TAS LIVE

Einstein's Revolution, and Counterrevolution

By Tom Bethell on 6.21.07 @ 12:06AM

This article appears in the June 2007 issue of *The American Spectator*. Click here to subscribe.

With an hour's wait at Penn Station, I picked up a copy of Walter Isaacson's new Einstein biography *Einstein: His Life and Universe* (Simon & Schuster, 675 pages, $32), turned to the index, and started to read a particular passage. I was impressed. I had feared that this would be one more exercise in hagiography, describing Einstein's askew love life, his left-wing politics, his first wife who didn't get credit for her contributions to relativity, and his thoughts about God, all decked out with garlands to the great man's genius and his epic contributions to science. But no. It was more than that. Here is what I read, on page 318:

> ... after he finished his theory of general relativity, [Einstein] concluded that the gravitational potentials in that theory characterized the physical qualities of empty space and served as a medium that could transmit disturbances. He began referring to this as a new way to conceive of an ether. "I agree with you that the general relativity theory admits of an ether hypothesis," he wrote Lorentz in 1916.

Surprise, surprise. Two full pages about Einstein's reintroduction of an ether followed. Many people know that in his special theory of relativity, Einstein abolished the luminiferous medium, or ether. Very few know that eleven years later he reintroduced a rather different ether. It is never mentioned in the Easy Einstein books and hardly ever in Einstein biographies. I decided to buy the (signed) book on the spot -- New York City taxes and all. And I would have four hours to read it on the slow train to Washington (distracted, of course, by the incessant cell-phone jabbering).

I recommend the book. Isaacson, the CEO of the Aspen Institute, came to his task with a strong interest in science, inspired by his father; he further enlisted the aid of physicists and Einstein scholars. He even ran his manuscript by a few journalists to be sure it was intelligible to them. Overall, he has done a great job of translating relativity and quantum physics into plain language. Special relativity, I fear, will remain a bit mystifying to those who study his chapter on that conundrum; he never quite elucidates the sleight-of-hand involved (Banesh Hoffmann, an earlier biographer, did). But he makes up for it by taking a valiant stab at explaining general relativity in layman's terms, which is rarely attempted.

The book is subtitled "his life and universe." I won't go into his life, beyond saying that

Isaacson has made full use of the Einstein papers newly released in 2006. It is the most definitive and readable Einstein biography to date.

A BASIC POINT ABOUT EINSTEIN'S life (1879-1955) is that he became more conservative when he reached middle age; not so much politically -- he remained a man of the left to the end -- but in his scientific outlook. This was reflected above all in his prolonged and unresolved dispute with Niels Bohr and Werner Heisenberg about quantum mechanics. If you are unfamiliar with that controversy, there could be no better introduction than Isaacson's. He covers it in about 40 lucid pages, encompassing the contributions of Erwin Schroedinger and others. Most of us know little more than that Heisenberg enunciated an uncertainty principle, wherein observation affects the thing observed; to which Einstein retorted that God does not play dice. Here you will learn, painlessly, a good deal more than that.

Heisenberg insisted that an electron does not have a definite position or path until we observe it. This was a feature of the universe, he claimed, not just some deficiency in our ability to measure. In denying that there is an objective reality out there, it undermined classical physics. When Einstein objected, Heisenberg confidently replied: "I believe that indeterminism, that is, the non-validity of rigorous causality, is necessary."

On the 200th anniversary of Newton's death, in 1927, Einstein defended classical mechanics. Two decades earlier he had "toppled many of the pillars of Newton's universe, including absolute space and time," Isaacson writes. Now he was a defender of Newton, of rigorous causality and (by implication) the established order.

Einstein: "You don't seriously believe that none but observable magnitudes must go into a physical theory?"

He was confronted with his own youthful rebelliousness.

Heisenberg: "Isn't that precisely what you have done with relativity?"

"Possibly," Einstein said, "but it is nonsense all the same."

Einstein had ruled out the ether in 1905 because all attempts to detect it had failed. Its removal had been a central feature of his special relativity.

Einstein then complained to an early biographer, Philipp Frank, that a new and disagreeable fashion had arisen: the new physicists were arguing that things were not real if they couldn't be observed. Frank reminded Einstein that that fashion "was invented by you in 1905."

"A good joke should not be repeated too often," Einstein replied.

By 1920, Einstein had brought back his new ether, and I'll return to that. It may yet open the door to a revisionist look at relativity.

SPECIAL RELATIVITY MAKES VERY Peculiar claims. You and I, next to one another, carry identical rulers and wear exactly synchronized watches. When I move, I see your ruler shrink and your watch slow down. You observe no such changes -- called time dilation and length contraction -- but you do see *my* ruler shrink and *my* watch slow down.

So, exactly the same question that Einstein asked of quantum mechanics could be asked of relativity.

Isaacson: "Some may be tempted to ask: Which observer is 'right'? Whose watch shows the 'actual' time elapsed? Which length of the rod is 'real'?" Mindful of the perplexing history here, he diplomatically finesses the question ("it is not a question of whether rods *actually* shrink or time *really* slows down...").

At the end of a new book called *It's About Time*, the recently retired physics professor N. David Mermin, who taught relativity at Cornell for decades, asks the same question. He asks of moving sticks and clocks that allegedly shrink and lag: "Do these things really happen, or are they just secondary manifestations... leading to disagreements about what constitutes a valid measurement?"

