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

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Overview of Invited Talks and Sessions

Invited Talks

AGPhil 1.1	Mon	11:00–11:45	H4	**What's so special about initial conditions?** — •Matt Farr
AGPhil 1.3	Mon	12:15–13:00	H4	**Structuralism as a Stance** — •Kerry McKenzie
AGPhil 2.1	Tue	11:00–11:45	H4	**Quantum Metaphysics** — •Alastair Wilson
AGPhil 7.1	Thu	11:00–11:45	H7	**Four Attitudes Towards Singularities in the Search for a Theory of Quantum Gravity** — •Karen Crowther

Invited talks of the joint symposium Entanglement (SYEN)

See SYEN for the full program of the symposium.

SYEN 1.1	Mon	16:30–17:10	Audimax	**Squeezed and entangled light - now exploited by all gravita-tional-wave observatories** — •Roman Schnabel
SYEN 2.1	Mon	17:10–17:50	Audimax	**Entanglement and Explanation** — •Chris Timpson
SYEN 3.1	Mon	17:50–18:30	Audimax	**Entanglement and complexity in quantum many-body dynamics** — •Tomaz Prosen

Sessions

AGPhil 1.1–1.3	Mon	11:00–13:00	H4	**Metaphysics of Physics**
AGPhil 2.1–2.4	Tue	11:00–13:15	H4	**Quantum Theory 1**
AGPhil 3.1–3.4	Tue	14:00–16:00	H5	**Quantum Theory 2**
AGPhil 4.1–4.4	Wed	14:00–16:00	H8	**Quantum Theory 3**
AGPhil 5.1–5.4	Wed	16:30–18:30	H8	**Quantum Theory 4**
AGPhil 6	Wed	18:30–19:00	MVAGPhil	**Mitgliederversammlung der AGPhil**
AGPhil 7.1–7.3	Thu	11:00–12:45	H7	**Quantum Gravity 1**
AGPhil 8.1–8.3	Thu	14:00–15:30	H7	**Quantum Gravity 2**
AGPhil 9.1–9.3	Thu	16:30–18:00	H7	**General Relativity and Black Holes**
AGPhil 10.1–10.4	Fri	11:00–13:00	H3	**Quantum Mechanics, Time and Information**

Annual General Meeting of the Working Group on Philosophy of Physics

Wednesday 18:30–19:00 MVAGPhil

- Wahlen
- Bericht
- Planung 2021/22
- Verschiedenes

AGPhil 1: Metaphysics of Physics

Time: Monday 11:00–13:00 Location: H4

Invited Talk AGPhil 1.1 Mon 11:00 H4
What's so special about initial conditions? — •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 consistent with an directionless ontology of time, and argue that although there is no intrinsic difference between initial and final conditions, once we have sufficient structure to discern them we should not seek explanations of low-probability initial conditions.

AGPhil 1.2 Mon 11:45 H4
The mereological problem of entanglement — •Paul M. Näger — Department of Philosophy, WWU Münster, Germany

The discipline of mereology treats the question how parts and wholes relate and has its roots in ancient Greek philosophy. Especially in the 20th century its concepts have been sharpened considerably resulting in a formalism called classical mereology. From this point of view, entangled quantum systems are an anomaly since they are well-known to involve some kind of holism in the sense that the quantum state of the whole cannot be reduced to the quantum state of the parts. Are entangled systems undivided wholes? In this talk I shall argue on the basis of the quantum mechanical formalism that they are not: When two objects are entangled, there are only these objects but no whole, and the holistic entangled property is carried collectively by these objects. (Paper available at: https://philarchive.org/rec/NGETMP)

Invited Talk AGPhil 1.3 Mon 12:15 H4
Structuralism as a Stance — •Kerry McKenzie — UC San Diego, USA

Bas van Fraassen argues in 'The Empirical Stance' that physicalism - the view that fundamentally all is physical - should be viewed not as a doctrine but rather as a 'stance': that is, as a cluster of attitudes, policies, and heuristics concerning how to theorize and conduct research. In this talk, I will argue that the same considerations support regarding ontic structuralism - the view that fundamentally all is structure - as a stance also. More specifically, I will argue that rather than a doctrine about how the world is fundamentally, structuralism should be viewed as the injunction to always foreground in one's metaphysics the fact that the language of physics is mathematics. Some benefits of doing so will be presented.

