Why reasoning?

A discussion of Matthias Frisch: *Causal Reasoning in Physics*

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1 Introduction

Mathias Frisch's book *Causal Reasoning in Physics* is perhaps most surprising – despite its title – in that it truly concentrates on *reasoning*. Frisch engages in a distinctive project, which he describes: '[T]he functional project asks what role, if any, causal notions play as part of our epistemic toolkit and as part of the representational resources.' (Frisch 2014, 9; following Woodward, 2014.) As a philosopher of causality working primarily on cases from the life sciences, I read a book-length treatment of reasoning about causes in physics with enormous interest. Other contributions to this symposium cover more details in Frisch's book, including his extended treatment of the apparent symmetry of physical laws, and his use of a broadly interventionist framework for causality. In this contribution I will concentrate on the functional project.

The approach of the functional project is the hinge of the overall argument of the book, as can be seen in Frisch's summary:

> Causal structures, I will argue, are an important part of the toolkit that we use to represent the world within the context of physical theorizing. That is, there is no good reason for not treating causal structures on par with other representational resources that we employ in physics, such as dynamical laws or other kind of constraints. (Frisch 2014, 11.)

To succeed in this, Frisch has to persuade readers not to confine their attention to the laws of physics, but to take other features of practice in physics, particularly use of causal structures, seriously.

In examining this, I wish to pull out as remarkable how an approach that is not uncommon in practice-based philosophy of the life sciences, following, among others, Ian Hacking's appositely named *Representing and Intervening* (1983), seems to yield controversial results when applied to philosophy of physics. Simultaneously, a fascinating implication of Frisch's book for philosophers of causality is that applying a common approach to causality in physics as to the life sciences may help bridge the chasm between philosophy of physics and of other sciences. In section 2, I will examine Frisch's account of representation, and show how he applies this to dissolve some influential arguments against causality in physics. In section 3, I will attempt to indicate how Frisch's approach might be extended beyond the cases he covers, to open up thinking about causality in physics. While I will defend Frisch's work, this will serve to make clear its controversial implications, and emphasise that his detailed arguments must be assessed against the background of his methodology.

2 Taking representation seriously

It is crucial for Frisch that the laws of physics cannot tell the whole story of physics. Rather, we must take seriously what all of the relevant representational practices – including the laws – tell us. To get this project off the ground, Frisch needs to present a substantive account of representation that can deal with some problems. The most obvious problem is the pragmatics of representation, as it has been a common thought that the pragmatics of our representational practices are in some sense incidental to how the world is (for impact on this debate, see e.g. Norton, 2003). The second

problem is the common objection to structuralism as an account of the relation between model and target that there are too many available structural similarities (Frigg, 2010). Ultimately Frisch needs an account that can be used to understand the interactions between structural features and pragmatics, and show the importance of our representational practices.

Frisch sets about providing this by defending an account of modelling as both structuralist and pragmatic: 'The central tenets of the view I will explore are the claims that representation is an essentially pragmatic notion, and that representation, at least in physics, is structural representation.' (Frisch, 2014, 24, inspired by van Fraassen, 2008.) I am forced to summarise, so I will recommend Frisch's text, and move to the heart of the story, which is that the context of use of a representation such as a model is pragmatic, but it is what sets the relevant structural similarities between model and target. In general, the structural similarity between the model and the target is crucial to the content of the representation, and it is the successful use of the model that indicates, of all the possible structural similarities, the relevant ones. So integration of pragmatics and structuralism becomes a *strength* of the view.

The view is further strengthened by showing what can be achieved with it. It allows Frisch to take seriously the entire modelling or other representation process, and one immediate result is to draw attention to neglected aspects of the process: 'not only are target and content of a representation determined by a context of use, but the target itself is structured by the user in a given context for certain representational purposes.' (Frisch, 2014, 24.) So we should note that we have models of laws or theories, as well as models of target systems, and these are not the same. This means that while we might have many quantum mechanical models in the sense of having a model of the *theory*, that is not to have a genuine quantum mechanical model of a real system. On Frisch's view, it is significant that we just don't have quantum mechanical models of macro phenomena. In brief, the domain of scientific theories extends beyond systems actually modelled to those with well-defined answers to what modelling them *would* be like, but this does not extend to any system whatsoever. Frisch notes that his view is incompatible with foundationalism: 'the view that physics aims to discover fundamental micro theories that have a universal domain of application and in principle possess models of all phenomena.' (Frisch, 2014, 37.)

