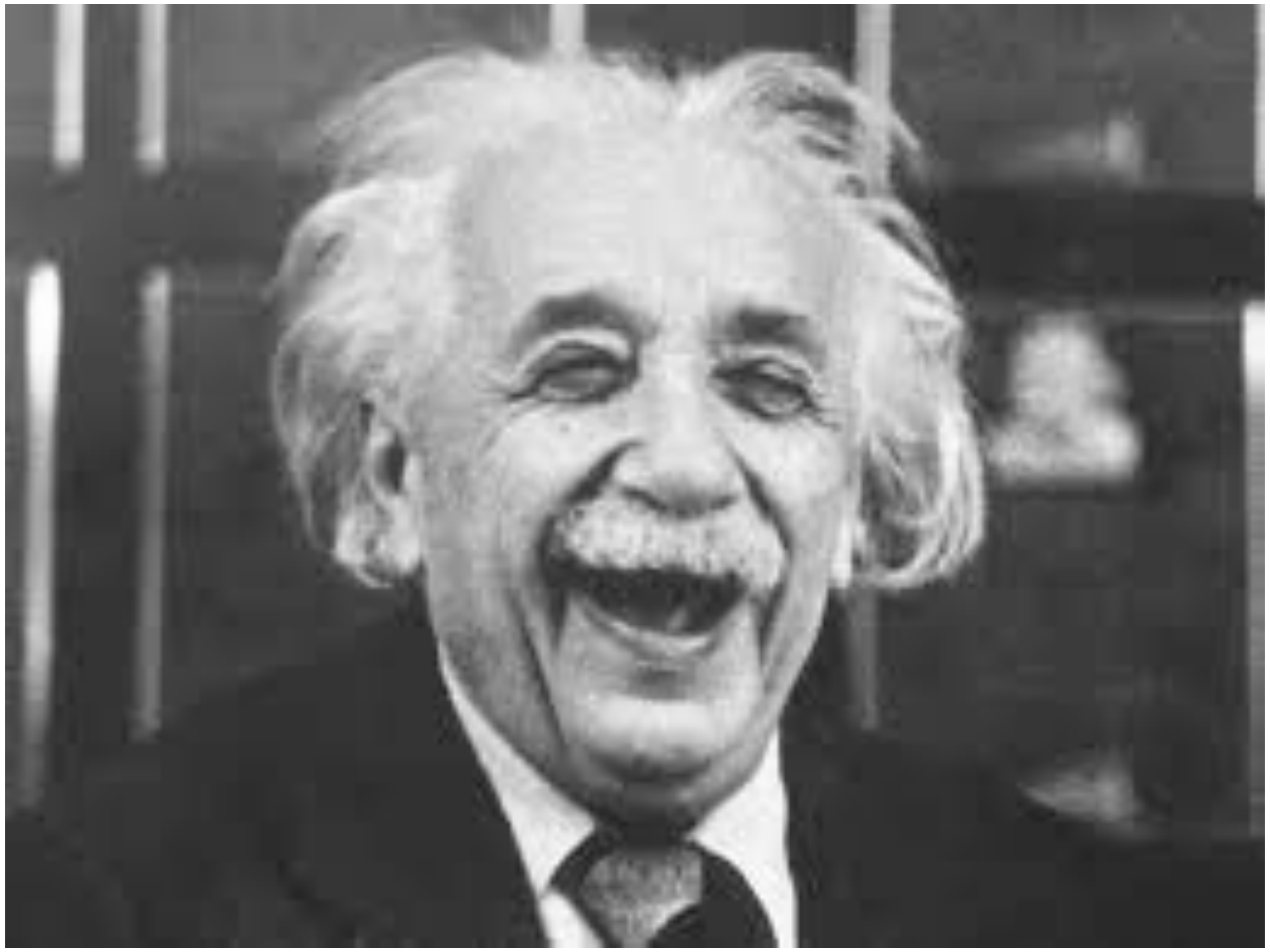
