Imagination, Fiction and the Reality of Minkowski's Discovery of Spacetime

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Abstract

One of the greatest achievements of modern physics is the discovery of spacetime by Hermann Minkowski. If we take for granted that spacetime offers a compelling explanation of relativity and its physical effects, then it is no surprise that its discovery should count as one of the most significant success of modern history of science (Petkov 2009). Nevertheless, I would like to suggest that talking about the "discovery" of spacetime cannot be done without further questioning its status as a scientific object. Claiming that spacetime was discovered, I suggest, implies the following two philosophical questions. Firstly, what kind of thing is it: Is it an entity, a physical substrate (i.e. an underlying physical layer on which material objects are said to be coincident), or a mathematical model? Secondly, was spacetime discovered as a real object, or was it invented as an alternative description of the classical space-time structure of the world.

The challenge with the concept of discovery is that it involves two contradicting interpretations of the status of what was discovered. While "soft" discovery can be seen as an act or process by which a scientific object is thought and devised, without there being any concrete evidence of the reality of the object itself (fantasies like complex numbers, supersymmetries, twistor space), "strong" discovery can be taken as finding the existence of a physical object (the electron, white dwarf stars, black holes) (Achinstein 2011; Penrose 2016). Accordingly, one can dispute the claim that spacetime was discovered, if discovery is understood in the strong sense. Indeed, the disagreement concerns the ontological status of spacetime (Sklar 1974). The substantival view asserts that spacetime is a physical substance that does have an independent existence of its own. In contrast, the relationist view claims that spacetime is not a real existing physical structure; only spatiotemporal objects, events and the relations between them, exist out there. The complication also stems from the fact that spacetime was was not found through direct observation and experimental work, but imagined and invented by Minkowski (Corry 1997; Galison 1979; Holton 1996; Minkowski 1908/2020b).

My plan in this contribution is to present, in section 2, the general conundrum created by the idea that scientific imagination can be taken as a source of strong discoveries about the physical world. In section 3, I outline the philosophical debate on the ontological status of spacetime, and I point out that substantivalism appears to be the appropriate position to justify

the claim that Minkowski discovered spacetime. In section 4, I explain what role scientific imagination played in Minkowski's discovery of spacetime, and I show to what extent scientific imagination enables to find hidden structure in the physical world. Section 5 should provide an overview of the extent to which the spacetime structure imagined by Minkowski furnishes crucial elements of explanation of the relativistic effects we observe in the world. Finally, by showing how imagination and explanation work together in a fictionalist strategy, I intend to show in section 6 that there is no reason to doubt the veracity of the discovery of spacetime and its physical reality.

Bibliography

Achinstein, P. (2001) *The Book of Evidence*, Oxford University Press.

Corry, L. (1997) "Hermann Minkowski and the postulate of relativity", Archive for History of Exact Sciences volume 51, p. 273-314.

Einstein, A. (2018) *Relativity*, Montreal, Minkowski Institute Press.

Frigg, R. (2009) "Models and fiction", Synthese volume 172, p. 251-268.

Galison, P-L. (1979) "Minkowski's space-time: From visual thinking to the absolute world", Historical Studies in the Physical Sciences, Vol. 10, p. 85-121.

Godfrey-Smith, P. (2005) "The strategy of model-based science", Biology and Philosophy volume 21, p. 725-740.

Godfrey-Smith, P. (2009) "Models and fictions in science", Philosophical Studies volume 143, p. 101-116

Holton, G. (1996) "On the art of scientific imagination", Daedalus Vol. 125, No. 2, p. 183-208.

Holton, G. (1975) "On the role of themata in scientific thought", Science 25, Vol. 188, Issue 4186, p. 328-334.

Levy, A. and P. Godfrey-Smith (ed.) (2020) *The Scientific Imagination.* Oxford University Press.

Levy, A. and P. Godfrey-Smith (2020) "Introduction" in *The Scientific Imagination.* Oxford University Press.

Minkowski, H. (2020a) "The relativity principle" in Petkov, V. (ed) *Spacetime. Minkowski's Papers on Spacetime Physics*, Montreal, Minkowski Institute Press.

Minkowski, H. (2020b) "Space and Time" in Petkov, V. (ed) *Spacetime. Minkowski's Papers on Spacetime Physics*, Montreal, Minkowski Institute Press.

Minkowski, H. (2020c) "A derivation of the fundamental equations for the electromagnetic processes in moving bodies from the standpoint of the theory of electrons" in Petkov, V. (ed), *Spacetime. Minkowski's Papers on Spacetime Physics*, Montreal, Minkowski Institute Press.

Penrose, R. (2016) *Fashion, Faith, and Fantasy.* Princeton, Princeton University press.

Petkov, V. (2009) *Relativity and the Nature of Spacetime*, Springer international.

Petkov, V. (2012) *Inertia and Gravitation.* Montreal, Minkowski Institute Press.

Pyenson, L (1979) "Physics in the shadow of mathematics", Archive for History of Exact Sciences volume 21, p. 55-89.

Poincare, H. *Science and Method.* Cosimo Classics.

Salis, F. and Frigg, R. (2020) "Capturing the scientific imagination" in *The Scientific Imagination.*

Sklar, L. (1974) *Space, Time, and Spacetime.* University of California Press.