Book of Abstracts

Foundations 2018, Utrecht University

Pablo Acuña

Kochen-Specker Theorem in the Context of von Neumann's 'Impossibility Proof'

Wednesday, 9:30 - room 0.42

The Kochen-Specker theorem allegedly imposes a significant contextuality constraint on hidden variable theories. On the other hand, after Bell's analysis, the importance of von Neumann's 'impossibility proof' has been severely questioned: it is supposed to rule out only an uninteresting class of such theories. I argue that this evaluative comparison of the importance of the theorems is upside down. Elaborating on Bub's reappraisal of the impossibility proof, I will show that if the true and significant constraint imposed by von Neumann's theorem on hidden variable theories is considered, the relevance of the Kochen-Specker theorem gets substantially weakened.

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Emily Adlam

A Tale of Two Anachronisms

Thursday, 13:30 - room 'Blauw'

Scientific reasoning is constrained not only by the outcomes of experiments, but also by the history of human thought and our own place in it. As a result, even our best theoretical models often incorporate features which are present more as the result of historical accident than as the endpoint of a process of evidence-based deliberation, and it is sometimes possible to make considerable progress by identifying and eliminating such features. In this talk, I will identify two features of current thought about quantum physics which may be anachronisms of this kind. I will briefly discuss their history and then raise some arguments against them. Both of these features have previously been recognized as problematic by parts of the physics community, but I argue that this recognition is not sufficiently widespread and that both features are actively limiting progress in the field of quantum foundations.

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Alexander Afriat

Topology, holes & sources

Friday, 15:10 - room A

The Aharonov-Bohm effect is seen as 'topological' by Aharonov & Bohm, Wu & Yang, Nash & Sen, Ryder and especially Batterman (and others too). But it seems no more topological than magnetostatics, electrostatics or Newton-Poisson gravity (or just about any radiation, propagation from a source). I distinguish between two senses of "topological."

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Valia Allori

Some Remarks on Explanation in Statistical Mechanics

Thursday, 11:10 - room 'Rood'

David Albert has argued that, in the context of quantum statistical-mechanical explanation, the GRW theory should be preferred to any deterministic alternative because he thinks the statistical postulate can be dispensed of. This is because in an indeterministic theory probabilities intervene only once, at the dynamical level, rather than twice, as in the case of the deterministic theories. In this paper I argue that the content of the postulate is not needed, and even if it is, it needs not to be postulated but can be inferred from the dynamics.

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Vincent Ardourel

Phase Transitions, Renormalization Group, and Finite Size Scaling Theory

Friday, 16:30 - room D

This paper argues that the Finite Size Scaling theory allows us to explain reductively phase transition and their universality in finite systems. After having briefly introduced this theory, I reply to Morrison's objection who points out that infinite limits are still needed with this theory since it uses fixed points of Renormalization Group. I argue that, even if fixed points are used, they are mere mathematical tools and not crucial ingredients for explaining universality in finite systems. For that purpose, I discuss how the Renormalization Group theory is applied to finite systems within Finite Size Scaling theory.

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Guido Bacciagaluppi, Ronnie Hermens & Gijs Leegwater

Non-locality for measurement-dependent theories

Thursday, 11:50 - room D

Measurement dependence (or settings-source dependence) is the last and hardest loophole in Bell's and other non-locality theorems. In this paper we prove a non-locality theorem that covers also hidden variables theories with measurement dependence. Our theorem is a variant of the Colbeck-Renner theorem and reads informally as: every non-trivial hidden variables theory with or without measurement dependence leads to signalling. If one disallows signalling with or without a preferred frame, then the theorem is a no-go result for measurement-dependent hidden variables theories. If one allows signalling as long as it introduces no preferred frame, then the theorem shows that measurement-dependent theories may have striking empirical consequences.

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Robert Bishop

Determinism in Context

Thursday, 9:30 - room D

Philosophers and scientists often think of physical determinism as an all or nothing property of physical systems–or even of the physical world as a whole. Philosophers of physics over the last few decades have raised some deep questions about these judgments. There are indications that physical determinism is a contextual feature of models and systems that fits well with the more general account of contextual emergence. This situation raises questions for how we think of determinism as a universal feature of macroscopic physics, as well as has implications for free will/determinism debates.

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Alexander Blum

Heisenberg's 1958 Weltformel and the roots of post-empirical physics

Wednesday, 9:30 - room 'Rood'

I will discuss the history of Werner Heisenberg's 1958 non-linear spinor theory ("Welt-formel") with a focus on the modes of theory motivation, selection, and justification. I will compare these with contemporary non- or post-empirical modes of theory evaluation, as discussed primarily in the context of string theory. I find striking similarities, which I will trace in particular to a general non-empirical bent in the underlying structure of quantum field theory.

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Jeremy Butterfield

On Dualities and Equivalences Between Physical Theories

Thursday, 14:30 - room 'Rood'

The main aim of this paper is to make a remark about the relation between (i) dualities between theories, as `duality' is understood in physics and (ii) equivalence of theories, as `equivalence' is understood in logic and philosophy. The remark is that in physics, two theories can be dual, and accordingly get called `the same theory', though we interpret them as disagreeing---so that they are certainly NOT equivalent, as `equivalent' is normally understood. So the remark is simple: but, I shall argue, worth stressing---since often neglected.

I will establish this point---I shall call it `Remark'---by: (a) reporting the account of duality in physics, developed by De Haro, which I endorse and which we call a `Schema'; and then (b) supporting the Schema with examples from classical and quantum physics, some of which illustrate the Remark .

As we shall see in these examples, two dual theories can `disagree' in either of two ways: either (Contr): by the theories making contrary assertions about a common subject-matter; (they may well agree on some claims, but they contradict each other over other claims); or (Diff): by the theories describing different subject-matters (though the descriptions are `isomorphic' or `matching'---hence the duality). (I will make precise the notion of a subject-matter: although for most of the paper this precision is not needed). I also agree that (Diff) hardly merits the label `disagreement', since both theories could be true. But `disagree' is just my convenient umbrella term. The main point is the same, for either (Contr) or (Diff): in both situations, one would not say that the dual theories are `equivalent', on any normal understanding.

Establishing the Remark leaves two tasks that occupy the second half of the paper. First, I spell out an *Implication* of the Remark: namely, a limitation of proposals (both traditional and recent) to understand theoretical equivalence either as logical equivalence or as a weakening of it. In short: two disagreeing dual theories might be formalised so as to be logically equivalent. And this implies that logical equivalence is too weak a criterion of theoretical equivalence---as is, therefore, any of the recently proposed weakenings of logical equivalence.

Second, I briefly discuss the Remark's application to dualities in string theory. Of course, this is a vast topic, which I cannot properly address. But my having established the Remark with examples from elementary (classical and quantum) physics prompts the question: Do dualities in more advanced physics, in particular in string theory, also illustrate it?

Indeed, this question is all the more pressing since (so far as De Haro and I know) the one duality in advanced physics that has been exhibited in detail as an example of our Schema (viz. bosonization, in De Haro and Butterfield 2017, Sections 4, 5) is, as it happens, a

duality in which the two dual theories do not disagree in either of the senses (Contr) or (Diff). Rather, they are both about a common subject-matter (viz. a quantum field system in 1+1 dimensions, i.e. with space one-dimensional), about which they say different but consistent things. Bosonization is thus a cousin---a very advanced cousin!---of position-momentum duality in elementary quantum mechanics: in which the position and momentum descriptions do not disagree but say different things about a common subject-matter.

In any case, I will argue that Yes, some string-theoretic dualities do illustrate the Remark. In fact both T duality and gauge-gravity duality (i.e. AdS/CFT duality) do so. Thus the paper has three main stages. The first stage establishes the Remark, with elementary examples from physics. Though the examples are elementary, the `tone' is philosophy of physics, rather than of logic. In the second stage, philosophy of logic comes to the fore. The third stage returns to philosophy of physics, with examples from string theory: examples which are, unfortunately, not as rigorously established as the elementary examples.

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Cristin Chall

Model-Groups as Scientific Research Programmes

Wednesday, 15:10 - room A

The framework of Lakatosian research programmes, modified to accommodate the model-groups of particle physics, explains the model dynamics within the search for physics beyond the standard model in the Higgs sector. At the moment, there is no evidence for BSM physics, despite a concerted search effort. The notion of scientific research programmes explains the way aspects of the periphery of a model-group change as the available parameter space shrinks, while the hard core remains unaltered. By way of motivation, I examine the case study of composite Higgs models under pressure from the discovery of the Higgs boson.

