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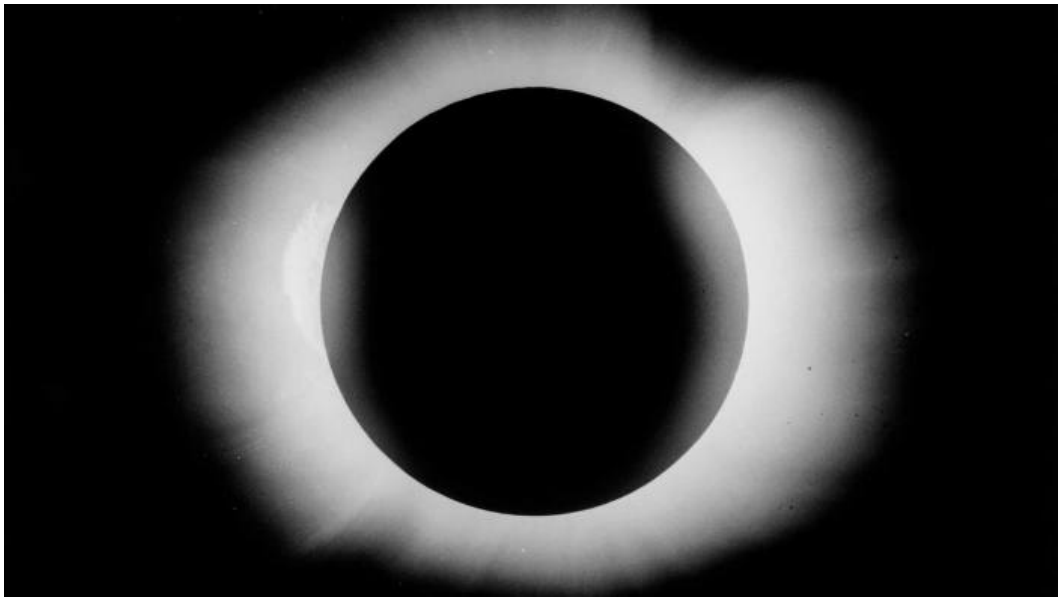
Einstein, quantum theory and the battle for reality

Has physics been hijacked by an anti-realist philosophy?



An image taken by British astronomer Arthur Eddington of the 1919 solar eclipse, an event that helped scientists confirm Einstein's theory of general relativity © Science Photo Library

Anjana Ahuja APRIL 5, 2019

"I think I can safely say that nobody understands quantum mechanics." So quipped the late, great physicist Richard Feynman in the 1960s — and his words feel just as fresh today. The quantum mechanical explanation of how the universe works at the atomic level offends intuition. Schrodinger's cat, the unfortunate moggie trapped in a box with a radioactive atom whose unpredictable decay will release poisonous gas, is both dead and alive until we open the box to look. A particle has no definite position until we measure it, its precise location neither here nor there but a tangle of probabilities.

Hang on. Looking, measuring — do our actions really make the difference? Isn't that poor feline either dead or alive before we open the box? Surely the world behaves independently of our perception of it? Albert Einstein thought so: he championed realism, in which the universe can be understood and described without regard to our interactions with it. His nemesis was the Danish physicist and ardent anti-realist Niels Bohr, who argued that no such objective picture is possible, only an overlying canvas depicting what we can observe and measure.

Anti-realism won the day. Quantum mechanics as promoted by Bohr, which relegates reality to an irrelevance, is the prevailing picture of nature at the atomic and subatomic scale.

It should be overthrown, according to Lee Smolin, along with the "magical" thinking that

accompanies it. Smolin, a leading figure in the fight to reinstate realism as the bedrock of science, insists that now is the right time to take up arms. “Science is under attack,” he writes in *Einstein’s Unfinished Revolution*, “and with it the belief in a real world in which facts are either true or false . . . when fundamental physics itself gets hijacked by an anti-realist philosophy, we are in danger.” The risk, he warns, is the surrender of the centuries-old project of realism, “which is nothing less than the continual adjustment, bit by bit, as knowledge progresses, of the boundary between our knowledge of reality and the realm of fantasy.”

