Ernst Mach Workshop IX: Non-causal explanation in physics
Time zone: CEST (UTC + 2)

DAY 1 (Thursday, September 17, 2020)

13:30 – 14:50 **Juha Saatsi** (University of Leeds)
A functional "understanding-first" approach to non-causal explanations

15:00 – 15:50 **Martin King** (University of Bonn)
Explanations with (and of) the Higgs Mechanism

16:10 – 17:30 **Lina Jansson** (University of Nottingham)
Counterfactuals and explanatory directionality

17:40 – 18:30 **Joaquim Giannotti & Silvia Bianchi** (University of Glasgow, Institute for Advanced Study IUSS Pavia)
Grounding Ontic Structural Realism and Metaphysical Explanation

DAY 2 (Friday, September 18, 2020)

13:30 – 14:50 **Lukáš Zámečník** (Palacky University in Olomouc)
Are distinctively mathematical explanations ad hoc *explanations?*

15:00 – 15:50 **Antonio Vassallo** (Warsaw University of Technology)
Hybrid Explanations in General Relativity and Quantum Gravity

16:10 – 17:30 **Sorin Bangu** (University of Bergen)
Formalist explanations in physics

17:40 – 18:30 **Nicholas Danne** (University of South Carolina)
Mathematical Realism, Program Explanation, and Seeing Red

Abstracts

INVITED SPEAKERS

Sorin Bangu (University of Bergen)

Formalist explanations in physics

The main aim of this talk is to draw attention to a certain kind of answers to some why-questions often asked in physics. I shall call these answers 'formalist' since they appeal to the formal features of the mathematical representations of the physical systems. In being answers to why-questions, such answers may be prima facie characterized as 'explanations'. Moreover, in virtue of their formal(ist) character they may be prima facie called 'non-causal'. While part of the discussion will be critical (I shall address some recent attempts to spell out the notion of non-causal explanation), most of the talk will be devoted to exploring this new (?) notion - of a formalist/non-causal explanation - with the help of several examples (from classical mechanics, electromagnetism and quantum mechanics).

Lina Jansson (University of Nottingham)

Counterfactuals and explanatory directionality

Any non-causal account of explanation faces the challenge of developing a non-causal solution to the problem of explanatory directionality. Recently, Lange (2019) has argued that accounting for explanatory directionality raises particularly serious difficulties for many counterfactual approaches to non-causal explanation. Here I respond to some of these challenges and show how a counterfactual approach can be of help (but only help) in addressing questions such as whether symmetry principles are explanatorily prior to conservation laws.

Juha Saatsi (University of Leeds)

A functional "understanding-first" approach to non-causal explanations

There are various competing philosophical accounts of non-causal explanations in physics. How should determine which theory is the best? In this talk I will begin to develop an "understanding-first" approach to this question. This approach beginswith a functional characterisation of explanation: explanation is whatever provides understanding. I will propose that we try to pin down the nature of non-causal explanations by seeing how intuitive judgements of understanding vary as a function of reducingor increasing different kinds of information contained in a physical theory or model.

Lukáš Zámečník (Palacky University in Olomouc)

Are distinctively mathematical explanations ad hoc *explanations?*

This paper aims to discuss three argumentation sketches which, if elaborated, could be used vis-a-vis the view of distinctively mathematical explanations. The main thesis is that these explanations are

often constructed ad hoc with no basic theory explicitly elucidating the relationships between these explanations or their hierarchical order. If these argumentation sketches were cogent, we would have to consider their implications for some non-causal explanations in physics.

CONTRIBUTED PAPERS

Martin King (University of Bonn)

Explanations with (and of) the Higgs Mechanism

The Higgs mechanism is the best explanation we have of the origin of the masses of elementary particles. Despite its name, however, the Higgs mechanism is most often not regarded as a physical mechanism, nor as a kind of causal process. The Standard Model (SM) Higgs explains particle masses by showing how the vacuum expectation value (vev) of a scalar field results in a broken electroweak symmetry, which is needed for particle masses in a renormalizable theory. The value of the Higgs vev is, however, itself unexplained in the SM. Other models of electroweak symmetry breaking offer dynamical accounts that put strong constraints on this value and the resulting Higgs mass, but the SM Higgs does not. Thus, one may argue that the non-causal explanation afforded by the SM Higgs is rather shallow. Given that a SM-like Higgs has been discovered, one may wonder what avenues remaining for a deeper explanation. This paper focuses on two ways of potentially deepening the non-causal Higgs explanation. I first review the prospects that remain for a dynamical explanation within the Higgs sector, by compositeness, or partial compositeness, of the Higgs. As these prospects are quite slim, I consider i) explanations by anthropics, and ii) by the cosmological relaxation of the Higgs potential. The thrust of the paper is that even though we have an explanation, it is non-causal and does not itself account for what does the explaining. Nonetheless, there are ways of potentially deepening this explanation that are also non-causal. This introduces a kind of explanatory depth by nesting.