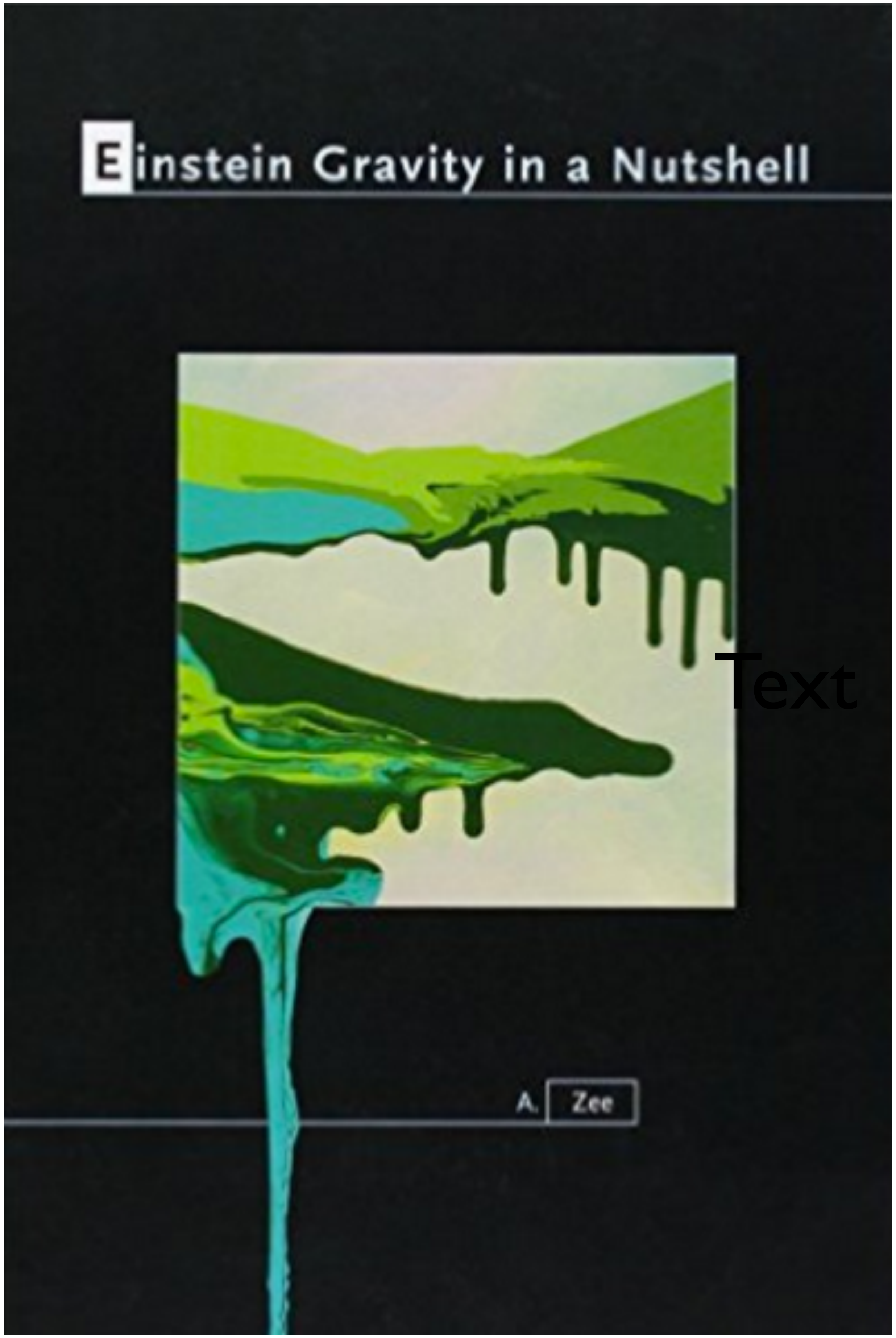
EINSTEIN GRAVITY

