Einstein

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This is no conventional biography bringing the subject from his cradle to his grave. It purports to give to the general reader some inkling of Einstein's momentous achievements, dispensing with any mathematics (except possibly in footnotes). Thus the book is divided into three parts, corresponding to his breakthroughs in special relativity, gravitation and quantum theory. Interspersed are a few anecdotes to sweeten the pill.

Einstein stemmed from a Jewish family of merchants, a family showing no traces of scientific distinction, neither before nor afterwards. There is a myth that Einstein was bad at school (thus giving heart to those who are not of a scholarly bent yet may dream about scholarly success). True he did not shine during his stint at the Polytechnical Institute at Zürich of which he was a student, but had graduated from school with top grades in mathematics and physics. At the polytecnique he had very good and distinguished teachers, such as Minkowski, who would later put the theory of relativity on an elegant mathematical footing, but to no avail. He had to do some cramming to pass his exams, which he resented, claiming that afterwards he felt unable to do any serious work for months. Due to his rather indifferent record he was not able to secure an academic position and eventually landed a relatively low-level job at the patent office at Bern. He also married a fellow student and in due time two sons would be born. The work at the office was one of drudgery and did not leave him much spare time to do his own thinking. He had no contacts with other physicists nor did he have any access to a library, such literature not being available at such an office.

So what was he thinking of? He professed a certain distaste for mathematics, because in that subject there were so many distractions that he did not trust himself to recognize the real basic problems, because after all he was ambitious and wanted to make something out of his life, not merely to play. In physics though it was easier for him to identify promising avenues of research, in fact by the end of the 19th century physics was in a kind of crisis. On one hand physics seemed to be finished as a discipline of discovery and there was a feeling that the basic foundation was already laid, no more surprises to be found, only working out the details (at the very end of the century there would be a real surprise namely radioactivity, which would finally solve the riddle of how the sun could have shone so brightly for geological time periods) . On the other hand there were some inconsistencies of physics that had to be ironed out. Newton had introduced universal gravitation in the 17th century, and seldom has a scientific idea have had more spectacular consequences. Maxwell came along in the 18th and gave the foundations for electromagnetic theory, which was far more sophisticated than Newtonian theory, which for one thing could be phrased in simple ordinary differential equations, while Maxwell needed coupled partial differential equations. One of the consequences of Maxwell was electromagnetic radiation that seemed to propel through empty space, which from a standard mechanical point of view was unsatisfactory leading to the invention of the ether. More interesting though was the equations predicted strange phenomena when traveling at the speed of light. This problem attracted Einstein and he spent his time wondering what would happen if you traveled at such speed, which after all seemed to be trivial to achieve by Newtonian mechanics, no matter what acceleration if sufficiently sustained it would eventually lead you there. This question was almost as philosophical as physical, and the young Einstein was influenced by the instrumental approach by Mach, who thought about forces (and incidentally also atoms) as mere fictions. Eventually Einstein came up with a radical and simple solution, and in the magic year of 1905 he published four papers, each one sufficient to make his name. It was noteworthy that those papers had indeed been conceived in isolation and contained no references. Einstein had been forced to discover for himself many things in physics, he would otherwise had learned from colleagues or through a more comprehensive education (but Einstein did not savor study). At the time the negative outcome of the Michelson-Morley experiment was very much in the mind of the physics community. Those outstanding experimenters (at least Michelson) had failed in spite of valiant attempts to detect any difference in the speed of light due to different directions or throughout the movement of the earth through the ether. A lot of different ad-hoc solutions had been proposed to explain away the anomaly, such as contractions of lengths when in motion suggested by Fitz-Gerald and the distinguished Dutch theoretical physicist Lorentz. In fact prior to Einstein much of the formalism of relativity theory was already in place, by Lorentz and the French mathematician Poincaré. The group that leaves the Maxwell equations invariant, and which also plays a pivotal role in relativity theory now bears the name of the Dutch sage. In fact so much was done that people in retrospect have been tempted to see that relativity theory was in fact essentially discovered by Lorentz and Poincaré[1]. But in fact it was only through Einstein that a comprehensive view of the matter was provided touching on fundamental philosophical issues as to what is the nature of space and time. According to Einstein, the negative result of the Michelson-Morley experiment was of no interest to him. He knew what he was doing and needed no experimental nudging to get thinking in the right direction. The author points out that this gives a lecture in how science develops, theories are not necessarily brought into the world as reactions to observations, it is rather the other way around. Observations are provoked by scientific theories, the origin of which are creative leaps and opaque to inspection.

The essence of relativity theory is the rejection of an absolute space, and with that the abolishing of the ether. What remains is that the speed of light is an invariant in all systems of reference systems in uniform motion with respect to each other. In particular it means that the notion of simultaneity does not coincide among observers in motion with respect to each other, due to the finite speed of light. In fact crucial for any time-keeping is this notion of simultaneity, and not being fixed, it also means that time, objectively

[1] The British mathematician Whittaker took that view, writing that Einstein basically just cleaned up some work that was already there, and the mathematician Armand Borel undertook an investigation almost a century later to sort things out, suspecting that Poincaré and Lorentz had played more decisive roles than given credit for. However, he came to the conclusion that any due which is due, is due to Einstein. I recall a very nice colloquium lecture he gave on the subject at Ann Arbor in the spring of 1999. A very nice article in the Enseignements des Institut Fourier ensued

measured, will differ depending on the relative system. It is all very simple if at first counterintuitive. A mathematical explanation is of course the simplest one, not only formally, and any explanation that seeks to circumvent mathematics will invariably be confusing. There were also other consequences of relativity theory, such that the inert mass increases, in fact goes to infinity as the speed approaches that of light. Hence it is impossible that physical bodies, weighed down by mass, will ever attain the speed of light, let alone surpass it. And perhaps most famously, the equivalence between energy and mass, resulting in the one formula that any popular science book not only is allowed to present but also never can resist. We are of course talking $E = mc^2$.