AGPhil 2: Quantum Theory 1

Time: Tuesday 11:00–13:15 Location: H4

Invited Talk AGPhil 2.1 Tue 11:00 H4
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 argue that philosophy and physics can work together to help us understand some of the deepest mysteries of nature: in particular, chance, possibility and necessity. I suggest that the Everett interpretation of quantum mechanics - if correct - can cast light on many core questions of metaphysics, while embedding the Everettian approach in a suitable metaphysical framework can strengthen it in turn. The overall method I advocate is 'naturalistic metaphysics' - theorizing about the most general aspect of reality in a way informed and constrained by our best physics - and I will end by asking how far this naturalistic approach can be taken.

AGPhil 2.2 Tue 11:45 H4
The Representation and Determinable Structure of Quantum Properties — •Samuel C. Fletcher and David E. Taylor — University of Minnesota, Twin Cities

Let us begin with a puzzle. Consider an electron with a two-dimensional Hilbert state space, and the properties of having spin in the x- and y-directions, respectively. On the one hand, it is standard to represent these as the Pauli operators σ_x and σ_y, whose eigenvalues represent the values of spin-up and spin-down in their respective directions. And it is well-known that these operators do not commute. On the other hand, it is also commonly acknowledged that projection operators, as self-adjoint operators, can also represent these quantities, whose eigenvalues represent the property obtaining or not. But each of these quantities is only plausibly represented by the identity operator on the Hilbert space, and these operators obviously commute. Operators commute iff the properties they represent are compatible. So the spin-x and spin-y properties are both compatible and not compatible: a contradiction. We propose to resolve this puzzle by denying that self-adjoint operators represent properties simpliciter: rather, they represent a determinable property, whose extension is the domain of the operator, **plus** a particular level of specification with associated determinates, which are named by the eigenvalues. So the different operators in the puzzle actually reflect different levels of specification of one and the same property. Thus it is not the properties of a quantum system which are incompatible in a non-classical way, but rather the levels of specification.

AGPhil 2.3 Tue 12:15 H4
Spatial Separation of Magnetic Moment and Location as an Argument for a Trope-Ontological Interpretation of Quantum Field Theory — •Karim Baraghith[1] and Nina Nicolin[2] — [1]Heinrich Heine Universitaet Duesseldorf, GER — [2]Heinrich Heine Universitaet Duesseldorf, GER

It has been suggested to interpret particles in quantum field theory (QFT, in particular AQFT) as bundles of tropes, see e.g. Kuhlmann (2010). In this reading, a *thing* (like a particle) does not *have* its properties, it is the specific combination of the properties which constitute the thing in the first place. We will present an empirical matter-wave interferometer experiment (Denkmayr et. al. [2014]), which shows that one can indeed separate a particle*s properties, experimentally (Chesire Cat phenomenon). It indicates that when sending neutrons through a silicon crystal interferometer, while performing weak measurements in or-der to probe the location of the particle and its magnetic moment, the system behaves as if the neutrons go through one beam path, while their magnetic moment travels along the other. Following a specific interpretation of these observations, it seems to be the case that what we call a *property* may exist fundamentally and independently of its particle (or at least can be isolated from it). We argue that a trope theoretical interpretation of quantum particles * which sees the particle*s properties and not the particle itself as fundamental * is probably the most com-patible ontological interpretation of this phenomenon.

AGPhil 2.4 Tue 12:45 H4
The Unactualized Certainty-Actuality Correspondence — •Armin Nikkhah Shirazi — University of Michigan, Ann Arbor, USA

This talk investigates the correspondence between unactualized certainties and actualities. It does this first through the lens of a recently proposed enrichment of axiomatic probability which makes it possible to distinguish mathematically between actualities and unactualized possibilities, including those which are certain. Two kinds of unactualized certainties are considered: those due to the sample space being a singleton, and those involving a sample space with more than one element.

After comparing standard axiomatic probability with the enrichment in regards to how they represent the distinction, attention is then focused on quantum mechanics. There, the correspondence will be examined through the lens of a recently proposed modification of the standard formalism, the Heisenberg Interpretation, which, unlike the standard quantum formalism but like the enriched axiomatization of probability, also permits formal distinctions between unactualized possibilities and actualities. Two situations are found to exemplify the correspondence there: one involving partially measured entangled systems and the other involving the Born rule.

