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

Dennis Lehmkuhl
Institut für Philosophie
Rheinische
Friedrich-Wilhelms-Universität
Bonn 53113 Bonn
dennis.lehmkuhl@uni-bonn.de

Radin Dardashti
Philosophisches Seminar/IZWT
Bergische Universität Wuppertal
42119 Wuppertal
dardashti@uni-wuppertal

Overview of Invited Talks and Sessions

(Lecture hall PTB SR AvHB)

Invited Talks

AGPhil 1.1	Mon	9:30–10:15	PTB SR AvHB	**The Dark Energy Crisis as a Problem of Underdetermination of Pursuit-worthiness** — •Patrick Duerr
AGPhil 2.1	Mon	11:30–12:15	PTB SR AvHB	**The AdS/CFT correspondence: Status and new relations between information and geometry** — •Johanna Erdmenger
AGPhil 3.2	Mon	15:30–16:15	PTB SR AvHB	**Singular terms and singular spacetimes** — •Tushar Menon
AGPhil 4.1	Mon	17:00–17:45	PTB SR AvHB	**Out of nowhere: loop quantum gravity and spacetime functionalism** — •Christian Wüthrich
AGPhil 5.1	Tue	9:30–10:15	PTB SR AvHB	**The road to Hawking radiation** — •Klaas Landsman, Jeroen van Dongen
AGPhil 5.2	Tue	10:15–11:00	PTB SR AvHB	**The Hawking Effect, Its Desiderata and Its Discontents** — •Erik Curiel
AGPhil 7.1	Wed	9:30–10:15	PTB SR AvHB	**Consistency as a guide to quantum gravity** — •Karen Crowther
AGPhil 7.2	Wed	10:15–11:00	PTB SR AvHB	**Transplanckian QED: The Discovery of the Landau Pole** — •Alexander Blum

Sessions

AGPhil 1.1–1.3	Mon	9:30–11:15	PTB SR AvHB	**Quantum and Classical Gravity 1**
AGPhil 2.1–2.3	Mon	11:30–13:15	PTB SR AvHB	**Quantum and Classical Gravity 2**
AGPhil 3.1–3.3	Mon	15:00–16:45	PTB SR AvHB	**Classical Gravity 1**
AGPhil 4.1–4.3	Mon	17:00–18:45	PTB SR AvHB	**Quantum Gravity 3**
AGPhil 5.1–5.2	Tue	9:30–11:00	PTB SR AvHB	**Semi-Classical Gravity 1**
AGPhil 6.1–6.3	Tue	11:30–13:00	PTB SR AvHB	**Semi-Classical Gravity 2**
AGPhil 7.1–7.2	Wed	9:30–11:00	PTB SR AvHB	**Quantum Gravity 4**
AGPhil 8.1–8.2	Wed	11:00–11:15	PTB SR AvHB	**Poster Session**
AGPhil 9.1–9.3	Wed	11:30–13:00	PTB SR AvHB	**Philosophy of Physics 1**
AGPhil 10.1–10.3	Wed	15:00–16:30	PTB SR AvHB	**Particle Physics 1**
AGPhil 11.1–11.3	Wed	17:00–18:30	PTB SR AvHB	**Particle Physics 2**
AGPhil 12	Wed	18:30–19:00	PTB SR AvHB	**Members' Assembly**
AGPhil 13.1–13.3	Thu	9:30–11:00	PTB SR AvHB	**Philosophy of Physics 2**
AGPhil 14.1–14.3	Thu	11:30–13:00	PTB SR AvHB	**Quantum Mechanics**
AGPhil 15.1–15.3	Thu	15:00–16:30	PTB SR AvHB	**Quantum Gravity 3**
AGPhil 16.1–16.4	Thu	16:45–18:45	PTB SR AvHB	**Quantum Gravity 4**
AGPhil 17.1–17.4	Fri	9:30–11:30	PTB SR AvHB	**Quantum and Gravity**

Members' Assembly of the Working Group on Philosophy of Physics

Mittwoch 18:30–19:00 PTB SR AvHB

- Bericht
- Planung 2024/25
- Verschiedenes

AGPhil 1: Quantum and Classical Gravity 1

Time: Monday 9:30–11:15 Location: PTB SR AvHB

Invited Talk AGPhil 1.1 Mon 9:30 PTB SR AvHB

The Dark Energy Crisis as a Problem of Underdetermination of Pursuit-worthiness — •Patrick Duerr — von Weizsäcker Institut für Grundlagenforschung in den Wissenschaften, Eberhard Karls Universität Tübingen, Germany

We ought not to conceive of the Dark Energy problem as a crisis in the traditional–Kuhn-inspired–way. Insteady of a frenzy of motley explored ideas, triggered by an empirical or theoretical anomaly that defies the prevalent cosmological framework, the LCDM model, the Dark Energy crisis consists in a proliferation of approaches to account for the pertinent phenomena–in the hopes of hitting on a conclusive empirical anomaly. The main hypothesis, defended in this talk, is that the Dark Energy crisis is best construed in terms of underdetermination of pursuit-worthiness (rather than the more familiar plight of evidential underdetermination). What renders the Dark Energy crisis so perplexing is that none of them stands out as uncontroversially preferred in terms of their promise–the rational justification for their pursuit, i.e. the reasons to work on them. I substantiate this claim by applying a Peircean economic model of pursuit-worthiness to the main Dark Energy proposals. I conclude with counselling two complementary research strategies, implemented already in the cosmology community. The first, remiscent of Feyerabendian ”anarchism”, encourages bold heterodox ideas, with the goal of enhancing the testability of the present paradigm through theory pluralism. Secondly, reminiscent of Wheeler's ”daring conservativism”, we should explore the implications of the LCDM model, and seek to devise more and stricter tests.

AGPhil 1.2 Mon 10:15 PTB SR AvHB

Dark Matter or Modified Gravity? A pragmatic choice between two working hypotheses — •Antonis Antoniou — Institut für Philosophie, Rheinischen Friedrich-Wilhelms-Universität Bonn

The debate between dark matter and modified gravity scenarios in response to the cosmological anomalies observed in the 1970s and 1980s is often framed in the philosophy of physics as a clash between two competing theories or models: the standard cosmological model with general relativity (ΛCDM) and Milgrom's Modified Newtonian dynamics (MOND) (cf. Massimi 2018; Jacquart 2021; Martens and King 2023; Duerr and Wolf 2023). This discussion questions the fairness of directly comparing ΛCDM and MOND due to their different theoretical statuses. A more nuanced understanding of the philosophical question regarding the preference between the two possible lines of explanation for the observed cosmological anomalies emerges by framing the debate as a pragmatic choice between two working hypotheses: (1) introducing a non-baryonic form of matter to the mass-energy budget of the universe and (2) modifying gravitational dynamics. A historical analysis of the scientific situation in the 1980s suggests that, although no conclusive evidence supports the former hypothesis, the pragmatic advantages of adopting a dark matter scenario far outweigh the pursuit of a modified theory of gravity with a different phenomenology on the galactic scale.

AGPhil 1.3 Mon 10:45 PTB SR AvHB

Functional unity in quantum gravity — Alex Seuthe[1] and •Luigi Laino[2] — [1]TU Dortmund University, Dortmund, Germany — [2]University of Naples Federico II, Naples, Italy

The unification of General Relativity (GR) and Quantum Mechanics (QM) is a significant open question in physics. This issue, tackled by approaches such as Loop Quantum Gravity (LQG), challenges our conventional interpretation of space and time (and spacetime).

LQG is in tension with Kant's philosophy of pure reason, where space and time are pure intuitions. We think that Cassirer's neo-Kantian revision of Kant's Aesthetics may be of service for framing questions arising here. Hence, our paper will:

1) Illustrate how later neo-Kantian interpretations of Kantian Aesthetics prevent a collapse of a revised Kantian philosophy in light of new developments in physics, particularly by leveraging the idea of “functionalism” (also upheld by Rovelli and relational QM).

