

Reichenbach's Axiomatic and the Prehistory of the Dynamical Approach to Special Relativity

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Introduction

Harvey Brown and Michel Janseen are engaged in a dispute This is the arrow of explanation debate in special relativity. about whether the symmetries of space-time explain the Lorentz invariance of dynamical laws or the Lorentz invariance of dynamical laws explains the symmetries of space-time. One the great to have refrained in term fo confirmation (e.g. the between convetionalism and), but in term of explation, is a radical with respect that have domianted was by logical empiricism. This paper, that this indeded, the first author to recast in term of explanatio was Hans Reichenbach, that should regarded as sort father of the dynalical as opposed to geometrical one. This is already present in his 1924 (Weyl 1924), but it is probbale a 1925 article A good opportunity to point to epxaon aout fas the alleged refutation of Michelson experiemnt by Miller 1970. The reust of the expeimernt were contested, but question could be addressed.: what would happen to special relativty if the Michelson-Morely expeormt was rejec,t that is when turent to be correct?

1 Two Kinds of Contractions

Before addressing the question, Reichenbach made some remarks about the philosophical interpretation of special relativity. Reichenbach warned his readers not to subscribe uncritically to a common interpretation of special relativity. In order to explain the negative result of the Michelson experiment, Lorentz made the *ad hoc* assumption that one arm of the apparatus is *contracted* by the amount $\sqrt{1 - v^2/c^2}$ when it moves relative to the ether. The theoretical asymmetry between the ether frame and those moving with respect to it is hidden from observation by a sort of universal conspiracy of nature. Einstein, on the contrary, considered both arms *equally long*, if measured at relative rest in the rest system, but one arm would appear contracted by the factor $\sqrt{1 - v^2/c^2}$ if measured from a moving system. In this way, the theoretical symmetry between the rest and moving system is reestablished. This of course was the consequence of the fact that the definition of the simultaneity of distant clocks using light signals is frame

dependent. As any length measurement requires that both ends of the rod be measured at the same time, two observers in relative motion refer to something different when they talk about the length of the arm of the apparatus.

Reichenbach, however, explicitly rejected this standard interpretation. To avoid confusion, Reichenbach suggested that it is necessary to distinguish between. The *Einstein contraction* depends on the relativity simultaneity and “is related to the comparison of *different magnitudes* within the *same theory*” (Reichenbach 1925, 44; tr. 2006, 188). The *Lorentz contraction* is related to “the behavior of the *same magnitudes* according to *different theories*” (Reichenbach 1925, 45; tr. 2006, 188) (the classical and relativistic proper length). According to Reichenbach, only the Lorentz contraction is at stake in the Michelson experiment, not the Einstein contraction: “It just happens that both contractions depend upon the same factor $[1/\sqrt{1 - v^2/c^2}]$, and this is probably the reason why they are always confused with one another” (Reichenbach 1925, 46; tr. 2006, 189).

2 Two kinds of explanations

Both theories the Lorentz contraction, that is shorter than expectation by the classical theory, where the length of a moving segment was tacitly assumed to be identical with its length at rest. However, Lorentz theory is unsatisfactory was *bad explanation* of the Lorentz contraction, since there is no reason to consider the classical behavior of rods as natural. Einstein was unsatisfying because he provided *no explanation* at all, and simply declare by convention that relativistic rods are rigid. According to Reichenbach, the problem of explanation should not be simply *circumvented* by adopting conventionalist stratagem, but addressed in a different form. One must not explain why measuring rods and clocks *disagree* the classical light-geometry from, which we have no reason to consider natural. We have to explain why they *all agree* with the relativistic light geometry and not with a different one. Paradoxically Here Reichenbach to resort to an idea by his opponent Weyl. Already in his 1924 monograph (Reichenbach 1924, 70–71; tr. 1969, 90–91) Reichenbach using Weyl’s expression *adjustment* as a good way to express this peculiar form of causality, to contrast to that of *deflection* (*Abweichung*).

The analogy with special relativity seems to be the following: “*Einstein’s idea* can be formulated as meaning that *light geometry and matter geometry are identical*” (Reichenbach 1924, 11; tr. 1969, 14). It is an odd coincidence that any physical system we use as a rod—whether it is made of steel, wood, etc.—always measures at equal lengths that are light-geometrically equal. “Light is a much simpler physical object than a material rod, and, when searching for a relation between the two, it should be initially supposed that it would not correspond to so ideal a scheme as the posited matter axioms” (Reichenbach 1925, 47–48; tr. 2006, 95). This coincidence cries out for an explanation. However, the explanation should not account for the *divergence* from an alleged correct behavior, but for the *convergence* toward a non-trivial one, that is that light and matter geometry agree

Conclusion

After Reichenbach clarified the distinction between Lorentz and Einstein contraction, he could proceed further to show what would happen if a Michelson-type experiment

gave a positive result. As we have mentioned, in those years, raising this issue was more than just a mental exercise. If the experiment were rejected, this would only mean that “rigid rods do not after all possess the preferred properties that Einstein still attributes to them” (Reichenbach 1925, 328; tr. 2006, 203). This result is incorporated in 1926 finished, that incorporates the same result, and extended but recast only in terms of Minkowski.

However, this That for Reichenbach a Minkowski is only a graphical representation and does not explain, the Lorentz is a bad explanation, any Minkowski is only a graphical representation, geometrization does not add anything to result; the still that needs an explanation. The most important how the content of the light- and matter-axioms can be “visualized geometrically” by the world- geometry of Minkowski. Reichenbach views Minkowski-spacetime as nothing but a ‘graphical representation,’ an expression he borrowed from Arthur Stanley Eddington1925a<empty citation>. Once again, that theory of matter could provide a proper explanation. Indeed, that makes clear that is metrogenic (relative to the same rods), and that in the same system. However, Minkowski does that explanation is needed. Once again, for Reichenbach, Weyl’s expression ‘adjustment’ aptly expresses the need for an explanation, but it provides no details as to what it would look like. “The answer can of course be given only by a detailed theory of matter, of which we have not the least idea” (Reichenbach 1928, 233; tr. 1958, 201; translation modified).

References

- Reichenbach, Hans. 1924. *Axiomatik der relativistischen Raum-Zeit-Lehre*. Vieweg: Braunschweig. Repr. in **Reichenbach1977**.
- . 1925. “Über die physikalischen Konsequenzen der relativistischen Axiomatik.” *Zeitschrift für Physik* 34:32–48. Repr. in **Reichenbach1977**.
- . 1928. *Philosophie der Raum-Zeit-Lehre*. Berlin/Leipzig: Walter de Gruyter. Repr. in **Reichenbach1977**.
- . 1958. *The Philosophy of Space and Time*. Edited by Maria Reichenbach. Translated by Maria Reichenbach and John Freund. New York: Dover Publ.
- . 1969. *Axiomatization of the Theory of Relativity*. Edited and translated by Maria Reichenbach. With a foreword by Wesley C. Salmon. Berkeley: University of California Press.
- . 2006. *Defending Einstein: Hans Reichenbach’s Writings on Space, Time, and Motion*. Edited by Steven Gimbel and Anke Walz. Cambridge et al.: Cambridge University Press.
- Weyl, Hermann. 1920. “Elektrizität und Gravitation.” *Physikalische Zeitschrift* 21:649–650. Repr. in **Weyl1968**.
- . 1924. “Review of Reichenbach, *Axiomatik der relativistischen Raum-Zeit-Lehre* [Reichenbach 1924].” *Deutsche Literaturzeitung* 45:2122–2128.