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

Meinard Kuhlmann
Philosophisches Seminar
Johannes-Gutenberg-Universität
55099 Mainz
mkuhlmann@uni-mainz.de

Christian Wüthrich
Département de Philosophie
Université de Genève
CH-1211 Genève 4
Christian.Wuthrich@unige.ch

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

Overview of Invited Talks and Sessions

(Lecture hall H-HS IV)

Invited Talks

AGPhil 3.1	Tue	17:00–17:45	H-HS IV	**Why initial conditions aren't so special** — •Matt Farr
AGPhil 3.2	Tue	17:45–18:30	H-HS IV	**How to be a Spacetime Functionalist.** — •Eleanor Knox
AGPhil 5.1	Wed	14:00–14:45	H-HS III	**Laws of nature and their modal surface structure** — •Andreas Hüttemann
AGPhil 5.3	Wed	15:15–16:00	H-HS III	**When do we stop digging? Conditions on a fundamental theory of physics** — •Karen Crowther
AGPhil 6.1	Wed	16:30–17:15	H-HS III	**Quantum metaphysics** — •Alastair Wilson

Invited talks of the joint symposium SYEN

See SYEN for the full program of the symposium.

SYEN 1.1	Thu	11:00–11:40	J-HS D	**Entanglement and Complexity in Quantum Many-Body Systems** — •Tomaz Prosen
SYEN 1.2	Thu	11:40–12:20	J-HS D	**Entanglement and Explanation** — •Chris Timpson
SYEN 1.3	Thu	12:20–13:00	J-HS D	**Production and observation of entanglement in quantum optics** — •Roman Schnabel

Sessions

AGPhil 1.1–1.3	Mon	11:00–12:30	H-HS III	**Statistical Mechanics**
AGPhil 2.1–2.4	Tue	11:00–13:00	H-HS IV	**Space, Time and Symmetry I**
AGPhil 3.1–3.2	Tue	17:00–18:30	H-HS IV	**Space, Time and Symmetry II**
AGPhil 4.1–4.4	Wed	11:00–13:00	H-HS III	**Space, Time and Symmetry III**
AGPhil 5.1–5.3	Wed	14:00–16:00	H-HS III	**Laws of Nature**
AGPhil 6.1–6.3	Wed	16:30–18:15	H-HS III	**Quantum Theory I**
AGPhil 7	Wed	18:30–19:00	H-HS III	**Annual General Meeting**
AGPhil 8.1–8.4	Thu	14:00–16:00	H-HS III	**Quantum Theory II**
AGPhil 9.1–9.3	Thu	16:30–18:00	H-HS III	**Quantum Theory III**
AGPhil 10.1–10.4	Fri	11:00–13:00	H-HS III	**General Topics I**
AGPhil 11.1–11.3	Fri	14:00–15:30	H-HS III	**General Topics II**
AGPhil 12.1–12.1	Mon	10:00–18:00	H-HS III	**Poster (Monday - Friday)**

Annual General Meeting of the Working Group on Philosophy of Physics

Wednesday 18:30–19:00 H-HS IV

- Wahlen
- Bericht
- Planung 2020/21

- Verschiedenes

AGPhil 1: Statistical Mechanics

Time: Monday 11:00–12:30 Location: H-HS III

AGPhil 1.1 Mon 11:00 H-HS III

The origins of observation — •Athamos Stradis — King's College London

In statistical mechanics, a system E at a given moment is described by a 'microstate', an exact microscopic configuration of its constituent particles. However, we only observe certain indistinguishable clusters of E's microstates ('familiar macrostates', $\{F_i\}$). Why do we observe *these* clusters, and not others ('alternative macrostates', $\{A_i\}$)? Some have offered an evolutionary explanation: since observing robust regularities is advantageous, and since $\{F_i\}$ exhibits such regularities (e.g. the Second Law), it*s no surprise that we observe $\{F_i\}$ rather than $\{A_i\}$.

To assess this explanation, we must interpret the word 'observe'. Understood passively as 'monitors', we monitor $\{F_i\}$ in that some of our states merely correlate with $\{F_i\}$. But my explanation undercuts the evolutionary explanation: since $\{F_i\}$ are the regular macrostates, they*re the ones involved in correlations, so how could we have monitored $\{F_i\}$ rather than $\{A_i\}$? One might argue that we don*t just monitor $\{F_i\}$, but also enlist them to guide our actions, and *this* is what evolution can explain. But my explanation undercuts even this: since enlisting $\{F_i\}$ presupposes monitoring $\{F_i\}$ via cognitive states in the first place, how could we have enlisted $\{F_i\}$ rather than $\{A_i\}$?

AGPhil 1.2 Mon 11:30 H-HS III

The time arrow in physics — •Grit Kalies — HTW University of Applied Sciences, Dresden, Germany

The experience of irreversibility, i.e. the empirical reality that processes have a direction and that yesterday can be distinguished from tomorrow, has occupied philosophers and physicists for centuries. Whereas quantum mechanics, special and general relativity etc. interpret processes as reversible, thermodynamics includes a physical term for the fact that a time arrow exists. This is called "The Paradox of Time" [1] that could not yet be explained by a physics approach.