Smolin offers a masterful exposition on the state of quantum physics, smoothly blending a history of the field with clear explanations, philosophical context and an accessible introduction to fresh ideas. His narrative on how two competing perspectives on quantum behaviour hardened into Bohr’s counter-intuitive orthodoxy, is spellbinding.

Einstein fired the starting gun by embracing the idea that light could show the properties of both a particle, which occupies a defined location, and a wave, which is more diffuse. In 1905, when he was just 26 and working as a patent clerk, he showed that shining light on metal could liberate electrons. He had discovered what came to be known as the photoelectric effect, proving that light came in little packets or “quanta” (now called photons). It would earn him a Nobel Prize in 1921.

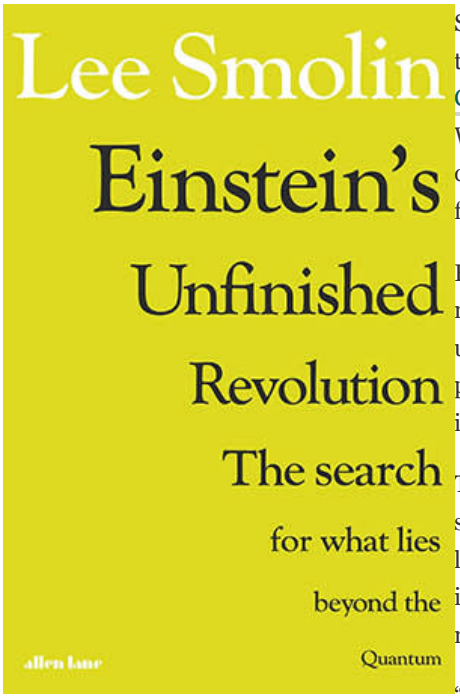
Niels Bohr (left) and Albert Einstein © Science Photo Library

Niels Bohr spotted that Einstein’s theory of light might be usefully applied to atoms. A young Parisian aristocrat called Louis de Broglie then furnished a critical insight: if light could be both a wave and a particle, could the same bizarre duality be true of electrons and other matter?

In 1925, Erwin Schrodinger, an adulterous professor at the University of Zurich, heard of de Broglie’s thesis and took it, plus girlfriend, for a holiday in the mountains. Within days, he had invented the relevant equations (when he travelled to Stockholm to accept his Nobel, the rascal reportedly took both wife and girlfriend).

Bohr grasped that all these breakthroughs were coalescing into a theory filled with puzzling probabilities and uncertainty, a shocking departure from the familiar, deterministic outcomes of

classical physics. But the new theory of quantum mechanics seemed to work, if not intuitively then mathematically. Bohr seized his moment, Smolin writes, "announcing the birth not just of a new physics but of a new philosophy. The moment for radical anti-realism had come and Bohr was ready for it."



Since Bohr's institute in Denmark was the hotbed for these ideas, the philosophy became known as the Copenhagen interpretation. When German theorist Werner Heisenberg arrived at the same formulation of quantum mechanics via a different route, Bohr was further vindicated.

Even if Einstein folded in the face of Danish dominance, realism never quite died. De Broglie later pioneered a unifying idea called pilot wave theory, in which the particle is guided by a "pilot" wave. It was rediscovered in the 1950s and still has its adherents.

The past half-century has given rise to other novel ideas such as loop quantum gravity, in which Smolin is a leading researcher. But he and colleagues are under no illusions about the monumental challenge ahead: the need to invent new physics, as Einstein and others did.

"So maybe it's all up to a brilliant student somewhere, impossibly arrogant, as the young Einstein was, but blindingly talented enough to absorb the essentials of all we have done, before putting them to one side and confidently starting over."

