PHYSICS

# Einstein's magnum opus

## An insightful tome recounts the heady early days of general relativity

*By* **Andrew Robinson**

On the centenary of general relativity, physicist Hanoch Gutfreund and historian Jürgen Renn published *The Road to Relativity*, a facsimile of Albert Einstein's 1915–1916 German manuscript with an English translation and page-by-page commentary placing this seminal work in its historical and scientific context. Their new book, *The Formative Years of Relativity*, discusses in detail—yet deliberately without mathematics—general relativity's development up to the early 1930s, focusing mainly on Einstein's lectures at Princeton in May 1921.

The authors begin by quoting a London lecture given by Einstein in June 1921. "The abandonment of certain notions connected with space, time, and motion hitherto treated as fundamentals must not be regarded as arbitrary, but only as conditioned by observed facts," he explained, stressing the origin of relativity not in philosophical speculation but in physical observation.

No doubt Einstein had in mind the May 1919 solar eclipse that confirmed general relativity's exact prediction of the gravitational bending of starlight. So instant was the public reaction to this announcement in November of that year that the first nonmathematical English-language account of relativity, Oxford University physicist Henry Brose's booklet *The Theory of Relativity: An Introductory Sketch Based on Einstein's Original Writings*, was reprinted four times between December 1919 and March 1920. (Einstein's own best-selling book, published in German in 1917, would not appear in English until August 1920.)

Relativity undoubtedly had a profound influence on cosmology, despite the fact that cosmology "scarcely played a role" in its genesis. In 1915, for example, it was employed to explain the perihelion motion of Mercury; it predicted gravitational waves in 1916, which were finally detected in 2016; and it introduced the cosmological constant in 1917, which helped to facilitate our understanding of the structure of the universe (although not the existence of black holes, which Einstein puzzlingly rejected). It also played a role in the quest for a unified field theory, which preoccupied Einstein until his dying day.

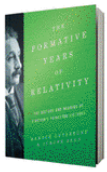
The authors also consider relativity's relationship with philosophy, notably the work of Ernst Mach and Moritz Schlick, and with politics, including the books that emerged from the antirelativity movement. These include the notorious *100 Authors Against Einstein* (which contains only 28 contributions), published in German shortly before the Nazis' rise to power.

The book refers extensively to *The Meaning of Relativity*, Einstein's summary of the Princeton lectures intended for mathematically sophisticated listeners. Indeed, this book is reprinted in *The Formative Years of Relativity*, along with, for the first time, an English translation of a stenographic record of two lectures intended for a nonprofessional audience.

This record is intriguing, because it allows the reader to "hear" an enthusiastic Einstein, but frustrating, because crucial words are missing or were misunderstood by the stenographer. "Part of the theory he explained on the blackboard," noted a watching journalist. "The rest he explained out in space, with the chalk drawing imaginary lines ... balanced between his fingers like the baton ... of an orchestra leader (*1*)."

In his 1917 book, Einstein tried to make relativity comprehensible by including dialogues with the reader, examples from daily life, and only a few mathematical formulae. But, as Gutfreund and Renn validly note, "it does not compromise on scientific rigor, and the reader soon discovers that an intellectual effort is required to follow the flow of Einstein's thoughts and arguments."

Einstein himself called the original German edition "quite wooden" in a letter to Michele Besso (*2*). He liked to quote Max Planck's shrewd remark: "Einstein believes his books will become more readily intelligible if every now and again he drops in the words 'Dear reader'" (*3*).



**The Formative Years of Relativity**
*Hanoch Gutfreund and Jürgen Renn*
Princeton University Press, 2017. 430 pp.

No such criticism can be leveled at Gutfreund and Renn, who combine years of Einstein scholarship with readability and insight. However, they cannot rival Einstein's flair for witty simplification. In April 1921, Einstein offered this—admittedly half-joking—distillation of relativity to a hungry press: "It was formerly believed that if all material things disappeared out of the universe, time and space would be left. According to relativity theory, however, time and space disappear together with the things" (*4*). ■


REFERENCES

1. J. Illy, Ed., *Albert Meets America* (John Hopkins Univ. Press, Baltimore, MD, 2006).
2. Einstein to Michele Besso, 9 March 1917, *Collected Papers of Albert Einstein*, vol. 8, doc. 306.
3. A. Robinson, *Einstein: A Hundred Years of Relativity* (Princeton Univ. Press, Princeton, NJ, 2015).
4. R. W. Clark, *Einstein: The Life and Times* (HarperCollins, New York, 2011).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**An estimated 6 million emojis are used every day, allowing users to convey information otherwise absent from digital communications.**

PODCAST

**The Emoji Code**
**The Linguistics Behind Smiley Faces and Scaredy Cats**
*Vyvyan Evans*
Picador, 2017. 264 pp.

Nonverbal cues can clue listeners into implied meaning during in-person conversations, but, until recently, tone and nuance were often lost during digital interactions. Enter the emoji. This week on the *Science* podcast, linguist Vyvyan Evans argues that these icons better allow us to signal our attitudes and emotions in text-based discussions, ultimately making us more capable communicators.

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