2) Demonstrate how, through Cassirer's advanced philosophy of symbolic forms, unity can be perceived as a functional concept. We will also utilise his books *Zur Einsteinschen Relativitätstheorie* (1921) on GR and *Determinismus und Indeterminismus in der modernen Physik* (1937) on QM, focusing on Cassirer's systematic method and his approach to establishing functional unity as the focal point in the epistemology of physics.

In 2024, as we celebrate the 300th anniversary of Immanuel Kant and the 150th of Ernst Cassirer, it is an opportune moment to critically revisit their philosophical insights.

AGPhil 2: Quantum and Classical Gravity 2

Time: Monday 11:30–13:15 Location: PTB SR AvHB

Invited Talk AGPhil 2.1 Mon 11:30 PTB SR AvHB

The AdS/CFT correspondence: Status and new relations between information and geometry — •Johanna Erdmenger — Lehrstuhl für Theoretische Physik 3, Julius-Maximilians-Universität Würzburg

Based on string theory, the AdS/CFT correspondence conjectures a duality between a quantum gravity theory and a quantum field theory without gravity. A central conceptual element is the holographic principle, according to which a gravity theory in a given volume has the same amount of degrees of freedom as the theory on its boundary. This is reminiscent of the Bekenstein-Hawking formula, according to which the entropy of a black hole scales with its horizon area.

Within AdS/CFT, information-theoretic measures are mapped to geometry. Examples include entanglement entropy (mapped to a minimal surface by the Ryu-Takayanagi formula) and computational complexity. Recent developments allow for the evaluation of the Page curve describing the evolution of von Neumann entropy under black hole evaporation. Moreover, operator algebras of algebraic quantum field theory are used to address the ‘factorization puzzle’ of AdS/CFT.

I will give an overview over these recent developments, and briefly mention own work that uses the topological concept of geometric phases for characterizing the factorization properties of the operator algebra associated to the AdS eternal black hole [1].

[1] S. Banerjee, M. Dorband, J. Erdmenger, A.-L. Weigel, ‘Geometric phases characterise operator algebras and missing information’, JHEP 10 (2023) 026.

AGPhil 2.2 Mon 12:15 PTB SR AvHB

The quantum theory of gravitation, effective field theories, and strings: yesterday and today. — •Alessio Rocci[1] and Thomas Van Riet[2] — [1]Vrije Universiteit Brussel and Solvay Insitutes, Brussels, Belgium — [2]KU Leuven, Leuven, Belgium

This paper analyzes the effective field theory perspective on modern physics through the lens of the quantum theory of gravitational interaction. The historical part argues that the search for a theory of quantum gravity stimulated the change in outlook that characterizes the modern approach to the Standard Model of particle physics and General Relativity. We present some landmarks covering a long period, i.e., from the beginning of the 1930s until 1994, when, according to Steven Weinberg, the modern bottom-up approach to General Relativity began. Starting from the first attempt to apply the quantum field theory techniques to quantize Einstein's theory perturbatively, we explore its developments and interaction with the top-down approach encoded by String Theory. In the last part of the paper, we focus on this last approach to describe the relationship between our modern understanding of String Theory and Effective Field Theory in today's panorama. To this end, we briefly describe the modern concepts of moduli stabilization and Swampland to understand another change in focus that explains the present framework where some string theorists move.

AGPhil 2.3 Mon 12:45 PTB SR AvHB

The Cosmological Quantum Measurement Problem —

•Charlotte Erika Zito — University of Geneva, Switzerland

Despite being enormously successful on the practical level, quantum mechanics (QM) still faces a lot of conceptual challenges. One of these is represented by the quantum measurement problem (QMP), that has as many formulations as solutions in the dedicated literature. Arguably though, the QMP has echoes beyond the framework of non-relativistic QM. There exists indeed a precise analogue of the QMP in the early universe cosmology: while geometric properties of large scales appear determinate, the more fundamental levels, and particularly those closer to the initial singularity, appear to be fully quantum.

Different cosmological models based on QG, from loop quantum cosmology to string cosmology, have been developed. Yet, the cosmological version of the QMP is rarely mentioned in the literature and even more rarely discussed. In this talk I will start to fill this gap by addressing the issue that concerns the formulation of the QMP in cosmology, which arguably will not focus on the role of an external observer. Rather, I will argue that the cosmological QMP coincides with the problem of spacetime emergence, that affects theories of QG, and discuss the challenges that the main interpretations of QM face in this context, paying particular attention to Everettian solutions.

AGPhil 3: Classical Gravity 1

Time: Monday 15:00–16:45 Location: PTB SR AvHB

AGPhil 3.1 Mon 15:00 PTB SR AvHB

On Penrose's Analogy between Curved Spacetime Regions and Optical Lenses — •Dennis Lehmkuhl, Christian Röken, and Juliusz Doboszewski — Lichtenberg Group for History and Philosophy of Physics, Institute of Philosophy, University of Bonn, Am Hof 1, 53113 Bonn

We present an analysis of the analogy between the focusing effects of particular families of Ricci- and Weyl-curved spacetime regions on the one hand and anastigmatic and astigmatic optical lenses on the other. This gravito-optical analogy was pioneered by Roger Penrose in the early 1960s. We put the analogy in its historical context, showing among other things how Penrose drew on results of Ray Sachs, and investigate its underlying assumptions, its range of validity, and how it should be interpreted.

Invited Talk AGPhil 3.2 Mon 15:30 PTB SR AvHB

Singular terms and singular spacetimes — •Tushar Menon — Dianoia Institute of Philosophy, Melbourne, Australia

The question of whether or not we should be scientific realists turns crucially on what it is to interpret a scientific theory. In this talk, I argue that the representationalist model, according to which we interpret theories by (i) deciding which objects in the world are represented (/referred to) by its central singular terms, and then (ii) making claims about these objects' properties and relations, is deeply flawed. In its place I propose a model based on a Sellars-Brandom-style inferentialism. On this view, theory interpretation is an exercise in spelling out the contribution that scientific claims make to good inferences. This model allows for a much more compelling and nuanced view about how good scientific theories come to be about the world. To borrow terminology from Lehmkuhl (2020), this model underpins a careful, as opposed to a literal, interpretation of a physical theory. I demonstrate the power of this approach by discussing, as a case study, the interpretation of singularities in classical and quantum gravity.

AGPhil 3.3 Mon 16:15 PTB SR AvHB

On why the prediction of infinite curvature does - while that of geodesic incompleteness does not - indicate breakdown of General Relativity. — •Kiril Maltsev — HITS / University of Heidelberg, Schloss-Wolfsbrunnenweg 35, 69118 Heidelberg

We review three definitions (missing point(s) unsteadiness, infinite quadratic curvature invariant, and geodesic incompleteness) of what a gravitational singularity is, and argue that prediction of a gravitational singularity is problematic for General Relativity (GR), indicating breakdown of the theory, only insofar as it concerns the infinite curvature (IC) singularity characterization. In contrast, the geodesic incompleteness (GI) characterization is GR's innovating hallmark, which is not meaningfully available in Newtonian gravity formulations (locally infinite density field, and locally infinite gravitational force) of what a gravitational singularity is. GI is compatible with but does not require divergence in any curvature quantities. Prediction of IC formation contradicts principles of Quantum Theory and Special Relativity, while that of GI does not. It is the continuous, non-quantized, nature of Lorentzian geometry, which admits indefinite continuation of gravitational contraction. Curvature singularities are admitted to form in GR not only from collapse of mass-energy but even in a vacuum spacetime, for example from collision of gravitational waves, under certain conditions. Therefore, in order to prevent IC formation, instead of imposing a curvature bound as consequence of a limiting mass-energy density, a curvature bound should be imposed by first-principle assumption that the Planck scale is ultimate.

