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REVIEW

RELATIVISTIC SOURCES

Jürgen Renn (ed.), *The Genesis of General Relativity: Sources and Interpretations*. Dordrecht: Springer, 2007 (Boston Studies in the Philosophy of Science, Vol. 250). Pp. xxix + 1152 (in four volumes, not available separately). US\$799.00 HB.

By Anne Kox

Most people know that Albert Einstein published his celebrated General Theory of Relativity in November 1915. Less well-known is that it took Einstein more than 2 years to reach the conclusion that the predecessor to General Relativity, published in 1913 in a paper co-authored with the mathematician Marcel Grossmann, was seriously flawed and had to be abandoned. Putting it briefly, the Einstein–Grossmann theory was not generally covariant, whereas the final theory was. Since for Einstein a generally covariant theory was an important and desirable goal, it has been a long-standing puzzle for historians of relativity why Einstein first gave up this goal and then, after 2 years, returned to it.

A first step towards resolving this puzzle was taken in the early 1980s in papers by John Stachel and John Norton. Stachel, founding editor of the *Collected Papers of Albert Einstein*, had discovered among Einstein's papers a notebook with calculations pertaining to the Einstein–Grossmann theory. Careful analysis of this notebook, especially by Norton, brought to light the fact that Einstein had been very close to a generally covariant theory (to be precise, he had considered the Riemann tensor as a candidate for the construction of a generally covariant field tensor) but had then veered away from it. As Norton and Stachel reconstructed it, Einstein had made an incorrect assumption for the Newtonian limit of his theory – an assumption that proved to be incompatible with a generally covariant theory.

In 1995 the notebook was published, together with commentary, in Vol. 4 of the Einstein Edition. But it was felt by some experts that the analysis of the notebook, now known as the 'Zurich Notebook' after the place of its origin, was only preliminary and that much more research was needed. This led to the formation of an informal discussion group, led by Stachel, Norton, and Jürgen Renn, one of the editors of Vol. 4 and future Director of the Berlin Max Planck Institute of History of Science. The group started meeting regularly in Berlin to systematically expand the analysis of the Zurich Notebook.

In 2007, more than 10 years later, this effort has resulted in four heavy volumes, heavy not just in weight, but also in content. During those ten years, the scope of the project has widened considerably, to analyse not just the Zurich Notebook, but also to provide various forms of historical context as well. In Vol. 1, for instance, we find an essay by Renn on the history of theories of gravitation, starting with Aristotle, and a piece by Stachel on what he calls the 'first two acts': the formulation of the equivalence principle in 1907 and the work leading to the Einstein–Grossmann theory of 1913. In this same volume, an attempt is made (in a paper by Renn and Tilman Sauer) to give an account of the genesis of general relativity in the framework of what the authors call 'historical epistemology', which they describe as a discipline 'that integrates historical analysis, epistemology, and cognitive science'.

Volumes 3 and 4 – which belong together, as do Vols. 1 and 2 – contain (English translations of) primary papers on gravitation by others than Einstein, as well as historical essays on these alternative approaches, that are meant to function as a backdrop to Einstein's research. Although in some cases the material is far removed from Einstein's work – what are we to make of Hendrik Lorentz's electromagnetic theory of gravitation of 1900, for example? – these volumes do provide a comprehensive overview of the history of gravitational theories, both through the historical essays and the original sources.

The Zurich notebook is the centre of Vols. 1 and 2, and, in fact, of the whole edition. A careful transcription and a photographic reproduction are provided in Vol. 1, whereas detailed annotation is presented in Vol. 2, so that the document and the commentary can be studied side by side. Interestingly, and perhaps disappointingly to some, all this work has not led to a consensus among the

various authors on central questions such as: Why did Einstein abandon general covariance, while he was so close to it? And: Why did it take him so long to realise his mistake? Different answers to these questions are given in essays in Vol. 2 by Norton and Michel Janssen (a former Einstein editor). There is agreement that in Einstein's work a distinction can be made between what can be called the mathematical and the physical strategies. Following the mathematical strategy would have made Einstein choose the Riemann tensor, whereas the physical approach that took precedence made him rely on his intuition considering the classical limit of the metric tensor. Both Janssen and Norton qualify this scenario differently: Norton by emphasising the role of so-called coordinate restrictions and postulating an unconscious reification of space-time by Einstein; Janssen by arguing (in a paper co-authored by Renn) that the eventual choice for a covariant theory was the result of the physical, not the mathematical strategy, and (in a second paper) stressing the role of opportunistic motives in Einstein that blinded him to the flaws of the Einstein–Grossmann theory. As pointed out in Renn's Introduction in Vol. 1, these are not isolated cases of disagreement. In fact, he speaks of “a lack of consensus [among the authors] about the interpretation of the material”. Rather than being a shortcoming, this makes the volumes more exciting to read, because it forces readers to assess the various arguments critically and make up their own minds.

Clearly, these volumes are not for the weak of heart (nor for the small of purse). But the effort to delve deep into the various essays is worth it. One may have a personal preference for one essay over another one – I, for one, tend to prefer the more technical ones – but altogether the papers in these volumes present a detailed view, in a broad context, of the genesis of general relativity, one of the most exciting chapters in the history of physics. The fact that not all authors agree on everything does not detract from the value of the edition.

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