A. Zee
University of California, Santa Barbara, CA, USA
Qing Hua University, Beijing, July 18, 2019



Einstein Gravity
1915



Text

Pedagogy
&
History

Princeton University Press 2013

With due modesty

Einstein Gravity in a Nutshell

$78.99 FREE Shipping. | Only 8 left in stock (more on the way). Ships from and sold by Amazon.com. Gift-wrap available.

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Most Relevant Customer Reviews

86 of 88 people found the following review helpful

★★★★★ **The one GR book I'd bring to a deserted island**

By FC22 on April 26, 2013

Format: Hardcover

My favorite popular physics book happens to be Prof. Zee's own _An Old Man's Toy_. I found that book more enlightening than (the likewise excellent) books by Brian Greene or Michio Kaku, for example. _Toy_ is infused with physical insight and clear writing. This unique textbook from Prof. Zee reads much like _Toy_ but with all the added mathematics. Thus, it imparts that same physical insight but this time backed by the underlying mathematical and scientific details. The result is a textbook that's humorous, playful, and authoritative mixed with equal parts irreverence, verve, and gusto. Learning general relativity has never been so fun.

And funny, I might add. There are lots of excellent textbooks on general relativity. Professor Zee's new offering differs from all of them, however, in that he takes a lighthearted approach to the subject without sacrificing rigor or thoroughness. Passages describing light following a least time principle because light isn't "stupid" enough not to and dutifully informing us that "After Lagrange invented the Lagrangian, Hamilton invented the Hamiltonian" made me break out laughing. The book abounds with dry humor and witticisms. His introduction of the action principle is particularly mirthful.

But for all the comedy, the book is thorough. One example is the treatment of Hawking radiation. It's as complete as I've seen in other relativity textbooks and even Raine and Thomas's textbook on specifically black holes. Another example is the emphasis on the action principle. For that Prof. Read more ›

5 Comments | Was this review helpful to you? Yes No Report abuse

35 of 35 people found the following review helpful

★★★★★ **Simply the Best That's Out There**

By William O. Straub on June 4, 2013

Format: Hardcover | **Verified Purchase**

I learned general relativity from the old 1965 Adler-Bazin-Schiffer introductory text, which at the time was the best available. Then Misner-Wheeler-Thorne's Gravitation book came out in 1973 which, though commendable, was basically an advanced graduate-level text. Since then many more general relativity books have appeared, but to me none as useful as ABS.

Most Recent Custome

★★★★★ **Masterpiece**

Einstein Gravity in a Nutshell i
me about three weeks to work
textbook. Read more

Published 14 days ago by Love E

★★★★★ **Five Stars**

Very Good!

Published 22 days ago by Han J

★★★★★ **Perfect for tale grad students**

I have read most of the gravity
MTW to d'Inverno to Stephani
Ryder. Read more

Published 5 months ago by mahl

★★★★★ **Amazing Book**

I like these 'Nutshell' books: "C
and "Einstein Gravity in a Nuts

Published 6 months ago by munt

★★★★★ **Wonderful!**

Really Well Done! A Splendid

Published 7 months ago by Richa

★★★★★ **Five Stars**

Great book

Published 8 months ago by Andr

of science, a popularizer, a communicator, an educator, and a moderator of science on the international stage. Einstein deliberately lent his name not only to political causes but also to the public dissemination of scientific knowledge on a worldwide level. Like few other scientists, he succeeded in conveying the results of his work to a broader public. Einstein not only published popular works and newspaper articles on his relativity theories but also held generally comprehensible lectures in publicly accessible venues, such as adult education institutions and planetariums. In February and March 1920, for example, he gave a series of 10 lectures on kinematics and equilibrium of bodies for the general public at the Adult Education College of Berlin. And in 1931 he famously lectured at the Marxist Workers' School on "What a Worker Needs to Know about the Theory of Relativity."[4] The playwright Berthold Brecht attended this lecture and was inspired by it in writing *The Physicist* (part of his famous anti-Nazi play *The Private Life of the Master Race*).[5]

ward, Einstein took action to fulfil Itelson's ...
part of his valuable library to Jerusalem and to sell part of it to provide funds for Itelson's foster daughter. Itelson's library was indeed sent to Jerusalem and was subsequently incorporated into the Hebrew University library.