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Valeriya Chasova

Observers, references and symmetries

Wednesday, 09:30 - room D

I argue that an empirical symmetry needs two observers or at least two references to be established. I show what this implies for building a representation of an empirical symmetry and how this clarifies the ontology of theoretical symmetries.

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Elliott Chen

On Maxwell Gravitation

Wednesday, 16:30 - room 'Rood'

In this paper, I follow the general strategy of Dewar (2017) and express a version of his "Maxwell gravitation," free from appeals to covariant derivative operators--or equivalence classes thereof. Instead, restrictions to the mass-momentum tensor are made in terms of the standard of rotation introduced in Weatherall (2017) and more basic operators so as to make use of precisely the structure of Maxwell spacetime. I demonstrate that this new formulation is indeed equivalent to Dewar's, and argue that this vindicates Dewar and Weatherall's contention that there exists a unique correspondence between models of Maxwell gravitation and Newton-Cartan theory.

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Fabio Costa & Sally Shrapnel

Contextuality in ontological models without causal assumptions

Wednesday, 14:30 - room 0.42

All known no-go theorems against hidden-variable models for quantum mechanics assume ordinary dynamical laws, where an arbitrarily-picked initial state uniquely generates the future evolution. This leaves open the possibility for hidden variable models with exotic causal structure, where the future can influence the past or distant systems might be correlated due to global constraints. Here we show that such a possibility does not avoid the problem of contextuality: any model reproducing quantum predictions requires physical properties to depend on contextual aspects of the measuring procedure used to reveal them.

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Erik Curiel

Irreversibility in Thermodynamics versus in Statistical Mechanics

Thursday, 10:10 - room 'Rood'

I argue that formulations of the Second Law based on cyclic engines are the most powerful ones in classical thermodynamics, and that they have nothing intrinsically to do with temporal asymmetry. The fundamental asymmetry built in to classical thermodynamics has rather to do with the possibility of transforming heat into work as opposed to transforming work into heat. It bear no intrinsic relation to any temporal concepts at all. This raises immediate problems for reducing thermodynamics to statistical mechanics, since the irreversibility there is intrinsically related to temporal asymmetry. I conclude by discussing the status of black hole thermodynamics with regard to these issues.

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Radin Dardashti

What Constitutes a Problem in Physics? The Case of the Strong CP Problem

Wednesday, 17:10 - room D

In current fundamental physics empirical data is scarce, and it may take several decades before the hypothesised solution to a scientific problem can be tested. So, scientists need to be careful in assessing what constitutes a problem or not, for there may be the danger of providing a solution to a non-existing problem. In this talk I consider the strong CP problem of Quantum Chromodynamics as a case study. I take a philosophical look at the various arguments given for why it constitutes a problem, and the solutions for solving it.

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Siddhant Das & Detlef Dürr

Arrival Time Distributions of Spin-1/2 Particles

Friday, 11:50 - room 0.42

The arrival time statistics of spin-1/2 particles governed by Pauli's equation and defined by the respective Bohmian trajectories show unexpected and very articulated features. Comparison with other proposed statistics of arrival times as arising from the usual quantum flux or from semiclassical considerations suggests that the notable deviations be tested in an experimentum crucis for the validity of the Bohmian prediction for arrival times for spin-1/2 particles. The suggested experiment, including the preparation of the wave functions, could be done with present-day experimental technology.

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Richard Dawid

Finetuning and the Lack of Fundamental Free Parameters

Wednesday, 10:10 - room 'Rood'

The paper discusses the way in which the perspective of a universal fundamental theory without free parameters changes the role of finetuning arguments in physics. It has been suggested that finetuning arguments merely express aesthetic preferences. The assumption of a fundamental theory without free parameters allows for a substantially stronger role of finetuning arguments that is more reminiscent of stating low p-values in hypothesis testing. This is consistent with the broader view that an adequate understanding of the significance of finetuning arguments must account for the nature and status of expectations with regard to the next levels of fundamentality.

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Sebastian De Haro

Formulating Emergence in the Physical Sciences

Thursday, 15:10 - room 'Rood'

In this talk, I present a framework for emergence in the physical sciences, which I illustrate in two examples: the emergence of the property of masslessness in a massive theory, and the emergence of space in an algebraic model, a so-called random matrix model.

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Anne Deng

The Role of General Philosophy of Science in the Interpretation of Physical Theories: A Case Study

Wednesday, 14:30 - room D

This paper rejects the naïve view that general philosophy of science plays a role in the interpretation of physical theories, because it studies the concepts used to articulate an interpretation. Instead, this paper argues that in many cases, general philosophy of science plays a role, because it provides the resources with which we can articulate and hold a particular account of the philosophical concepts an interpretative claim uses. Doing so is useful in these cases, because it allows us to derive a further interpretative claim from the original one. This paper uses the Hertzian interpretation of force as a case study.

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Natalja Deng

Presentism, Triviality, and the Relativity Objection

Wednesday, 9:30 - room A

It's surprisingly difficult to elucidate what 'presentists' and 'eternalists' disagree on. Certain events happened that are not happening now; what is it to disagree about whether these events exist (simpliciter, or else tenselessly)? In spite of widespread suspicion concerning the status and methods of analytic metaphysics, skeptics' doubts about this debate have not generally been heeded, neither by metaphysicians, nor by philosophers of physics. This paper revisits the question in the light of prominent elucidation attempts from both camps (by Ted Sider and Christian Wüthrich). The upshot is that skeptics were right to be puzzled.

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Maaneli Derakhshani

Stochastic Mechanics is a Viable Foundation for Quantum Mechanics

Friday, 14:30 - room 0.42

Stochastic mechanics aims to provide a measurement-problem-free foundation for quantum mechanics, in terms of a theory of classical particles interacting with a classical-like ether such that the former undergo position-space diffusions that conserves their average energy (i.e., conservative diffusions). I will sketch the basic idea of stochastic mechanics, a long-standing objection to it (Wallstrom's criticism), and recent work that answers this objection (zitterbewegung stochastic mechanics). I will also explain how stochastic mechanics differs significantly from Bohmian mechanics, entails a certain "psi-epistemic" reading of the wave function, and implies deviations from standard quantum mechanics in certain domains.

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Thomas De Saegher

The Fate of Some Semantic Problems for Fuzzy Links in Relativistic Dynamical Reduction Models

Friday, 15:10 - room 'Rood'

I consider three sets of statements, made in the context of nonrelativistic quantum mechanics, that we would like to hold as equivalent in meaning but that fail to have common truth conditions in the ontology of these theories, with fuzzy link semantics. I argue that in relativistic collapse models using the past lightcone criterion of property attribution and nonstandard degrees of freedom, the corresponding statements are importantly differentiated and, therefore, problems of this form which have received considerable attention in the literature do not arise. I then explore what the application of fuzzy links in these relativistic theories does predict.

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Juliusz Doboszewski

On cosmological fatalism and large scale structure of spacetime

Thursday, 16:30 - room A

I discuss interpretational issues related to the question of determinism of cosmological models of classical general relativity in the light of the so-called cosmological no hair theorems. The emerging picture is the following: despite the fact that general relativitiy as such is an indeterministic theory, if we assume certain choices of physically reasonable global spacetime properties, cosmological models become deterministic in a very strong sense, namely future developments of any initial data are uniquely determined and converge to a unique physical state.

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John Dougherty

The inertial structure of a Newtonian cosmos

Wednesday, 11:10 - room A

Knox and Saunders have drawn attention to the inertial structure in Newtonian gravitation. Subsequent work by others has argued that Knox's and Saunders' recommendations converge on an essentially unique spacetime structure. In this paper I show that this work has neglected an important alternative formulation, and I argue that this alternative more faithfully captures the sense in which linear acceleration is a "gauge" symmetry. With this analogy in view, it is clear that potential-based formulations of Newtonian gravity are not indeterministic. I use this example to argue against the Wallace—Greaves analysis of phenomena like Galileo's ship experiments.

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Stephan Eijt

1, 2, Many: Emergence in positron-electron systems

Friday, 10:10 - room D

Positron-electron systems form an prospective starting point to examine the concept of emergence in physics. The development of quantum electrodynamics – "the theory of positrons" – shifted the character of a single particle theory of electrons to a many-body theory, leading to a fundamentally more complex base level in the hierarchy of science. Positronium – the bound state of a positron and an electron – on the other hand can be considered as a single electron entity in 4-dimensional space-time, bound by self-interaction via photons. It will be argued that positronium, di-positronium molecules and positron-electron pair plasmas constitute relatively simple systems to investigate emergence in physics, including phenomena as plasma waves and Bose-Einstein condensation.