AGPhil 4: Quantum Gravity 3

Time: Monday 17:00–18:45 Location: PTB SR AvHB

Invited Talk AGPhil 4.1 Mon 17:00 PTB SR AvHB

Out of nowhere: loop quantum gravity and spacetime functionalism — •Christian Wüthrich — University of Geneva, Switzerland

Quantum gravity is of great interest to the philosopher of nature: the conceptions of space and time arising from our manifest image of the world have already been challenged by general relativity, and adding quantum effects to the mix promises to add significant complications. As it turns out, most approaches to quantum gravity suggest that our world is ultimately neither spatial nor temporal. How can one conceptualize such a non-spatiotemporal world? How can space and time not be fundamental, but instead emerge from a non-spatiotemporal structure just as the liquidity of water emerges from molecules which are themselves not liquid? Using loop quantum gravity, an approach to quantum gravity based on a canonical quantization of general relativity, I will illustrate these questions, and argue how a philosophical approach known as 'spacetime functionalism' contributes to their resolution.

AGPhil 4.2 Mon 17:45 PTB SR AvHB

Causation in Quantum Gravity: an Assessment — •Luca Gasparinetti — University of Italian Switzerland, Lugano, Switzerland

Is there causation in fundamental physics? It has been argued in several places that causation does not play any legitimate role in fundamental physical theories. Based on recent developments in cutting-edge physics, I will show that this tradition can be renovated with a novel challenge. I will call it the timeless challenge. As I will present it in more detail, the challenge roughly proceeds as follows. According to several approaches to the most fundamental theory called Quantum Gravity (QG), time is fundamentally unreal. Hence, since causal relations are typically grounded in temporal relations, one might conclude that along with temporal relations, causal relations are fundamentally unreal. Therefore, there is no fundamental causation in our most fundamental physical theory. In this talk, I will reject this challenge and motivate that at least in some cases QG itself makes the case for anchoring causation in fundamental physics. In the first part, I will present in more detail the timeless challenge. In the second, based on specific approaches to QG, I will develop two strategies to address the challenge aimed at showing that there can be fundamental causation. I will finally conclude with some brief remarks on the current research about causation and QG.

AGPhil 4.3 Mon 18:15 PTB SR AvHB

Growing Block in Causal Set Theory: Not Quite — •Marco

Forgione — University of Milan

In this contribution, I shall explore the possibility of characterizing the emergence of time in causal set theory (CST) in terms of the growing block universe (GBU) metaphysics. I will show that although GBU seems to be the most intuitive time metaphysics for CST, it leaves us with a number of interpretation problems, independently of which dynamics we choose to favor for the theory -here I shall consider the Classical Sequential Growth and the Covariant model. Discrete general covariance of the CSG dynamics does not allow us to individuate a single history of the universe (defined by a causal history of different causal sets), thereby making the claim that "the past exists" at best problematic. In addition, because the evolution of the universe in CSG dynamics leads to an outward branching causal tree, it becomes impossible to determine a proper "line of becoming", thereby blurring the presentists' claim that only the present exists. Similarly, the covariant approach runs into the same, if not even more severe problems, since each configuration of the universe would amount to a set of possible causal sets, thereby making the individuation of a single configuration of the universe -and thus the physical interpretation of the theory- implausible.

AGPhil 5: Semi-Classical Gravity 1

Time: Tuesday 9:30–11:00 Location: PTB SR AvHB

Invited Talk AGPhil 5.1 Tue 9:30 PTB SR AvHB
The road to Hawking radiation — •Klaas Landsman[1] and Jeroen van Dongen[2] — [1]Radboud University Nijmegen — [2]University of Amsterdam

Almost exactly 50 years ago, the March 1, 1974 issue of Nature contained a short (1.5 page) article by Stephen Hawking called "Black hole explosions?" in which the author showed that black holes evaporate due to the emission of black body radiation, culminating in an explosion "equivalent to 1 million Mton hydrogen bombs." His obituary published by the Royal Society in 2019 stated that "it is fair to say that Stephen's discovery ranks as one of the most important results ever in fundamental physics." Using both public and private sources (including oral history), we sketch the context and history of Hawking's calculation and interpretation, both within his own career and in comparison with his peers in the U.S., the U.K., and the Soviet Union. Our detailed analysis provides clear reasons why at the time it was Hawking who pulled this through, despite being a novice in quantum field theory.

Invited Talk AGPhil 5.2 Tue 10:15 PTB SR AvHB
The Hawking Effect, Its Desiderata and Its Discontents — •Erik Curiel — Lichtenberg Group for History and Philosophy of Physics Universität Bonn — Black Hole Initiative, Harvard University

I give a heuristic overview of the emission of radiation by black holes when quantum effects are taken into account—the "Hawking effect". I will not work through any particular derivation of the effect in detail, as the rough, intuitive ones tend to be badly misleading, and the precise, rigorous ones are too technically demanding given the constraints of this talk. I will rather sketch the basic ingredients any derivation requires, the choices one must make in constructing a derivation, including what exactly it is one hopes to show, and discuss physical and conceptual problems those ingredients and conclusions raise and face. I focus on apparent inconsistencies among several of the most popular approaches, and how they may (or may not) be resolved. I also discuss whether or not the different derivations can be understood as all sharing a common core of empirical content. I conclude with some thoughts on how to understand the possible bearing of these issues on the widespread use of black hole thermodynamics in general, and the Hawking effect in particular, as a guide in the search for a theory of quantum gravity.

AGPhil 6: Semi-Classical Gravity 2

Time: Tuesday 11:30–13:00 Location: PTB SR AvHB

AGPhil 6.1 Tue 11:30 PTB SR AvHB
Essential Idealization in Hawking Radiation: A New Paradox for Semi-Classical Black Holes — •Dominic Ryder — London School of Economics, London, UK

In this paper, I argue that three mainstream derivations of Hawking radiation contain an essential idealization. They are Hawking's original derivation, Fredenhagen and Haag's mathematically "watertight" derivation, and the algebraic derivation of the Unruh vacuum. These derivations are carried out in a spacetime which does not model black hole evaporation, whereas, given the existence of Hawking radiation, black holes are expected to evaporate. Given the assumption of non-evaporation is unphysical, one should be able to de-idealize by removing it. However, I show that assumptions essential for the derivations breakdown in evaporation spacetimes. The idealization of non-evaporation is essential for these derivations.

First, I introduce the paradox that arises for each derivation because of this essential idealization. The paradox is distinct from standard issues of idealization in physics: usually, the soundness of physical assumptions is challenged, but here the problem is an invalid argument. Second, I discuss possible resolutions to the paradox. Hawking himself recognized the troublesome idealization and proposed an approximation regime to resolve the issue. I argue that Hawking's proposal fails and canvas alternative resolutions. Rejecting the claim that quantum gravity can resolve the issue, I propose a resolution which relies upon weakening the premises of Hawking's derivation.

AGPhil 6.2 Tue 12:00 PTB SR AvHB
The Holographic Dual of Black Hole Thermodynamics — •Manus Visser — DAMTP, University of Cambridge, UK

Black hole thermodynamics contains important clues for quantum gravity. Often black hole entropy is viewed as a low-energy constraint that every quantum theory of gravity has to satisfy. However, black hole thermodynamics itself poses conceptual puzzles, since it contains certain features that are seemingly different from those in standard textbook thermodynamics. For instance, black hole entropy scales with the horizon area, unlike the entropy of usual thermal systems that is proportional to the volume. Another puzzle is that the first law of black hole mechanics does not seem to contain a work term. These and other disanalogies between black hole thermodynamics and standard thermodynamics have led philosophers to argue that black holes are not really thermodynamic. In this talk I will explain how holography or gauge/gravity duality resolves these puzzles in an interesting way. In such a framework black holes in the 'bulk' geometry are dual to thermal states in the 'boundary' field theory. Crucially, these thermal states satisfy the usual laws of thermodynamics, for instance their entropy is extensive. I will develop a holographic 'dictionary' that relates the nonstandard laws of black hole thermodynamics to the standard laws of the dual field theory thermodynamics.