THE CHINESE TRANSLATION

In the early 1920s, Albert Einstein and the theories of relativity attracted broad interest in China. This interest was cultivated by young Chinese physicists, trained in Japan, Europe, and the United States. One of the most prominent members of this group was Xia Yuanli, who received his bachelor's degree from Yale University and continued his studies in Berlin, where he met Einstein and attended his lectures. Xia was one of the first Chinese theoretical physicists to spread the theory of relativity in China. He taught courses on relativity, wrote newspaper articles, and gave public lectures.

Xia translated Einstein's booklet on the special and general theory of relativity into Chinese. The first edition was published in April 1921 in the special "relativity issue" of the magazine *Gaizao* (The Reconstruction), and in 1922 it was printed as a separate volume by Commercial Press. It became the first book on relativity theory in China and was

Japanese June 1921 p 266

8 Cited in Freudenthal, Gideon, and Tatiana Karachentsev. "G. Itelson: A Socratic Philosopher," in *Otto Neurath and the Unity of Science*, ed. J. Symons, O. Pombo, and J. M. Torres (New York: Springer, 2011), 114.

English translation 1920
French 1921
Italian 1921
Polish 1921
Russian 1921

*Tragically, in 1926, the 74-year-old translator of the Russian edition, G. Itelson, was brutally beaten to death on a main street of Berlin by a mob.

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to the hospital and died a
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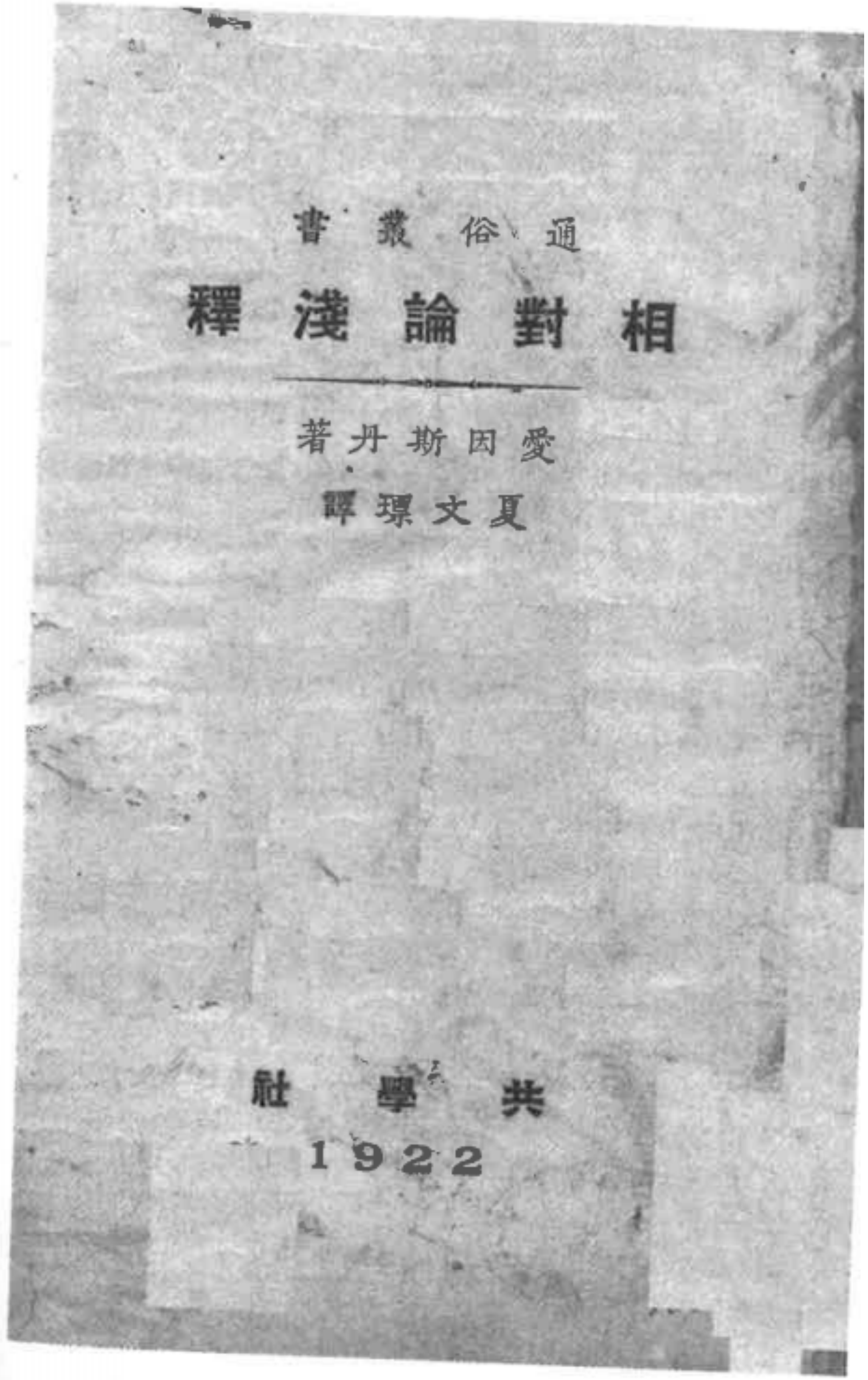
通俗叢書