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Peter Evans

A sideways look at faithfulness

Friday, 11:50 - room 'Rood'

Wood and Spekkens argue that any causal model purporting to explain the observed correlations in an entangled bipartite quantum system must violate the assumption of faithfulness. This talk is an attempt to undermine the reasonableness of the assumption of

faithfulness in the quantum context. Employing a symmetry relation between an entangled bipartite quantum system and a 'sideways' quantum system consisting of a single photon, I argue that Wood and Spekkens' analysis applies equally to this sideways system. As a result, either there is no causal explanation of the sideways system, or a violation of faithfulness in both is more tolerable than first thought.

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Benjamin Feintzeig

Quantization, Approximation, and Interpretation

Wednesday, 16:30 - room A

I use the mathematical tools surrounding quantization procedures to spell out a detailed notion of "approximation on certain scales". I show that the same mathematical tools are not available in the formalism for effective field theories even though the effective field theory interpretation relies on such a notion of "approximation". I argue that either further philosophical work needs to be done to interpret the mathematical tools in effective field theories or else further mathematical work needs to be done to construct a formalism for effective field theories that we can interpret in the standard ways.

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Aldo Filomeno

Statistical necessity without a guiding dynamics

Thursday, 11:50 - room 'Rood'

Can stable regularities be explained without appealing to governing laws or any other modal notion? In this paper, I consider what I will call a 'Humean system'—a generic dynamical system without guiding laws—and assess whether it will display stable regularities. First, I present what can be interpreted as an account of the rise of stable regularities, following from Strevens (2003), which has been applied to explain the patterns of complex systems (such as those from meteorology and statistical mechanics). Second, since this account presupposes that the underlying dynamics displays deterministic chaos, I assess whether it can be adapted to cases where the underlying dynamics is not chaotic but truly random—that is, cases where there is no dynamics guiding the time evolution of the system. If this is so, the resulting stable, apparently non-accidental regularities are the fruit of what can be called statistical necessity rather than of a primitive physical necessity.

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Samuel Fletcher

Reduction and Causal Set Theory's Hauptvermutung

Thursday, 11:10 - room A

The reduction of causal set theory to general relativity has played such a central role in that theory's research program that it has been named its hauptvermutung. Thus it provides a rich case study for reduction in the making, both to synthesize clearly what the problems are and to provide a fresh example through which to examine the venerable issue of intertheoretic reduction. In particular, I hope that putting in the conceptual and technical work to clarify what the hauptvermutung is supposed to claim reveals that the character of the proposed reduction cannot be easily subsumed under the Nagelian model.

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Sebastian Fortin, Hernán Accorinti & Jesus Alberto Jaimes Arriaga

Phonons: a case of intra-theoretic relationship

Friday, 09:30 - room D

Usually, a solid is conceived as a network of atoms that can vibrate around its equilibrium position generating propagating waves. However, the fact that the energy of these waves is quantized suggests an analogy with the electromagnetic field; then, the quantum "particle" called phonon is defined. In this work we study the relation between the description levels of phonons and of atoms as a case of intra-theoretical relationship. Finally, we will analyze the possibility of conceiving the ontological status of phonons from a pluralist perspective.

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James Fraser

The Renormalization Scheme Dependence Problem: A Topography and Analysis

Wednesday, 14:30 - room A

The renormalization procedure of perturbative quantum field theory suffers from an ambiguity: there are different ways of fixing the renormalization scheme which give rise to different predictions when the series is truncated. I review the various proposed solutions to this problem, distinguishing between strategies based on an analysis of the structure of the Feynman diagram expansion, which I argue are conceptually misguided, and those based on renormalization group arguments. I close by sketching a framework for accounting for the success of perturbative quantum field theory which fits neatly with the principle of minimal sensitivity approach to scheme dependence.

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Simon Friederich

Testing multiverse theories and the problem of researcher degrees of freedom

Friday, 17:10 - room A

This contribution discusses whether physical theories that postulate other universes with different laws and constants – together forming a "multiverse" – can be empirically tested. It comes to a pessimistic conclusion, but the problem is not merely that hypothetical other universes cannot be directly accessed. The true problem for testing multiverse theories is that researchers must in practice choose an "observer proxy" and a "cosmic measure" to equip those theories with empirical content. We can expect researchers to – consciously or unconsciously – become victims of confirmation bias and exploit thoses choices to arrive at findings compatible with their preferred multiverse frameworks, thus undermining the credibility of any claimed successful tests of concrete multiverse theories.

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Marco Giovanelli

'Like classical Thermodynamics before Boltzmann'. Why did Einstein Compare Relativity Theory with Thermodynamics?

Friday, 14:30 - room D

The paper investigates the pre-history of Einstein's 1919 claim that relativity theory is a principle theory, like classical thermodynamics, and not a constructive theory, like the kinetic theory of gases. Einstein started to compare relativity theory to 'classical thermodynamics before Boltzmann' in 1907/1908 to defend his derivation of the velocity dependence of the electron mass. Sommerfeld, Ehrenfest, and Born insisted that Einstein's derivation was not justi?ed without making some assumptions about the shape, charge distribution, and nature of the mass of the electron. By contrast, Planck, Minkowski, and Laue recognized the validity of Einstein's strategy of setting up a relativistic mechanics of structureless point particles. The paper argues that, by investigating this debate, it is possible to get a deeper insight into the meaning of Einstein's principle/constructive theory opposition. Di?erently to what it is usually claimed, Einstein's thermodynamics/relativity theory analogy was not meant to emphasize that relativity theory is ultimately a byproduct of some deeper level theory analogous to the kinetic theory of gases. On the contrary, it was meant to show that the relativity principle, like the two principles of thermodynamics, is a constraint that we impose on such theories, but whose validity does not depend on any of them.

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Nicolas Gisin

Indeterminism in Physics, Real Numbers, Classical Chaos and Bohmian Mechanics

Friday, 9:30 - room 'Rood'

It is usual to identify initial conditions of classical dynamical systems with mathematical real numbers. However, almost all real numbers contain an infinite amount of information. Since a finite volume of space can't contain more than a finite amount of information, I argue that the mathematical real numbers are not physically real. Moreover, a better terminology for the so-called real numbers is ``random numbers'', as their series of bits are truly random or, equivalently, ``finite-information number'' as no finite program allows one to compute all their digits. I propose an alternative classical mechanics that uses only finite-information numbers. This alternative classical mechanics is non-deterministic, despite the use of deterministic equations, similarly to quantum theory. Interestingly, both alternative classical mechanics and quantum theories can be supplemented by additional variables in such a way that the supplemented theory is deterministic. Most physicists easily supplement classical theory with real numbers to which they attribute physical existence, while most physicists reject Bohmian mechanics as supplemented quantum theory, arguing that Bohmian positions have no physical reality. I argue that more economical and natural is to accept non-determinism with potentialities as a real mode of existence.

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Márton Gömöri

Why do initial conditions in an actual sequence of experiments approximately follow the uniform distribution over phase space with respect to the Lebesgue measure?

Thursday, 16:30 - room D

In many physical situations (such as in gambling games or in statistical mechanics) the distribution of actualized initial conditions in a sequence of repeated experiments is assumed to be approximately uniform over a certain region of phase space. How is this assumption justified? In the talk I will propose a new answer to this question based on the Principle of the Common Cause.

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Alexei Grinbaum

What's in the input/output distinction?

Thursday, 10:10 - room 0.42

Only two fundamental assumptions are at work in a device-independent approach: the inputs and the outputs are clearly distinguished; and the connection between them is

physical. A philosophy of physics that supports this conception is free of any human element. It describes what the observer is through what the observer does: it operates with strings in finite alphabets. Our framework puts forward a set of conditions for a theory to contain the notions of physical system, local observer and causality; it also shows a natural way to obtain contextuality and probability starting only with the inputs and the outputs.

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Bixin Guo

The Bare Manifold and the Metric Structure: The Nature of Spacetime in General Relativity

Thursday, 9:30 - room A

In the general theory of relativity, the classical debate between substantivalism and relationism becomes fuzzy. I will approach this debate, and in particular this fuzziness, by analyzing how the debate is related to the discussion about whether the dynamics or the geometry comes first in special relativity, which is normally taken to be a distinct debate. I will argue that the metric and topological structures of spacetime need to be separated in both of these debates, and that such a separation shows how substantivalism and relationism need to be developed in general relativity and what problems they need to overcome.

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Ronnie Hermens

Ψ-ontic models without Ψ

Wednesday, 15:10 - room 0.42

In this talk I will explain a new loophole for Psi-ontology theorems. Specifically, it concerns a mismatch between the formal definition of Ψ-onticity adopted in theorems (in terms of non-overlapping probability distributions) and the philosophical idea that in a Ψ-ontic model the ontic state of a systems determines the quantum state of that system. Explicit examples will be given of ontic models that are Ψ-ontic according to the first definition, but not the second.