Using this view of representation, Frisch argues, in the spirit of the functional project, that representations in physics, including causal representations, are not so different from representations elsewhere. Only two chapters into the book, Frisch has shaken up the usual dialectic of the debate about causality in physics, by undermining crucial assumptions of his opponents. Particularly, his view undermines physics as complete and precise, characterised by Frisch using the work of Woodward and Field:

> "In contrast to the incomplete relationships of limited invariance between coarse-grained factors that are characteristic of the upper level sciences, fundamental laws typically take the form of differential equations, deterministically relating quantities and their space and time derivatives at single spatiotemporal locations" (Woodward 2007, 83). What is more, the relations between different spatiotemporal locations are such that "information about what happens at an earlier time can't suffice to determine the event unless it includes information about each point at that time that is within the past light cone," as Field emphasizes (Field 2003, 439,…)
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> (Frisch, 2014, 50).

Frisch has argued that the laws cannot tell the whole story of physics, and has laid the groundwork by giving an account of representation to allow us to try to tell the story in a different way – a way that will be in another sense more complete.

To begin, Frisch sets about clearing away two opposing arguments: that, unlike in physics, causal relations are coarse-grained and are subject to background conditions. Frisch notes that these sometimes get intertwined, and also that neither condition might be necessary for causal relations. However, they have been influential arguments (Woodward, 2007), and Frisch sets about dissolving them.

First, Frisch argues that to say that causal relations are coarse-grained while relations described by dynamical equations in physics are not is to confuse relations between the variables within a theory's models with the relation between a model and the target system – i.e. it is, again, to miss an important feature of modelling practices. Frisch shows how both causal and dynamical models can have equations relating precisely defined state variables within the model, and both can have a relation between the model and the real-world system it is meant to represent which is to some degree vague, imprecise, and approximate.

Second, the idea that causal relations are distinctive in being subject to background conditions comes down to distinguishing causally relevant factors (such as a fire hose) from local but irrelevant factors (such as praying that the fire will go out). The core idea is that complete models in physics need no such distinction. However, again this is to ignore features of our modelling practices. Frisch points out that very few models are truly complete, examining the partial models of multiple theories used to understand the Large Hadron Collider. Frisch summarises: 'In both dynamical and causal models, background factors do not show up within the model but are appealed to as part of the justification why a given model is appropriate in the circumstances at issue.' (Frisch, 2014, 65.)

These are largely negative arguments, but crucial in clearing the ground for the later more positive arguments. They do illustrate the power of the approach that takes representation seriously, not allowing laws to possess the story about causes, unless the way they are generated and used to build models also supports that story.

3 Discussion

Frisch goes on to give more positive arguments for the view that there's an important role for causes in representations even in fundamental physics, but this is covered elsewhere in this symposium. I wish to close by indicating briefly how Frisch's approach could be applied to non-standard kinds of cases. I will continue to write about the 'story' of physics in an effort to remain neutral, as Frisch wishes, between a realist or instrumentalist reading of the practice (Frisch 2014, 11, criticised elsewhere in this symposium).

Stars appear in this literature (Russell, 1921, 99–100, quoted by Frisch, 2014, 20), and I wish to discuss them further. This will further defend Frisch's functional project, as I will sketch an argument that the astrophysics of stars also shows how important studying messy representational practices are even to our understanding of 'fundamental' physical theory. It will also show that this result of Frisch's is general in that it is independent of his adoption of a broadly interventionist framework (Woodward, 2003).

Take the causes of sudden bright 'new' stars, i.e. supernovae, or the cause of a particular supernova such as SN1987A. The science of this is enormously complicated, and riddled with representational practices. In brief, we use multiple physical theories to create stellar structure models; use stellar

structure models to model at least two types of mechanism of supernova; and then adapt the mechanism of type II supernovae by building simulations to explain features of a supernova such as SN1987A. Considered carefully, these practices look strikingly like the practices of the life sciences.

Presumably, opponents of Frisch would say that this is not the domain of physics that is of interest – only fundamental laws matter. But Frisch has undermined this move, because none of this is independent of the laws which are used to build and constrain models, *and the laws are not independent of these practices*. It is only from practices like this that we get evidence for the laws. First, successfully integrating 'fundamental' laws into this whole story yielded important support for them, such as in the explanation of the Hertzsprung–Russell diagram, and the ongoing use of type Ia supernovae as 'standard candles' used to measure the expansion of the universe. Second, SN1987A was historically crucial to creating agreement about the neutrino burst in the mechanism of type II supernova, and also galvanised particle physics, being the first detection of neutrino bursts from such a source. It is surely right that the story the laws tell us must be interpreted in the context of understanding these practices – the practices that connect the laws to both the evidence for them and their application. Frisch provides us with the means to do this.

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