In this paper is shown that the time paradox can be solved and the time arrow can be established in the whole of physics (nature), in full agreement with the experimental evidence. To this end, matter-energy equivalence [2,3] suggests abandoning the energetic idealizations of special relativity. This has far-reaching consequences for metaphysics in physics and fundamental concepts because special relativity and the associated idea of spacetime form a basis for the current standard models. The second law of thermodynamics can be understood as a fundamental law of nature, i.e. time symmetry is excluded [4].

[1] I. Prigogine, I. Stengers: Das Paradox der Zeit, Piper, München, Zürich, 1993. [2] G. Kalies: Matter-Energy Equivalence, Zeitschrift für Physikalische Chemie, 2019, DOI: 10.1515/zpch-2019-1487. [3] G. Kalies: Vom Energieinhalt ruhender Körper: Ein thermodynamisches Konzept von Materie und Zeit, De Gruyter, Berlin, 2019. [4] G. Kalies: A Solution of Time Paradox of Physics, International Journal of Theoretical Physics, 12/2019, submitted.

AGPhil 1.3 Mon 12:00 H-HS III

Deriving the local arrow of time — •Daniel Saudek — Frankfurt am Main, Germany

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 this is not true for indices greater than t. Thus, the local past is fixed, and the future open.

AGPhil 2: Space, Time and Symmetry I

Time: Tuesday 11:00–13:00 Location: H-HS IV

AGPhil 2.1 Tue 11:00 H-HS IV

Energy-momentum conservation and the specificity of general relativity — •Valeriya Chasova — Archives Henri-Poincare (AHP-PReST UMR 7117), University of Strasbourg — Centre de philosophie des sciences et societes (CEFISES), Universite catholique de Louvain

Harvey Brown [2005] argued that general relativity (GR) is specific in that inertial motion enjoys a specific status there, and he derived this status using the fact that Einstein's equations ensure the conservation of the energy-momentum tensor. In a recent paper [2019 in Studies], Weatherall shows however that the same status can also be achieved in other theories including special relativity (SR) and Newtonian gravitation (NG), and for this he relies on the fact that in these theories as much as in GR the energy-momentum conservation can also be derived from properties of the dynamics of the matter. If Weatherall is right, the specificity of GR can no longer hinge on the status of inertial motion, so I consider whether it may hinge instead on the specificity in deriving the energy-momentum conservation. Here Brown's remark that Einstein's equations ensure this conservation in GR is of help, as there is no analogue of this in SR or NG. So GR would come out as specific provided, when considering what makes a theory specific, one relied on deriving the energy-momentum conservation via field equations rather than via the dynamics of the matter. So I discuss whether we are entitled to do so.

AGPhil 2.2 Tue 11:30 H-HS IV

Symmetries and relationism — •Guy Hetzroni — Tel-Aviv University, Tel-Aviv, Israel

Despite the "century of symmetry" in physics, it seems that we have not yet achieved a satisfactory understanding of the reason that symmetry considerations repeatedly turn out helpful in constructing and unifying theories. The presented research provides an examination of the method through which symmetry principles are used in three different cases: the gauge principle in quantum field theories, general covariance in the general theory of relativity, and Mach's principle in classical mechanics. It shall be argued that the applications of symmetry arguments in all of these are all based in similar ways on a common hidden assumption, roughly stating that every possible transformation of the mathematical representation of a given system has a corresponding physical change in the state of the system with respect to another physical system. In addition to this account of the methodology, I shall claim that the most natural way to explain its success is by appealing to a certain form of relationism with respect to fundamental degrees of freedom. I shall argue that this view has the potential of providing a down-to-earth physical understanding of the applicability of symmetry considerations that stands in contrast to common descriptions of symmetries in terms of mathematical necessity, beauty of unexplained miracles.

AGPhil 2.3 Tue 12:00 H-HS IV

Measuring expansion of the universe — •Ari Belenkiy — SFU, Vancouver, Canada

Apart from the ongoing debate on who is the discoverer of the Expanding Universe, there is another debate as to whether the space around us is expanding. The debate originated as early as 1933 by G. C. McVittie and the conclusions are swinging since then. In 1973, Misner, Thorne and Wheeler suggested a standard picture for global expansion is that of a rubber balloon being gradually filled in with air. Asking whether atoms expand, whether the meter stick expand, whether the distance between sun and earth expand, Misner et al an-

swer all three questions in negative: "Only distances between clusters of galaxies and greater distances are subject to the expansion. Only at this gigantic scale of averaging does the notion of homogeneity makes sense." This conclusion however left open the question about expansion on smaller scales where homogeneity is absent and Friedman solutions are not necessarily present. In 1998, Cooperstock, Faraoni and Vollick took a contrarian view, claiming that "effects of dark energy are observable not only globally, but also in local systems. These effects can be measured and are comparable with the present value of the Hubble constant." As a result of this uncertainty, as recently as 2008, John Peacock renewed the discussion asking similar questions: "Is the space in my bedroom expanding, and what would this mean? Do we expect the Earth to recede from the Sun as the space between them expands?" All these surprising and often counter-intuitive results ask for an experiment.