相對論淺釋

愛因斯丹著

夏元瑮譯

共學社

1922

broadly influential throughout China and Southeast Asia.[9] Several new editions appeared between 1923 and 1933. To one of them Yuanli added a "Brief Biography of Einstein." In addition to an ordinary account of Einstein's personal and scientific life story, Xia recalls: "When I was in Berlin in 1919, I became acquainted with Einstein through [Max] Planck. I attended Einstein's lectures at Berlin University and he always tried tirelessly to dispel my doubts."

After the booklet was published, readers complained that it was difficult to understand. To respond to these complaints and to help their readers, the editors of *Gaizao* suggested that Xia provide a more accessible explanation of Einstein's ideas. This led to Xia's article "Einstein's Relativity and his Biography," which was published in *Gaizao* in April 1922.

LA REKONSTRUO 改造

相對論號

第三卷第八號

要目

Notice the poet Zee Zhimo here, on "Einstein Relativism"

Einstein archive at Hebrew University in Jerusalem

12.〔给汤玛斯·曼（Thomas Mann）的信〕
1933年4月29日写。见《爱因斯坦论和平》222页。

见《我的世界观》英译本182-184页。

10.*〔1933年4月5日和12日给普鲁士科学院的两封信〕
见《我的世界观》英译本174-176页。

11.*〔1933年4月21日给慕尼黑巴伐利亚科学院的信〕
见《我的世界观》英译本181-182页。

13.〔给朗之万（Paul Langevin）的信〕
1933年5月5日写。见《爱因斯坦论和平》，220-221页。

14.*〔给劳厄（Max von Laue）的信〕
1933年5月26日写。论科学家对政治斗争的态度。见《爱因斯坦论和平》，218-219页。

15.〔辟谣——同第三国际无关的声明〕

伦敦《泰晤士报》1933年9月25日，12页，d列。
这声明是1933年7月7日发出。

16.*〔给比利时国王阿耳伯特（Albert）的信〕
1933年7月14日写，关于良心拒绝服兵役问题。
《爱因斯坦论和平》，227-228页。

17.*〔给A.纳翁（Nahon）的信〕
1933年7月20日写，指出只能以军事准备来对付纳粹德国。
《人类故乡》（La Patrie Humaine）
1933年8月18日，1页5列。

