

## Albert Einstein

(editorial)

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The year 1879 was an important one for physics; on the 5th of November, the Scottish physicist James Clerk Maxwell died. Maxwell had demonstrated that electric and magnetic fields travelled through space as waves at the speed of light. This unification of light and electrical phenomena was a monumental work but not fully understood.

Ironically, a baby was born a few months earlier that would eventually use Maxwell's equations to destroy the Newtonian universe, only to create a new one. On the 14th day of March 1879 in a small town called Ulm, in the Kingdom of Württemberg in the German Empire, Albert Einstein was born. It was indeed a serendipitous year for physics.

### Centenary

More poignantly is the fact that this year is the centenary of *Einstein's General Theory of Relativity*. One hundred years ago this year, one man described a theory of the universe that would be deemed to be the greatest intellectual achievement by one man, Albert Einstein.

### A tenuous beginning

After an unremarkable childhood and education at Zürich Polytechnic, a young Einstein graduated in July of 1900. Strangely, he found himself out of work. Young Albert had gained a diploma in teaching physics, yet he could not secure a position. Having an unemployment status did not stop the soon to be physicist from writing papers and submitting them to the prestigious *Annalen der Physik*.

Einstein submitted his first paper in December of 1900; it was entitled, *Conclusions Drawn from the Phenomena of Capillarity*. He went on to publish other papers, one in April of 1902 and June of that same year, and another a couple of weeks later. Then on the 16th June 1902 Albert gained employment as the lowest rank patent clerk, provisionally as a Technical Expert Class 3. Almost two years later he published his fifth paper in the March of 1904. However interesting these papers were, they would not impact on physics as much as the four ground-breaking papers of 1905.

### Annus Mirabilis

1905 was Einstein's Annus Mirabilis or miracle year. The first paper he published that faithful year was, *On a Heuristic Point of View Concerning the Production and Transformation of Light*. This paper was the photoelectric paper, whereby light consists of photons or particles of a given quantum of energy. This work was in a way the true beginning of Quantum theory, in spite of the earlier work Max Planck, for no one had understood the true nature of the quanta. Ironically Einstein had built an edifice to a theory that he would later reject; namely, Quantum mechanics.

In April 1905, Einstein submitted his thesis, to Alfred Kleiner, it was entitled, *A New Determination of Molecular Dimensions*. Shortly afterwards, he was awarded a Ph.D. by the University of Zürich.

The second paper of that year was then submitted, *On the Movement of Small Particles Suspended in Stationary Liquids Required by the Molecular-Kinetic Theory of Heat*. Followed shortly by, a paper that would revolutionise physics, *On the Electrodynamics of Moving Bodies*. This paper was his *Special Theory of Relativity*. Then later he published the fourth and final paper of 1905, entitled, *Does the Inertia of a Body Depend upon its Energy Content?* This work revealed the fact that mass was equivalent to energy, and vice versa. This humble paper would produce the most famous equation in history, which everyone would know of,  $E = mc^2$ .

In spite of the profound papers of 1905, it would be several years before anyone would understand them fully, and any recognition of the great physicist would be realised.

### The Special Theory of Relativity

In terms of the *special theory of relativity*, for many it is not clear what science went before. Most believe Einstein constructed every aspect of relativity. In fact, it was about a conceptual leap rather than constructing a whole new theory and mathematics, for all the science was there waiting for the correct interruption.

Understanding the finite velocity of light is the primary precept of relativity. Many great minds of antiquity have conjectured theories of light, including Pythagoras, Plato, Euclid, Alhazen, and many others, while some theories were correct and others were not. Many believed that the speed of light was infinite, yet

some believed light had a finite velocity, such as Empedocles. But it was Einstein that stated two fundamental postulates. 1) The speed of light is invariant and finite; namely, the speed of light in a vacuum is the same in all inertial frames. 2) The laws of nature are the same in all inertial reference frames.

Einstein had done away with the ether and shown that the Newtonian universe of absolute time and space was only an approximation. Time was relative, and simultaneity was not the same for all observers.

However, there was an issue; this theory would only apply to reference frames in relative motion at constant velocity. It would take Einstein ten years to develop a version of relativity that would describe spacetime within accelerating reference frames.

#### *The General Theory of Relativity*

Unlike the formation of the *special theory of relativity*, Einstein would need to rewrite the law of gravity and use complex mathematical geometry to do so. The *general theory of relativity* would become a geometric theory of gravity and describe a universe that was either expanding or contracting. The full version of this new gravity was published in 1916, yet a correct earlier draft was published the preceding year, in November of 1915.

In 1916, it was believed that the universe was static, for it wasn't till 1921 that Edwin Hubble's first paper on the expansion of the universe was published. And so Einstein invented a fudge factor to his field equations to make the *General Theory of Relativity* describe a static universe. It was called the *Cosmological Constant*  $\Lambda$ , and could make the field equations behave as required. However, with the discovery that the universe was expanding, Einstein called it his biggest blunder and rejected it.

There is so much irony with Einstein. And the *Cosmological Constant*  $\Lambda$  is not devoid of irony as well, for modern cosmologists have since reclaimed it and use it in a modern version the *General Theory of Relativity* to describe an accelerating universe. Einstein's mistake turns out to not be a mistake but a modern view of the larger universe. In fact, if Einstein had investigated his invention of  $\Lambda$  more closely, he may have well predicted the acceleration of the universe.

The *General Theory of Relativity* was probably the most important work in physics since Newton. Together with the *Special Theory of Relativity* both theories have been tested time and time again for a century and have passed every test. The work is pure genius. More irony lay in the fact that Einstein was awarded the Nobel Prize for the photoelectric paper and not the *Special Theory of Relativity*.

#### *Unified Field Theory*

Einstein contributed in many areas: special relativity, quantum theory, thermodynamics, and theoretical physics in general. It is even more intriguing that a man who had achieved so much would spend the second half of his life, pursuing an extension the *General Theory of Relativity*; namely the holy grail of physics, the *Unified field theory*.

Einstein said towards the end of his life that, "the generalization of the theory of gravitation has occupied me unceasingly since 1916." In other words, he spent from 1916 to 1952 searching for the mathematical formulation of the unification of laws into one set of equations. He published four papers on the research and withdrew them all. In fact, it has even been said that he continued to work on the *Unified field theory* on his death bed. A man such as Albert Einstein had achieved so much yet failed to complete the work he strived for most, the unification of the laws of physics.

To this day, many have taken up the mantle but none have solved the "mind of God," as Einstein called it. Einstein has left an unprecedented legacy and inspiration to many. However, we must remember something fundamental from his work and successes and indeed failures: that it is the work that is important and to continue the research. This physicist published over 300 hundred papers, many dozens of book chapters and dozens of books. Albert Einstein was a remarkable man and probably the most famous physicist in history, and his greatest legacy that he has left us is, the power of the imagination!