Workshop "Reduction and Emergence in Physics and Cosmology"

Abstracts:

Reduction and Emergence in Physics, Cosmology, and Technology

George Ellis

A key issue in discussing reduction and emergence is the difference between synchronic and diachronic effects. In the former case full knowledge of the lower-level state does indeed determine the higher-level state at that time. In the latter case this is not true because all real physical and technological systems are open systems, therefore full knowledge of the initial state does not determine the final state. Astrophysical systems and digital computers are examples. The usual arguments about the differences between weak and strong emergence are in practice unimportant. What matters is that effective laws at each emergent level are indeed effective. In Aristotelian terms they are cases of efficient causation, enabled by both formal and material causation - both instances of downward causation. Examples are existence of quasi-particles in crystals, of Cooper pairs in superconducting media, and of nucleosynthesis and structure formation in cosmology. Abstract causation occurs in the case of digital computers, because algorithms and data are abstract entities that determine outcomes. Final causation also occurs in this case because all technological devices have a purpose that determines their design, algorithms, and data.

Levels of Description and Levels of Reality: A General Framework

Christian List

I will sketch a general framework for representing levels and inter-level relations. The framework is intended to capture both epistemic and ontological notions of levels and to clarify the sense in which levels of explanation might or might not be related to a levelled ontology. The framework also allows us to study and compare different kinds of inter-level relations, especially supervenience and reduction but also grounding and mereological constitution. This, in turn, enables us to explore questions such as whether supervenience implies explanatory reducibility and whether there can be irreducible higher-level explanations or even "emergent" higher-level properties. The paper on which the presentation is based is available at: https://philpapers.org/archive/LISLOD.pdf

Analogy-Based Reduction: Lessons from the NJL Model

Stephan Hartmann

The Nambu–Jona-Lasinio (NJL) model provides a philosophically rich example of how theoretical innovation can arise from material analogy and later integrate into

the framework of effective field theory. Originally inspired by BCS superconductivity, the NJL model transferred a shared causal mechanism—fermion pairing, condensate formation, and gap generation—from condensed matter to particle physics, offering a mechanistic account of chiral symmetry breaking before the advent of QCD. It was later reinterpreted as a low-energy effective theory that captures QCD's chiral dynamics without invoking gluons. We use this case to articulate a form of analogy-based reduction, where analogically constructed models are retrospectively anchored in fundamental theory through partial matching and retain explanatory autonomy. This framework differs from traditional reductionist accounts and emphasizes the epistemic role of material analogy, effective methodology, and explanatory pluralism. A comparison with Chiral Perturbation Theory illustrates how multiple effective theories can coexist within a layered architecture of scientific explanation.

Emergent (Relational) Cosmology from Quantum Gravity
Daniele Oriti

We outline key steps, assumptions and approximations taken to extract an emergent cosmological dynamics for both cosmological backgrounds and perturbations around them (thus effective quantum field theory) from quantum gravity models in the tensorial group field theory (thus spin foam and LQG) formalism. We also discuss in more detail recent results, showing an emergent cosmological acceleration at both late- and early-times produced by quantum gravity interactions.

Laws without Spacetime: the Strategy from Global Constraints
Laurie Letertre

Recent approaches in quantum gravity suggest that spacetime may not be a fundamental aspect of reality, but rather an emergent phenomenon arising from a non-spatiotemporal substratum. This raises a significant challenge for traditional accounts of laws of nature, which are typically grounded in spatiotemporal concepts. In this talk, I will explore a possible strategy for formulating laws of nature without spacetime, drawing on the framework of laws as global constraints. The aim is to defend this conception of laws against the objection that it is too thin to provide genuine understanding and explanatory power.

The Causal Argument for Physicalism
Alyssa Ney

Curiously, although most philosophers today count themselves as physicalists, there is no argument in defense of the position that is widely accepted. The aim of this paper is to present the best version of the causal argument, originally developed by Jaegwon Kim (1998, 2005) and David Papineau (2001), a version that responds to the most prominent concerns that have been raised to it (by physicalists) over the past 25 years. My conclusion will be that this version of the argument is sound and should be regarded as the most state of the art argument for physicalism. But at the same time, one must recognize that the argument relies on some claims about which

reasonable people can disagree. And so even if physicalism becomes, in light of the causal argument, a reasonable position to adopt, it is not a scientific certainty.

How to Reduce the Quantum Formalism? The Quantum Reconstruction Program vs. The Ontological Model Framework
Mario Hubert

I argue that the Quantum Reconstruction Program (QRP) and the Ontological Model Framework (OMF) represent analogous, yet competing approaches to reduce the operational formalism of quantum mechanics: QRP builds on information-theoretic principles (creating principle theories), while OMF requires an underlying ontic state (generating constructive theories). I show that their overlap is limited to ψ-credal interpretations, with most QRP-derived theories being incompatible with the OMF. This incompatibility reflects a deeper philosophical divide about whether physical theories should emerge from principles or from postulates about objective physical states.

What is Effective Metaphysics?
Sebastien Rivat

Kerry McKenzie recently challenged the possibility of effective metaphysics in the context of naturalized metaphysics, where by 'effective metaphysics' she means the study of non-fundamental items in their own terms and independently of fundamental metaphysics. The goal of this talk is to address her argument and propose a refined account of what effective metaphysics consists in. In particular, I will suggest that we ought to be more selective: the possibility of effective metaphysics hinges on focusing on non-fundamental items that depend only very little on fundamental ones from the perspective of the theories that describe them.