AGPhil 3: Quantum Theory 2

Time: Tuesday 14:00–16:00 Location: H5

AGPhil 3.1 Tue 14:00 H5

Kurt Gödels Notizen zur Quantenmechanik — •Oliver Passon — Bergische Universität Wuppertal

Kurt Gödel hat unter anderem ein umfangreiches Erbe aus Notizen und Arbeitsbüchern in Gabelsberger Kurzschrift hinterlassen. Dieser Vortrag stellt die bisher unveröffentlichten Arbeitsbücher zur Quantenmechanik aus den Jahren 1935/36 vor. Ein Schwerpunkt liegt auf der Frage, welche Stellung Gödel zu den Grundlagenproblem und Interpretationsfragen der Quantentheorie eingenommen hat.

AGPhil 3.2 Tue 14:30 H5

Persistence and Nonpersistence as Complementary Models of Identical Quantum Particles — •Philip Goyal — University at Albany (SUNY), Albany, NY

In our ordinary conception of the physical world, it is tacitly assumed that the appearances perceived in the present moment are underpinned by objects that persist through time, and that are reidentifiable on the basis of their stable characteristic properties.

It is widely accepted that the quantum treatment of assemblies of identical particles brings this assumption into question, but no consensus on a modification of this assumption has thus far emerged.

In this talk, we propose a new understanding of identical particles based on a recent derivation of the symmetrization postulate [1].

We adopt an operational approach in which the raw data consists of identical localized events. We construct two distinct models of the event data, namely a persistence model and a nonpersistence model. These differ in whether or not it is assumed that successive events are generated by individual persistent entities ('particles'). We then show that these models can each be described within the Feynman formulation of quantum theory and be synthesized to derive Feynman's form of the symmetrization postulate.

On this basis, we propose that the quantal behaviour of identical particles reflects a complementarity of persistence and nonpersistence, analogous to the way in which the behavior of an individual electron reflects a complementarity of particle and wave.

[1] P. Goyal, New J. Phys. 17, 013043 (2015)

AGPhil 3.3 Tue 15:00 H5

Quantum modal realism and Everettian actualism: a methodological appraisal on scientific realism — Jonas Rafael Becker Arenhart[1] and •Raoni Wohnrath Arroyo[2] — [1]Federal University of Santa Catarina, Department of Philosophy, Florianópolis, Brazil. — [2]Federal University of Santa Catarina, Graduate Program in Philosophy, Florianópolis, Brazil.

A recent tension splits scientific realism into two types, 'shallow' and 'deep', depending on how they relate to metaphysics. The division is better appreciated by employing a distinction between 'ontology' and 'metaphysics' by their subject matter, the former dealing with existence-questions and the latter with nature-questions. Deep scientific realists argue that one should 'go deep' into metaphysical questions, otherwise one's scientific realism is not sufficiently informative about its realist content; hence, not genuinely realist. Shallow realism stops at the level of providing an ontology. With this methodological background, we consider two realist approaches to Everettian quantum mechanics: quantum modal realism and Everettian actualism; the former being a defense of the existence of a many-world ontology and the latter being a defense of a single-world ontology. This, in turn, produces a tension regarding the 'realism' of such approaches: the current debate revolves around existence questions concerning the multiplicity of worlds (leaving unanswered questions regarding their nature), so either the mentioned realist approaches are not realist enough by deep realists' standards or their very standard of dealing with metaphysical questions is not a reasonable one.

AGPhil 3.4 Tue 15:30 H5

Derivative metaphysical indeterminacy and quantum physics — •Alessandro Torza — Instituto de Investigaciones Filosóficas, UNAM

A growing literature regards quantum mechanics as a hotbed of metaphysical indeterminacy (MI), which is to say, indeterminacy with a nonrepresentational source. However, Glick (2017) has argued that quantum mechanics provides evidence of MI only if MI can be merely derivative (i.e., arising only at the nonfundamental level); and Barnes (2014) has argued that MI cannot be merely derivative. I will respond to both Glick and Barnes by providing two ways of understanding quantum mechanics as giving rise to merely derivative MI. My overarching argument is as follows:

1. MI is characterized relative to a logical space: MI arises in logical space L just in case there is a fact (state of affairs) in L which neither obtains nor fails to obtain.
2. A quantum system S defines both a classical logical space C_S (i.e., a logical space which is a model of classical logic) and a quantum logical space Q_S (i.e., a logical space which is a model of quantum logic). Crucially, MI arises in Q_S but not in C_S (Torza 2021).
3. Given a system S, there are two ways of understanding C_S as fundamental and Q_S as derivative: if a metaphysically privileged description of reality involves classical logic (Sider); and if reality is fundamentally isomorphic to a Hilbert space (Carroll & Singh ms).
4. Therefore, there are two ways of understanding quantum MI as arising derivatively (in Q_S) but not fundamentally (in C_S).