AGPhil 2.4 Tue 12:30 H-HS IV

Symmetry and the equivalence of models — •Joanna Luc — Jagiellonian University, Kraków, Poland

In my talk I will defend the thesis that symmetry-related models of the same physical theory should be regarded as representing one and the same physical state (this thesis will be called SYM-ONE). I will start from listing potential counterexamples to this interpretative principle present in the literature (Belot 2013, Belot 2018, Fletcher 2018, Roberts 2015). Then, the conceptual framework will be proposed that enables one to analyse these examples in a way that avoids abandoning SYM-ONE. The crucial ingredient of this framework is the distinction between theoretical and applied models. The latter include elements that are needed to relate theoretical models to the actual measurements, such as the choice of reference frame and the choice of units. The fact that symmetry-related models are often treated as representing physically distinct states in scientific practice can be explained by the fact that scientists use implicitly applied models, not their theoretical counterparts. Therefore, the arguments from scientific practice against SYM-ONE do not work and arguments of other types are claimed to be less forceful in this context.

AGPhil 3: Space, Time and Symmetry II

Time: Tuesday 17:00–18:30 Location: H-HS IV

Invited Talk AGPhil 3.1 Tue 17:00 H-HS IV

Why initial conditions aren't so special — •Matt Farr — University of Cambridge, UK

The early universe is thought to be extremely low probability in a way that calls for explanation. Some have used the 'initialness defence' to argue that initial (as opposed to final) conditions are intrinsically special in that they don't require further explanation. Such defences commonly assume a primitive directionality of time to distinguish between initial and final conditions. I outline and support a deflationary account of the initialness defence, and argue that although there is no intrinsic difference between initial and final conditions, once we have sufficient structure to discern between them we should not seek explanations of low-probability initial conditions.

Invited Talk AGPhil 3.2 Tue 17:45 H-HS IV

How to be a Spacetime Functionalist. — •Eleanor Knox — King's College London

Spacetime functionalism has become a popular topic, but the devil is in the details - it is easy to advance a broad functionalist thesis, but if such a position is to have interesting applications it needs to be fleshed out. This talk will articulate one version of spacetime functionalism, inertial frame functionalism, and defend it against some recent objections.

AGPhil 4: Space, Time and Symmetry III

Time: Wednesday 11:00–13:00 Location: H-HS III

AGPhil 4.1 Wed 11:00 H-HS III

The history and interpretation of event horizons — •Dennis Lehmkuhl — Institut für Philosophie, Universität Bonn, Am Hof 1, 53113 Bonn

I will describe the conceptual evolution of what we today call the event horizons of black holes. I will first discuss Einstein's interpretation of the so-called "Schwarzschild singularity" in Schwarzschild's original coordinates of the first exact solution to the Einstein field equations, and the subsequent discussions during the 1920s of how that singularity ought to be interpreted. I will then describe Penrose's reinterpretation of the Schwarzschild solution in the late 1950s and early 1960s, inspired by Eddington-Finkelstein coordinates, and how he reconceptualised the "Schwarzschild singularity" in terms of what we today call an event horizon. In the course of comparing Einstein and Penrose, I will comment on the evolution of thoughts on real vs coordinate singularities, singularities vs event horizons, and local vs global structures of spacetime.

AGPhil 4.2 Wed 11:30 H-HS III

Information in black hole complementarity — •Saakshi Dulani — University of Geneva

Lured by Wheeler's adage 'it from bit,' theoretical physicists are increasingly tempted to interpret the foundations of physics as consisting in information (bit), rather than substances such as particles or fields (it). The consequences of this informational turn are many and profound, including at the frontier of contemporary physics where the question arises whether bits of information get lost in black holes. However, there is widespread disagreement about what the relevant notion of information is. Scholars such as Maudlin [2017] and Wallace [2018] have recently argued that the Black Hole Information Paradox was never about information. 'Information loss' is just a catchy phrase to mean non-unitary evolution. I will argue that the Black Hole Information Paradox is indeed about information, a concept which urgently requires clarification. Bekenstein-Hawking entropy was cast in terms of Shannon entropy from its inception. Furthermore, to claim that black hole evaporation either violates or respects unitarity, one must invoke the behavior of von Neumann entropy, another concept which is foundationally ambiguous. As a case study, I will analyze the meaning of information in Susskind's [2008] controversial solution called Black Hole Complementarity (BHC). I will argue that BHC is incoherent because it represents a hodgepodge of contradictory philosophical positions: operationalism, realism, relationalism, and absolutism. Nonetheless, BHC offers insights into what an observer-dependent definition of information looks like.

AGPhil 4.3 Wed 12:00 H-HS III

Relativity without miracles. — •Adán Sus — University of Valladolid (Spain)

It has recently been claimed that the fact that all the non-gravitational fields are locally Poincaré invariant and that these invariances coincide, in a certain regime, with the symmetries of the spacetime metric is miraculous in general relativity (GR). In this talk I will show that, in the context of GR, it is possible to account for these so-called miracles of relativity. The way to do so involves integrating the realisation that the gravitational field equations (Einstein field equations in GR) impose constraints on the behaviour of matter in a novel interpretation of the equivalence principle, which dictates the determination of local inertial frames through gravitational interaction. This proposed explanation of the miracles can also deal with the cases that are problematic (counter-examples) for the attempts at explaining the coincidence of symmetries in the context of the standard geometrical perspective on relativity theory.

