Discipline and style in relativity theory, 1905–1915

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The contributions of Hermann Minkowski to the theory of relativity are remarkable from the point of view of discipline and style. First of all, by the end of the 19th century, German mathematicians no longer contributed to theoretical physics. From the 1870s, theoretical physics emerged in Germany as an autonomous subdiscipline of physics, in parallel with the construction of new physical institutes (cf. Jungnickel & McCormmach, 1986). Minkowski was known for foundational contributions to the geometry of numbers, and from 1902, held a chair in pure mathematics at the University of Göttingen. His interest in physics deepened in Göttingen, extending from fluid dynamics and capillarity to electron theory and heat radiation (Corry 2004). Upon reading works on relativity theory by Poincaré, Planck, and Einstein, Minkowski conceived an ambitious program to reformulate the laws of physics in four-dimensional, Lorentz-covariant terms (Walter 2008). In 1908 he published the first relativistic theory of the electrodynamics of moving media, which he couched in a new four-dimensional matrix calculus. Physicists were impressed by his theory, but preferred, with Einstein and Laub (1908), to translate it into three-dimensional terms. Minkowski then focussed, in his next publication, on the merits of his four-dimensional formalism alone. His celebrated Cologne lecture, *Raum und Zeit*, described the requirement of covariance of laws of nature with respect to the transformations of the inhomogeneous Lorentz group as the essence of relativity theory. Thereby, Minkowski claimed, the theory of relativity was well-adapted for exploitation by mathematicians. Despite scattered protests, theoretical physicists like Arnold Sommerfeld, Max Planck, and Max Laue recommended a four-dimensional approach for research on relativity, such that by 1911, this approach had come to dominate the pages of Planck's journal, the *Annalen der Physik.* Collectively, mathematicians contributed a quarter of all articles on relativity published from 1909 to 1915 (Walter 1999). Thus questions of discipline and formalism (or style) are important for understanding the history of relativity theory.

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