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Manuel Herrera

Conservation laws: a philosophical analysis of their status

Wednesday, 11:10 - room 'Rood'

According to an extended view in physical sciences, conservation laws are derived from the dynamical laws of a theory. Nonetheless, the status of conservation laws has been widely discussed in the philosophy of science, and some philosophers hold that conservation laws have a more fundamental character than dynamical laws. In this talk, we will argue in favor of this view by appealing to modal notions. Besides this, we will claim that the status assigned to conservation laws is decisive in some philosophical problems of the philosophy of physics.

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Gábor Hofer-Szabó

What is quantum contextuality, and what is not?

Wednesday, 10:10 - room 0.42

In this paper I will argue that Spekkens' (2005) (measurement) noncontextuality assumption does not express noncontextuality; rather it is a kind of inference to the best explanation prescribing, roughly, that the probabilistic structure of an operational theory should match with that of the underlying ontological model. Next, I review various interpretations of contextuality by Bohr, Bell and others and define contextuality in a strict physicalist sense. I will argue that the Kochen-Specker theorems are ineffective against this physicalist noncontextuality for the simply reason that commutativity in quantum theory does not capture the notion of simultaneous measurability.

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Marc Holman

Some Issues and Non-Issues in Concordance Cosmology

Friday, 14:30 - room 'Rood'

The so-called "flatness problem" is widely taken to be a major outstanding problem of modern cosmology and as such forms one of the prime motivations behind inflationary models. Upon distinguishing three different versions of this putative problem, I show that the observational fact that the large-scale Universe is so nearly flat is ultimately no more puzzling than similar "anthropic coincidences", such as the specific (orders of magnitude of the) values of the gravitational and electromagnetic coupling constants. In particular, there is no fine-tuning problem in connection to flatness of the kind usually argued for. Furthermore, the arguments regarding flatness and particle horizons typically found in cosmological discourses in fact address a mere single issue underlying the standard FLRW

cosmologies, namely the extreme improbability of these models with respect to any "reasonable measure" on the "space of all spacetimes". In other words, there is arguably a serious cosmological fine-tuning problem, but it pertains to generic FLRW geometries. By their very nature, dynamical mechanisms such as inflation are inapt for addressing this latter problem.

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Sabine Hossenfelder

How Beauty leads Physics Astray

Tuesday, 16:15 - 'Aula' Academiegebouw, Domplein 29

To develop fundamentally new laws of nature, theoretical physicists often rely on arguments from beauty. Simplicity and naturalness in particular have been strongly influential guides in the foundations of physics ever since the development of the standard model of particle physics. In this talk I argue that arguments from beauty have led the field into a dead end and discuss what can be done about it.

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Josh Hunt

Symmetry and Degeneracy in the Hydrogen Atom

Thursday, 17:10 - room 'Rood'

I interpret the symmetries of hydrogen using Marc Lange's accounts of natural laws and mathematical coincidences. Hydrogen possesses both a geometrical SO(3) symmetry and a dynamical SO(4) symmetry. The SO(3) symmetry functions as a meta-law that explains conservation of hydrogen's angular momentum but not vice versa. In contrast, the dynamical SO(4) symmetry is merely a byproduct of first-order laws, preventing it from explaining its associated conservation law. Finally, I interpret the degeneracies associated with these symmetry groups, illustrating an explanatory difference between deriving degeneracies from equations of motion alone vs. deriving them from symmetry principles. Lange's account of mathematical coincidences accounts for this explanatory difference.

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Caspar Jacobs

Why Cosmology Does Not Prove the Past Hypothesis

Thursday, 15:10 - room A

It is generally thought that to reconcile the time-asymmetric nature of thermodynamics with the time-reversal symmetry of the fundamental laws of nature, we need to postulate that the entropy of the universe at or near the Big Bang was low (the Past Hypothesis (Albert 2000)). Furthermore, it is often claimed that modern cosmology proves that the Past Hypothesis is correct (e.g. Callender (2008), Frigg (2012), Price (1996)). I dispute both claims. More specifically, I argue firstly that the PH need not be postulated at or near the Big Bang, and secondly that cosmology does not prove but assumes the PH.

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Ted Jacobson

Diffeomorphism invariance and the information paradox

Friday, 13:30 - room 'Blauw'

The apparent conflict between boundary unitarity and local quantum field theory presents the sharpest form of the information paradox. I'll argue that the paradox arises not only for processes involving black holes, but much more generally, and that its resolution requires accounting fully for the consequences of diffeomorphism invariance for the nature of states and observables. A resolution like this should be expected since, according to an argument of Marolf, it is diffeomorphism invariance that is responsible for boundary unitarity.

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Rasmus Jaksland

Probing spacetime with a holographic relation between spacetime and entanglement

Friday, 11:10 - room A

This paper introduces and examines the prospects of the recent research in the Ryu-Takayanagi formula; a holographic relation between entanglement and spacetime. Based on this relation, Mark van Raamsdonk speculates that "[b]y removing all the entanglement […], the dual spacetime disappears entirely!" (2016, 23). The present paper argues that any quantitative verification of this speculation faces immediate difficulties. Furthermore, a qualitative assessment finds that the energy density risks diverging when all entanglement is removed. This questions the validity of the Ryu-Takayanagi formula in this regime and therefore van Raamsdonk's speculation.

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Kevin Kadowaki

On Rotation Curve Analysis

Friday, 16:30 - room A

Saari (2015) contends that the standard method of using rotation curves analysis to trace the mass profiles of galaxies significantly overestimates the mass of these galaxies. I show that his interpretation of his results is flawed that he does not accurately represent these standard methods.

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Raffael Krismer

Pragmatist Quantum Mechanics

Thursday, 9:30 - room 0.42

I assess Richard Healey's pragmatist interpretation of quantum mechanics (Healey: 2011, 2017), which is built around the idea that the quantum state is non-representational. After arguing that Healey's argument in favour of his view is unsatisfactory, I will propose that Rovelli's (1996) relational quantum mechanics (or some variant thereof) allows us to make the best sense of the idea that quantum state ascriptions do not represent or describe objective facts about the world.

†††

Luigi Laino

Between Knots and Links: an Argument in Favour of the Transcendental Representation of Space in Loop Quantum Gravity

Friday, 14:30 - room A

The proposal aims to show the possibility of a transcendental construction of physical reality within LQG. Hence it deals with two basic aspects of such a theory: 1) the analysis of the concept of granularity of space, especially pointing out the divergences running between such a granularity and that of matter, and 2) the enquiry on the structure of the quanta of space. The proposal finally shows that the integration of the knots with links presupposes the logical function of proximity and allows an a priori representation of space.

†††

Thao Le & Alexandra Olaya-Castro

Perceived objectivity via strong quantum Darwinism and spectrum broadcast structure

Wednesday, 16:30 - room D

\Quantum Darwinism and spectrum broadcast structure are two similar theories to understand and define the emergence of objective state properties. However, they give unequal conclusions to perceived objectivity. Here, we unify the two theories by upgrading quantum Darwinism to "strong quantum Darwinism" and proving that it is equivalent to spectrum broadcast structure. By doing so, we now have equivalent methods of approaching perceived objectivity: via the geometric picture in spectrum broadcast structure, and via the information-theoretic/entropic picture of strong quantum Darwinism.

†††

Gijs Leegwater

Turning indeterminism into determinism: Does it matter when God throws his dice?

Friday, 10:10 - room 0.42

Einstein wrote in a letter to Max Born that he thought that God does not throw dice, referring to the indeterminism present in the theory of quantum mechanics. In this talk, we will use this picture of a dice-rolling God to illustrate a general method of turning an indeterministic theory into a deterministic one. Then, we will discuss how this relates to Bell's theorem about the incompatibility of quantum mechanics and local determinism.

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Leevi Leppäjärvi & Teiko Heinosaari & Sergey Filippov

Measurement simulability in general probabilistic theories

Thursday, 16:30 - room 0.42

One of the most fundamental features of quantum theory is the existence of incompatibility as it can be found in the core of many distinguished features of the theory such as the violation of Bell inequality and the no-broadcasting theorem. A recent operational notion of obtaining new observables by classical means from existing ones, measurement simulability, can be seen as an extension of compatibility of measurements. We consider measurement simulability in the operational framework of general probabilistic theories with applications to quantum theory and examples in a class of toy models of polygon state spaces.