AGPhil 4: Quantum Theory 3

Time: Wednesday 14:00–16:00 Location: H8

AGPhil 4.1 Wed 14:00 H8

On the objectivity of measurements — •Elias Okon — UNAM (Mexico)

Recent arguments, involving entangled systems shared by sets of Wigner*s friend arrangements, allegedly show that the assumption that the experiments performed by the friends yield definite outcomes is incompatible with quantum predictions. From this, it is concluded that the results of (at least some) quantum measurements, cannot be thought of as being actual or objective. Here, I will show that these arguments depend upon a mistaken assumption, regarding the correlations between the results of "the friends" and those of "the Wigners," which leads to invalid predictions. It is not, then, that the assumption of definite outcomes leads to trouble, but that the results derived with such an assumption are contrasted with faulty predictions. I will trace these inadequate predictions to a lack of recognition i) that hidden variables, with their inevitable contextual and non-local nature, are being (implicitly) postulated, and ii) that, in spite of such features, signaling is fully avoided. As for the "correct" predictions for the scenarios under consideration, I will show that the proposed experiments would allow for an empirical discrimination between hidden-variable and objective collapse models. Along the way, I will illustrate my claims with explicit calculations in the context of pilot-wave theory.

AGPhil 4.2 Wed 14:30 H8

The Wave-Function Must Be Psi-Ontic — •Mario Hubert — California Institute of Technology

The PBR-theorem aimed at proving that the wave-function has to represent objective features of a single physical system. There have been many attempts to interpret the wave-function as not representing the objective physical state of a quantum system by abandoning one of the two explicit assumptions of the PBR-theorem: (i) the existence of objective physical states and (ii) preparation independence. I argue that each theory that violates either of these assumptions meets unsurmountable problems. Although these alternative theories are physically possible, they are for several reasons implausible or problematic. I, therefore, advocate to search for quantum theories that fulfill the assumptions of the PBR-theorem.

AGPhil 4.3 Wed 15:00 H8

Temporal global correlations in time symmetric collapse models — •Pascal Rodríguez — Utrecht University

We propose that time symmetric collapse models require the existence of temporal global correlations across histories. We elaborate on a recent discussion regarding whether time-symmetric quantum mechanics requires retrocausality (Price, 2012; Leifer and Pusey 2017), spooky-action-at-temporal-distance (Adlam 2018), or neither of them. The moral is that quantum theories meeting certain assumptions either violate time-symmetry or imply retrocausality. Adlam argues we should give up the assumption that every quantum correlation is λ-mediated, meaning that there is spooky-action-at-temporal-distance. We consider that both proposals are metaphysically strong, although the point needs to be taken seriously. We suggest an analysis of time-symmetric collapse models, in which the wave-function is taken as a temporally asymmetric predictive tool to make the theory Markovian (Bedingham and Maroney 2017). We propose that the model does not require retrocausality since not every correlation is mediated by an ontic state. Nevertheless, we show that it does not need action-at-temporal-distance either; the temporal correlations exhibited violate temporal outcome independence (TOI) across histories. Analogously to the spacelike case, these TOI should not be interpreted as action-at-temporal-distance, but as temporal global correlations. We conclude with remarks about whether these correlations involve violations of Measurement Independence in an EPRB-scenario.