AGPhil 6.3 Tue 12:30 PTB SR AvHB
Black boxes in black hole imaging — •Juliusz Doboszewski[1,2] and Elder Jamee[3,2] — [1]Lichtenberg Group for History and Philosophy of Physics, University of Bonn — [2]Black Hole Initiative, Harvard University — [3]Tufts University

Machine learning methods are increasingly adapted to various problems in black hole imaging. Examples include the 2023 M87* image based on PRIMO (a dictionary-learning algorithm), alpha-DPI (a deep learning framework for, among others, posterior estimation of black hole parameters), and machine learning-based denoisers (suggested as a plug-in component within more conventional imaging algorithms). As a result, issues related to the notion of epistemic opacity also become relevant to black hole imaging. In this talk, I will first argue that at least one problematic form of opacity is already present in black hole imaging: GRMHD simulations of some (e.g. SgrA*; but not all, e.g.

M87*) sources are opaque to some extent. This form of opacity signals limitations of the current understanding of the source*s models. However, there are also forms of opacity (including opacity resulting from the use of a deep neural network) which can remain entirely unproblematic when seen as a part of a broader inferential framework. I will propose six conditions under which that can plausibly the case, and discuss how opaque methods can be useful in the context of the next generation Event Horizon Telescope.

AGPhil 7: Quantum Gravity 4

Time: Wednesday 9:30–11:00 Location: PTB SR AvHB

Invited Talk AGPhil 7.1 Wed 9:30 PTB SR AvHB
Consistency as a guide to quantum gravity — •Karen Crowther — University of Oslo, Norway

In the absence of novel empirical data, the search for a theory of quantum gravity is primarily motivated, guided, and constrained by theoretical and philosophical concerns. I argue that consistency is the most basic principle functioning in these roles. Consistency is seen as essential, and is widely taken as a constraint in physical theorising, yet scientists do not, and should not, reject inconsistent theories. There are different forms of consistency in science: empirical inconsistency, external inconsistency, and internal inconsistency. I explore how these play a role in motivating and constraining the search for quantum gravity, with an eye to pinpointing and evaluating the status of the different forms in each of these functions. I find that the “inconsistencies” usually appealed to, are not of the form expected, and may not in fact be inconsistencies at all, while some actual inconsistencies that could be relevant are dismissed as uninteresting. I also consider the heuristic value of inconsistency, and the relationship between consistency and unification in the search for quantum gravity.

Invited Talk AGPhil 7.2 Wed 10:15 PTB SR AvHB
Transplanckian QED: The Discovery of the Landau Pole — •Alexander Blum — May Planck Institute for the History of Science, Berlin, and Albert Einstein Institute, Potsdam

One of the main hopes for a quantum theory of gravity is that it will resolve the ultraviolet behavior of quantum field theory. In my talk, I will discuss the origins of this hope in the mid-1950s, when physicists started exploring the high-energy behavior of quantum electrodynamics and gradually came to realize that the theory would inevitably break down at scales far beyond the Planck scale. I will then reflect on the symbiotic relationship this engendered between quantum field theory (QFT) and quantum gravity (QG): QFT could rest assured that its foundational difficulties would be taken care of by QG, while QG received a robust motivation from the high-energy breakdown of QFT.

AGPhil 8: Poster Session

Time: Wednesday 11:00–11:15 Location: PTB SR AvHB

AGPhil 8.1 Wed 11:00 PTB SR AvHB
Ein ethisches Problem bei der Betrachtung der Makroobjektenteleportation als theoretisch mögliche — •Marina Zakharchuk — Moscow, Russia

Teleportation ist heute mehr als nur ein Science-Fiction-Konzept. Die Möglichkeit der Quantenteleportation wurde experimentell nachgewiesen. Wenn wir davon ausgehen, dass Teleportation auf Makroebene aufgrund der entsprechenden technologischer Entwicklung theoretisch möglich ist, dann können wir sie betrachten als die Zerlegung eines Objekts in seine atomaren Bestandteile, die Übertragung dieser Informationen an einen anderen Ort und die vollständige Rekonstruktion des Objekts dort. Obwohl es vorstellbar ist, unbelebte Objekte zu teleportieren, ist die Übertragung von Tieren, Vögeln und Menschen schwieriger. Um als ”dieselbe Person” betrachtet zu werden, muss jemand räumlich und zeitlich verbunden sein. Bei der Teleportation wird der Körper jedoch vollständig zerstört und am Zielort wieder zusammengesetzt, was dazu führen kann, dass das teleportierte lebende Objekt als Kopie des Originals betrachtet wird. In diesem Fall können die Forschungen der neuronalen Prozessen bei den Tieren nützlich sein. Wenn Zoologen und Tierpsychologen in die Arbeit einbezogen werden, kann man durch die Analyse teleportierter trainierter Tiere mehr über die Erhaltung der Persönlichkeit erfahren. Allerdings man kann nicht sagen,dass es bei menchen genauso funktioniert. Ähnlich wie beim Schiff des Theseus-Paradoxons stellt sich die Frage, ob ein Objekt dasselbe Objekt bleibt. Die Identität einer Person immer noch ein Rätsel bleibt. Das ethische Problem dann nicht gelöst werden kann.

AGPhil 8.2 Wed 11:00 PTB SR AvHB
Die Entstehung der Physik von Galileo Galilei in der Perspektive von Piama Gaidenko und Kurt Lewin — •Olaf Miemiec[1] und Alexey Iakovlev[2] — [1]Rosa-Luxemburg-Stiftung Berlin Kopenhagener Straße. 76 10437 Berlin — [2]Moscow, Russia

Die sowjetische und russische Philosophin Piama Pawlowna Gaidenko erforscht in ihren Werken die Zusammenhänge der neueren europäischen Philosophiegeschichte mit der Geschichte der Naturwisenschaften. Die Entstehung der wissenschaftlichen Methode von Galileo Galilei verbindet sie mit der Veränderung des ganzen Verständnisses der menschlichen Fähigkeiten. Galilei ist bekannt aufgrund seiner Experimente. Die Möglichkeit dazu entstand nicht nur aufgrund der Änderung der Kultur insgesamt, sondern konkret aufgrund einer anderen Art des Sehens. Sie bemerkt, dass die für diese Zeit neue Kunst die Perspektive einführte. Das änderte sowohl die Kunst an sich, aber auch das Verständnis von den Sinnesfähigkeiten des Menschen. So änderte das andere Verständnis vom Sehen die Kunst in der Verbindung mit der Naturforschung. Wie genau sich das moderne Verständnis der Wissenschaften paradigmatisch von dem der antiken und scholastischen Tradition abhebt, dass neue wissenschaftliche Produktion gerade auch von einem weltanschaulichen Rahmen abhängig sein kann, verdeutlicht die Arbeit des Psychologen und Wissenschaftstheoretikers Kurt Lewin. Er macht deutlich, worin sich die formalen Strukturen des *galileischen* vom *aristotelischen* Denken unterscheiden.

AGPhil 9: Philosophy of Physics 1

Time: Wednesday 11:30–13:00 Location: PTB SR AvHB

AGPhil 9.1 Wed 11:30 PTB SR AvHB

What is fundamental in fundamental physics? — •Alexander Niederklapfer — London School of Economics and Political Science, London, UK

Metaphysicians as well as philosophers of science often turn to particle physics for a description of the most fundamental level of the material world. The common assumption is that it describes one clear account of what the basic building blocks of our universe are, and how they compose with one another to form more complex objects. I argue that this picture contains a major difficulty, because particle physics allows for more than one metaphysically meaningful procedure to decompose a system into (fundamental) parts. I identify and interpret two widely used decomposition relations appearing in quantum theories: the first relies on Wigner's "definition"' of particles and decomposes a quantum system based on the theory of group representations into a direct sum of parts, which is popular amongst recent structuralist interpretations of quantum theories. The second is the decomposition into a tensor product of statistically independent components, common in the literature on entanglement and quantum information. I then show that these two decompositions lead to different results for what the parts of a given system might be. I argue that these considerations show that there are conventional choices involved in finding the fundamental parts of an object which have not yet been widely recognised by either metaphysicians or philosophers of science. I also take this to provide a sense in which, as a result, a physical theory on its own is not enough to determine the fundamental ontology of the world.

