The Scale of Reality:
Metaphysics of Quantities and the Laws of Nature

December 9–11, 2026

University Jean Moulin Lyon 3, Lyon, France

Program

Wednesday, December 9, 2026

14h **Jo Wolff** (University of Edinburgh)
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Making contact: measurement is more than prediction

Prediction is not measurement, and measurement is not prediction. This seemingly uncontroversial view has recently come under pressure from two directions. On the one hand, philosophers of measurement have emphasised the role of modelling in measurement and the rejected empiricist foundationalist accounts of measurement in favour of coherentism. On the other hand, philosophers studying computer simulations have suggested that under certain circumstances, we should treat the outputs of computer simulations as measurement outcomes.

I argue here that this conflation of prediction and measurement is best avoided: the conceptual difference between prediction and measurement does important epistemic work, even if we reject naive empiricist foundationalism and acknowledge that recent uses of computational modelling have made the distinction more blurry. To help articulate this conceptual difference, we need to understand the distinctive role of physical interaction in measurement.

15h **Alessandro Giordani** (Università Cattolica del Sacro Cuore)
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A Defense of Classical Realism

In recent decades, the question of the appropriate metaphysical framework for understanding quantities has received increasing attention in the philosophical literature, generating new interpretations and sharpening the debate between realists and antirealists about quantities. In this presentation, I develop a defense of Classical Realism, a position characterized by a rich ontology and close connections with realism about numbers in the philosophy of mathematics and realism about laws in the philosophy of physics. I propose a general framework that clarifies the relationships between objects, quantities, and numbers, understood as ratios between quantities, and develop grounding arguments showing how a range of why-questions can receive elegant and robust answers within a realist setting. Finally, I contrast Classical Realism with Structural Realism, focusing on their accounts of quantitative relations as internal and external, respectively, and argue that the traditional interpretation of quantities as determinate properties internally related by ratios is still the better option for a realist account.

16h-16h30 Coffee break

16h30 **Ada Köprülüler** (University of Barcelona)
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Bohmian Particles as Individuals Without Intrinsic Properties

What makes a physical object an individual, and must it possess intrinsic properties to be physically meaningful? This paper approaches these questions through Bohmian mechanics, arguing that its ontology provides an illuminating case study for the debate between absolutist and comparativist accounts of physical quantities and properties. Bohmian particles are individuated by their positions and trajectories, while quantities such as mass enter the theory's dynamical equations as parameters. Spin, for instance, is represented in the multi-component structure of the wavefunction, rather than attributed to particles. This raises two related questions: First, should quantities such as mass and position be understood as absolute properties of individual objects, or through their role in a wider relational structure? Second, how should we understand the wavefunction itself, given that it is an entity that is understood as the 'bearer' of properties such as spin instead of the particles? Is it a representation of relations among independently individuated particles, or does it constitute a more fundamental structure upon which their individuality and physical characteristics depend? I approach these questions from priority-based ontic structural realism. On this account, particles remain real, but are ontologically derivative nodes of a fundamental wavefunction-structure. The wavefunction does not merely describe relations among already constituted individuals; it plays a fundamental role in determining their dynamical properties and individuality. I argue Bohmian mechanics shows that objects need not be understood as bearers of intrinsic properties, since their physical significance may instead be grounded in the structure within which they are situated. Hence, Bohmian mechanics motivates structuralism and challenges object-first accounts of physical quantities.

17h30 **George Hobart** (University of Bristol)
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Which Quantities are Fundamental for Elementary Particles?

This paper takes a naturalistic metaphysical approach to the question, "given our most fundamental theory (the Standard Model of Particle Physics (SM)), what should the fundamental types in our ontology be?" This question hinges on which quantities are considered fundamental within physics and can thereby be used to distinguish ontic types. This paper sets out desiderata for these type-distinguishing quantities motivated by naturalistic assumptions, namely "stability" (that fundamental types should persist when not interacting) and "selectability" (that fundamental types should be isolatable by some physical process). The standard interpretation of particles in the SM is that the following quantities are all fundamental: electric charge, intrinsic spin, colour, weak isospin, mass, and flavour. We consider two phenomena well-known in particle physics but under-studied in philosophy: Neutrino Oscillation and Neutral Meson Mixing. Both demonstrate that particles cannot simultaneously be defined by both flavour and mass, leading to what we call the 'Flavour-Mass Dilemma': at most one of either flavour or mass can be a fundamental quantity in this context. In the case of neutrinos, opting for flavour results in an ontology that fails the stability condition, while mass fails selectability, so neither is adequate. We propose a new ontology in which neither quantity is fundamental, resulting in a radical and more parsimonious conception of fundamental types in the SM. Because neutral mesons are however composites comprised of elementary particles, this introduces new complexities to the discussion, leading to the conclusion that flavour should be deemed more fundamental relative to this non-elementary scale.