18.* 文明和科学（Civilization and Science）。
1933年10月3日在伦敦阿耳伯特厅（Albert Hall）万人大

Newton had his plague and Schwarzschild his heavy gunfire

> As you see, the war treated me kindly enough, in spite of the heavy gunfire, to allow me to get away from it all and take this walk in the land of your ideas.
>
> —Karl Schwarzschild, writing to A. Einstein

In 1915, the very same year that Einstein published his theory of general relativity, Karl Schwarzschild (1873–1916), an officer serving in the German army on the Russian front during World War I, wrote to Einstein saying that he had found[1] the solution for the spacetime metric around a spherical mass distribution. Interestingly, in Einstein's celebrated 1915 article, he only found an approximate solution valid for large r (using Cartesian coordinates!?), which was in fact adequate for his purpose of working out observational tests of his theory. By the way, the family name Schwarzschild means "black

students of general relativity believe. Tragically, Schwarzschild died a year later of a painful autoimmune disease contracted on the battlefield.

A footnote about a physicist almost lost to history

Amazing though Schwarzschild's story is, what happened to the obscure Dutchman Johannes Droste (1886–1963) is perhaps no less remarkable.[20] Droste, who received his doctorate in 1916 with Lorentz in Leiden, solved Einstein's 1915 field equations around a spherically symmetric mass, starting with the preliminary version of the field equation published by Einstein in 1913. His work[21] was communicated by Lorentz to the Royal Dutch Academy of Sciences on May 27, 1916, a few months after Einstein had communicated Schwarzschild's solution to the Prussian Academy of Sciences on January 13, 1916. In my opinion, Droste's paper is cleaner and less confused than Schwarzschild's, and furthermore contains an analysis of the motion of a particle in the spacetime.

much, long before Weyl. For some reason, the physics community totally ignored this work. Droste became a high school teacher, and later a professor of mathematics at Leiden University. (While writing this appendix, I asked a professor of physics at Leiden University, who said he had never heard of Johannes Droste. He did

The deflection of light and a factor of 2

Newton himself wondered, "Do not Bodies act upon Light at a distance, and by their action bend its Rays?" In 1801, Johann Soldner used Newton's corpuscular theory supposing light to consist of a stream of miniscule particles and calculated the deflection of light by astronomical objects, thus obtaining the Newtonian value against which we now compare

Maxwell's theory wiped out Soldner.

History often takes curious turns. In 1911, Einstein, unaware of Soldner's calculation, predicted that light would bend in a gravitational field in his still-evolving theory of gravity.

* As a naive theorist, Einstein wrote to George Hale, the director of the Mount Wilson Observatory, wanting to know "how close to the Sun fixed stars could be seen *in daylight*" (italics Einstein's). Hale explained that exploiting a solar eclipse would be more promising.

Later, Nazi accusation of stealing from a "pure" German

Factor of 2

Newton: “I curved time.”

Einstein: “I curved space also.”

Einstein's luck

~~But that was staircase wit on Einstein's part.~~ In fact, he was almost preternaturally lucky, as documented by Waller.[10] After Einstein's mistaken calculation in 1911, reproducing Soldner's 1801 Newtonian result, there was in 1912 an Argentinian eclipse expedition that encountered bad weather. Next, with Einstein still blissfully unaware of his error, he convinced his friend the astronomer Erwin Freundlich to organize an expedition, financed by the munitions manufacturer Krupp, to observe the deflection of light during a solar eclipse in the Crimea on August 21, 1914.[11] Not surprisingly, but fortunately for Einstein, the German astronomers, with all their telescopes and financing by Krupp, were promptly arrested by the Russians as spies.

Meanwhile, during the war, Einstein discovered his factor-of-2 error. Without these twists and turns of history, his celebrity-making triumph might have been a wet fizzle.

