

that Einstein's contemporaries noticed the problem with calculating the pressure of monochromatic thermal radiation from Einstein's entropy-volume relation, nor has this problem been pointed out in commentaries about this paper.^{2,3}

What is the solution to the pressure paradox? Einstein considered the volume dependence of the radiation entropy for fixed frequency ν , but in an actual thermodynamic process, where the volume V is changed by moving a piston, the frequency does not remain fixed, because the wavelength is proportional to the linear dimensions of the cavity. Hence, the frequency ν varies as $V^{-1/3}$, giving the entropy an additional volume dependence that was not discussed by Einstein. It can be readily verified that this addition leads to a thermodynamic derivation of Maxwell's relation for the pressure of isotropic radiation, filling in a long-standing gap in Einstein's earliest thermodynamic argument for the existence of photons.

References

1. A. Einstein, *Ann. der Phys. (Leipzig)* **17**, 132 (1905); reproduced in *The Collected Papers of Albert Einstein*, vol. 2, J. Stachel, ed., Princeton U. Press, Princeton, NJ (1989), p. 150.
2. M. Klein, *The Natural Philosopher* **2**, 59 (1963).
3. J. Stachel, ed., *Einstein's Miraculous Year: Five Papers That Changed the Face of Physics*, Princeton U. Press, Princeton, NJ (1998), p. 177.

Michael Nauenberg
(michael@physics.ucsc.edu)
University of California
Santa Cruz

Feynman Stamp Is Dedicated

On 11 May, Richard Feynman's birthday, I had the privilege of attending the ceremony dedicating a stamp in his honor at the Far Rockaway Post Office in Queens, New York (see *PHYSICS TODAY*, May 2005, page 30). Among the attendees were his son, Carl; daughter, Michelle; and many other Feynman relatives. Directly after the ceremony, one corner of Cornaga Avenue in Far Rockaway, a street on which he had lived, was named "Richard Feynman Way."

The Feynman diagrams on the stamp show how Feynman's work that was originally applicable to quantum electrodynamics, and for which he won the Nobel Prize, was later used to elucidate the electro-weak force. This force is illustrated



Albert Einstein to Heinrich Zangger¹

Translated and annotated by Bertram Schwarzschild
Einstein writes to his friend Zangger (1874–1957), professor of physiology at the University of Zurich, the day after he submits the final version of the general theory of relativity to the Royal Prussian Academy of Sciences. While Einstein speaks of the theory's "incomparable beauty," his judgments of people are dark. He complains bitterly of his separated wife's malign influence on their children and of what he takes to be David Hilbert's plagiarism.

Berlin, 26 November 1915

Dear friend Zangger,

I'm sorry to hear that you're laid up and in pain. But I didn't understand the Latin name of the cause. Please tell it to me in German, or—still better—tell me that you're fully recovered.

... The general theory of relativity is finally completed. It wonderfully explains the rotation of Mercury's perihelion. From observation, astronomers have found that the planet's orbit rotates 45 ± 5 arcseconds per century. And from the theory, I get 43 arcseconds. Added to the line shifts of stellar spectra,² that's a rather good confirmation of the theory. For the bending of light by stars, the theory now predicts twice the deviation I previously derived [see *PHYSICS TODAY*, September 2005, page 14]. When we see each other, I'll tell you where that comes from.

The theory is of incomparable beauty. But only *one* colleague has really understood it, and he is trying, rather skillfully, to "nostrify" [*nostrifizieren*] it.³ That's [Max] Abraham's coinage [from the Latin for "to make ours"]. In my personal experience, I've hardly come to know the wretchedness [*Jämmerlichkeit*] of humanity better than in connection with this theory.

My son [11-year-old Hans Albert] still hasn't answered my inquiry about meeting in Krummenau [in the Swiss Alps]. That's surely the influence of the woman [Einstein's wife Mileva]. You'll see, more and more, on which side goodwill and honesty are to be found. There are reasons that I couldn't abide staying with that woman, despite the tender love that binds me to my children. When we first separated, the thought of my children stabbed me like a dagger every morning when I woke up. Nonetheless, I never regret having taken the step. . . .