Einstein was not a mathematician, and this would in some sense prove a handicap to him. The most elegant formulations are due to mathematicians, and when he would develop his theory he would be forced to learn a lot of 19th century mathematics, which no doubt strained his capacity.

The papers of 1905 brought him recognition, at first among his colleagues, although the process of diffusion was not very rapid, we are told that even a few years later, Born had never heard of him, but of course immediately recognized his stature, once he was directed to his papers. A recognition that would later evolve into public fame of a kind which sixty years after his death seems not to have abated. As a result of this recognition he was given academic appointments at Zürch and Prague respectively, and eventually called to Berlin, the Mecca of physics at the time. He also ended up divorcing his wife and taking up with a divorced cousin of his, already with two daughters.

Given the time that was his due he could embark on his life work, the theory of general relativity. Much of that grew up though thought experiments, such as observers in an accelerated elevator would feel a gravitational pull, or that a light beam would appear curved, as if it too was affected. The latter would even be a consequence of Newtonian mechanics, and Einstein worked out the displacement which would result. Unfortunately, or rather fortunately as things would turn out, the war that broke out prevented a German expedition to study a total eclipse in Russia, and instead they were taken war prisoners. Fortunately as the predictions of Einstein was premature, only later when working out the curvature of space, would he come up with the correct perturbations, which is about twice as much as purely Newtonian considerations would give. In 1919 there was yet another total eclipse, this time taking place against a very favorable background of bright stars. The British astronomer Eddington was a great admirer of Einstein and an indefatigable proponent of relativity theory and took the initiative to arrange two expeditions to locations of totality, one in West-Africa the other in South America. What came out was a confirmation of Einstein's prediction, although numerically not a very strong. Nevertheless the drama of the situation caught the imagination of the public, skillfully fanned by scientific popularizers [2]. Overnight Einstein became a celebrity.

His general relativity explained many puzzles that had plagued astronomers, such as the precession of the perheiion of Mercury, which was bigger than could be explained by Newtonian mechanics given the influence of other planets. More importantly it revived interest in cosmology. How did the universe look like? Was it infinite and homogenous with stars? This classical assumption, at least in an idealized version, led to the paradox

[2] Russell, among others, did his stint, explaining to the British public what they needed to know.

of Olbers. Einstein was looking for a static universe, and for his equations to confirm he needed to add a certain term, the so called cosmological constant, later considered by him as the greatest mistake of his life. Without it the universe would expand, and as later on the expansion of the universe would be discovered and established by Hubble, one may well understand his regret. The expanding universe led to the idea of the Big Bang[3] which supplied the universe with a history in contrast to Hutton's view of the Earth (no vestiges of a beginning, no prospects of an end) and thus also incidentally connected with religious sensibilities.

Einstein's general relativity holds a monumental place in modern physics, complete as no other physical theory and also with a mathematical elegance seen nowhere else. Yet to be honest it is more to be seen as the completion of classical physics, and the truly revolutionary development of the 20th century was the advent of the Quantum theory, whose practical consequences dwarf those of relativity[4]. However, quantum theory in spite of its experimental verfication and practical utility, remains logically inconsistent, and has of yet not been made to comply with Einstein's global theory. Physicists can live with that, mathematicians cannot. Neither could Einstein. His opposition to quantum theory is notorious and has led most physicists to regard him as a stubborn recluse, not doing any significant work after the 20's, locked in a sterile quest. 'God does not play dice' he famously has said. Still many of the initial breakthroughs in quantum theory are also due to Einstein. The authors in particular brings up his work on Brownian motion, which apparently even convinced Mach of the existence of atoms. He also mentions the photo-electric effect, which strangely enough, was the motivation given by the Swedish Academy for awarding him the Nobel prize in physics. Peculiarly the motivation was only given after the prize was officially rewarded, and Einstein never went and picked it up himself, it was in due time delivered to him.

The developments in Germany made continued residence impossible and Einstein while visiting the States decided to among the plentitude of offers to accept the one at the newly established Institute for Advanced Study, whose prestige greatly benefitted from the appointment. He became not only a public curiosity but also a moral voice. He was sought out to sign the letter to Roosevelt, although he did not take the initiative, nor formulate it, but only he, it was thought, would carry enough weight. Although a pacifist by inclination and unchecked habit, Hitler made him, at least temporarily abandon his guiding principle, but he took no active part at Los Alamos, and besides he would have little to contribute, the kind of nuclear engineering that it involved not being part of his expertise nor to his taste. After the war he was aghast at what had been unleashed.

As noted this is not a standard biography with a blow-by-blow account of the vicissitudes of an eventful life, but some telling anecdotes are supplied. Einstein comes across as a lively, fun-loving person, with a good sense of humor, and an uncanny kind of laugh. Yet for his friendliness and lack of social snobbery, exceptional for an academic at his time, he was fundamentally reserved, with little real need for companionship. Did he have any real friends?

[3] The author refers the notion to George Gamow, but the term itself supposedly stems from Fred Hoyle who used it in order to disparage, but it ultimately had the opposite effect.

[4] When it comes to space travel, Newtonian mechanics is perfectly adequate.

A stocky, muscular guy, going to fat in his later years, he eventually was plagued with ill-health, making death not an altogether disagreeable event. He died in the night in his bed, with some unfinished calculations next to him, no doubt intended to be continued in the morning that never was.

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