†††

Olimpia Lombardi & Manuel Herrera

Understanding decoherence by comparing classical and quantum irreversibility

Wednesday, 17:10 - room A

If decoherence is an irreversible process, its physical meaning might be clarified by comparing quantum and classical irreversibility. In this talk we carry out this comparison, from which a unified view of the emergence of irreversibility arises, applicable both to the classical and to the quantum case. According to this unified view, in the two cases the relation between the irreversible macro-level and the reversible micro-level is a kind of generalized coarse-graining, mathematically defined as a projection. This position supplies an understanding of the phenomenon of decoherence different from that implicit in most presentations: the reduced state is not the quantum state of the open system, but a coarse-grained state of the closed composite system; as a consequence, decoherence is not a phenomenon resulting from the interaction between an open system and its environment, but rather it is a coarse-grained evolution that emerges from disregarding certain degrees of freedom of the whole closed system.

†††

Cristian Lopez

Time reversal, the arrow of time and metaphysical commitments

Wednesday, 10:10 - room A

In this presentation, I shall in general argue that the widely-extended view to formally represent time reversal in quantum mechanics, and the claim that the Schrödinger's equation is time-reversal invariant, can both be challenged. I shall put forward two arguments. In the first place, I shall show that such extended view encloses some metaphysical commitments that have been frequently overlooked and which can be contested. In the second place, I shall argue that such extended view on time reversal conflicts with the problem of the arrow of time's main motivations.

†††

Leon Loveridge, Paul Busch & Takayuki Miyadera

Symmetry, Reference Frames, and Relational Quantities in Quantum Mechanics

Thursday, 15:10 - room 0.42

Physical quantities are defined/measured relative to a physical frame of reference. If quantum mechanics is fundamental, this reference frame is described by quantum mechanics. From this emerges a new kind of quantum relationalism and a fresh perspective on basic concepts in quantum mechanics: states and observables must be understood as relating to two systems, quantum coherence finds a new definition, and a resolution of an

old controversy on the nature and scope of superselection rules dating back to an exchange between Wick, Wightman and Wigner and Aharonov and Susskind follows naturally. Moreover, "timeless" formulations of quantum theory have a natural place in the relational formalism.

†††

Joanna Luc & Tomasz Placek

On generalised probability space representations of quantum mechanical experiments

Thursday, 17:10 - room 0.42

The program of generalised probability spaces allows one to refrain from ascribing joint probabilities to outcomes of measurements of non-commuting observables. This feature was hoped to block the derivation of Bell-type theorems. Our aim is to see to what extent this hope is vindicated and (more generally) to compare generalised probabilities and classical probabilities with respect to their capacities to model quantum mechanical experiments. Our results indicate that the project of generalized probability spaces is more successful than one might have initially thought.

†††

Joshua Luczak & Lena Zuchowski

The Ehrenfests' Use of Toy Models to Explore Irreversibility in Statistical Mechanics

Thursday, 17:10 - room D

This article highlights and discusses the Ehrenfest's use of toy models to explore irreversibility in statistical mechanics. In particular, we explore their urn and P-Q models and highlight that while the former was primarily used to provide a simple counter-example to Zermelo's objection to Boltzmann's statistical mechanical underpinning of the Second Law of Thermodynamics, the latter was intended to highlight the role and importance of the Stosszahlansatz as a cause of the tendency of systems to exhibit entropy increase. We also explain the sense in which these models are toy models and why agents can use them, as the Ehrenfest's did, to carry out this important work, despite the fact that they do not represent any real system.

†††

Jb Manchak

Some "No Hole" Spacetime Properties Are Unstable

Wednesday, 15:10 - room 'Rood'

It has been argued that "it is a general feature of the description of physical systems by mathematics that only conclusions which are stable, in an appropriate sense, are of physical interest'' (Geroch, 1971, 70). Here, we consider the (in)stability of the spacetime property of effective completeness which rules out "local holes'' in spacetime (see Earman 1989).

The main result of the paper is this: effective completeness is not stable; an effectively complete spacetime can be arbitrarily "close" to spacetimes without this property. The result holds in *any* of the usual topologies that one can place on the space of spacetimes -- including those which are quite fine (Geroch 1971). This result is quite surprising and calls into question the very significance of this promising condition of effective completeness.

†††

Niels Martens

Symmetry-to-reality inferences: The Aharonov-Bohm Efffect as a Case Study for Motivational Realism

Thursday, 16:30 - room 'Rood'

According to the received view on symmetry-to-reality inferences, models related by a symmetry can and should invariably be interpreted as representing the same physical state of affairs. A recent opposing view (Møller-Nielsen, 2017) claims that symmetries merely motivate us to explicate a common ontology underlying models related by these symmetries. Only once such an explication is found, if at all possible, are we licensed to interpret those models as representing the same possible world. I generalize and modify the latter view by taking into account the role of explanatory power, and illustrate it with a case study: the Aharonov-Bohm effect.

†††

Vera Matarese

Quantum Gravity: A Threat to Humeanism?

Friday, 15:10 - room D

This paper discusses whether quantum gravity constitutes a threat to Humeanism. It is well known that while Humeans posit spatiotemporal relations at the most fundamental level of our reality, Quantum Gravity aims to conceptualize a layer of reality more fundamental than our spacetime, a 'quantum spacetime', which does not look like a spacetime at all.

Therefore, the threat: are the Humeans still right in positing spacetime at the fundamental level of our reality? Shouldn't their position be discarded in the light of the teachings from Quantum Gravity?

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C. D. McCoy

Why is Planck's constant a universal constant?

Friday, 11:10 - room 'Rood'

I raise the question of the title, suggest some motivations for doubting the presupposition of the question, and survey how experimental results, both historically and more recently, are interpreted as bearing on Planck's constant.

†††

Tushar Menon

Clocks and Chronogeometry: Rotating spacetimes and the relativistic null hypothesis

Wednesday, 11:50 - room A

In 2013, Fletcher proved a theorem, which he interpreted as demonstrating that "for any timelike curve in any spacetime, there is a light clock that measures the curve's length as accurately and regularly as one wishes". Fletcher takes, as definitional of light rays, that they always traverse null geodesics of the metric field. In this talk, we discuss a recent result by Asenjo and Hojman, which demonstrates that light does not always traverse null geodesics. Thus, even in classical general relativity, the operational significance of the metric may be harder to come by than has hitherto been appreciated.

†††

Ruward Mulder

Emergence and Pragmatism in David Wallace's Emergent Multiverse

Wednesday, 17:10 - room 0.42

In this paper two elements of David Wallace's "The Emergent Multiverse", the most thorough work on contemporary Everettian quantum mechanics, are analyzed. First, in the emergence of quasi-classical worlds from the universal wavefunction, it is found that the concept of 'emergence' is of the weak kind rather than the strong: they are easily derived by a Laplacian demon. Second, the use of functionalism through what Wallace calls 'Dennett's criterion', in which he appeals to the virtue of usefulness as a criterion for reality. This criterion obscures the conclusion of weak emergence. I point out an analogy with van

Fraassen's pragmatic theory of explanation, namely that in the context of a pragmatic goal the classical pattern is made salient over other patterns, which are non-classical, but objectively existing. I conjecture three situations in the context of which the classical pattern is indeed special: (i) the *reduction* of classical mechanics to quantum mechanics, (ii) the anticipation and rejection of a *many-minds*-like reply, and (iii) *locality*, specifically the possibility to speak about 'emergent local beables' in classical spacetime structures. Nevertheless, in the absence of such goals, there is no reason to regard the classical pattern as `more real' than other patterns, and the pragmatic values imported through Dennett's criterion are not necessary to solve the measurement problem. The functionalism does work well in addressing the form that the ontology problem takes in Everettian quantum mechanics.

†††

Angelika Mus-Nowak

Is grounding metaphysics on the findings of current scientific theories justified?

Friday, 11:50 - room D

Structural realism is a weakened form of scientific realism. Depending on the version structuralism assumes eliminative or restrictive form: according to the ontological structuralism the world consists of structures only; its epistemological version, although acknowledges the existence of objects, assumes that their nature is cognitively inaccessible to us. Ontological structuralism is said to provide adequate response to the findings of the modern physics, particularly quantum mechanics, quantum field theory and general relativity. The main objective of the talk is to present new charge against structuralism: I will question whether the grounding metaphysics on the findings of current scientific theories is reasonable.

†††

Wayne Myrvold

Explaining Thermodynamics: What Remains to be Done?