Affectionate greetings from your

Einstein

A week before this letter was written, Hilbert had presented a paper incorporating Einstein's theory into an attempt at a unified theory of gravity and electromagnetism.³ Aside from complaining about Hilbert's improper appropriation of his work, in a 1916 letter to Hermann Weyl, Einstein criticized the physical assumptions Hilbert had added to the theory as being "childish, in the sense of a child that doesn't know the tricks of the outside world."⁴

References

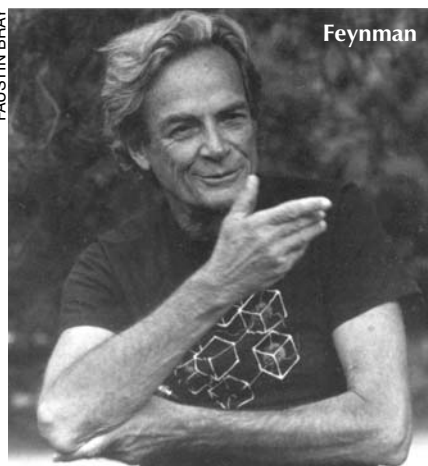
1. *The Collected Papers of Albert Einstein*, vol. 8, R. Schulmann, A. J. Fox, M. Janssen, J. Illy, eds., Princeton U. Press, Princeton, NJ (1998), p. 204.
2. Einstein is referring to Erwin Freundlich's spectral measurements that seem to confirm the gravitational redshift predicted by general relativity. Later Einstein saw these results as only a qualitative verification. See ref. 1, p. 94.
3. See ref. 1, p. 195; L. Corry, *David Hilbert and the Axiomatization of Physics (1898–1918)*, Kluwer, Boston (2004), p. 287; A. Pais, *'Subtle Is the Lord . . .': The Science and the Life of Albert Einstein*, Oxford U. Press, New York (1982) p. 257.
4. Ref. 1, p. 278.

on the stamp by vertex diagrams for the flavor-changing quark transitions emitting the $W^\pm$ boson, and flavor-conserving quark transitions emitting the Z^0 , where $W^\pm$ and Z^0 represent respectively the charged and neutral intermediate vector bosons mediating the force.

Feynman's letters have recently been published in a widely respected book edited and annotated by Michelle Feynman.¹ Besides corre-

sponding with physicists, he also answered letters from people from all walks of life. While in high school, according to the book, he taught himself "gamma functions, elliptic functions and differentiating under an integral sign." So it should be no surprise that as an undergraduate at MIT, Feynman was one of five national winners of the Putnam mathematics competition.

On the cover of a book written by



Feynman and Ralph Leighton² is a photograph of Feynman, in which he wears a T-shirt showing the schematic of the parallel supercomputer Connection Machine CM-1, with chips connected in the shape of a hypercube (see photograph above). The idea for the machine was initiated at MIT's Artificial Intelligence Lab in the early 1980s. When Feynman heard of the project, he helped design the machine's connecting network. Carl worked on the machine and its successors.

The US Postal Service sent Michelle a preliminary design of the Feynman stamp, by the artist Victor Stabin. Caltech's Steven Frautschi and Leighton edited the Feynman diagrams for the final version. Who submitted the original diagrams that are the basis for the stamp remains a mystery.

References

1. M. Feynman, ed., *Perfectly Reasonable Deviations from the Beaten Track: The Letters of Richard P. Feynman*, Basic Books, New York (2005).
2. R. P. Feynman, as told to R. Leighton, *What Do You Care What Other People Think?* Norton, New York (1988). This and Michelle Feynman's book were given to ceremony attendees.

Samuel L. Marateck
(marateck@cs.nyu.edu)
Courant Institute of
Mathematical Sciences
New York University
New York City

Of Titans and Gods and Knowing the Difference

I enjoyed reading Paul Guinness's Issues and Events piece "Statue Hid Hipparchus Star Catalog" (PHYSICS TODAY, April 2005, page 27). Insight into ancient historical

achievements teaches, if nothing else, humility about our achievements. There is a minor error in the explanatory text: Atlas is not a Greek god, but a Titan, and thus an adversary of the gods.

According to classical Greek mythology,¹ after a 10-year war, the gods won, and all male Titans except Atlas were exiled to an island in the Far West. The female Titans were left unharmed, since two of them had aided the gods in their struggle. Atlas, as ringleader, got a particular sentence: He was condemned to carry the heavens on his shoulders.

Reference

1. R. Graves, *The Greek Myths*, Penguin Books, New York (1955).

Klaus Helbig
(helbig.klaus@t-online.de)
Hannover, Germany

Correction

September 2005, page 31—The median number of physics bachelor's degrees awarded in 2003 by departments that don't have a graduate program was 3. The average number was 3.9. ■

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