AGPhil 4.4 Wed 12:30 H-HS III

Knox's spacetime functionalism and Leibniz's modal relationism — Radmila Jovanovic Kozlowski[1] and •Andrej Jandric[2] — [1]Faculty of Philosophy,University of Belgrade, Serbia — [2]Faculty of Philosophy,University of Belgrade, Serbia

In this paper we compare a new, functionalist approach to spacetime, advanced by Eleanor Knox, with Leibniz's metaphysical account, which was the most influential opposition to Newtonian substantivalism in his time. Knox's account of spacetime is inspired by Brown's dynamic approach to relativity, which is typically used as as an argument for relationism, yet she uses it to defend a view which in some aspects resembles substantivalism. Knox characterises her view as "simple realism about spacetime", "substantivalism-lite" or "substantivalism stripped off the containment metaphor". According to her, spacetime is defined via its functional role in a physical theory: to determine local inertial frames. Leibniz, on the other hand, is usually classified as a relationist, although there is an ongoing debate about what type of relationism should be ascribed to him: non-modal or modal. In non-modal relationism, space and time are simply an assemblage of relations which actually obtain between objects; in modal relationism, space and time form a geometrical network of all possible positions that objects may take, even if no object actually does. We argue that the modal interpretation of Leibniz better fits textual evidence, and that it presents a proto form of functionalism in the sense of Knox.

AGPhil 5: Laws of Nature

Time: Wednesday 14:00–16:00 Location: H-HS III

Invited Talk AGPhil 5.1 Wed 14:00 H-HS III

Laws of nature and their modal surface structure — •Andreas Hüttemann — Universität zu Köln

I will start by arguing that the practices of explanation, confirmation, manipulation and prediction require a particular reading of the law statements involved, namely as making claims about systems. These claims, I will argue further, are modal statements, statements about how systems may or may not behave. More particularly I will defend three claims about the modality of laws. First, law statements attribute a space of possible states to systems. Second, laws constrain the temporal development of systems by virtue of what I will call law equations. Thirdly, the laws* inviolability or natural necessity can be explicated in terms of the fact that they are invariant with respect to a number of different kinds of circum-stances.

AGPhil 5.2 Wed 14:45 H-HS III

The modal status of the laws of nature. Tahko's hybrid view and the kinematical/dynamical distinction. — •Salim Hirèche[1], Niels Linnemann[4], Robert Michels[1,2,3], and Lisa Vogt[1,5] — [1]Université de Genève — [2]Université de Neuchâtel — [3]Università della Svizzera italiana — [4]Universität Bremen — [5]Universitat de Barcelona

Tahko (2015) recently argued for a hybrid view of the laws of nature, according to which some physical laws are metaphysically necessary, while others are metaphysically contingent. His core idea is that the metaphysically necessary laws feature fundamental natural kinds, while the contingent laws do not. We show that this criterion is on its own insufficient: First, it lacks robustness, since it fails to rule out redescriptions of Tahko's crucial case study of a metaphysically contingent law (Coulomb's law) according to which the law features a natural kind and therefore qualifies, pace Tahko, as metaphysically necessary. Second, the focus on kinds is unwarranted, given that natural kinds could be in principle substituted by different entities whose essences ground the metaphysical necessity of the law. Third, the criterion does not have a clear motivation from the perspective of naturalized metaphysics. We then propose an alternative way of drawing the metaphysically necessary/contingent-distinction for laws of physics based on the central kinematical/dynamical-distinction used in physical theorising. As we argue, this new criterion can be used to amend Tahko's own account, but can also be combined with different metaphysical views about the source of necessity.

Invited Talk AGPhil 5.3 Wed 15:15 H-HS III

When do we stop digging? Conditions on a fundamental theory of physics — •Karen Crowther — University of Oslo

In seeking an answer to the question of what it means for a theory to be fundamental, it is enlightening to ask why the current best theories of physics are not generally believed to be fundamental. This reveals a set of conditions that a theory of physics must satisfy in order to be considered fundamental. Physics aspires to describe ever deeper levels of reality, which may be without end. Ultimately, at any stage we may not be able to tell whether we've reached rock bottom, or even if there is a base level—nevertheless, I draft a checklist to help us identify when to stop digging, in the case where we may have reached a candidate for a final theory. Given that the list is—according to (current) mainstream belief in high-energy physics—complete, and each criterion well-motivated, I argue that a physical theory that satisfies all the criteria can be assumed to be fundamental in the absence of evidence to the contrary.

