

Preface

In 1908 Hermann Minkowski gave the four-dimensional (spacetime) formulation of special relativity [1]. In fact, Henri Poincaré [2] first noticed in 1906 that the Lorentz transformations had a geometric interpretation as rotations in a four-dimensional space with time as the fourth dimension. However it was Minkowski, who successfully decoded the profound message about the dimensionality of the world hidden in the relativity postulate, which reflects the experimental fact that natural laws are the same in all inertial reference frames. Unlike Poincaré, Minkowski did not regard spacetime – the unification of space and time – as a convenient *mathematical* space, but insisted that this absolute four-dimensional world, as Minkowski called it, represents physical phenomena and the world more adequately than the relativity postulate: “the word *relativity-postulate*... seems to me very feeble. Since the postulate comes to mean that only the four-dimensional world in space and time is given by the phenomena... I prefer to call it the *postulate of the absolute world*” [3].

The impact of Minkowski’s ideas on the twentieth century physics has been so immense that one cannot imagine modern physics without the notion of spacetime. It would hardly be an exaggeration to say that spacetime has been the greatest discovery in physics of all times. The only other discovery that comes close to spacetime is Einstein’s general relativity, which revealed that gravity is a manifestation of the curvature of spacetime. But it was the discovery of spacetime, which paved the way for this deep understanding of what gravity really is. Einstein saw the link between the geometry of spacetime and gravitation only after he overcame his initial hostile attitude toward the notion of spacetime.

The implications of Minkowski’s revolutionary ideas of space and time for philosophy, and especially for the philosophy of space and time, have also been enormous. I think just one example will suffice to demonstrate the extent of those implications. The views of time flow, becoming, and ultimately of what exists are all defined in terms of *simultaneity*. For instance, the present – the three-dimensional world at the present moment – is defined as everything that exists *simultaneously* at the moment ‘now’. When Einstein published his special relativity in 1905 the implications of one of its major consequences – *relativity of simultaneity* – for the view of reality had not been immediately realized. But it is now evident that the widely held presentist view of the world contradicts relativity of simultaneity – on the presentist view it is only the present (the class of *absolutely simultaneous* events at the present

moment) that exists, whereas according to special relativity two observers in relative motion have different classes of simultaneous events. The temptation to interpret the fact that every observer has a different class of simultaneous events in a sense that what exists is *relative* to an observer could hardly be defended, especially in view of the understanding, stressed by Minkowski, that the very appearance of relative quantities in a theory is a manifestation of the existence of an absolute underlying reality. And indeed, the *different* presents (the different classes of simultaneous events) of two observers in relative motion are merely different three-dimensional ‘cross-sections’ of spacetime and the truly challenging question then is – Is reality an absolute four-dimensional world?

In 2008 the one hundredth anniversary of Minkowski’s talk “Space and Time” given on September 21, 1908 in Cologne provided an excellent opportunity to commemorate his major contribution to physics and its profound implications for physics, philosophy, and our entire worldview. There were several events which marked this anniversary. The Third International Conference on the Nature and Ontology of Spacetime (<http://www.spacetimesociety.org/conferences/2008/>) held at Concordia University, Montreal, on June 13–15, 2008 was dedicated to the centennial anniversary of Minkowski’s talk. On September 7–12, 2008 the 414th WE-Heraeus-Seminar (<http://www.uni-koeln.de/minkowski/>) also commemorated Minkowski’s famous lecture at its meeting “Space and Time 100 Years after Minkowski” in the Physikzentrum Bad Honnef, Germany. The September–October 2008 special issue of *Annalen der Physik* “The Minkowski spacetime of special relativity theory – 100 years after its discovery” [5] was dedicated to the memory of Minkowski. The volume *Minkowski Spacetime: A Hundred Years Later* [4] published in the Springer series *Fundamental Theories of Physics* contains a new translation of Minkowski’s talk “Raum und Zeit”, accompanied by the original German version, and papers by physicists specifically written on the occasion of Minkowski’s anniversary.

This volume is part of the celebration of the centennial anniversary of spacetime and compliments [4] by exploring the implications of Minkowski’s discovery for issues in physics not covered in [4] and most importantly for the physical foundations and the philosophy of space and time, which alone warrants the publication of a separate collection of papers. The volume contains selected papers by physicists and philosophers, most of which were presented at the Third International Conference on the Nature and Ontology of Spacetime. One of the selection criteria was to have examples of the influence of Minkowski’s ideas on different issues in physics, philosophy, and other disciplines. The first six papers, comprising Part I of the book, provide examples of the impact of Minkowski’s spacetime representation of special relativity on the twentieth century physics. Part II also contains six papers which deal with implications of Minkowski’s ideas for the philosophy of space and time. The last part is represented by two papers which explore the influence of Minkowski’s ideas beyond the philosophy of space and time.

References

1. H. Minkowski, “Raum und Zeit”, *Physikalische Zeitschrift* **10** (1909) pp 104–111; *Jahresbericht der Deutschen Mathematiker-Vereinigung* **18** (1909) pp 75–88
2. H. Poincaré, “Sur la dynamique de l’électron”, *Rendiconti del Circolo matematico Rendiconti del Circolo di Palermo* **21** (1906) pp 129–176
3. H. Minkowski, “Space and Time.” New translation in [4] (pp xiv–xlii) p xxv
4. V. Petkov (ed.), *Minkowski Spacetime: A Hundred Years Later* (Springer, Heidelberg 2010)
5. *Ann. Phys. (Berlin)* **17**, No. 9–10, pp 613–851 (2008)

Space, Time, and Spacetime

Physical and Philosophical Implications of Minkowski's

Unification of Space and Time

Petkov, V. (Ed.)

2010, XII, 314 p., Hardcover

ISBN: 978-3-642-13537-8