Mermin's answer is one that you might consider surprising in a book published exactly 100 years after Einstein's theory was invented:

> There is by no means unanimity among practicing physicists on this question, and one frequently finds assertions that, for example, moving clocks *appear* to run slowly when measured by stationary ones, or that moving sticks *appear* to shrink.

He's right about that.
Here is Arthur Eddington, the famous British astronomer who led the 1919 eclipse expedition that confirmed Einstein's prediction about the bending of starlight grazing the sun. Eddington wrote: "The shortening of the rod is *true*, but it is not *really* true. It is not a statement about reality (the absolute) but it is a true statement about appearances in our frame of reference."

Got that? It's in Eddington's *The Nature of the Physical World* (1928). There's an apocryphal story about Eddington. Someone told him he was one of only three people who understood the general theory. He is said to have replied: "I'm trying to think who the third one is." By the way, the bending of starlight is *really* real, and it confirms something important that Einstein had written in 1916. "The principle of the constancy of the velocity of light *in vacuo must be modified*." Yet that principle had been central to special relativity.

Isaac Asimov posed the same question about shrinking sticks and lagging clocks in 1966: "Which [observer] is really 'right'? The answer is neither and both," he wrote.

Many such examples could be given. There is something unsatisfactory about such a theory, surely. Experts cannot agree whether its most famous predictions -- that time goes more slowly and lengths contract in things that move with respect to an observer -- are real or not.

Here's a simpler answer to the above question: Length contraction has never been measured at all. Not once. Sticks "really must" behave in this odd way, says Mermin, but only in the sense that it follows mathematically from the two postulates on which Einstein's special theory was based. But it has not yet been observed.

As to time dilation, it has been shown that particles moving at high speed through the Earth's gravitational field survive longer than slower-moving particles, and this has been construed as evidence for time dilation. But it is a very weak confirmation, with a simpler explanation.

Saying that atomic *clocks* (or particles) slow down under certain conditions is not the same as saying that *time* slows down.

MAYBE YOU CAN SEE WHERE this is going. The consensus among physicists is that Einstein erred in his stubborn and "conservative" resistance to the Copenhagen interpretation of quantum mechanics. It was with relativity, in his gloriously rebellious youth, that he scored his great triumph. This is Isaacson's view. In all things he quietly sides with the consensus, brings diplomacy to bear on every controversy, promotes no novel interpretation, upsets no apple carts, and is at all times moderate and balanced. Given his position, and the book's ambition, this is to be expected. We don't expect a work that aspires to be (and is) authoritative to adopt controversial positions.

To me, however, Isaacson's *Einstein* unexpectedly reinforces a contrarian view that I have long entertained. It is this: that Einstein was right about quantum mechanics, and will eventually be vindicated. Furthermore, sooner or later his much admired notions about relativity will have to be discarded.

This is not just cussedness, although it may betray a conservative bias. Science, I believe, can be radical (in the sense of going to the roots) and it must be innovative. But it can hardly be "revolutionary"; it cannot dig up those roots and overthrow the fundamentals, as special relativity did with space and time.

The emeritus Caltech professor Carver Mead writes in his book *Collective Electrodynamics* that new researchers (he mentions several unfamiliar names) "have put us in a position to finally settle the Einstein-Bohr debate -- with a resounding victory for Einstein." Mead also said in an interview that Bohr & Co. "took the limitation of their cumbersome experiments as evidence for the nature of reality." Likewise, Einstein's views about space and time were based on experiments using 19th-century equipment.

Einstein's position on the quantum was so mild that it surely has to be vindicated. The theory was "incomplete," he said. I believe also that in holding out, almost alone, against a powerful consensus Einstein was doing exactly what scientists are supposed to do but usually lack the courage to do.

Here's something else. Edwin T. Jaynes, one of the dissenters cited by Carver Mead, said that when he studied physics at Berkeley in 1947, his thesis director, J. Robert Oppenheimer, would never countenance any retreat from the Copenhagen position, and derived "some great emotional satisfaction from just those elements of mysticism that Schrodinger and Einstein had deplored." Enthusiasm for that blend of mysticism and science survives to this day.

AS FOR THE NEW ETHER, Robert B. Laughlin, winner of the 1998 Nobel Prize in physics, discusses it in his book *A Different Universe* (2005). He notes the irony that Einstein's most creative work, his general theory of relativity, "should boil down to conceptualizing space as a medium when his original premise was that no such medium existed." The modern conception of the vacuum of space, he writes, "is a relativistic ether. But we do not call it that because it is taboo."

How Einstein came to conclude that space was a medium "is a fascinating story," Laughlin continues, but he does not tell it. It has been told (in part) in Ludwik Kostro's *Einstein and the Ether*, issued by a dissident publisher in Montreal, and not listed in Isaacson's bibliography.

The topic needs a fuller treatment.

As for general relativity, it seems to give the right results, but by an extraordinarily complicated method. It is like Ptolemaic astronomy. You could navigate by it, but there was a simpler way. As the late Edward Teller said to me in an interview, who can understand the curvature of four-dimensional spacetime? Petr Beckmann, who taught at the University of Colorado, proposed a great simplification of Einstein's relativity by replacing the old ether of Lorentz and Maxwell with one that is equivalent to the local gravitational field. And unless I am much mistaken, that is precisely Einstein's new ether. Yet I believe Beckmann did not know about Einstein's adoption of this same idea.

If relativity theory ever is replaced, Einstein himself will have pointed us in the most promising new direction. Meanwhile, we can all learn a great deal from Isaacson's excellent book.

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