AGPhil 6: Quantum Theory I

Time: Wednesday 16:30–18:15 Location: H-HS III

Invited Talk AGPhil 6.1 Wed 16:30 H-HS III

Quantum metaphysics — •Alastair Wilson — University of Birmingham, Birmingham B15 2TT, UK

Philosophy, specifically natural philosophy, used to be our main route to understanding the deep underlying structure of reality. Physics emerged out of natural philosophy during the Scientific Revolution, and over the past few centuries it has come to seem as though physics is all we need to understand the natural world. But is there still any role for philosophy to play? In this talk I'll argue that metaphysics and physics overlap in their subject-matter, and that they can work together to help us understand some of the deepest mysteries of nature: chance, possibility and necessity. My focus is objective modality: the possibilities, necessities and contingencies inherent in nature (if any there be). What bearing does progress in physics have on objective modality? A prioristic modal metaphysics is conceived as demarcating a space of possibilities that is epistemically prior to and independent of the discoveries of science. Naturalistic metaphysics is metaphysics which brings scientific considerations to bear on modal questions; the greater the role given to science by an approach to modality, the more naturalistic that approach. I develop and defend a fully naturalistic reductive account of objective contingency in nature, drawing on resources from Everettian (many-worlds) quantum mechanics. I distinguish four degrees of naturalistic involvement in the theory of modality; the proposed quantum modal realism is naturalistic in all four senses. I also sketch some consequences of the account for the methodology of metaphysics.

AGPhil 6.2 Wed 17:15 H-HS III

How to be a wave function realist—and why you should not be one — •Tushar Menon — University of Cambridge, Cambridge, UK — University of Bonn, Bonn, Germany

Wavefunction realism is a metaphysical proposal for non-relativistic quantum mechanics according to which the state vector of quantum mechanics is interpreted as a complexvalued physical field in a (very) high-dimensional space. This high-dimensional space is its true arena, in the sense that it represents the fundamental spatial ontology associated with quantum theory. In this paper, I articulate an objection to wavefunction realism that applies even in its originally intended domain of non-relativistic quantum mechanics. I argue that the metaphysical motivation behind the arena view of physical space, together with a standard position regarding the definability of observables, man-

date a belief that it is a principal fibre bundle, not a configuration space that should be taken to represent the physical arena of a non-relativistic quantum system. I conclude by considering amendments to the position, none of which, I contend, capture the original spirit of the proposal.

AGPhil 6.3 Wed 17:45 H-HS III

Why wavefunction realists should be Hilbert-space fundamentalists — •David Schroeren — Philosophy Department, 1879 Hall, Princeton University, Princeton, NJ 08544, USA

I argue that wavefunction realists should endorse *Hilbert-space fundamentalism*: the thesis that the Hilbert space of abstract 'kets' characterizes a fundamental physical space in its own right. I proceed as follows. For a system with spin, the wavefunction-realist physical field is mathematically characterized by an element of the form $\psi(x) \otimes |\varphi\rangle$, where $|\varphi\rangle$ is a ket in a spin Hilbert space $\mathcal{H}$ spanned by basis elements $|j, m\rangle$ for $-j \leq m \leq j$. The goal is to show that wavefunction realists should be fundamentalists about Hilbert spaces $\mathcal{H}$ as *linear* spaces rather than as projective spaces that consist of rays. My argument proceeds from two observations: first, that the actual world is such that its quantum properties are characterized in terms of *projective* representations of symmetry groups rather than linear ones; and second, that the nature of projective representations of $SO(3)$ entails that spin is half-integer-valued, rather than integer-valued. I then argue both that we *can* and *should* regard this as a physical explanation of the fact that spin is half-integer valued. Subsequently, I argue that the relevant explanation is contrastive: if the world had been such that its physical properties are characterized by linear representations of symmetry groups *rather than projective ones*, then spin would be integer-valued. Finally, I argue that this contrastive explanation implies fundamentalism about spin Hilbert spaces as linear spaces.

AGPhil 7: Annual General Meeting

Time: Wednesday 18:30–19:00 Location: H-HS III

Duration: 30 min.

AGPhil 8: Quantum Theory II

Time: Thursday 14:00–16:00 Location: H-HS III

AGPhil 8.1 Thu 14:00 H-HS III

Is there room for entanglement relations in the Humean mosaic? — •Lorenzo Lorenzetti — University of Lugano, Lugano, Switzerland

This paper concerns the notoriously difficult relationship between Humean Supervenience (HS) and quantum entanglement. The most conservative strategy to defend Humean Supervenience is to add the problematic entanglement relations to the supervenience basis, alongside spatiotemporal relations. In this paper I am going to present a novel argument against this strategy. I will analyse the thesis of HS and make explicit one necessary condition - concerning the nature of the relations in the mosaic - that has to be posited a priori to save HS from being trivial. I will then show how entanglement relations fail to satisfy that condition in some particular cases of tripartite entanglement states, i.e. GHZ states. These states are also critical for locality, one of the central tenets of HS. I conclude that the conservative move is untenable and the Humean is therefore forced to pursue more demanding and controversial strategies, e.g. claiming that the physical world is spatially 3N-dimensional.