Thursday, 9:30 - room 'Rood'

I will argue that we have satisfactory statistical mechanical explanations of the Zeroth, First, and Second Laws of thermodynamics. This means that what remains to be done, in the task of providing a statistical mechanical explanation of thermodynamics, is to explain the Minus First Law: the tendency of systems to equilibrate. There is considerable physical literature on this, which has so far attracted little attention from philosophers. The aim of this talk is to convince philosophers that equilibration results deserve their attention, and to discuss the foundational significance of one such result, that of Linden, Popescu, Short, and Winter.

†††

Paul M. Näger

A Stronger Bell Argument for (Some Kind of) Parameter Dependence

Friday, 9:30 - room 0.42

It is widely accepted that the violation of Bell inequalities excludes local theories of the quantum realm. Deriving Bell-like inequalities from non-trivial non-local theories, this paper shows how the Bell argument can be strengthened to exclude also certain non-local theories. Rather than by 'outcome dependence or parameter dependence' (the established analysis), the remaining smaller set of theories which can violate Bell inequalities (among them quantum theory) are characterised by the fact that at least one of the measurement results in some sense (which is made precise) depends probabilistically both on its local as well as on its distant measurement setting ('parameter').

†††

Daniel Sega Neuman

Is Cosmic Inflation a Testable Theory?

Thursday, 14:30 - room A

Results from the Planck Collaboration published in 2013 and 2016 have discarded some models of inflation and favor others. Nevertheless, some cosmologists have put into question the testability of inflation. Using a Bayseian framework of confirmation, and Popper's notion of testability, we study the structure of current theories of inflation to determine their testability. We find inflation to be untestable under these frameworks, at least in its current form. Finally, we attempt a less rigorous, and ask what benefits, if any, does being rigorous about testability can bring us in the quest of studying the origins of the cosmos.

†††

Pablo Ruiz de Olano

Symmetries in Physics: Variational, Dynamical, and Hamiltonian

Wednesday, 10:10 - room D

In this paper, I investigate the manner in which symmetries and conservation laws relate to each other in quantum and in classical mechanics. My main two claims are as follows. First, I argue that the nature of the connection between symmetries and conservation laws is different in the Hilbert space formulation of quantum mechanics and in the Hamiltonian formulation of classical mechanics. Secondly, I account for the significance of this result in

light of the existing work in the literature on symmetries in physics. I engage, in particular, with the work of Pablo Ruiz de Olano, Harvey Brown and Peter Holland, and Peter Olver.

†††

Jorge Alberto Manero Orozco

Imprints of the Underlying Structure of Physical Theories

Friday, 11:10 - room D

In the context of scientific realism, this paper intends to provide a formal and accurate description of the structural-based ontology posited by classical mechanics, quantum mechanics and special relativity, which is preserved as these theories evolve. Along the lines of ontic structural realism, such a description is undertaken by a particular ontological commitment: the belief in the existence of a freestanding actual structure, represented by a subgroup of the inhomogenous symplectic group (up to group homomorphisms), and their corresponding state-space representations. Accordingly, the hierarchy and the complexity of this group-theoretical structure is represented by appropriate philosophical tools, namely, by the language of partial structures. Upon this approach, the lack of knowledge of some relations that hold at the boundary between mathematics and physics, and the presence of surplus structure within the structural edifice are explored and represented. The conclusive issue appeals to an interesting example of a surplus but fruitful structure, where superposition of states with different mass are suggested to be actual relativistic remnants within non-relativistic quantum mechanics, as opposed to the standard interpretation where they are empirically meaningless.

†††

Patricia Palacios & Lapo Casetti

Redefining Equilibrium for Long-range Interacting Systems

Thursday, 14:30 - room D

We address the problem of defining equilibrium for long-range interacting systems on the basis of statistical ensembles and argue that this problem is due to the lack of a relevant time-scale in the statistical mechanical description. In consequence, we contend that adding a specific time-scale to the statistical treatment can give us a satisfactory definition of equilibrium for the examples being considered. Finally, we relate this discussion with Werndl and Frigg's work on the difference between Gibbs' and Boltzmann' formalisms and argue that the case of long-range interacting systems fits better with what they take as the Boltzmannian equilibrium.

†††

Tim Palmer

A Finite Theory of Quantum Physics

Friday, 11:10 - room 0.42

Hardy's axiomatic approach to quantum theory revealed that just one axiom distinguishes quantum theory from classical probability theory: there should be continuous reversible transformations between any pair of pure states. The raises the question: Does there exist a finite theory of quantum physics (FTQP) - necessary different from quantum theory - which can replicate the tested predictions of quantum theory to experimental accuracy? Here we show that an FTQP is possible providing the metric of state space is based on p-adic rather than Euclidean distance. The close relationship between fractals and p-adic numbers suggests that laws of physics in space-time derive from a fundamental fractal-like geometry in cosmological state space.

†††

Taimara Passero

The Geometrization as a Thema in the History of Physics

Wednesday, 11:50 - room 'Rood'

Different types of Geometrization can be seen in different periods. We can think about at least three distinct moments: Geometrization in Antiquity, in Natural Philosophy and in Modern Physics. I propose to consider the notion of Geometrization as a thema in Gerald Holton's sense. The study of Geometrization from the perspective of a thema provides us with: a broader view that takes into account different contexts in which there was a Geometrization; and the ability to see in different periods, in spite of the conceptual specificities of the time, what remains constant.

†††

Roger Penrose

Worlds Before the Big Bang: Colliding Black Holes and the Creation of Dark Matter

Wednesday, 20:00 - 'Theatron'

Using pictures, I introduce the cosmological scheme of conformal cyclic cosmology (CCC), which takes what is normally thought of as the entire history of our universe to be but one aeon in an infinite succession of such aeons. Collisions between supermassive black holes in the aeon previous to ours produce observed circular features in our cosmic microwave background. CCC's equations demand the creation of new material at the beginning of each aeon, conjectured to be the mysterious dark matter.

†††

J. Brian Pitts

What Are Observables in Hamiltonian Einstein-Maxwell Theory?

Wednesday, 17:10 - room 'Rood'

Is change missing in Hamiltonian General Relativity with Maxwellian electromagnetic fields? This question requires an adequate definition of observables, the finding and testing of which is a multi-step process. Pitts has proposed bifurcation of observables to require invariance under internal gauge symmetries but only covariance (a 4-dimensional Lie derivative) under external gauge (coordinate) symmetries. This definition implies that the electromagnetic field strength is observable for Maxwell and the metric and its concomitants are observable for Einstein, considered in isolation. But does the definition yield plausible results when applied to Einstein-Maxwell theory, which exhibits a combined internal-external gauge symmetry?

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Oliver Reardon-Smith & Paul Busch

Measurement uncertainty and covariance

Thursday, 14:30 - room 0.42

It is well known that the presence of symmetries significantly simplifies a wide variety of mathematical tasks, as well as having a crucial role in fundamental physics. Here I introduce covariance as a systematic approach for exploiting available symmetries and detail an interesting case study, a problem in the field of measurement uncertainty, which is made tractable in arbitrary finite dimensions by the covariance framework.

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Miklós Rédei & Zalán Gyenis

Categorial independence in categorial quantum field theory

Thursday, 11:10 - room D

In the categorial approach to quantum field theory initiated by Brunetti, Fredenhagen and Verch (2003), the independence of spacelike separated quantum systems is implemented by imposing locality conditions on the covariant functor representing the quantum field. In the talk a purely categorial notion of subobject independence is suggested and its general properties analyzed. It is argued that specifying the suggested categorial independence

concept in terms of the category of operator algebras with operations as morphisms one obtains an independence condition that should be postulated for the covariant functor to hold in order to express physical locality in categorial quantum field theory.

†††

Sam Rijken

Non-locality and timelike Bell-type inequalities

Thursday, 11:10 - room 0.42

I analyze the physical meaning of independence assumptions required for the factorizability of timelike Bell-type inequalities, and, consequently, what it means when such inequalities are violated. Then, I discuss how we may distinguish between often-conflated conceptions of retrocausality, retrodiction, and even conspirational determinism. I aim to shed light on the qualitative differences between spacelike and timelike non-locality, on where and how locality constraints enters physics, and on how violations of locality constraints motivate theory choice.

†††

Martin Ringbauer

Experimental metaphysics: Probing the foundations of quantum theory

Friday, 15:10 - room 0.42

Quantum mechanics is our most successful physical theory, yet the debate about what it actually says about the world remains as active as ever. In a photonic experiment on high-dimensional quantum systems, we demonstrated that if there is any observer-independent reality in our world, the quantum wavefunction must be part of that reality. We further show, in a Wigner's friend-type experiment, that different observers can experience fundamentally incompatible realities. Interpretations which reject the notion of observer-independent reality, must thus also give up objective facts of the world. To maintain realism, one could subscribe to a many-worlds interpretation.