Thursday, December 10, 2026

9h30 **Andreas Hüttemann** (University of Cologne)
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Laws, Constraints and Modal Structure

In recent years several authors have argued that laws of nature should be understood as or in terms of constraints (Adlam 2022, Chen & Goldstein 2022, Meacham 2025). Two kinds of reasons are given to motivate this suggestion. First, the notion of constraint allows for a more inclusive characterisation of the modal aspects of scientific practice. Second, compared to other non-Humean accounts it requires only a minimal metaphysical commitment. However, as I will argue, it remains unclear what this modal commitment amounts to and how postulating constraints helps solving problems that other non-Humean accounts of laws have been confronted with (see also Loewer 2024 for this criticism). I will suggest that these problems can be solved if the modal content of constraints is understood in terms of invariance relations. Because we have direct empirical access to invariance relations (see Hüttemann 2021, chapter 1) we don't need to postulate additional metaphysical structure to explain how laws constrain.

10h30 **Mahmoud Jalloh** (California Institute of Technology)
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Laws as Equations: Methodological Primitivism

The metaphysics of laws literature is largely divided between Humean and Non-Humean approaches. Both of these approaches attempt to ontologically reduce laws to either an amodal (e.g., Humean mosaic) or modal (e.g., powers) basis. Recently, a non-reductionist account has gotten some momentum, primitivisim. For the primitivist the laws are ontologically basic (and perhaps of a sui generis kind). By analogy, we might say that the analysis or methodological construal of the laws has largely been divided between syntactic and semantic accounts of the meaning of the laws. These accounts are both methodologically reductive, providing either a logical or a model-theoretic account of the laws. I propose a methodologically primitivist account of the laws. Laws (in physics) are equations. Pursuing this approach provides a productive perspective on live issues regarding the nomological status of the constants, a novel form of underdetermination, and the effective theory point of view.

11h30 **Anna Garoflid-Oprescu** (University of Geneva)
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The Metaphysics of the Ideal Gases Law

Scientific models and laws often rely on idealisations: they deliberately omit or distort features of their targets. This seems to challenge veritism—the view that truth is the primary epistemic good of scientific inquiry—since idealised models and laws are often considered false because they fail to represent their targets.

In this talk, I argue that this assumption rests on a misconception about the representational relation between scientific laws and the world. Using the ideal gas law as a case study, I challenge the standard view that it represents the total pressure exerted by a real gas and is inaccurate because it omits molecular volume and intermolecular forces. Instead, I propose that the law represents a "component pressure": the pressure resulting from the relation between the amount of gas, the gas constant, temperature, and volume. The factors omitted from the ideal gas law contribute to another component pressure ; together, these components make up the total pressure exerted by the gas.

Substantiating this interpretation requires a metaphysics of pressure. The proposal is viable only if pressure can be divided into components and those components can be added. To defend this claim, I draw on Massin's (2009) account of component Newtonian forces and compare force and pressure as quantities. I argue that pressure, like force, can have real components whose contributions combine to yield a total quantity. This account supports a revised reading of the ideal gas law: rather than treating it as an inaccurate description of total pressure, we can understand it as accurately representing one component. If some idealised laws can be true of the components they represent, these idealised laws need not undermine veritism.

12h30-14h Lunch

14h **Caspar Jacobs** (Leiden University)
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Niels Martens (Utrecht University)
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The Metaphysics of Physical Constants

Although a philosophical interpretation of constants of nature is relevant for debates about fine-tuning, the possibility of time-variation of these constants, the absolutism-comparativism debate, and the trichotomy between spacetime, matter and constants of nature, little attention has been paid to constants of nature beyond philosophising about laws more generally. We introduce five possible interpretations of fundamental constants of nature: 1) anti-realism; and constants as 2) laws, as 3) world-properties, as 4) fields, or as 5) kinematic structure. We evaluate for each interpretation how it affects modal variability/rigidity — can the value of the fundamental constants of nature vary across different nomologically possible worlds - and spatiotemporal variability/rigidity - can the value of the fundamental constants of nature vary across space and or time within a nomologically possible world? Finally, these issues are illustrated by two case studies: Newton's constant and the cosmological constant.

15h **Jean-Marc Levy-Leblond** (Nice)
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On the status of the cosmological constant

The current mainstream version of theoretical cosmology, known as LambdaCDM, employs in its formalism a 'cosmological constant' Λ, the status of which is highly ambiguous. It can be interpreted as the average energy density of the vacuum on a cosmological scale, but quantum fluctuations lead to a numerical estimate of its value that is immensely greater than the measured value. Alternatively, one might consider that the cosmological constant is in fact a universal fundamental constant (such as Planck's constant, for example), characterising space-time. However, recent observations suggest that the expansion of the Universe is slowing down, which would imply that the cosmological 'constant' is not constant. We shall discuss the status of the cosmological constant from the perspective of the classification of physical constants.

16h-16h30 Coffee break

16h30 **Gauvain Leconte-Chevillard** (Université de Caen Normandie)
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Florent Barzic (Université de Caen Normandie)
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What cosmology does with and to constants and their value

Fundamental constants of physics are defined to be both measured locally and universally invariant. Astrophysics and cosmology, dealing with the widest range of scales, are in a good position to test the invariance of constants both in space and through time.