If Einstein feels like the man of the moment, it is because 2019 marks the centenary of the most spectacular test of his powers: the British effort to confirm his theory of relativity using the total solar eclipse of 1919. This experiment and its legacy is the subject of *No Shadow of a Doubt*, by Daniel Kennefick of the University of Arkansas.

Einstein had calculated that starlight should bend as it passes a massive object — the Sun, say — because the object's gravity warps the fabric of space-time. The eclipse on May 29, 1919, promised a rare chance to test his otherworldly prediction. British scientists seized the opportunity and planned expeditions to two locations, Principe Island in the Gulf of Guinea, and Sobral in Brazil.

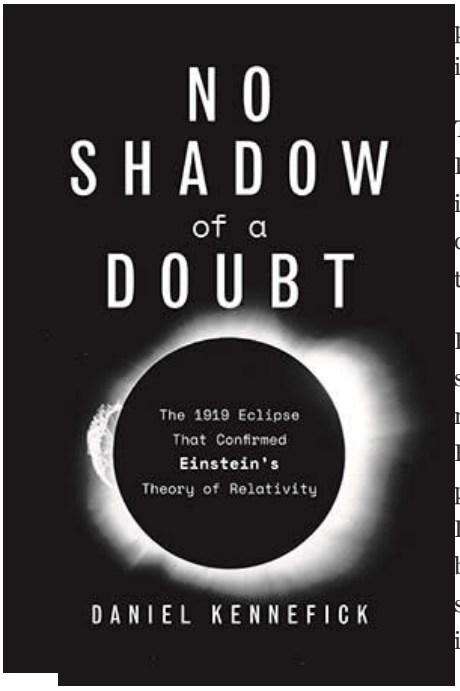
When the Moon passes in front of the Sun during such an eclipse, it blocks the sunlight from the solar disc and turns day into night. The temporary blackout allows stars around the rim of the Sun to be seen (as well as the Sun's halo-like corona). By comparing the stars' true locations to their apparent locations during the blackout, scientists could deduce whether the Sun was indeed deflecting the starlight.

Kennefick brings a thrilling mix of ingredients together into a dense but rewarding read: the chutzpah of Einstein; the glamour, luck and sense of adventure of eclipse-chasing; the audacity of planning such a demanding experiment during the first world war and executing it in its chaotic aftermath. An earlier attempt to confirm relativity ended badly: German scientists viewing the 1914 eclipse in Crimea were arrested as spies by the Russians.

The war inevitably also cast a shadow over the 1919 eclipse. Planning fell to two brilliant astronomers, both pacifist "oddballs": Sir Arthur Eddington, director of the Cambridge Observatory, and Sir Frank Dyson, then Astronomer Royal and based at Greenwich. Eddington, a Quaker refusenik, faced jail until his university made a poignant appeal to the conscription board, arguing that following the wartime deaths of the observatory's first and second assistants, nobody else in Cambridge knew how to catch an eclipse.

A shortage of civilian ships also posed difficulties in dispatching the necessary equipment. But the expeditions somehow set sail, the sun mostly shone, and the requisite observations were secured.

And what observations they were! In November 1919, six months after the eclipse, Eddington and Dyson revealed that they had confirmed Einstein's prediction. It was a global sensation. "Lights all Askew in the Heavens" ran the headline in the New York Times.



The confirmation even influenced the culture of science: Einstein's readiness to submit his ideas to experimental investigation persuaded philosopher Karl Popper to develop "falsifiability" as the litmus test of scientific truth.

