Copenhagen interpretation is corrected to respect irreducibility. Then, physics will be totally deterministic, with its "parallel-world" scenarios becoming mere fiction.

The crucial new challenge is to reconcile "motion" with a static, deterministic world. A key role might play the human notion of a "menory", which is unilaterally directed towards past events.

For more information on QG and GUT see www.q-grav.com.

AGPhil 10.2 Tue 17:00 SPA SR22

Physics of the Hilbert Book Model — •Hans van Leunen — Heerbaan 6 Asten 5721LS Netherlands

The Hilbert Book Model is the name of a personal project of the author. The model is deduced from a foundation that is based on quantum logic and that is subsequently extended with trustworthy mathematical methods. What is known from conventional physics is used as a guideline, but the model is not based on the methodology of contemporary physics. In this way the model can reach deeper into the basement of physics. The ambition of the model is rather modest. It limits its scope to the lowest levels of the physical hierarchy. Thus fields and elementary particles are treated in fair detail, but composites are treated marginally and only some aspects of cosmology are touched. Still the model dives into the origins of gravitation and inertia and explains the diversity of the elementary particles. It explains what photons are and introduces a lower level of physical objects and a new kind of ultra-high frequency waves that carry information about their emitters. It explains entanglement and the Pauli principle. Above all the HBM introduces a new way of looking at space and time. Where contemporary physics applies the spacetime model, the HBM treats space and progression as a paginated model.

AGPhil 10.3 Tue 17:30 SPA SR22

One interpretation for both Quantum Mechanics and General Relativity — •Ewoud Halewijn — Voorburg, Netherlands

In reconciling General Relativity with Quantum Mechanics, it is challenging to resolve the combined mathematical equations and to find an interpretation that makes sense ontologically.

Such an interpretation has been developed by quantizing descriptive components in both the theories and other views. The resulting micro-components have been re-integrated within the scope of known gaps between science and *the real world*. The odd peculiarities in these theories have been made look *normal* by fully untraditionally answering fundamental questions.

The interpretation is suggesting that we define time as a discrete operator and its eigenvalues as constraints on space-time manifolds, in order to reconcile the mathematical equations. Outside the mathematical arena we suggest reconsidering the concepts of Black Holes, the Big Bang, the epistemological problem of perception in philosophy and the supposed clash between scientific and the spiritual worldviews.

It is concluded that developing one consistent ontological interpretation for both theorie is possible. It is a weird story, but it is making powerful suggestions for reviewing some of our fundamental convictions.

AGPhil 11: Poster

Time: Tuesday 18:00–18:15 Location: SPA SR22

AGPhil 11.1 Tue 18:00 SPA SR22

Newtons Mechanik ist Quantenmechanik — •Ed Dellian — Bogenstr. 5 14169 Berlin, Germany

In den Jahren 1984 und 1985 veröffentlichte Fritz Bopp zwei Arbeiten: Newtons Optik als unvollendetes quantenphysikali- sches Konzept (Phys.Bl. 40 (1984) Nr. 9 S. 306), und: Newtons Wissenschaftslehre als Basis der Quantenphysik (Ann.d.Phys. 7. Folge Bd. 42 Heft 3 (1985) S. 217). Die Originaltexte von Newton (und von Galilei, auf dessen Arbeit Newton aufbaut) zeigen: Bopp hatte Recht: Newtons (und Galileis) Mechanik ist Quantenmechanik. Die "klassische" Kontinuumsmechanik hingegen ist ein Konstrukt, das Leonhard Euler und Joseph Louis Lagrange auf der Basis Leibnizscher Konzeptionen in Berlin erarbeiteten. Ich nenne sie "Berliner Mechanik" (BM). Dass diese BM ein Irrweg war, beweist die Übereinstimmung von Prinzipien Galileis und Newtons und der modernen Quantenmechanik. Als Beispiel diene die authentische Form des zweiten Axioms Newtons genannt: Es handelt sich um eine geometrische Proportion zwischen Quanten von "Kraft" und "Bewegungsänderung", verbunden durch eine Proportionalitätskonstante mit der Dimension "Raumelement durch Zeitelement".