In this talk we first present how cosmologists and astrophysicists adopt a Bachelardian phenomenotechnical stance and use the universe as a cosmic laboratory to put tighter and tighter bounds on the variation of fundamental constants. Yet such tests can only ever bound variation, but never confirm invariance itself. Second, we discuss how this issue of measurement led cosmologists to three (non mutually exclusive) approaches: treating invariance as a postulate (within a broader principle such as Einstein's equivalence principle), deriving values from a deeper theory, or developing a theory allowing for the variation of constants through time and/or space. An analysis of this latter approach leads to a discussion of the arguments for fine-tuning and the anthropic principle (in its weak and strong forms). Finally, we examine whether a physical variation of a fundamental constant would amount to a new set of laws in each of these approaches and if we could regard the history of our observable universe as a series of different physical universes.

17h30 **Giovanni Rizzotto** (Università della Svizzera Italiana)
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Two Arguments against Hossack's Theory

Hossack, in an Aristotelian spirit, proposes a theory of numbers where they are understood as magnitudes of quantities. (Quantities have the structure of Classical Extensional Mereology.) He then derives the structure of the positive natural and real numbers from that of selected quantities by means of an Homomorphism Theorem. The present paper, after outlining Hossack's theory, presents two arguments against it. The first one is the not-only-logical argument where I explain how the notion of a logical sum endorsed by Hossack involves also non-logical aspects. These turn out to be crucial in order to prevent the theory to make claims which cannot be assessed or which are in contrast between each other. To begin with, I analyse the quantities endorsed by Hossack: pluralities and continua. Thereafter, by focusing on his example of lines as continuous quantities, I resolve that sticking to only logical terms is not enough to discriminate between cases which need to be distinguished within Hossack's framework. The second one is the straitjacket argument which consists in defending the claim that Hossack's theory does not allow to account for some important systems of magnitudes. On the basis of his standpoint, I show that, under some further assumptions, the system of magnitudes of electric charge cannot be recovered. In order to do so, I start by unpacking two requirements of his theory. Then, I show that they lead to problems in accounting for electric charge since some axioms of the theory are violated. Finally, I propose a challenge whose solution will allow to do justice to the system of magnitudes of electric charge.

19h30 Diner

Friday, December 11, 2026

9h30 **Zee Perry** (University of Birmingham)
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TBA

10h30 **Neil Dewar** (Cambridge University)
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Representation, measurement, and quantities

The Representational Theory of Measurement (RTM), most famously expressed in the multi-volume Foundations of Measurement, has had an enormous influence on the philosophy of measurement and quantities. However, various critiques of RTM in those literatures have pointed to some problems with its approach. In this paper, I consider how we might update RTM to make it more robust against those critiques.

11h30 **Andrea Abbondandolo** (University of Pisa)
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Causal Essences and the Quantitative Nature of Fundamental Physical Properties

The quantitative character of physical laws, one might think, can be explained by appealing to that of the properties they relate; yet, this raises a further question: what grounds the quantitativity of fundamental physical properties themselves? In my talk, I argue that the causal theory of properties can answer this question and, more generally, provide a unified account of the quantitative nature of properties, constants, and laws. First, the claim that quantitative powers such as having a charge of -e should be regarded as fundamental is defended against Barbara Vetter's arguments in favor of the fundamentality of powers in their generic form. Then, I argue that their quantitativity is grounded in their causal essences: the numerical values of fundamental physical properties should be understood as representing their intensities from within a framework inspired by the Dynamical Operator account developed by Roselli and Austin, where neither stimuli nor manifestations belong to the essences of powers. This account allows the causal theory of properties to explain quantitativity more satisfactorily than categoricalist approaches, according to which the causal roles associated with fundamental properties are not determined by their intrinsic natures. I then turn to physical constants, arguing that even if some may not correspond to genuine physical features of the world, others, such as Newton's gravitational constant, may be understood in terms of the causal essences of fundamental powers – more precisely, as capturing the relation between these essences and their manifestations. The approach thus developed promises to account for the quantitative character of any element appearing in laws within a unified metaphysical framework.

From Galileo to Eugene Wigner, the idea that nature is written in "mathematical language" and that reality is quantitative in nature is a fundamental assumption of physics. Yet the metaphysics of this "quantitative reality" remains a work in progress. What exactly is the nature of physical quantities—distance, mass, charge? What is the structure of the quantitative laws that connect them, and what do the equations of physical theories describe? And what is the ontological status of the fundamental constants that link these quantities and set the scales of our theories?

The scientific ambition of the workshop is to better connect separate areas of research in contemporary metaphysics of sciences: the metaphysics of quantities, the metaphysics of laws of nature, and the emerging metaphysics of fundamental constants, by examining together the nature of physical quantities, the quantitative structure of laws, and the ontological status of the constants that relate quantities and set the scale of physical reality.

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