AGPhil 4.4 Wed 15:30 H8

On the Explanatory Power of the Hidden Variables Hypothesis — •Louis Vervoort — School of Advanced Studies, University of Tyumen, Russian Federation

In the debate whether 'hidden variables' could exist underneath quantum probabilities, the 'no hidden-variables' position is at present favored. However, if the hidden variables are allowed to be superdeterministic, the hidden-variables hypothesis can answer three foundational questions, whereas the opposing thesis ('no hidden variables') remains entirely silent for them. These questions are: 1) How to interpret probabilistic correlation in a coherent way in the classic and quantum domain ?; 2) How to interpret the Central Limit Theorem ?; and 3) Are there degrees of freedom that could unify quantum mechanics and general relativity, and if so, can we (at least qualitatively) specify them ? As I will show in this talk, it appears that only the hidden-variables hypothesis can provide coherent answers to these questions; answers which can be mathematically proven in the deterministic case. This suggests that the hidden-variables hypothesis has the greater explanatory strength, and that, to the least, an open-minded attitude towards it is recommendable.

AGPhil 5: Quantum Theory 4

Time: Wednesday 16:30–18:30 Location: H8

AGPhil 5.1 Wed 16:30 H8

Mereological Atomism's Quantum Problems — •Ryan Miller — University of Geneva, Switzerland

The popular metaphysical view that concrete objects are grounded in their ultimate parts is often motivated by appeals to realist interpretations of contemporary physics (Feynman et al., 2015; Fine, 1992; Pettit, 1993; Loewer, 2009). Given that appeals to small-scale physics are fundamentally quantum mechanical, this paper argues first that mereological atomism is only plausible in conjunction with Bohmianism, and second that it exacerbates Bohmianism's existing tensions with serious Lorentz invariance. Neither of Bohmianism's leading realist competitors yields a decomposition of the physical world into a multiplicity of non-overlapping fundamental concrete objects. Everettians can't rely on decoherence for such a decomposition (Wallace, 2012; Crull, 2013; pace Ney, 2021) and none of the proposed ontological elements for GRW (mass density, flashes, flash families) can play the role of multiple synchronic atomic parts.

Bohmian particles, on the other hand, provide a natural set of ultimate parts for atomists. The trouble is that different reference frames have different particle numbers (Unruh & Wald, 1984), and in classical mereology concrete objects are invariant fusions of determinate parts, so the Bohmian hidden privileged reference frame corresponds to a set of hidden privileged macroscopic concrete objects. Mereological atomism is thus undercut rather than supported by contemporary physics.

AGPhil 5.2 Wed 17:00 H8

Non-Accessible Mass and the Ontology of GRW — •Cristian Mariani — Institut Néel (CNRS), Grenoble, FRANCE

The Mass Density approach to GRW (GRWm for short) has been widely discussed in the quantum foundations literature. A crucial feature of GRWm is the introduction of a Criterion of Accessibility for mass, which allows to explain the determinacy of experimental outcomes thus also addressing the tails problem of GRW. However, the Criterion of Accessibility leaves the ontological meaning of the non-accessible portion of mass utterly unexplained. In this paper I discuss two viable approaches to non-accessible mass, which I call anti-realist and realist, and will defend the latter. First, I show that the anti-realist approach suffers from various objections. Second, I develop an account of non-accessible mass density states as objectively indeterminate states of affairs. Finally, I discuss the main conceptual consequences of the realist approach to non-accessible mass with respect to the current debate on the Primitive Ontology of GRW.

AGPhil 5.3 Wed 17:30 H8

Master equations for Wigner functions with spontaneous collapse and their relation to thermodynamic irreversibility* — •Michael te Vrugt[1,2], Gyula I. Tóth[3], and Raphael Wittkowski[1] — [1]Institut für Theoretische Physik, Center for Soft Nanoscience, Westfälische Wilhelms-Universität Münster, D-48149 Münster, Germany — [2]Philosophisches Seminar, Westfälische Wilhelms-Universität Münster, D-48143 Münster, Germany — [3]Interdisciplinary Centre for Mathematical Modelling and Department of Mathematical Sciences, Loughborough University, Loughborough, LE11 3TU, United Kingdom

Wigner functions allow for a reformulation of quantum mechanics in phase space. They are, as shown in our recent work [1], very useful for understanding effects of spontaneous collapses of the wavefunction as predicted by the Ghirardi-Rimini-Weber (GRW) theory. We derive the dynamic equations for the Wigner function in the GRW theory and its most important variants. The results are used to test, via computer simulations, David Albert's suggestion that the stochasticity induced by spontaneous collapses is responsible for the emergence of thermodynamic irreversibility. We do not observe the equilibration mechanism proposed by Albert, suggesting that GRW theory cannot explain the approach to thermal equilibrium.