Joaquim Giannotti & Silvia Bianchi (University of Glasgow, Institute for Advanced Study IUSS Pavia)

Grounding Ontic Structural Realism

Ontic Structural Realism (OSR) comprises diverse views that claim to offer the metaphysics most befitting of contemporary physics. Despite specific differences, ontic structuralist approaches endorse two theses:

(1) the Fundamentality Thesis: structures are fundamental physical entities.
(2) the Priority Thesis: structures are ontologically prior to putative fundamental physical objects.

The ontic structuralist should find a rigorous articulation of (1) and (2). To this end, we outline and defend the adoption of a grounding-based OSR.
Candidate notions to elucidate (1) and (2) such as supervenience and ontological dependence fail to accomplish this aim. Our aim is to show that grounding is not only preferable but also ideally suited to capturing the metaphysical commitments of standard OSR views. We argue that a grounding-based OSR approach has three major advantages over non-grounding views: (i) it elucidates the

Fundamentality Thesis and the Priority Thesis in a unified way; (ii) it offers a framework for metaphysical, non-causal explanation between structures and objects; and (iii) it is immune from the objections against supervenience and ontological dependence.
However, McKenzie (2018) argues that even metaphysical determination fails to illuminate OSR: in Quantum Field Theory, symmetry groups do not metaphysically determine fermion kinds. Granted that grounding is a form of metaphysical determination, McKenzie concludes that that symmetry groups do not ground fermions. Thus, OSR in the idiom of determination faces a serious counterexample.
Our strategy to escape McKenzie's objection is to reformulate the links between grounding, fundamentality, and priority by implementing the distinction between partial and full ground. We argue that the emerging machinery is extremely serviceable for regimenting the metaphysical claims at play in OSR.
Here we explore the explanatory connections between structures and objects that emerges from the proposed grounding-based OSR, and conclude by submitting an original taxonomy of standard OSR-approaches as grounding views.

Antonio Vassallo (Warsaw University of Technology)

Hybrid Explanations in General Relativity and Quantum Gravity

General relativity is a rather peculiar theory in that (i) it unifies gravitational and spatiotemporal phenomena by using the framework of Riemannian geometry, and (ii) it describes the coupling of these geometric degrees of freedom with the usual material ones.
The strong geometrical character of the general relativistic dynamics is a source of controversy when considering how the theory explains some key aspects of the gravitational interaction. Indeed, some authors claim that the mutual influence between spacetime and matter is perfectly explained in non-causal terms, given that such an explanation involves geometric concepts. This view is usually contrasted by pointing out that the "physically active" way in which spacetime and matter act on each other seems causal in an intuitive sense.
In this talk, I will start by reviewing the debate on causal/noncausal explanations in general relativity, arguing that much of the controversy stems from the fact that many conceptual tools usually employed in the analysis of explanations are not fit for the gravitational context. I will then introduce a novel analytical framework based on structural equation modeling. This framework decomposes complex explanations in a series of simpler steps, and assigns to each of these steps either a causal or a non-causal character, depending on whether they mention some law of nature. I will use this framework to analyze a particular gravitational phenomenon, namely, rotational frame-dragging. The analysis will show how explanations in general relativity are not strictly speaking either causal or non-causal, but some sort of hybrid of both. Finally, I will show how this novel kind of analysis can be fruitfully carried over to those theoretical frameworks that seek to straightforwardly quantize the gravitational field. In particular, I will focus on the way these theories explain the emergence of classical spacetime from the underlying quantum regime.

Nicholas Danne (University of South Carolina)

Mathematical Realism, Program Explanation, and Seeing Red

In the debate over whether mathematical facts, properties, or entities could explain physical events, Aidan Lyon's (2012) affirmative answer stands out for its employment of the program explanation (PE) methodology of Frank Jackson and Philip Pettit (1990). Program explanations are ontic explanations consisting of real properties that explain without causing a physical event, and Lyon argues that various mathematical properties and entities program explain some common phenomena (e.g. cicada lifecycles). He then reifies the allegedly explanatory mathematical entities by the Enhanced Indispensability Argument (EIA). In this paper, I develop two insights for the broader indispensability community. The first is that not all mathematics indispensable to defining a programming property explain the explanandum. I argue that Fourier harmonics are indispensable to Frank Jackson's (1998) program explanation of color experience, but not explanatory of color experience. Secondly, I reify Fourier harmonics without the EIA, by showing them indispensable to real property (i.e. reflectance) ascription and manifestation. By this maneuver I also partially answer Lyon's critic Juha Saatsi (2012), who demands an account of the metaphysical "connection" obtaining between reified program explanatory mathematics and the world. I dub "constitution" the metaphysical connection obtaining between the manifestation of reflectance and Fourier harmonics.

I reify harmonics to block a regress that ensues from two premises held in tension: (1) the dispositional reflectance in Jackson's PE is the 'per-wavelength' efficiency of a surface to absorb and reemit light; (2) due to the widely documented empirical law I call "harmonic dispersion"—the inverse relationship of an electromagnetic pulse's duration to its bandwidth—there are no finite-duration 'per-wavelength' propagations. The vicious regress that ensues is that of the reflectance value at any given wavelength. The ratio of energy in to energy out plummets to 0/0, due to harmonic dispersion. Only superimposed harmonics reflect 'per wavelength' for any given duration.