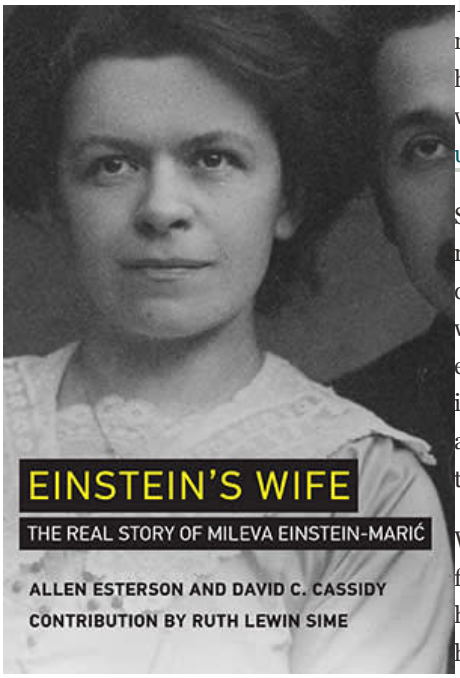
Kennefick dissects the scepticism that has since shrouded this historic experiment. After the war, he notes, most German scientists faced ostracism. Did Eddington and Dyson plot to prove relativity in a postwar bid to reunite scientists and the wider world? Did they show bias by rejecting some data? The fact that both Eddington and Dyson were adept at publicity also seems to have sullied their reputations — unjustifiably, in Kennefick's view. "It is mistaken to believe that the truth needs no advocate," he writes. The 1919 experiment, he believes, achieved its sole objective: to prove Einstein either right or wrong.

When fundamental physics itself gets hijacked by an anti-realist philosophy, we are in danger

Not that the great man needed such affirmation. When asked what he would have done had the results been less obliging, Einstein declared: "Then I would have to be sorry for dear God. The theory is correct."

Let us reserve our pity, then, for Mileva Maric, or *Einstein's Wife*, as a new biography selectively describes her (he was married twice). The cerebral Serbian, among the earliest female science students in Europe, met Albert in 1896 at the Zurich Polytechnic, where both studied mathematics and physics.

A fellow student described Mileva as "a very good girl, clever and serious, she is small, frail, dark, ugly . . . limps a little bit, but has very nice manners". Albert, several years younger, was bewitched; he called her Dollie and she called him Johnnie. Their families did not approve. Mileva became pregnant. A daughter, Lieserl, was born out of wedlock but, astonishingly, her fate remains unknown. Surviving letters hint at Lieserl either dying of scarlet fever or being given up for adoption.



Recommended

This, though, is not the question that this book, by retired physics lecturer Allen Esterson and science historian David C Cassidy, sets out to answer. Instead: was Mileva, as previous biographers have speculated, an uncredited contributor to Einstein's research?

School and university reports suggest she was bright but not preternaturally so. When the couple corresponded during periods apart (including the pregnancy), he wrote excitedly of his ideas but her replies did not elaborate on them. A meticulous analysis of letters, interviews, gossip, second-hand reports, translations and re-retranslations, leaves the authors unconvinced by the Mileva myth.

What emerges instead is a portrait of a capable but frustrated young woman who tragically did not achieve her full potential as a scientist "nor did she realise her hopes and dreams in marriage and in life". By 1919, the year of the eclipse, Einstein had divorced Mileva to marry his first cousin Elsa, herself a divorcee with children. Letters recently came to light suggesting Einstein had designs on one of Elsa's daughters.

This biography of Einstein's forgotten first wife instead offers a haunting indictment of Albert as a distant and ultimately disloyal companion: a quantum husband who was neither here nor there; a visionary who saw the starlight in the universe but not the darkness closer to home.

Einstein's Unfinished Revolution: The Search for What Lies Beyond the Quantum, by Lee Smolin, *Allen Lane, RRP£25, 322 pages*

No Shadow of a Doubt: The 1919 Eclipse that Confirmed Einstein's Theory of Relativity, by Daniel Kennefick, *Princeton, RRP$29.95/£24, 416 pages*

Einstein's Wife: The Real Story of Mileva Einstein-Marić, by Allen Esterson and David C Cassidy, *MIT, RRP$29.95/£24, 336 pages*

Anjana Ahuja is a science commentator

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