Shortly after the end of World War I, the Royal Society financed two expeditions, one to Brazil led by Andrew Crommelin and one to Africa led by Arthur Eddington, to observe the total solar eclipse* of May 29, 1919, with the express purpose of testing Einstein's theory.

Few people know that Brasil (big country!) contains sand dunes and a vast desert (but I do!). In this award-winning Brazilian movie (about time, incidentally, spanning decades starting in 1910), the main character was stumbling around in the desert, lost, when she suddenly ran into a bunch of formally dressed strange-looking men with telescopes. A discussion about curved space and time then followed!

Now some pedagogy

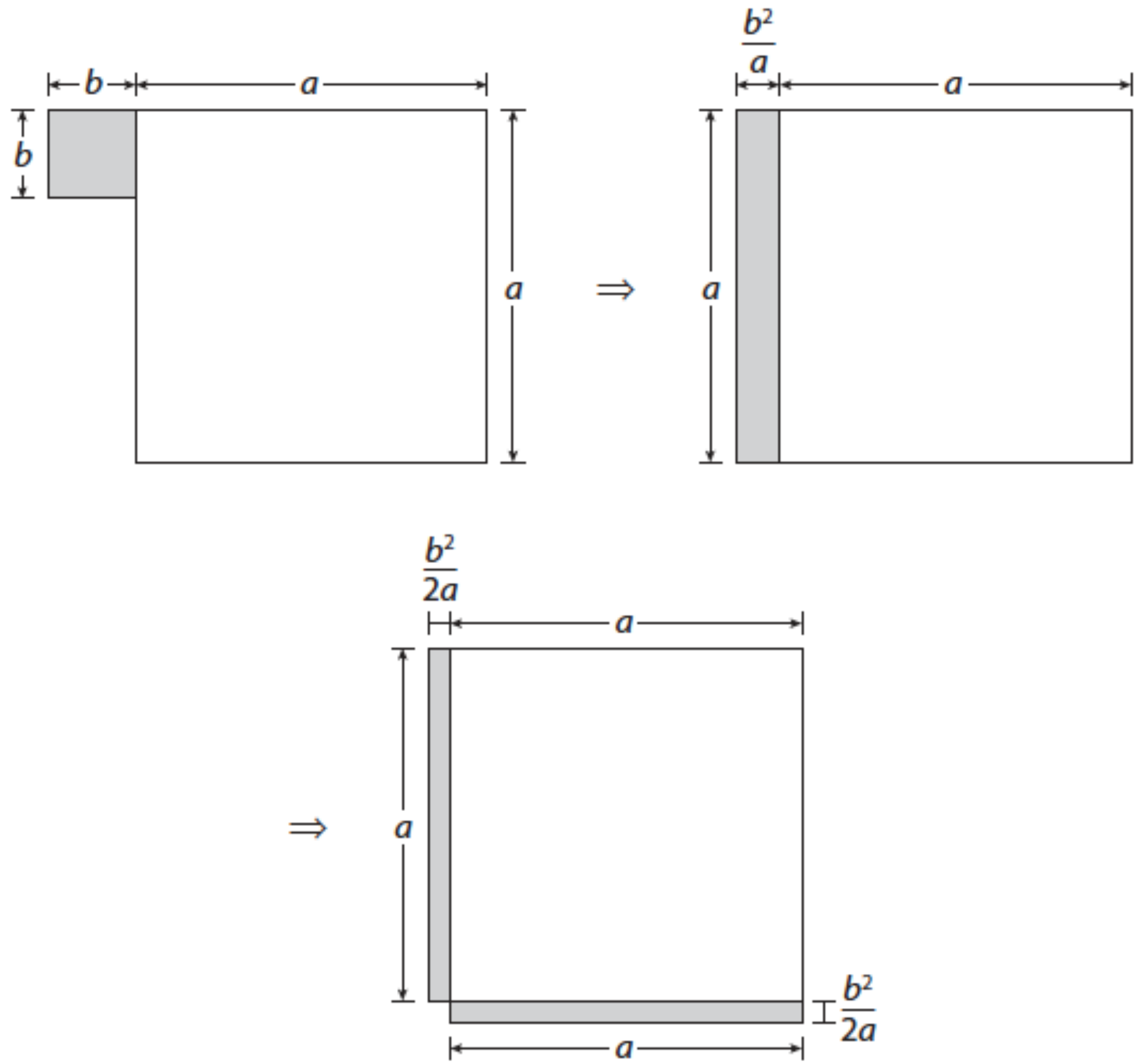

Figure 2 A Babylonian tablet (drawn in a modern pictorial representation).

Babylonian tablet

There is a Babylonian tablet from about 6,000 years ago on which figure 2 was inscribed.*

* What figure 2 shows is of course my attempt at copying the tablet, not the original tablet.

Here is the algebraic translation of the Babylonian tablet

$$\sqrt{a^2+b^2} \simeq a + \frac{b^2}{2a} + \cdots \tag{19}$$

Clever, no? That guy would have surely gotten the Fields Medal had it existed. That tablet blew me away when I saw it. I wondered whether that Babylonian could have thought, in his wildest imagination, that his discovery also held the secret of space and time. If so, he deserved the Nobel Prize in addition to the Fields Medal.

$$\sqrt{a^2-\varepsilon^2} \simeq a - \frac{\varepsilon^2}{2a} + \cdots \tag{2}$$

Extragalactic fables: Imagine how physics could have developed differently in civilizations far far away