AGPhil 9.2 Wed 12:00 PTB SR AvHB

Do atemporal theories of quantum gravity presuppose the notion of time? — •Anastasiia Lazutkina — University of Wuppertal, Wuppertal, Germany

I examine an argument proposed by Henrik Zinkernagel against quantum fundamentalism (QF), the view that everything is fundamentally of a quantum nature (ontological QF) and can be described exclusively in quantum theoretical terms (epistemological QF). According to Zinkernagel, the absence of time in the main approaches in quantum gravity (QG) leads to a problem for QF. The central claim is that timeless QG cannot be more fundamental than general relativity (GR) because its central field of application, the early universe, is defined by a classical relativistic time concept - global time. And global time is based on Weyl's principle that requires well-defined notions of local time and length, which lose their physical basis in the early universe. Thus, QG relies on GR and cannot be more fundamental. I propose two readings of the argument: the first fails, while the second is successful but requires accepting a broad set of epistemological commitments like Niels Bohr's holism and Peter Zinkernagel's conditions of objectivity. Even if these commitments are accepted, I conclude that in this second extended form the argument only refutes the epistemological but not ontological version of QF.

AGPhil 9.3 Wed 12:30 PTB SR AvHB

LatticeQCD - between approximation and foundation — •Nico Formánek — HLRS, Stuttgart

LatticeQCD can be viewed as a clever approximative method to extract numerical predictions from QCD. But it also serves as a discrete foundation to define the QCD path integral. Philosophy of Science has focused mainly on the first aspect, worrying about the uncontrolled black box nature of the approximations, while lattice practitioners explicitly point to the foundational character. This apparent tension goes back, I argue, to the inception of LatticeQCD. Symanzik's conjecture on which the foundational character of the lattice relies was later developed into a numerical improvement programme. LatticeQCD is therefore not only conceptually but also historically a foundation and approximation. I will briefly spell out what this means for traditional views of physical theories in philosophy of science and how they might need to adapt.

AGPhil 10: Particle Physics 1

Time: Wednesday 15:00–16:30 Location: PTB SR AvHB

AGPhil 10.1 Wed 15:00 PTB SR AvHB

Towards a digital analysis of the concept of the virtual particle — •Adrian Wüthrich, Michael Zichert, and Arno Simons — Technische Universität Berlin

The concept of the virtual particle has been the object of lively debates concerning its ontological status and precise meaning of its associated terms. In the spirit of Wittgenstein, we start from the premise that the precise meaning of a term is determined by its use in a community of competent users. We also believe, in turn, that such use is best determined by analyzing as many instances as possible instead of only a few selected cases. Recent tools from the computational humanities have brought such comprehensive analyses within reach. Accordingly, in this talk, we discuss how some of these tools might help us determine the meanings of "virtual particle" and cognate terms on the basis of a large corpus of relevant texts. In particular we will present our preliminary results of a "semantic change detection" analysis. For this, we used contextualized word embeddings of occurrences of "virtual" in all articles of the relevant journals of the "Physical Review" family from 1924 to 2022.

AGPhil 10.2 Wed 15:30 PTB SR AvHB

On the emergence of virtual particles in classical mechanics — •Amaia Corral-Villate — University of the Basque Country, Spain

The indispensability of singular limits as a context for emergence has recently been questioned, but it is also known that they may entail the emergence of new properties in physics. Following this last idea, my objective in this talk is to build a very simple and illustrative model for emergence in classical mechanics, by analysing the singular limit consisting in taking the number of particles involved to be infinite.

Specifically, my model shows that under a general condition of locality, infinite classical mechanical systems may entail the emergence of entities that, given the similarities with virtual particles in quantum field theory, may be thought of as virtual particles in classical mechanics. Such similarities consist basically in (i) not satisfying the relation for energy and momentum, and (ii) belonging essentially to interactions.

Regardless of whether or not the basis for a model is itself physical, what can be learnt from it may help understand other processes that are physical. In particular, this simple and illustrative model of emergence in classical mechanics allows for a very intuitive grasp of the process of emergence of virtual particles itself, that can at the same time be analysed with clarity and precision.

AGPhil 10.3 Wed 16:00 PTB SR AvHB

A comparative computational analysis of epistemic markers in astrophysics and particle physics using contextualized word embeddings — •Arno Simons, Adrian Wüthrich, and Michael Zichert — Technische Universität Berlin, Berlin, Germany

We compare the different meanings and nuances of observation, experimentation and simulation in astrophysics and high-energy physics (HEP) over a 30-year period, spanning from 1992 to 2022. In particular, we use contextualized word embeddings trained on physics language to track semantic shifts in the meanings of these concepts in a corpus of over 600K physics articles from the arxiv preprint server. Our analysis is inspired, first, by recent empirical studies on the actual usage of epistemic concepts in science (Malaterre and Léonard 2023; Mizrahi 2022; Overton 2013) and, second, by ongoing debates in philosophy of physics on how astrophysics and HEP differ in their epistemic strategies, especially relating to the concepts we investigate (Ableson 2023; Karaca 2023; Jacquart 2022; Heidler 2017). In both these literatures, the meanings of concepts such as observation, experiment and simulation, are considered good indicators, or "markers", of the epistemic strategies used in different fields of physics or science more broadly. Despite our basic confidence in the fruitfulness of our computational and AI-based approach, we also critically discuss its applicability and its usefulness for the future of an empirical philosophy of science.

AGPhil 11: Particle Physics 2

Time: Wednesday 17:00–18:30 Location: PTB SR AvHB

AGPhil 11.1 Wed 17:00 PTB SR AvHB

Is the Planck scale more than a mere choice of units? — •Caspar Jacobs — Leiden University, Leiden, Netherlands

It is often asserted that quantum gravity becomes noticeable at the Planck scale, defined by c = G = h = 1. Behind this claim lies a 'simple dimensional argument' (Isham and Butterfield 1999), but as Weinstein and Rickles (2023) point out: 'the details of these dimensional arguments and the role of the Planck scale are calling out for a closer analysis'. It is unclear what elevates the Planck scale from a convenient choice of units to a physically relevant scale.

Baez (2000) justifies the Planck scale on the basis of mini black holes, but Meschini (2007) dismisses this as speculative physics. Instead, I propose to look at our current theories: effective field theories. Here, we see that fundamental constants are relevant to the procedure of renormalisation. This procedure only succeeds when coupling constants have certain dimensions. Although these dimensions are often expressed as powers of energy, they are in fact functions of c, G and/or h. It is only when the latter are set to 1 that the dimensions simplify. Planck units thus indicate when effective field theories become non-renormalisable.

Therefore, what matters are not Planck units, but what I will call Planck dimensions. Unlike a mere choice of scale, such a set of dimensions has physical content.

AGPhil 11.2 Wed 17:30 PTB SR AvHB

Theoretical Virtues and the Pursuit of Ugly Models — •Martin King — MCMP, LMU Munich

The lack of new physics discoveries at the LHC has changed the field of particle physics in a number of significant ways. One is that many of the long-cherished principles, such as naturalness, that guided model development for decades are falling to the wayside. Physicists are increasingly turning to model-independent methods and to models that do not exemplify epistemic theoretical virtues considered by some philosophers as being important or even necessary. Simple, unifying models with large empirical scope, like supersymmetry, are being increasingly passed over in favour of effective models with narrow scope that are relatively easy to assess with existing data. I argue that this is a reasonable response to the current situation and that what should be pursued in this research context are models that are easy to test or that take radically novel approaches.