[1] M. te Vrugt, G. I. Tóth, R. Wittkowski, arXiv:2106.00137 (2021)

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AGPhil 5.4 Wed 18:00 H8

Does Physics study the concrete? — •Samuel Dickson — University of York, York, UK

Metaphysicians classically divide objecthood into two categories, the abstract and the concrete. Physicists investigate the physical, and this is often taken to be part of the concrete. So physicists are investigating concrete objects. I think, however, that this is debatable. Concrete objects are typically taken to be both spatiotemporal and causal. However, I think the objects of fundamental physics, things like quarks and electrons, are not concrete objects, but this does not mean I think they are abstract. I think there is a middle ground between the abstract and concrete, and I think the objects of fundamental physics are in this middle ground, what I am calling exotic objects. For example, electrons are not categorised accurately with what we generally mean by spatial. Using the general sense, electrons do not exist in space (in that way). If this is the sense of spatial relevant for something to be a concrete object, then electrons are not concrete. If we soften what we mean by concrete to avoid this, then we will find equal need to soften what we mean by temporal and causal, meaning many things classed as abstract would become concrete. That is why we need a middle ground, the exotic.

AGPhil 6: Mitgliederversammlung der AGPhil

Time: Wednesday 18:30–19:00 Location: MVAGPhil

Mitgliederversammlung der AGPhil

AGPhil 7: Quantum Gravity 1

Time: Thursday 11:00–12:45 Location: H7

Invited Talk AGPhil 7.1 Thu 11:00 H7

Four Attitudes Towards Singularities in the Search for a Theory of Quantum Gravity — •Karen Crowther — University of Oslo

Singularities in general relativity and quantum field theory are often taken not only to motivate the search for a more-fundamental theory (quantum gravity, QG), but also to characterise this new theory and shape expectations of what it is to achieve. Here, we first evaluate how particular types of singularities may suggest an incompleteness of current theories. We then classify four different 'attitudes' towards singularities in the search for QG, and show, through examples in the physics literature, that these lead to different scenarios for the new theory. Two of the attitudes prompt singularity resolution, but only one suggests the need for a theory of QG. Rather than evaluate the different attitudes, we close with some suggestions of factors that influence the choice between them. [Based on joint work with Sebastian de Haro]

AGPhil 7.2 Thu 11:45 H7

Conditions for Theoretical Equivalence, Duality, and Implications Thereof — •Konner Childers — University of Birmingham, UK

Recent attention in philosophy of physics literature has been directed towards dualities between physical theories, furthering the *theoretical equivalence* questions into a new domain. After re-introducing the distinction between theoretical equivalence and dualities, this paper shall seek to critically assess 1) the sense in which dualities are (not) equivalences, with special attention given to categorical and physical equivalence, 2) the role of semantics and reference in addressing duality relations between theories, and 3) issues regarding the criteria of empirical (in)equivalence and predictions with respect to T-duality and gauge/gravity duality. Finally, these results shall be applied to fermionic particle-vortex and recently proposed 3d bosonization dualities to both elucidate the formal and empirical relations and to suggest further avenues for research.

AGPhil 7.3 Thu 12:15 H7

Composing Spacetime Out of Nowhere — •Baptiste Le Bihan — University of Geneva

According to a number of approaches in theoretical physics spacetime does not exist fundamentally. Rather, spacetime exists by depending on another, more fundamental, non-spatiotemporal structure. A prevalent opinion in the literature is that this dependence should not be analysed in terms of composition. We should not say, that is, that spacetime depends on an ontology of non-spatiotemporal entities in virtue of having them as parts. But is that really right? On the contrary, a mereological approach to dependent spacetime is not only viable, but promises to enhance our understanding of the physical situation.

AGPhil 8: Quantum Gravity 2

Time: Thursday 14:00–15:30 Location: H7

AGPhil 8.1 Thu 14:00 H7

A Tale of Two Machs: Relationalism in Quantum Gravity — •Mark Shumelda — University of Toronto, Canada

Several approaches to quantum gravity are explicitly motivated by temporal relationalism. This is the notion, historically prefigured by Leibniz and Mach, that time is simply not part of our basic ontological framework.