†††

Sébastien Rivat

Renormalization Scrutinized

Wednesday, 11:10 - room D

The goal of this talk is to introduce a new framework for understanding the conceptual structure of renormalization in high energy physics. I criticize the current view that the

Wilsonian Renormalization Group Theory fully dispels the worries physicists had in the 1940s, and I suggest to distinguish more generally between the "effective" and the "continuum" approach to renormalization. After presenting key formal and conceptual differences between the two, I argue that the contrast helps to dispel the mystery surrounding the success of the renormalization procedure and gives reasons to temper Butterfield and Bouatta's recent claim that continuum Quantum Field Theories are ripe for metaphysical inquiry.

†††

Davide Romano:

A Proposal for the Classical Limit in Bohm's Theory

Wednesday, 15:10 - room D

The problem of the classical limit of quantum mechanics is rather peculiar: classical mechanics is well-understood, and successfully describes the behavior of the macroscopic objects; quantum mechanics is also well-understood and successfully describes the behavior of the microscopic entities composing the macroscopic objects. Yet, surprisingly enough, there is no clear explanation for the connection between the two. In this paper, I shall present a strategy, based on two steps, to solve the classical limit problem in Bohm's theory. In this theory, an N particle system is represented by the usual wave function defined in configuration space plus a configuration of N actual particles in three-dimensional space. Therefore, the problem of the classical limit amounts to show that: 1. The wave function "disappears" in the classical regime; 2. The Bohmian trajectories becomes approximately Newtonian. The answer to the first question is due to the formation of well-localized effective wave-functions (WL-EWFs) for the subsystems of entangled states. The emergence of the WL-EWFs destroys the holistic non-local dynamics between very distant systems, and –because of that- we do not perceive the wave function at the macroscopic level. Moreover, this process provides a physical explanation of decoherence effects in Bohm's theory. Concerning the second question, I will suggest a solution based on the quantum potential of the subsystems of open quantum systems. It is well-known that, when Q is negligible, the Bohmian particles follow a Newtonian trajectory. A crucial problem seems to be that not for all quantum states Q can be made negligible (Q is constant for a stationary wave, for example). However, the classical regime is necessarily a "decoherence regime", and it can be shown (Zurek, Habib and Paz (1993) that the type of wave functions selected by decoherence will likely be Gaussian states. In Bohm's theory, this amounts to say that the WL-EWFs are Gaussian states. This is a good result: the quantum potential of a Gaussian becomes negligible under the conditions of big mass, small de Broglie wave-length and negligible quantum action. These conditions are the hallmark of the classical regime, and, therefore, it finally shows that a macroscopic Bohmian system in interaction with the environment will follow an (approximately) Newtonian trajectory.

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Joshua Rosaler & Robert Harlander

Naturalness, Wilsonian Renormalization, and "Fundamental Parameters" in Quantum Field Theory

Wednesday, 11:50 - room D

We analyze one influential justification for imposing naturalness in the sense that prohibits fine-tuning of bare Standard Model parameters. We highlight the dependence of this justification on the interpretation of bare parameters as “fundamental parameters," by analogy with microscopic lattice parameters in condensed matter theory. We describe an alternative interpretation of bare parameters as unphysical “auxiliary parameters,” based on an understanding of Wilsonian renormalization group transformations as invertible re-parametrizations of a single effective field theory (EFT), rather than coarse grainings that relate distinct EFT's. On this view, the fine tunings in question are neither problematic nor “unnatural."

†††

Timothy Schmitz

Computing in GRW Quantum Mechanics

Friday, 16:30 - room ‘Rood’

I will explore the computational models that can be constructed relative to GRW quantum mechanics, a formulation of quantum mechanics which solves the measurement problem by positing spontaneous collapses in the position basis. From this investigation we learn that different formulations of quantum mechanics allow different models of computation with correspondingly different notions of computational power, that we cannot expect to construct an analogue of a canonical computational model like a Turing Machine in a physical theory to get a good model of computation in that theory, and that not all physical theories allow Turing-equivalent computational models.

†††

Mike D. Schneider

Interpretation and crisis in the vacuum

Friday, 9:30 - room A

The ‘cosmological constant problem’ (CCP) is often summarized as a conflict between observations of large-scale dynamics understood in the framework of general relativity and theoretical predictions from quantum field theory. I argue that this historically popular understanding of the CCP hinges on two interpretational choices, each of which must be taken as warranted. Indeed, I find the further claims that they are each warranted to be lacking. This state of affairs suggests that other conceptions of the CCP that are built on

interpretations that dovetail with those just alluded to are worth at least as much consideration.

†††

Geoffrey Sewell

Thermodynamic Completeness and the Differentiability of Entropy

Thursday, 15:10 - room D

I provide a quantum statistical basis for a characterisation of a complete setoff thermodynamic variables and establish that the completeness condition implies the differentiability of entropy.

†††

Alexander Smith

Quantizing time: Interacting clocks and systems

Friday, 11:50 - room A

In the conditional probability interpretation of time, time evolution is realized through entanglement shared between a clock and a system of interest; the joint state of the clock and system does not evolve with respect to any background time. After reviewing this interpretation of time, I will present a generalization which allows for an interaction coupling the clock and system—we should expect such a coupling when the gravitational interaction between the clock and system is taken into account. I will demonstrate how such interactions result in a time-nonlocal modification to the Schrödinger equation, and discuss the ensuing consequences.

†††

Marij van Strien

Disentangling causality and determinism

Thursday, 10:10 - room D

'Causality' and 'determinism' are generally thought to be very closely related. At the same time, it has been argued that causes play no role in fundamental physics, and these arguments do not seem to have implications against determinism. I argue that whether determinism holds is independent of whether there are causal relations between macroscopic events. However, I consider two ways in which determinism may still be thought of as causal: the laws of physics themselves may be thought of as 'causal', and determinism can be conceived of as one of several 'principles of causality'.

†††

Adán Sus

Symmetries, physical possibilities and spacetime

Thursday, 10:10 - room A

In this talk I will look at the effects of taking into account whether or not proper conserved quantities are definable for counting physical possibilities in a spacetime theory. I will look, in particular, at how this affects the interpretation of situations in which shifts of the whole material content of the universe seem possible. This perspective provides a vantage point to discuss the assumptions that enter in the interpretation of the mathematical formalism that is needed to decide the question of the individuation of physical possibilities: conserved quantities provide a privileged place from which physical assumptions involved in the theory can be detected.

†††

Antoine Tilloy

A realist redefinition of interacting quantum field theories inspired from dynamical collapse models

Friday, 17:10 - room 'Rood'

Quantum field theory (QFT) presents the same problems of interpretation as quantum mechanics, in addition with serious mathematical difficulties. Using insights from dynamical collapse models -which provide an ad hoc solution to the measurement problem of non-relativistic quantum mechanics- I will show that it is possible to rewrite QFT as a stochastic field theory, with actual fields randomly fluctuating in space. Importantly, and perhaps counter intuitively, this rewriting does not lead to a modification of the predictions of QFT but to a realist redefinition that might also ease the difficulties associated to renormalization.

†††

Karim Thébault & Sean Gryb

Superpositions of the cosmological constant allow for singularity resolution and unitary evolution in quantum cosmology

Friday, 10:10 - room A

A novel approach to quantization is shown to allow for superpositions of the cosmological constant in isotropic and homogeneous mini-superspace models. Generic solutions featuring such superpositions display: i) a unitary evolution equation; ii) singularity resolution; iii) a cosmic bounce. Explicit cosmological solutions are constructed. These

exhibit characteristic bounce features including a `super-inflation' regime with universal phenomenology that can naturally be made to be insensitive to Planck-scale physics.

†††

Jos Uffink

Schrödinger and the prehistory of the EPR argument.

Wednesday, 11:10 - room 0.42

Although Schrödinger only coined the term "entanglement" (Verschränkung) in 1935, he (and others) had been thinking about the phenomenon of (what we now call) entangled wave functions for composite systems since 1927. Indeed, his letters from late 1927 show that he gave up on his original interpretation precisely because of this phenomenon. At that time, he thought that Born's statistical interpretation of the wave function did not suffer from the same problem. In November 1931, in response to a lecture in Berlin by Einstein on the photon box experiment, he developed what we now know as the EPR argument. I will argue that the influence Schrödinger had by his discussions with Einstein in this period have not been appreciated sufficiently by some historians of this period in physics.