AGPhil 8.2 Thu 14:30 H-HS III

Kurt Gödel on the interpretation of quantum mechanics — •Oliver Passon — Bergische Universität Wuppertal

Kurt Gödel wrote in 1935/36 his only recently transcribed notebooks on quantum mechanics. They allow for a unique insight into Gödel's thoughts on the foundation of this theory. At that time the formalism of quantum mechanics had already reached an early maturity (as indicated e.g. by the publication of von Neumann's "Mathematische Grundlagen der Quantenmechanik" in 1932). This development brought the issue of the interpretation of the theory to the center of the debate, as indicated most notably by the famous EPR paradox (Einstein et al.) or the Schrödinger-cat thought experiment.

The talk will report on an early stage in the work to relate Gödel's thoughts on quantum theory to the different strands of this debate on quantum mechanics.

AGPhil 8.3 Thu 15:00 H-HS III

Inconsistencies in the foundations of relational quantum mechanics — •Alistair Whittle — University of Bristol

Carlo Rovelli claims that in quantum mechanics, two different observers can give different but nevertheless correct descriptions of the same sequence of events (1996: 1643). This main observation is used to propose a new interpretation of quantum mechanics, termed Relational Quantum Mechanics (RQM), in which the states and values of physical systems are indexed relative to different observers. This paper argues that the main observation that underpins RQM is inconsistent with two assumptions of its assumptions, namely, that interaction between systems is necessary for a system to have information about the other and that all physical systems are equivalent. As such, this paper argues that the main observation cannot sustain the relational interpretation of quantum mechanics that it originally motivated. However, in pointing out these inconsistencies, the paper argues that RQM can nevertheless be reinstated as a viable interpretation if we stay true to Rovelli's assumptions.

AGPhil 8.4 Thu 15:30 H-HS III

'Relational Einstein' - revisiting the relational EPR — •Matthias Martin Ackermann — University of Bristol, United Kingdom

Relational EPR (R-EPR) was initially proposed to dissolve the commonly assumed non-local implications of the original EPR-argument and claimed to restore locality in Quantum Mechanics (QM). In this paper I suggest two things: first of all, an exchange of the foundation of *R-EPR*'s analysis; meaning that I refer to Einstein's own incompleteness argument instead of EPR. The main reason behind this replacement is *R-EPR*'s explicit reference to 'Einstein's realism' while at the same moment developing the relational approach from the EPR. And secondly, based on the first step, I consider a reading of *Relational EPR*'s analysis as separable and local in the framework of Einstein's argument. However, widening the scope of the framework can turn *R-EPR*'s core strength - the de-objectivisation of reality in terms of observer-relativity - into a major drawback. All in all, in its current state, *Relational Quantum Mechanics* is unable to provide an unambiguous account of locality.

AGPhil 9: Quantum Theory III

Time: Thursday 16:30–18:00 Location: H-HS III

AGPhil 9.1 Thu 16:30 H-HS III

Changing worlds through quantum mechanics — •Tina Wachter — Universität Siegen, Germany — Leibniz Universität Hannover, Germany

Based on Kripke's(1972/80) approach I present a distinction between 'possible worlds' and 'counterfactual situations' which must be distinguished for proper examinations of quantum mechanical interpretations and questions concerning the Identity of Indiscernibles. Whereby the first are important for thinking about 'ways the world might have been' (Lewis) by considering a whole world, somehow similar to our actual world but far enough to be as different as we wish it to be; the latter, counterfactual situations, (Kripke) are the relevant ones giving proper evidence for 'what happens to objects if certain circumstances have changed'. For possible worlds are much broader and not directly dependent on our actual world, counterfactual situations, understood as 'miniworlds' or 'ministates' as focussed cuttings of our actual world, are directly related to our understanding of actual world objects or properties. Therefore, descriptions must be sharpened with respect to this distinction, because only counterfactual situations provide proper evidence and (epistemologically) relevant results for our actual world, for they truly speak about the 'things we have' in our world. Even possible worlds considered as equivalent examples cannot provide the same relevant results for our world as counterfactuals do, neither with respect to QM nor the Identity of Indiscernibles.

AGPhil 9.2 Thu 17:00 H-HS III

From metaphysical postulates to dissipative quantum field theory — •Hans Christian Öttinger — ETH Zürich, Switzerland

Four metaphysical postulates concerning (i) mathematical images of Nature, (ii) space and time, (iii) infinities, and (iv) irreversibility are used to motivate a fundamental quantum master equation (QME) for quantum field theory (QFT) [1]. This thermodynamically consistent QME provides conceptually clear and mathematically rigorous foundations for QFT, as well as a distinct particle ontology. UV regularization is provided by dissipative smearing, IV regularization results for a finite Universe. The distinction between free and interacting particles gets a deeper meaning going far beyond perturbation theory or the interaction picture. Particles are not localized in space, but all interactions are strictly local; therefore, a high-energy collision in a particle accelerator, followed by many low-energy collisions in a detector, can be used to visualize a bunch of particle trajectories emerging from a vertex.

In the limit of weak dissipation, when the length scale associated with dissipation is smaller than any observable length scale, dissipative QFT reproduces the results of conventional approaches to effective field theories. As a benefit of dissipative QFT, in addition to conceptual clarity and rigor, one is led to a new dynamic simulation methodology based on stochastic unravelings of QMEs in Fock space. Dissipation at the Planck scale might even be considered as the origin of gravity.