Relational approaches to physics in general, and quantum gravity in particular, seek to describe the history of the universe not as curve in four-dimensional Minkowski spacetime, but rather in some kind of parametrization-invariant configuration space. Relational approaches such as loop quantum gravity are already well-known to philosophers. In my paper I begin a philosophical analysis of time in the light of two relatively new and very different approaches to quantum gravity: geometrogenesis and shape dynamics. In my analysis I contrast the opposing ways in which geometrogenesis and shape dynamics implement the basic tenets of Machian temporal relationalism.

It turns out that far from removing time altogether from the fundamental theory, both geometrogenesis and shape dynamics posit an ontologically robust sense of temporal passage, though in very different ways. I argue that while each approach has its philosophical merits, neither is able to describe time as a fully emergent concept. Time, it seems, is here to stay in the fundamental theory, even given a Machian, relationalist approach to dynamics.

AGPhil 8.2 Thu 14:30 H7

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 8.3 Thu 15:00 H7

Simplicity and naturalness in a fundamental complex dynamics — •Aldo Filomeno — Universidad Católica de Valparaiso

Some traditional criteria for the fundamentality of a theory – naturalness, simplicity, unification, among other conditions – appear to be inconsistent with our current best physics. In light of this, while some expect these criteria to show up in future quantum gravity theories, others argue that such criteria ought to be abandoned. In this paper we stress that there is a third way of thinking about this situation. If such criteria are preserved, another qualitatively different physics at the fundamental level gains plausibility, in that it would restore the naturalness and simplicity: a highly complex dynamics at the fundamental level. This amounts to an account of fundamental laws of nature that has long been studied and defended in various (unorthodox) projects in physics, while it has been neglected in philosophical accounts of laws of nature.

AGPhil 9: General Relativity and Black Holes

Time: Thursday 16:30–18:00 Location: H7

AGPhil 9.1 Thu 16:30 H7

The History and Interpretation of Penrose's Singularity Theorem — •Dennis Lehmkuhl — Lichtenberg Group for History and Philosophy of Physics, University of Bonn

The Nobel Prize of 2020 was awarded to Roger Penrose for his singularity theorem of 1965, which the Nobel foundation interpreted as "the discovery that black hole formation is a robust prediction of the general theory of relativity." However, the 1965 paper does not mention the term "black hole" but speaks of gravitational collapse and spacetime singularities, starting with remarks on Schwarzschild's 1916 solution to the Einstein field equations. In this talk, I will put Penrose's singularity theorem in its historical context, starting with Einstein's and Schwarzschild's interpretation of the Schwarzschild metric in the late 1910s and 1920s, and discuss how the metric was linked to the question of gravitational collapse by Oppenheimer and Snyder in the late 1930s, and reconsidered by Wheeler and others in the 1950s and 1960s; and how Penrose drew on all these developments. I will describe which conceptual and technical advances Penrose had to invent and combine in order to come up with his singularity theorem to go beyond considerations of specific spacetimes like that of Schwarzschild, and show why the theorem was such a game-changer. Finally, I will discuss different possible interpretations of the theorem.

AGPhil 9.2 Thu 17:00 H7

Operational vs Descriptive Black Hole Complementarity — •Siddharth Muthukrishnan — Department of History and Philosophy of Science, University of Pittsburgh, Pittsburgh PA 15260 USA

To what extent does the black hole information paradox lead to violations of quantum mechanics? Black hole complementarity has emerged as an influential framework to prevent any such violations from being empirically problematic. I distinguish between an operational and a descriptive principle of black hole complementarity. Recent results applying quantum information theory and quantum computational complexity theory to black holes then imply that the operational principle is successful where the descriptive principle is not. Keeping this distinction in mind helps clarify why one seeks a solution to the information paradox, and what such a solution needs to explain. In particular, if the operational principle is accepted, then the black hole information paradox is no longer pressing.

AGPhil 9.3 Thu 17:30 H7

Why Einstein may have had good reason to oppose the geometrization of gravity in general relativity. — •Femke Kuiling — University of Minnesota, Minneapolis, USA

Using Einstein's Methodological Realism (Lehner 2014), I strengthen Lehmkuhl's argument for why Einstein refused to conclude (as most others have) that General Relativity somehow reduces gravity to geometry.