AGPhil 11.3 Wed 18:00 PTB SR AvHB

The Operationalist Take on Scientific Concepts — •Nurida Boddenberg — University Bonn, Bonn, Germany

Exotic quarkonium" serves as an umbrella term to describe states in particle physics that have been increasingly detected since 2003 and share some characteristics with conventional quarkonium (theorized as a state constituted of a heavy quark and its antiquark), along with some exotic features. Although various theoretical models like tetraquarks, hadron-quarkonium, and hadronic molecules have been proposed, there is no consensus on a definitive model to describe and categorize these exotic states.

For this matter, I propose a different route for classification. Instead, I will focus on the experimental signatures that are associated with the respective states and their overlap. This approach enables an operational assessment and the construction of a network of uses*various ways in which a scientific concept can be used.

This endeavor draws inspiration from a revised operationalism that allows defining the meaning of scientific concepts when a theoretical framework is absent, or multiple models are competing. This can be useful for scientific discovery, but also for redefining conventional concepts such as those of temperature or even black holes.

AGPhil 12: Members' Assembly

Time: Wednesday 18:30–19:00 Location: PTB SR AvHB

All members of the Working Group Philosophy on Physics are invited to participate.

AGPhil 13: Philosophy of Physics 2

Time: Thursday 9:30–11:00 Location: PTB SR AvHB

AGPhil 13.1 Thu 9:30 PTB SR AvHB

Does quantum cosmology predict the age of the universe? — •Álvaro Mozota Frauca — Autonomous University of Barcelona

The problem of time of canonical approaches to quantum gravity has been argued to make them unsatisfactory. In this article I study how it affects quantum cosmology and reach the same conclusion. The advantage of studying the cosmological case is that its simplicity makes the discussion much clearer and less technically charged. The classical models I will be concerned with describe how two degrees of freedom, the scale factor and a scalar field, evolve with respect to a time variable. After quantizing the model, this time variable just disappears, and I argue that this is problematic. Indeed, this variable in the classical model allowed us to make claims like 'the universe is 13.8 billion years old' and I will argue that this is a physically meaningful prediction that is lost in quantum cosmology. I will analyze some of the relational positions in the quantum gravity and quantum cosmology literature that tend to deny the physical meaning of time variables and I will argue against them for the case of classical cosmology. In this sense, I will conclude that the age of the universe is a physical prediction of classical cosmological models, that it is missing from quantum cosmology, and that this should make us suspect that there is something wrong with this sort of approach.

AGPhil 13.2 Thu 10:00 PTB SR AvHB

Godel, Penrose and Paraconsistency: What Goes? What Stays? — •Kartik Tiwari — University of Bonn, Bonn, Germany

Penrose in "Emperor's New Mind" and "Shadows of the Mind" uses Godel's Incompleteness Theorem to argue for the non-computability of human intelligence and advocate for the necessity of novel physics to understand consciousness. Objections to Lucas-Penrose argument have received mostly dis-satisfactory responses, leading to a diminished interest in the subject amongst philosophers of mind. Conversely, the study of para-consistent formal systems have gained much traction over the past few decades. Naturally, one wonders about the status of Lucas-Penrose Argument and its objections in light of paraconsistency. In our paper, we briefly introduce Godel's (First) Incompleteness Theorem, Lucas-Penrose Argument and Paraconsistent Formal Systems. Then, we summarize - what is widely considered - an authoritative defeater of the Lucas-Penrose argument by David Chalmers. Following this, we systematically investigate the status of Lucas-Penrose Argument and its possible objections with the machinery of paraconsistent logic. We then conclude with some broader speculations about paraconsistency in the context of human intelligence and the soundness of Penrose's demand for novel physics to understand consciousness.

AGPhil 13.3 Thu 10:30 PTB SR AvHB

Energieerhaltung und Irreversibilität — •Grit Kalies[1] und Duong D. Do[2] — [1]HTW University of Applied Sciences, Dresden, Germany — [2]The University of Queensland, Brisbane, Australia

Die Energieerhaltung (der 1. Hauptsatz der Thermodynamik) gilt in vielen modernen physikalischen Theorien nur bedingt. Beispiele sind: 1. Quantenfeldtheorien, in denen Teilchen kurzfristig aus dem Nichts entstehen, um wieder darin zu vergehen (Quantenfluktuationen des Vakuums), 2. die kinetische Gastheorie, in der Gasteilchen im Moment des Stoßes gegen eine Wand keinerlei Energie besitzen, 3. die Allgemeine Relativitätstheorie, in der die potentielle Energie (Gravitationsenergie) in einem Feld außerhalb des Körpers liegt, womit die Energieerhaltung des Körpers beim freien Fall verletzt wird, 4. die Urknalltheorie, wonach Zeit, Raum und Materie aus einer Singularität entstanden sind, was die vorherige Existenz von Energie in Frage stellt. Die Irreversibilität von Prozessen wieder (der 2. Hauptsatz der Thermodynamik) spielt in der Mechanik, Quantenmechanik und den Relativitätstheorien keinerlei Rolle, was man das Paradox der Zeit [1] nennt, welches Physiker und Philosophen gleichermaßen beschäftigt. Gibt man die Idee einer Kraftwechselwirkung auf und geht dazu über, jegliche Wechselwirkung zwischen Objekten, wie z.B. Teilchen, über Prozesse zu beschreiben [2], ändert sich der Zugang zur Energieerhaltung und Irreversibilität grundlegend, sowohl in der Mechanik als auch der Quantentheorie. [1] I. Prigogine, I. Stengers: Das Paradox der Zeit, Piper, München, Zürich, 1993; [2] G. Kalies, D.D. Do, AIP Adv. 13 (2023), 065121, 055317, 095322, 095126.

AGPhil 14: Quantum Mechanics

Time: Thursday 11:30–13:00 Location: PTB SR AvHB

AGPhil 14.1 Thu 11:30 PTB SR AvHB

A two-worlds interpretation of quantum mechanics — •Hans Christian Öttinger — Quantum Center and Department of Materials, ETH Zürich, HCP F 43.1, CH-8093 Zürich, Switzerland

The stochastic nature of quantum mechanics is more naturally reflected in a bilinear two-process representation of density matrices rather than in squared wave functions. This proposition comes with a remarkable change of the entanglement mechanism: entanglement does not originate from superpositions of wave functions, but results from the bilinear structure of density matrices. Quantum interference is not an additive superposition mechanism, but rather a multiplicative phenomenon. A strict superselection rule, which can be motivated by obtaining quantum mechanics as a limit of quantum field theory (Fock space), requires that the content of fundamental particles in quantum systems is well-defined. The proposed bilinear representation of density matrices is given in terms of two stochastic jump processes.

These ideas are illustrated for the Einstein-Podolsky-Rosen and double-slit experiments. The expression of the stochastic nature of quantum mechanics in terms of random variables rather than their probability distributions facilitates an ontological viewpoint and leads us to a two-worlds interpretation of quantum mechanics.

AGPhil 14.2 Thu 12:00 PTB SR AvHB

A Presupposition of Bell's Theorem — •Carsten Held — Untergraben 13, 99423 Weimar

The most prominent version of Bell's theorem consists of the Bell-CHSH inequality and a quantum-mechanical example that violates it. The inequality is shown to rest on the non-trivial presupposition that the values of elementary spin quantities are scalars, and not, e.g., vectors. In the version considered, the theorem's argument succeeds for scalars and fails for vectors. However, the reference to vector values can be motivated by the physics of spin. Hence, recognizing the presupposition suggests a critical reassessment of the theorem.

AGPhil 14.3 Thu 12:30 PTB SR AvHB

Are quantum subsystems invariant? — •Guilherme Franzmann — Nordic Institute for Theoretical Physics and Stockholm University, Stockholm, Sweden

What is a physical subsystem? How classical physical subsystems localized in spacetime (causally independent) are identified from quantum ones? Traditionally, classical systems have been *uniquely* identified with quantum systems, typically represented as factors in Hilbert space for finite-dimensional systems or associated with a local (microcausality) algebra of operators in QFT. Both representations aim to instantiate a specific prescription of subsystems' independence, that they must be statistically independent for state preparations and measurements. Despite this prescription, it is easy to show that canonical linearized quantum gravity prevents us from obtaining a gauge-invariant local algebra, thus undermining one of the conditions needed for statistical independence of subsystems in QFT. Arguably, this precludes most of the modeling associated with early universe cosmology as well as current attempts to model gravity-induced-entanglement table-top experiments. Nonetheless, primarily it presents a major roadblock towards a theory of quantum gravity. In this talk, after reviewing the aforementioned points, I will propose that a way forward is that the unique identification between quantum and classical systems should be dropped, and instead this mapping should be dynamical, which opens the possibility for a single-world unitary quantum mechanics.

