Book Review: Mathias Frisch, *Inconsistency, Asymmetry, and Non-Locality: A Philosophical Investigation of Classical Electrodynamics*

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This book is a stimulating and engaging discussion of philosophical issues in the foundations of classical electromagnetism. In the first half, Frisch argues against the standard conception of the theory as consistent and local. The second half is devoted to the puzzle of the arrow of radiation: the fact that waves behave asymmetrically in time, though the laws governing their evolution are temporally symmetric.

The book is worthwhile for anyone interested in understanding the physical theory of electromagnetism, as well for the views it presents on philosophical issues such as causation, counterfactuals, laws, scientific theories, models, and explanation. While philosophers of physics tend to focus on quantum mechanics and relativity, Frisch's book shows that there are deep foundational issues in classical physics, equally worthy of attention.

That said, let me lodge disagreement on some key points. Frisch argues from an alleged inconsistency in classical electromagnetism—that Maxwell's equations, the Lorentz force law, and the conservation of energy cannot be jointly true—to the conclusion that the standard view of scientific theories as a formalism plus an interpretation is incorrect. Consistency is a necessary condition of any view on which scientific theories give us an account of "ways the world could be" (Frisch, 2005, 7). Since classical electromagnetism is successfully used by practicing physicists, consistency must be just one criterion of theory choice weighed equally among others.

This is an intriguing idea, but I am not sure that consistency can be given up so easily. That road leads dangerously close to accepting orthodox 'Copenhagen' quantum mechanics. Surely the inconsistency of that theory's basic axioms is a large problem, and it is a problem because it spells trouble for its depiction of the world. Philosophers want to figure out what physics says about the way our world is, and consistency, on the face of it, blocks any such project. If the theory isn't consistent, it can't be true.

Frisch thinks we can similarly eschew truth as a goal of scientific theorizing, even truth with respect to observable phenomena (van Fraassen, 1980). Instead, "acceptance involves only a commitment to the reliability of a theory" (Frisch, 2005, 42). He says this allows for a realist construal of inconsistent theories. This begs the question: why commit to the reliability of a theory, if not because we have reason to believe it is true? Frisch does not address this question, and one is left wanting a bit more to convince us of his account of theory acceptance. Instead, one might think a theory's reliability is good evidence of its truth, which in turn gives us reason to believe it will continue to be reliable. At best, it seems we ought to conclude that such theories are approximations to the truth, not internally inconsistent.

(One might also doubt Frisch's accusation of inconsistency. Belot (2007) argues that there is a consistent understanding available; and to the extent that there isn't, this is because we need another theory to handle particle-field interactions. That's to be expected of a non-fundamental theory.)

One goal of the book is to convince us of the need for irreducibly causal notions in fundamental physics, as his solution to the puzzle of radiation is supposed to show. Frisch argues that a causal constraint accounts for the wave asymmetry, the fact that we see waves appear after the motion of their sources, not before. The account in the book is a revised version of Frisch (2000). I have argued against this solution elsewhere (North, 2003), but let me say a few things about it here.

Frisch states the explanandum as follows: "There are many situations in which the total field can be represented as being approximately equal to the sum of the retarded fields associated with a small number of charges (but not as the sum of the advanced fields associated with these charges), and there are almost no situations in which the total field can be represented as being approximately equal to the sum of the advanced fields associated with a small number of charges" (2005, 108).

The puzzle is why this is the case, when the laws make no distinction between advanced and retarded solutions. Frisch's answer is that there is an additional constraint ruling out advanced solutions as physically impossible. According to the retardation condition, "each charged particle physically contributes a fully retarded component to the total field" (Frisch, 2005, 152).

The retardation condition presupposes that we can make sense of a charge being associated with a certain field. One might think the linearity of the wave equation indicates that we cannot talk about charges "causing" or "producing" particular field components in the first place. As Frisch points out, we can equally describe the waves we observe as either advanced or retarded, with the right background field. How, then, do we determine the field contributed by a charge? Frisch thinks we can do this by means of empirical evidence. Experiment tells us that the "field physically associated with a charge is that component of the field which would be absent if the charge were absent" (Frisch, 2005, 153).

Putting things in terms of counterfactuals, however, doesn't seem to help. For we can't *empirically* see what would have happened had a source not been there. The natural way to evaluate such a counterfactual is to hold fixed the actual background field, then alter the actual situation by removing the source and solving the wave equation. However, any description which says that fields due to charges are retarded assumes a *different* background field from the corresponding advanced description. If we hold fixed the background field of the retarded description and remove the source, then the total field will be the usual tiny background field. But if we hold fixed the background field of the *advanced* description and remove the source, then the total field will be a larger background field: an incoming wave that collapses onto the source which isn't there in the assumed counterfactual situation. What we actually observe doesn't determine which is the true background field we ought to hold fixed in counterfactual scenarios.

There are other reasons for thinking that Frisch's solution won't work. The existence of free fields suggests that the retardation condition isn't true of our world: not all waves satisfy this constraint, since some of the radiation we see is not attributed to sources' motions. Additionally, Maxwell's equations, the fundamental laws governing all electromagnetic phenomena, are deterministic. This means that Frisch's retardation condition, if it does hold, would be derivable from the initial conditions plus these equations. This throws doubt on his claim to be positing an additional constraint on a par with Maxwell's equations: it would be more like a special science law. (Without the retardation condition, things are not so dire as Frisch suggests; we could instead make an assumption about the background field.)

Third, there is reason to think the retardation condition can't be an exact law of our world (analogous to the reversibility objections to the statistical-mechanical grounding of thermodynamics). This constraint deems advanced radiation physically impossible. Yet there is reason to believe, given the fundamental dynamics, that we could see advanced waves. Reverse the motions of the particles and waves in a room, and the particle motions and associated waves should trace out the temporally reversed behavior: there would be advanced waves. Frisch's constraint says this is physically impossible, but there is no reason to think we couldn't set up such a situation. Take an electron that emits a spherical wave, reflect it with mirrors back on the electron to yield the time-reverse of the original wave and electron motion, and we'd see advanced radiation.

Finally, it's worth noting that Frisch's solution doesn't link up the wave asymmetry with other phenomena. Insofar as an explanation is to be preferred the more it is simple and unifying, one would like an explanation that unifies this asymmetry with other physical processes.

Despite the disagreement, I hope these comments serve to point out the thought-provokingness of the book. There is more in the book than what I've discussed here that is well worth thinking about (e.g., the asymmetry of counterfactuals), regardless of whether you ultimately agree with its conclusions.

References

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