$$S = \int dt \tfrac{1}{2} m \left(\frac{d\vec{x}}{dt}\right)^2 = \tfrac{1}{2} m \int \frac{(d\vec{x})^2}{dt}$$

Time and space treated very differently

$$\frac{(\Delta\vec{x})^2}{2\Delta t} = c\frac{(\Delta\vec{x})^2}{2c\Delta t} = -c\sqrt{(c\Delta t)^2 - (\Delta\vec{x})^2} + c^2\Delta t$$

Treat space and time on the same footing

$$S = -mc \int \sqrt{(c\,dt)^2 - (d\vec{x})^2},$$

which in units with $c = 1$ reads

$$S = -m \int \sqrt{dt^2 - (d\vec{x})^2}, \ = -m \int \sqrt{-\eta_{\mu\nu} dx^\mu dx^\nu}$$

How to include interaction?

$$S_{\rm NR} = \int dt \left(\frac{1}{2} m \left(\frac{d\vec{x}}{dt} \right)^2 - V(x) \right)$$

Two options: outside or inside the square root

Option E: $S = -\int \{m\sqrt{-\eta_{\mu\nu}dx^\mu dx^\nu} + V(x)dt\}$

or

Option G: $S = -m\int \sqrt{\left(1+\frac{2V}{m}\right)dt^2 - d\vec{x}^2}$

But the whole point was to treat space and time equally

Option E improved: $S = \int \{-m\sqrt{-\eta_{\mu\nu}dx^\mu dx^\nu} + A_\mu(x)dx^\mu\}$

Option G improved: $S = -m\int \sqrt{-g_{\mu\nu}(x)dx^\mu dx^\nu}$

Option E: $S = -\int \{m\sqrt{-\eta_{\mu\nu}dx^\mu dx^\nu} + V(x)dt\}$

or

Option G: $S = -m\int \sqrt{\left(1 + \frac{2V}{m}\right)dt^2 - d\vec{x}^2}$

But the whole point was to treat space and time equally

Option E improved: $S = \int \{-m\sqrt{-\eta_{\mu\nu}dx^\mu dx^\nu} + A_\mu(x)dx^\mu\}$

Option G improved: $S = -m\int \sqrt{-g_{\mu\nu}(x)dx^\mu dx^\nu}$

Varying to get the particle's equation of motion leads us to the electromagnetic and gravitational fields

It did not happen this way in our civilization but could have happened in some other civilizations far far away