This talk will present some of the results that came out of an historical effort to study Schrödinger's unpublished notebooks on his pre-1935 thoughts on entanglement. In particular, this talk will show that Schrödinger developed the essentials of the Einstein-Podolsky-Rosen (EPR) argument of 1935 already in 1931. I will comment on how this argument differs from the EPR version, and the version of the argument that Einstein communicated to Schrödinger in his post-EPR correspondence.

†††

Pierre Uzan

About Super-Quantum Correlations

Friday, 16:30 - room 0.42

The question about the existence of no-signaling, super-quantum correlations is critically examined. It is shown that the mainstream discussion on this question is skewed by an incorrect interpretation of the "no-signaling" assumption (NS). The usual probabilistic interpretation of (NS), whose link with relativistic causality is doubtful, is far too week to assert the absence of any exchange of information between the parties. A relevant informal interpretation of (NS) is nothing but a particular specification of Pawlowski's Information Causality principle, which only partially rules out the possibility of super-quantum correlations. It is then shown that for a composite system the (NS) condition allows a direct construction of a very general tensor-product representation in which the maximal degree of correlations is constrained by the Tsirelson bound – a representation that reduces to a quantum representation if we assume that the world is

"locally quantum". A genuine alternative to quantum theory is to abandon the latter informational principle, which would describe a rather amazing (but maybe real) world where non-local communication is possible.

†††

Lev Vaidman

Beyond "To be or not to be?" Degree and type of presence of a quantum particle in the past

Wednesday, 16:30 - room 0.42

I introduce the concept of a presence of a quantum particle pre- and postselected in general spacial superpositions according to the modification of the trace it leaves, relative to the trace left by a particle in the eigenstate of being in that location. I find theoretically and experimentally (with help of Harald Weinfurter's group in MPQ) a universal robust structure characterized by the weak value of the projection operator.

†††

Louis Vervoort

Are Hidden-Variable Theories for Pilot-Wave Systems Possible ? A Bell-test in Hydrodynamic Systems

Wednesday, 11:50 - room 0.42

Recently it was shown that certain fluid-mechanical 'pilot-wave' systems can strikingly mimic a range of quantum properties, including double-slit interference, quantization of angular momentum etc. How far does this analogy go? Could such systems also violate a Bell inequality, despite the fact they involve only local (sub-luminal) interactions ? Here the premises of the Bell inequality are re-investigated for particles accompanied by a pilot-wave, or more generally by a resonant 'background' field. We present arguments that two of these premises, namely outcome independence and measurement independence, are not necessarily valid when such a background is present. If this is true, the Bell inequality cannot be derived anymore and is possibly (but not necessarily) violated. We propose a hydrodynamic Bell experiment to test our model. Finally, it is shown that certain properties of background-based theories can be illustrated in Ising spin-lattices, where detailed calculations are possible.

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David Wallace

The Case for Black Hole Thermodynamics

Wednesday, 14:30 - room 'Rood'

Black hole thermodynamics is perhaps the most striking and unexpected development in the theoretical physics of the last forty years, but it has drawn skepticism from outsiders, suspicious of the information-theoretic bent of some of the main arguments and rightly observing that no direct empirical evidence supports it. The purpose of this talk is to give a clear outline of the positive case that black holes may be treated as thermodynamical systems in the fullest sense.

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Sylvia Wenmackers

What the two-envelopes paradox teaches us about the two-headed arrow of time

Thursday, 17:10 - room A

Carroll, Guth, and Tseng are developing a toy model with an infinite sample space, in which the a two-headed, thermodynamic arrow of time arises spontaneously, without positing a special initial condition.

They require a normalized probability distribution, thereby ruling out a uniform probability distribution on an infinite support, which they consider to be logically inconsistent. Their alleged inconsistency proof is closely related to the two-envelopes paradox. I report on the status of this paradox in the probability literature and apply a normalized and uniform, yet non-Archimedean, probability distribution (Benci et al., 2013) to the cosmological toy model.

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Charlotte Werndl

On the Relationship Between Boltzmannian and Gibbsian Equilibrium Calculations

Wednesday, 13:30 - room: 'Blauw'

This paper discusses the relations between Boltzmannian equilibrium values and Gibbsian phase averages. It is commonly thought that the averaging principle holds, i.e. that the values of the macro-variables of a system in Boltzmannian equilibrium coincide with their Gibbsian phase averages. We provide examples (including core models of statistical mechanics such as the six vertex and the Ising model) where Boltzmannian equilibrium values and the Gibbsian phase averages come apart. We also show that Boltzmannian and Gibbsian equilibria do not even exist under the same conditions. This raises the question under which conditions there is agreement between the Boltzmannian equilibrium values

and Gibbsian phase averaging. We identifed three conditions each of which is individually su?cient (but not necessary) to guarantee agreement: the (well-known) Khinchin condition, and two new conditions given by two new theorems, the Equilibrium Equivalence Theorem and the Cancelling Out Theorem.

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John van de Wetering

Reconstruction of quantum theory from universal filters

Friday, 17:10 - room 0.42

I will talk about two postulates for quantum theory inspired by categorical logical notions from effectus theory. These postulates state the existence of certain 'filters' that associate to each effect the subspace where it holds true. I'll show that in an operational probabilistic setting these weak postulates lead to a spectral theorem and a duality between pure states and effects. In such a theory it is already possible to define thermodynamic quantities like entropy. No assumptions on the existence of pure states or of reversible dynamics is necessary. By requiring some additional postulates quantum theory can be reconstructed.

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Howard Wiseman

Three boos for locality

Thursday, 11:50 - room 0.42

“Locality” is a concept which orthodox quantum mechanics respects. It is one of the two assumptions – the other being predetermination – in Bell’s 1964 version of his theorem. (The preceding are controversial claims in some quarters.) I will argue that there are at least three reasons to abandon this concept. First, locality is not naturally formed from more fundamental notions of causality, relativity etc. Second, it is accident of history – it compares poorly both to preceding concepts (e.g. Einstein’s nahewirkung) and to Bell’s later concept of local causality. Third, it is at odds with natural language descriptions of quantum interpretations.

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Jingyi Wu

Explaining Universality: Infinite Limit Systems in the Renormalization Group Method

Friday, 17:10 - room D

In the spirit of Norton, I advance an anti-idealizer's view, and argue that in RG explanations, the explanatory functions purportedly only exhibited by infinite limit systems can be adequately provided by approximations without loss (Norton 2012). I develop my argument by emphasizing what I regard as the crux of RG explanations: linearization* around the nontrivial fixed point, and provide topological analysis to show that properties purportedly only infinite limit systems possess can also be retrieved using finite systems. I respond to Batterman by pointing out that the convergence property he regards as crucial and necessary in RG explanations lacks explanatory relevance. I then propose a new crucial property for the explanation: the linearization* property. A system possesses linearization* property if its RG trajectory intersects with a linearization*-adequate neighborhood near the nontrivial fixed point. I argue that the linearization* property adheres more closely to how we use the nontrivial fixed point and reveals more characteristics about the universality class that the fixed point delimits. Finally, I analyze both heuristic and technical evidence in topology provided by Wilson and Kogut (1974) and Yin (2011) and show support that finite systems possess linearization* properties. Because it is possible for systems in the explanans to exhibit linearization* properties without exhibiting convergence properties, the convergence property is not necessary for RG explanations. As a result, I maintain my position that in RG explanations, the explanatory functions can be adequately provided by approximations without loss. Hence, those looking to accord infinite idealizations a prominent role in explanation should look elsewhere than RG explanations of critical phenomena.

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Christian Wüthrich & Vincent Lam

Laws beyond spacetime

Thursday, 11:50 - room A

Are Humeanism and naturalism compatible? More specifically, can one be a Humean about laws of nature and a naturalist who takes fundamental physics seriously? The co-tenability of these two theses has of course been questioned before. We argue here that looking at physical theories beyond empirically established quantum physics and relativity suggests a novel, and much deeper naturalist challenge to Humeanism about laws of nature than those debated before. The principal problem that arises is how to even articulate a Humean account of laws in a world that is fundamentally non-spatiotemporal.

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Magdalena Zych, Fabio Costa, Igor Pikovski & Caslav Brukner

Bell's Theorem for Temporal Order

Friday, 10:10 - room 'Rood'

In quantum theory space-time events unfold in a fixed order, while in general relativity temporal order is influenced by matter. When the latter requires a quantum description, it is often expected that quantum theory must necessarily cease to apply. To the contrary, here we demonstrate a direct construction of a quantum and general-relativistic causal structure where temporal order of events becomes "entangled". Our result implies that classical causal order is untenable in any theory compatible with the basic tenets of quantum mechanics and general relativity, and that it is not necessary to modify either theory to describe non-classical space-times.

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