[1] H. C. Öttinger, A Philosophical Approach to Quantum Field Theory (Cambridge University Press, 2017).

AGPhil 9.3 Thu 17:30 H-HS III

Limits of human knowledge and the relationship between mind and matter — •Matthias Hanauske — Frankfurt Institute for Advanced Studies — Institut für Theoretische Physik, Frankfurt, Germany

Fundamental metaphysical questions, like the human limits of knowledge have been discussed in the context of the confinement of quarks and the event horizon of black holes. Due to the strong gluonic interaction of QCD, the color space of quarks is not directly accessible by an external observer and black holes shield their inner area through event horizons. However, in future gravitational wave (GW) detections of binary neutron star merger systems it might be possible to detect the QCD phase transition by analysing the spectrum of the post-merger GW of the differentially rotating hypermassive hybrid star (HMHS). During the collapse of the HMHS to a Kerr black hole the color degrees of freedom of the pure quark core gets macroscopically confined by the formation of the event horizon. The second example focuses on metaphyisical problems of socio-economic complex networks and addresses the relationship between mind and matter by focusing on evolutionary quantum game theoretical concepts. Through a potential quantum-theoretical entanglement of the decision paths of the underlying players of the actor network, a population can escape a dilemma-like situation, if the value of entanglement is above a certain threshold.

AGPhil 10: General Topics I

Time: Friday 11:00–13:00 Location: H-HS III

AGPhil 10.1 Fri 11:00 H-HS III

Are we living in a bidirectional big bang / big crunch universe? — •Fritz Wilhelm Bopp — Universität Siegen, Walter-Flex-Str. 3, 57068 Siegen

The interrelation of macroscopic classical and usually microscopic quantum physics is considered. Arguments for fixed two state vector quantum mechanics are outlined in a somewhat pedagogic way. A heuristic concept is developed how something like classical physics could emerge in an early epoch of a finite universe with a compact initial state and an extremely extended final one. The concept contains no intrinsic paradoxes.

However it can not incorporate free agents which are somehow essential. To allow for free agents the fixed final state is replaced by a matching state of maximum extend between an expanding and a contracting universe. How a bidirectional macroscopic world with possible free agents could emerge in such a big bang / big crunch universe is the central object of the paper.

AGPhil 10.2 Fri 11:30 H-HS III

Experimentally proven: An argument used to justify mythological concepts and entities in theoretical physics. — •Osvaldo Domann — Stephanstr. 42, 85077 Manching, Germany

Theoretical physics concentrates on building models that allow obtaining calculated data that match with experimental data, independent of the physical world. That explains the existence of fictitious particles like gluons, gravitons, dark matter, energy, etc. and fictitious variables like time dilation and length contraction. Once these fictitious entities are integrated in the standard model they lose their character of *transitory makeshift solutions* and become the starting point of new physical and philosophical models magnifying the mythology. The argument used to justify the fictitious entities is, that they are experimentally proven, not realizing that the apparent prove of their existence is a fallacy. The argument avoids that new models build on well proven physical interaction laws are pursued, models which can explain experimental data without fictitious entities. This shows the necessity to recognise when the argument 'Experimentally Proven' is a real justification or simply a fallacy to justify mythological concepts. More at: www.odomann.com

AGPhil 10.3 Fri 12:00 H-HS III

On Leibniz's contribution to the concept of absolute space — •Dieter Suisky — Berlin

For having now available almost all writings of Leibniz and Newton, it becomes obvious that there are two versions of absolute theory of space and time and it is not exclusively Newton who represents the absolute side. The Leibnitian version is even the earlier one (1669-71). The later developments, however, manifested the roles of Newton and Leibniz in the relational/absolute debate (Barbour, Smolin). Leibniz himself contributed a lot to the later interpretation for he tried to enforce the impact of his criticism by the substantial turn in the end of 1670s. His arguments for and against absolute space are:

"If space is a certain thing consisting in a supposed pure extension, whilst the nature of matter is to fill space, and motion is change of space, then motion will be something absolute; and so when two bod-

ies are approaching one another, it will be possible to tell which of them is in motion and which at rest; (...). And from this will follow those conclusions which I once showed in the *Theory of Motion Abstractly Considered*. But in reality (...) motion is not something absolute, but consists in relation." (Leibniz (Early 1677))

It will be demonstrated that Leibniz mainly developed his absolute theory as a response to Huygens' *Rules of collision* in a writing entitled *On the causes of motion* whereas Newton's analysis in *On Gravitation* basically concerns Descartes' theory. The former debates will be related to the currently discussed question of background dependence.

AGPhil 10.4 Fri 12:30 H-HS III

Reduktionismus in der modernen Physik — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

Die moderne westliche Naturwissenschaft basiert generell auf dem reduktionistischen Ansatz. Simple Systeme bilden in ihrem Zusammenspiel komplexere bis hinauf zu den Systemen, aus denen unsere sichtbare Umgebung besteht und unsere menschliche Existenz selbst. Aufgabe der Wissenschaft ist es deshalb, die komplexen Systeme unserer Umgebung und unserer Wahrnehmung auf ihre einfacheren Grundlagen zurück zu verfolgen.