AGPhil 10: Quantum Mechanics, Time and Information

Time: Friday 11:00–13:00 Location: H3

AGPhil 10.1 Fri 11:00 H3

The Measurement Problem in Quantum Mechanics and the Surjective Environment — •Fritz Wilhelm Bopp — Department Physik, Universität Siegen, Siegen, Germany

Starting with unitary quantum dynamics, we investigate how to add measurements. Quantum measurements have four essential components: the furcation, the witness production, an alignment projection, and an actual choice decision. The first two components still lie in the domain of unitary quantum dynamics. Observations tell us that witnesses are essential for measurement processes and, in our opinion, interpretations in which they are not functional can be disregarded. They play a central role in the decoherence concept. Within such a concept, the alignment projection can be based on the requirement that witnesses reaching the end of time on the wave function side and the conjugate one have to match. No projection operator is needed, and simple quantum dynamics remains sufficient. The surjective environment conjecture explains the actual choice decision. It is based on a two boundary interpretation applied to the complete quantum universe. It offers a simple way to reduce these seemingly random projections and collapses to purely deterministic unitary quantum dynamics, eliminating aspects people like Einstein considered unacceptable for a complete theory.

AGPhil 10.2 Fri 11:30 H3

Deriving the local arrow of time — •Daniel Saudek — Philosophisch-Theologische Hochschule Sankt Georgen, Frankfurt a. M. (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 there is no event content for indices greater than t. Thus, the local past is fixed, and the future open.

AGPhil 10.3 Fri 12:00 H3

Information: Vieldeutiges Etwas oder Einheit der neueren Physik? — •Emanuel Seitz — emanuel_seitz@web.de

Carl Friedrich von Weizsäcker hat die bekannte Behauptung aufgestellt: Information ist das Maß für die Menge an Form oder ein Maß für die Gestaltenfülle. Hinter diesen Begriffen steckt das altgriechische Begriffspaar eidos und morphé, wie sie von Platon und Aristoteles gedacht wurden. Doch wie ist das eigentlich möglich, dass Form eine Menge und ein Maß haben sollen? Ein Ball hat nicht mehr oder weniger

Form als eine Tasse. In der neueren Wissenschaftsphilosophie, etwa bei Holger Lyre, gilt Information als ein letztlich wenig taugliches Wort, eine bloß nominale Vieldeutigkeit, um Zusammenhänge zu beschreiben, die eigentlich nicht die gleichen sind. In meinem Vortrag werde ich versuchen zu zeigen, dass der Begriff der Information * als Maß für die Wahrscheinlichkeit, für die Struktur oder für die Komplexität, als Bedeutung einer Nachricht oder biologische Präformation * auf einund dieselbe metaphysische Idee zurückgeht: auf das Verhältnis von Wesen und Ereignis.

AGPhil 10.4 Fri 12:30 H3

Quantentheorie verstehen — •Thomas Görnitz — FB Physik, Goethe-Univ. Frankfurt/M

Die Quantentheorie (QTh) ist die genaueste und beste Beschreibung der Realität. Unsere technische Zivilisation wäre ohne ihre Anwendungen undenkbar. Trotzdem finden sich noch immer Aussagen, die einem nicht mathematisch und physikalisch ausgebildeten Menschen ein Verstehen unmöglich machen.

Wird ihre mathematische Struktur gründlich reflektiert zeigt sich, dass die QTh unseren Erfahrungen sehr nah ist.

Unsere Handlungen werden von künftigen Möglichkeiten beeinflusst - so auch die Natur. Die QTh - eine Theorie über noch nicht faktische Möglichkeiten - genügt einer anderen Logik als die Fakten.

Zusammensetzungen zu komplexen Strukturen geschehen über das Tensorprodukt der Zustandsräume. Daher ist in der QTh ein Ganzes mehr als die Summe seiner Teile - so wie im Leben auch.

Quantenmechanik rechnet mit festen Anzahlen geladener Teilchen und deren Wechselwirkung mit einem (oft klassischen) elektromagnetischen Feld. Erst Quantenfeldtheorien (QFTh) erfassen, dass Teilchen entstehen und verschwinden, dass bereits virtuelle Teilchen reale Effekte bewirken. Ein QF kann verstanden werden als eine unbegrenzte Zahl von Quantenteilchen. Diese sind somit einfacher als ein QF.

Die einfachsten, also fundamentalen Quantenstrukturen sind AQIs (Absolute Bits of Quantum Information). Der Vortrag erklärt, wie mit ihnen wichtige Verständnisprobleme der Quantentheorie behoben werden.