AGPhil 15: Quantum Gravity 3

Time: Thursday 15:00–16:30 Location: PTB SR AvHB

AGPhil 15.1 Thu 15:00 PTB SR AvHB

Rethinking Geometry in Physics — •Amine Rusi El Hassani — University of Lausanne, Lausanne, Switzerland

The role of geometry in physics underwent a significant shift from Newton to Einstein. While Newton considered geometry as an a priori and fixed framework to describe the physical world, Einstein challenged this view and emphasized the importance of linking geometry to physical experiments and operational definitions. This led to the development of Einstein's "practical geometry" which played a crucial role in the development of his theory of general relativity. As we move towards the quantum world, the questions of how to think about geometry and its ontological status become even more crucial. Can we go beyond Einstein's practical geometry? What is the relationship between geometry and quantum theory of matter? These are the questions that I am currently exploring. By examining alternative theories of geometry, such as spectral geometry, we can gain new insights into the ontological status of geometry and its relationship with physical concepts. In this talk, I aim to provide a critical evaluation of Einstein's practical geometry and explore new avenues for thinking about geometry in the quantum world.

AGPhil 15.2 Thu 15:30 PTB SR AvHB

How "existence" can emerge from nothing at all: Ancient and modern perspectives on Information in Quantum Gravity — •Ewoud Halewijn — TU Delft, Netherlands

The concept of "existence" is indispensable for our functioning as human beings. To survive, we better regard information as if it were "about what is existing", such as food or dangerous animals. Believing that information is "about reality", is beneficial in real life, so we might strive for a quantum gravity theory that describes "what really exists".

In this talk, I advocate we should temporize our efforts to do so, for two reasons. Firstly, information is not just "about reality". It is also "part of reality". Ancient Mesopotamian and early Vedic scholars were aware thereof, but hereafter classical Greek philosophers, Catholic scholars and mostly Descartes have removed part of the meaning of the concept of information. Secondly, the more thoroughly we study quantum phenomena, the harder it gets to make a clear distinction between what semioticians call signs (e.g. variables in theories) and their meaning (the "things" they describe). Unfortunately, once signs and meanings coincide, what well-functioning human beings consider to be information and reality, both cease to exist.

If we nevertheless want to "describe reality", we should initially develop models that are unrelated to what most people believe is "existing". And later on expand them, to let "existence" emerge out of nothing at all.

AGPhil 15.3 Thu 16:00 PTB SR AvHB

An effective approach to quantum gravity : the pragmatic solution we never dreamt of, but already have — •Etienne Ligout — Institut d'Histoire et de Philosophie des Sciences, Paris, France

Upon quantization, general relativity proves to be unrenormalizable: the perturbative expansion breaks down at the Planck scale. Most of the efforts to devise a coherent quantum theory of gravitation have thus historically been focused on finding an ultraviolet completion of general relativity up to the Planck scale. In this talk, I shall argue that this endeavour - while relevant to tackle some limitations of the classical framework (such as singularities) - is not warranted from an empirical standpoint, simply because we are far from being able to probe the Planck scale. In fact, at all the scales currently accessible, the quantum corrections to the gravitational dynamics remain small, and - crucially - can be computed. This is achieved by adopting an effective approach, where only the dominant contributions in the action (at the energy scale considered) are retained. When carried out, this program yields a comprehensive quantum gravity theory at low energies, giving for instance the quantum corrections to the newtonian potential or to the bending of light around a star (see e.g. Donoghue 1994). Building on these results, I defend a pragmatic approach to the problem of quantum gravity : rather than wonder what happens to gravity at the Planck scale in spite of any empirical support, we should adopt an effective point of view and restrict our focus to energy regimes where the quantum gravitational effects are well controlled and understood.

AGPhil 16: Quantum Gravity 4

Time: Thursday 16:45–18:45 Location: PTB SR AvHB

AGPhil 16.1 Thu 16:45 PTB SR AvHB

Decoherence of a composite particle induced by a weak quantized gravitational field — •Thiago H. Moreira and Lucas C. Céleri — Institute of Physics, Federal University of Goiás, Goiânia, Goiás 74.690-900, Brazil

In recent years, several proposals for experimentally investigating quantum gravitational effects far from the Planck scale have recently appeared in literature, like gravitationally induced entanglement, for instance. An important issue of these approaches is the decoherence introduced by the quantum nature not only of the system under consideration but also from the gravitational field itself. Here, by means of the Feynman Vernon influence functional, we study the decoherence of a quantum system induced by the quantized gravitational field (in the linearized gravity) regime and also by its own quantum internal degrees of freedom. Due to the universal nature of the gravitational coupling, both environments are not independent, meaning that, within the Feynman Vernon influence functional technique, the non additivity of the noise effects results in a contribution to the decoherence rate that comes from the interaction between the two environments. This is another decoherence effect that should be taken into account when considering experimental proposals for detecting quantum effects of gravity. The decoherence rate was computed by considering a superposition of the relevant degrees of freedom, from which we estimated the decoherence time.

AGPhil 16.2 Thu 17:15 PTB SR AvHB

Simplicial Graviton from Selfdual Ashtekar Variables — •Wolfgang Wieland — University of Erlangen Nuremberg, Erlangen, Germany

Selfdual gravity is a reformulation of general relativity on the phase space of a SL(2,C) gauge theory. As pointed out by Abhay Ashtekar in the mid 1980ies, this reformulation uncovered a surprising simplicity of gravity. It was a well-known result at the time that the Hamiltonian of the theory is a sum of constraints generating hypersurface deformations. The surprise was that using selfdual variables, the constraints simplify in a very dramatic way. They assume the simplest possible polynomial form. In this talk, I lay out a new non-perturbative lattice approach for selfdual gravity with possible far-reaching consequences for quantum gravity. Three results will be discussed. First of all, I explain how to introduce a local kinematical phase space at the lattice sites. At each lattice site, a set of constraints is found that replace the generators of hypersurface deformations in the continuum. The second and most intriguing result is that the discretized constraints close under the Poisson bracket. The resulting reduced phase space describes the two radiative modes at the discretized level. As consistency check, I apply the construction to gravity in three-dimensions. In this way, the established spin-network representation of three-dimensional gravity is recovered from a local quantisation of space.

AGPhil 16.3 Thu 17:45 PTB SR AvHB

Only Euclidean Relativity Provides a Holistic View of Nature — •Markolf Niemz — Heidelberg University, Germany

Special and general relativity (SR/GR) describe nature "subjectively", that is, from the perspective of just *one observer at a time* (one group of observers, to be exact). Mathematically, SR/GR are correct. I show: (1) Physically, SR/GR have an issue. Despite the covariance of SR/GR, there is always just one active perspective. Because of this constraint, there is no holistic view of nature. The issue shows itself in unsolved mysteries. Still, the Lorentz factor and gravitational time dilation are correct. This is why the concepts of spacetime in SR/GR work well except for cosmology and quantum mechanics. (2) Euclidean relativity (ER) describes nature "objectively", that is, from the perspectives of *all objects at once.* Any (!) object's proper space d_1, d_2, d_3 and proper time τ span natural spacetime, which is 4D Euclidean space (ES) if we interpret $c\tau$ as d_4. All energy moves through ES at the speed c. An observer's reality is created by projecting ES orthogonally to his proper space and to his proper time. In SR, these concepts are considered coordinate space and coordinate time. Neither their reassembly to a non-Euclidean spacetime nor the parameterization in SR/GR provides a holistic view. The scalar τ, in particular, cannot factor in an object's 4D vector "flow of proper time" $\boldsymbol{\tau}$. The SO(4) symmetry of ES is incompatible with waves. This is fine because waves and particles are subjective concepts. We must distinguish between an observer's reality (described by SR/GR) and the master reality ES (described by ER). ER solves 15 mysteries (preprints.org/manuscript/202207.0399).