Die Physik hat seit der Zeit Newtons mit diesem Ansatz große Fortschritte erzielt, und vom theoretischen Ansatz her besteht Einigkeit über das Vorgehen. In der moderneren Physik allerdings wurde diese Linie zu einem gewissen Grade verlassen, besonders in den Gebieten, die als die Krone bisheriger Forschung gelten, nämlich in der Relativitätstheorie Einsteins und in der Quantenmechanik nach Bohr und Heisenberg.

Wir werden an einigen Beispielen aus der Zeitenwende um Newton und dann aus der Entstehungszeit von Relativität und QM zeigen, in welchem Maße dieser Ansatz aufgeweicht wurde. Und wir werden auf offene Problem der heutigen Physik hinweisen, die man als Folge dieses veränderten Paradigmas ansehen kann.

Zur Einführung: www.ag-physics.org

AGPhil 11: General Topics II

Time: Friday 14:00–15:30 Location: H-HS III

AGPhil 11.1 Fri 14:00 H-HS III

The fundamental role of the proper time parameter in general relativity and in quantum mechanics — •René Friedrich — Strasbourg

Einstein's relativity provides us with some hints about the nature of time which have not been fully taken into account in quantum gravity yet. The phenomenon of time dilation is replacing Newton's absolute time with a twofold, complementary time concept, consisting of the observer's coordinate time after time dilation and the observed object's proper time before time dilation.

Although many authors are highlighting the importance of proper time within GR, theories of quantum gravity are usually starting off with the assumption of a relative spacetime manifold. However, for fundamental questions about the nature of time we should not refer to coordinate time but to the more fundamental parameter of proper time. Following this approach, the universe of quantum gravity is composed of solipsistic worldlines which are parameterized by their respective proper time, including lightlike worldlines of fields whose length is zero.

The definition of proper time: "The time measured by a clock following a given particle" provides the particle with a well-defined physical property: its aging - in general relativity as well as in quantum mechanics. It will be shown that, in a first step, time is produced locally by the rest energy of mass particles in the form of proper time, and that only in a second step time is measured and synchronized by observers in the form of coordinate time.

AGPhil 11.2 Fri 14:30 H-HS III

Scientific paradigms and large groups — •Alexander Unzicker — Pestalozzi-Gymnasium München

In the past hundred years, the fashion of how scientists collaborate with each other has changed dramatically. Modern science seems to be impossible without groups involving a huge number of researchers. However, this has considerable side effects on the origin and persistence of paradigms in the sense of Thomas Kuhn.

AGPhil 11.3 Fri 15:00 H-HS III

For a new world view of physics without metaphysics — •Helmut Hille — D-74081 Heilbronn, Fritz-Haber-Straße 34

It is a human viewing habit to understand separately seen objects as separately existing objects, although the system sun-earth-moon proves the opposite. None of these bodies would have its orbit without the other und there would be no tides on earth. Entangled quanta have shown that their common origin makes them behave as being one. The Big Bang is the origin of all matter in our cosmos; the matter wants to reunite in form of gravitation. This is another proof for the power of the invisible, which has to be accepted. As a way out, today, we search the invisible in the dark matter and in energy. However, the invisible which I am concerned about has no name. It is only the reverse side of the visible, which we capture by means of the gravitational constant. Thus, gravitation is a form of entanglement of all concerned matter and energy, which I call provisionally super entanglement. In connection with another three reasonable premises this results in a world view of physics which is rational and not metaphysical like the actual one.

AGPhil 12: Poster (Monday - Friday)

Time: Monday 10:00–18:00 Location: H-HS III

AGPhil 12.1 Mon 10:00 H-HS III

A survey on foundational issues — Petr Jedlička[1] and •Šimon Kos[2] — [1]University of West Bohemia, Department of Philosophy, Pilsen, Czechia — [2]University of West Bohemia, Department of Physics, Pilsen, Czechia

As foundational debates are far from settled, in the past, a few authors tried to map out views on crucial issues in quantum theory, which confirmed ongoing deep rifts. The tradition originated with Max Tegmark and his 1997 poll (The Interpretation of Quantum Mechanics: Many Worlds or Many Words?, arXiv:quant-ph/9709032v1), in which he observed a gradual change in views in the past decades - the once dominant Copenhagen interpretation encountered its most serious contender in the Many Worlds interpretation, followed by the Consistent Histories, Bohm and Modified dynamics (GRW/DRM). In 2013, Schlosshauer, Kofler, and Zeilinger continued the poll with an enlarged set of questions, which also pointed out to the role of philosophical biases (A Snapshot of Foundational Attitudes Toward Quantum Mechanics, arXiv:1301.1069v1).

We replicated an updated SKZ poll in the community of physicists, as a part of our larger interdisciplinary project on objectivity, which focuses on the understanding of this concept among natural scientists. Apart from quantum phenomena we also addressed other questions on the border of science and metaphysics, e.g. the objectivity of existence of various objects, the relationship between mathematics and physics, the future of the discipline etc.