Physical Observations as Eigenforms

Michèle Friend
Department of Philosophy
George Washington University

Logic, Relativity and Beyond

23 – 27 August 2017, Budapest

1. Introduction

The ideas in this paper are informed by the approach to physics taken by the Andréka-Németi group, Krause and Arenhart's recent book The Logical Foundations of Scientific Theories; Languages Structures and Models (Springer, 2017) and by concerns addressed in: second-order cybernetics, second-order science and systems theory. In particular, they are informed by Kauffman's (2017) 'Cybernetics, Reflexivity and Second-Order Science'.

What I am after in the end is an account of objectivity and physical phenomena that is consistent with the pluralism of theories found in the logical foundations to science approaches.

2. Reflexive Domains and Eigenforms

- A *domain* is a set of objects, represented by ‘D’.
- A *reflexive domain* D is a domain where the automorphisms of the domain are in one-to-one correspondence with the domain itself. (Kauffman, 2017, 1)
- In more formal language: a *reflexive domain* is a domain D that is in one to one correspondence with certain automorphisms of D. D <—> [D,D].
- “This means that each element x of D acts on D and we can write xa for the action of x (morphism) on an element a. This includes the action of x on itself: xx. If we assume that [D,D] includes operators like G with Gx = F(xx) for all x in D and a specific F in D, then GG = F(GG), and we prove the existence of Eigenforms in the reflexive domain.”
- Each member of a *fully reflexive domain* “is also an actor who transforms that domain.” (Kauffman, 2017, 1).
- An *eigenform* is a fixed point for a transformation. (Kauffman, 2017, 2).
- A fully reflexive domain is therefore also an eigenform.
- An eigenform is the analogue of an eigenvector in analysis or linear algebra, but it is much more general, and includes the fixed points that occur in reflexive domains.” (Kauffman, 2017, 2).
- ‘Transformation’ is also a very general notion. In mathematics it similar to automorphism. In other areas of research, outside mathematics, it will have to be something broader.

3. Krause and Arenhart's Approach to Physics

Krause and Arenhart (2017) are looking for logical foundations of physics. They share their approach with the Andréka-Németi group in the following way. They take the logical foundations to be axiomatic, and they have a preference for ZF set theory.

They diverge from the Andréka-Németi approach in at least three ways.

(1) They avail themselves readily of second-order formal language.

(2) They also diverge in which phenomena they start with. Whereas the Andréka-Németi group started with special relativity, then developed general relativity, Newtonian mechanics and are moving now towards quantum theory; Krause and Arenhart start with quantum theory. The phenomena they are after include things like: wave-particle dualities, the Heisenberg uncertainty principle and so on.

(3) They are more interested in answering some philosophical questions than in understanding the physical phenomena. The philosophical questions include questions about truth, ontology, empirical adequacy, justification of belief and belief revision. This last difference is not only one of emphasis, but also in execution. They do not do much work giving actual languages, axioms or making calculations, instead they prepare the philosophical ground for this future work.

The Krause and Arenhart take on the Syntactic/ Semantic Debate in Philosophy of Science

The caricature of the logical empiricist's position is that they are committed to finding a first-order, formal, logical language, one set of axioms and some rules of inference that allow them to make gapless proofs to deduce the phenomena of all of physics. Moreover, there should be a one-to-one correspondence between the mathematically constructed objects and the physical objects, between the predicates of the mathematical theory and the properties of objects in the real world, and there should be a one-to-one correspondence between the mathematical relations of the theory and the relations between objects in the world.

The semanticists have a much more ‘model’ based approach, but ‘model’ is used in a loose sense, since they reject the heavy use of formal languages. Instead, they are after a class of models of the phenomena being studied, where the class is not formally defined. They emerged after the late 1960s, and are represented by Van Fraassen and, in some writings, Suppes. They claim to be influenced by Tarski, but the ‘influence’ is a little forced.

Krause and Arenhart retain the idea of a class of models satisfying the phenomena. But they insist on a, or several, formal language(s) in order to pick out the class of models. So, the models also have to satisfy a set of formal formulas. Thus, Krause and Arenhart encourage a closer reading of Tarski.

Thus, for Krause and Arenhart, the syntactic and the semantic approach need not preclude each other, and so reject the ‘debate’ in the philosophy of science all together. They bring a more closely mathematical understanding of the merits of the semantic approach, and they pepper the syntactic approach with a dash of pragmatism and pluralism. With these emendations, they see the two approaches as complimentary.

Choices of language and axioms

Krause and Arenhart consider axiomatization along two axes. One axis is the internal/ external approach. The other is the concrete, abstract and formal approach to axiomatics.

The ‘internal’ approach to constructing the axioms is Suppes’ approach. It is to work *within* the language of set theory only, and add axioms that are only satisfied by mathematical models that also satisfy the physical phenomena.

The ‘external’ way of constructing the axioms is based on Da Costa, Chuaqui and Rodrigues. They introduce predicates *from the physical theory* to the logical language to construct axioms that then determine the models that capture the physical phenomena.

Krause and Arenhart are pluralists about the external and internal approaches finding that each has its merits and demerits, and so retain both. Thus, they are prepared to consider several axiomatic theories, each capturing the physical phenomena in question.

The second axis for considering axioms is the: concrete, abstract and formal approaches to axiomatics. See their book for details.

4. The Phenomena and Objects of Physics as Eigenforms

Quoting Kauffman again: "…if science is to be performed in a reflexive domain, then one must recognise the actions of the persons in [on?] the domain. Persons and their actions are not separate [they are different aspects of the same members of a reflexive domain]. If an action is a scientific theory about the domain, then this theory becomes a (new) transformation of the domain."

Kauffman: "If an action is a scientific theory about the domain, then this theory becomes a (new) transformation of the domain. Theory inevitably affects the ground that it studies. Furthermore, the fact that an entire domain can be seen as an eigenform suggests that one can be an observer of that domain in a wider view of the landscape. Thus, physics can be seen as a reflexive domain and one can take a meta-scientific view, allowing physics itself to be one of the objects of a larger domain of which it (physical science) is one of the eigenforms."

5. Conclusion

“Objectivity is an emergent phenomenon.” (Kauffman, 2017, 1). In first-order science, in the name of objectivity, we seek to remove the human observer from the phenomena being observed. But this is an illusion bought at a price. The price is limitation to particular low-level eigenforms and refusal to recognise the reflexivity, circularity, spiralling growth, on the one hand, and the observer, human influence and intensionality, on the other hand in/on science.

Under a more second-order cybernetics view of science, we transgress these limitations. This is what the Andréka-Németi group have already done in their development of physics. This is what is encouraged by Krause and Arenhart.

What is common to both approaches to giving the logical foundations of science is pluralism and pragmatism. The pluralism in axiomatic theory leaves the phenomena being studied as fixed points across theories. The pragmatism concerns choices in axiomatic representation. Not any empirically adequate set of axioms will do. There are aesthetic and practical concerns, together with an aim to understand the phenomena better, and these bring in human judgement. In this way, the domain of the fixed points is also reflexive, in Kauffman’s sense of being also an eigenform.