AGPhil 16.4 Thu 18:15 PTB SR AvHB

Allgemeine Allgemeine Relativitätstheorie — •Thomas Schindelbeck — thomas.schindelbeck@iraeph.de

Grundlage der Allgemeinen Relativitätstheorie ist Differentialgeometrie, der Kraftbegriff wird durch Geodäten im gekrümmten Raum ersetzt. Der entsprechende Formalismus wurde historisch zuerst auf Gravitationseffekte angewandt und wird auch heute fast ausschließlich mit diesen verbunden. Das Konzept selbst setzt keine bestimmte Kraft voraus. T.Kaluza erkannte bereits 1919, dass sich auch die Elektrodynamik mit einem derartigen Formalismus beschreiben lässt. Eine Erweiterung der Metrik auf 5 Dimensionen ergibt, mit entsprechenden Randbedingungen, sowohl die Einsteinschen Feld-, als auch die Maxwellschen Gleichungen. Teilcheneigenschaften liegen in völlig falschen Größenordnungen. Bezieht man Kaluzas Ansatz in 1. Näherung nur auf die Elektrodynamik, erhält man korrekte Größenordnungen. Mit Spin = 1/2 als Randbedingung kann man diese (Masse, magnetische Momente, Ladungsverteilung etc.) auf Basis der Konstanten der Elektrodynamik * ab initio * mit einer Genauigkeit in der Größenordnung von QED-Korrekturen berechnen. Im Vortrag sollen die Konsequenzen eines solchen Vorgehens in Bezug auf die Relation Gravitation/ Elektrodynamik /Quantenmechanik diskutiert werden.

AGPhil 17: Quantum and Gravity

Time: Friday 9:30–11:30 Location: PTB SR AvHB

AGPhil 17.1 Fri 9:30 PTB SR AvHB

A dual space concept for particle models — •Hans-Dieter Herrmann — Berlin

Leptons and quarks are considered to be point-like and elementary in space-time, however extended and composite in a circular basic space. The basic space represents an eigenspace connected to the particle structure. The philosophical foundation of this concept is discussed at different levels of reality, such as the atomic, molecular, macromolecular, micro-organismic, organismic, and socio-cultural levels (see Philarchive: https://philarchive.org/archive/HERACQ).

At the subatomic level, an attempt was made to construct basic space models of composite leptons, ground state mesons, and baryons. Such models reproduce static properties, such as mass, charge, spin and magnetic moments, in reasonable agreement with the observed values. A universal mass quantum is proposed to be approximately 1/32 of the muon mass. Mass quanta of positive and negative sign may compensate each other, leading to the vanishing masses of neutrinos and the small mass of the electron.

The building stones of the models in basic space are rotons, entities with circulating masses and charges. Structures consisting of at least two rotons (birotons) represent particles observable in space-time. Single mono-rotons of positive and negative energy are suspected of representing dark matter and dark energy. They cannot be detected directly in space-time, but interact by gravitation.

AGPhil 17.2 Fri 10:00 PTB SR AvHB

Deriving the local arrow of time — •Daniel Saudek — Neuer Weg 28, Kitzingen

This contribution provides a derivation of time*s ordering properties, its metric properties, and its irreversibility on the basis of simple axioms. It does so in three steps: 1. It starts with the notion of the set of states of an object. There is a characteristic asymmetry on this set which can be defined independently of time, but which can be exploited to define temporal order (*before*) in a way which corresponds, as will be shown, with the order known from everyday experience. 2. The object is equipped with a counting mechanism based on successive inclusion, providing a natural parameter (as in Kuratowski*s construction of the naturals), which can then be fine-grained further to yield a rational and a real parameter. The local parameter so established is shown to increase monotonically with the before-ordering developed in (1). 3. It is shown that, given an object with a particular local index t (as developed under 2), the notion of changing the event content associated with indices less than t leads to a contradiction, whereas there is no event content for indices greater than t. Thus, the local past is fixed, and the future open. In sum, time*s passage is real, but local rather than global.

AGPhil 17.3 Fri 10:30 PTB SR AvHB

Die Natur der Gravitation — Helmut Hille[1] und •Alexander Schmidt[2] — [1]Fritz-Haber-Straße 34, 74081 Heilbronn — [2]Ulmenweg 3, 01458 Ottendorf-Okrilla

Newton erkannte, dass es nicht selbstverständlich ist, dass wir zur Erde hingezogen werden und auf ihr wandeln können, sondern das dafür eine unsichtbare Kraft verantwortlich ist, ebenso wie für das Kreisen der Planeten um die Sonne und des Mondes um die Erde, die er Zentripetalkraft nannte, weil sie alles zu einem Zentrum hinzieht.. Offen ist die Frage, warum der Himmel über uns trotz Big Bang diese gegliederte Struktur hat,. Bei einer Explosion strebt doch alles vom Explosionsort fort und auseinander. Hier kommt meine Idee der Verschränkung ins Spiel. Neben der kosmischen Fliehkraft muss es demnach von Anfang an eine ihr entgegen wirkende elementare Kraft gegeben haben, die ich "Elementarverschränkung" nenne, welche die Einheit des Big Bang erhalten will. Wo beide Kräfte im Gleichgewicht sind, haben sich Atome und letztlich aus ihnen Sonnen, Planetensysteme und Galaxien gebildet, deren Bahnen umeinander genauso dauerhaft sind wie sie selbst Wir müssen also den Materiebegriff um die Eigenschaft der Verschränkungsfähigkeit erweitern, wozu uns die Quantenphysik Hinweise gegeben hat, wobei deren Verschränkung nur eine weitere Form dieser Kraft ist. Und zumindest ist alles, was wir Gluonen nennen, auch eine ihrer Erscheinungen.

AGPhil 17.4 Fri 11:00 PTB SR AvHB

Physik als mathematische Formulierung von Theologie — •Jan M. Bürger — Europa-Universität Flensburg

Ausgangspunkt dieses Vortrags ist die Frage, ob und in wie weit es zu Konzepten der (modernen) Physik Äquivalente in religiösen (Gottes-) Aussagen (speziell des Christentums) gibt. Der Kern der Fragestellung ist die Feststellung, dass die Menschen seit jeher unter dem Einfluss und Erfahrung der Natur und der physikalischen Gesetze stehen, auch wenn deren mathematische Ausformulierung erst in der neueren Zeit entwickelt wurde.

Natürlich spielt die moderne Physik für den Alltag meist eine vernachlässigbare Rolle. Gleichzeitig stellt sich allerdings die Frage, ob nicht dennoch zumindest z.B. beim Denken und der Kreativität quantenmechanische Phänomene auftreten, die sich in theologischen Erfahrungen ausdrücken. Bezüglich des Universums lässt sich zudem die provokante Frage anschließen, ob es den Menschen im Sinne des starken Anthropischen Prinzips aufgrund einer physikalischen Notwendigkeit geben muss.

Insbesondere geht es darum, ob sich der (christliche) Auftrag, die Umwelt zu schützen und die Menschheit zu bewahren auch aus physikalischen Konzepten ableiten lässt. Es geht hierbei um einen Versuch Physik und Theologie mit ihren jeweiligen Stärken zu kombinieren. Insbesondere sollen Überlegungen erörtert werden, um ggf. einer breiteren Bevölkerung einen persönlicheren Bezug zu den aktuellen, z.T. sehr abstrakten Forschungsthemen der Physik zu ermöglichen, um damit auch Wohlwollen für deren Finanzierung zu entwickeln.