

Albert Einstein

A talk at IoP Satrosphere 15th April 2005

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When Alistair asked me if I'd say a few words on this occasion, I readily agreed. I'd read Einstein biographies, given a lecture course on special relativity a good while ago and read a bit about the history of Physics. "It won't take you long" said Alistair. Well, I've found it's not as easy as it might seem to talk about Einstein.

We all know something about Einstein - he is an iconic figure, almost a caricature figure. He was Time magazine's 'person of the century' in their issue of 31st December 1999; he has been widely quoted, widely parodied. There is a quotation of Einstein's on an advertising poster outside my office "*I have no special talents, I am only passionately curious*". The advert is for 'findAPhd.com'. The implication is that you too may think you have no talents but you may be a closet Einstein. It's a good advertising ploy. There are Einstein jokes around, too. I quite like the one that goes "*Why did Einstein cross the road? To get away from Niels Bohr, only he found that Bohr was on the other side too.*" The physicists will appreciate it.

Why it's hard to talk about Einstein is that it's difficult to get inside his skin. The person you see on the outside isn't the person who revolutionised 20th century physics. We're here today to celebrate the centenary of the year in which Einstein published 3 groundbreaking papers, any one of which could have won him the Nobel Prize. Actually he sent 5 papers to the periodical *Annalen der Physik* in that year, 4 of which were published before the end of the year. One of them did earn him the Nobel Prize for 1921. He published these papers when he was a Patent Clerk (3rd class) in the Bern Patent Office. When you read about his life until then, and for a few years after, it sounds exactly the kind of biography you might read of a patent clerk (3rd class), not the genius who would become 'person of the century'. [Time magazine readers in a poll in January 2000 were asked whom they would vote 'person of the century'. Can you guess who came top? It was Elvis Presley, narrowly ahead of Yitzhak Rabin, which says a lot about Time readers. At least the editorial board had the longer view]. I should begin at the beginning and give you some idea of Einstein's life up to 1905.

Einstein was born 126 years ago, on 14th March 1879 at 135 Station Road, Ulm, in southern Germany. His parents were low key Jews of a non dogmatic disposition. A year later the family moved about 200 km East to Munich, where

his father Hermann Einstein and uncle Jakob set up a supply firm that began as a provider of gas and water installations but transformed itself into an electro-technical manufacturer. It was only a modest success. It would get custom all over the world today but the name of Einstein didn't have any special cachet in those days.

At school Albert was quiet, didn't take to education by authority, scored well in exams but not brilliantly. 14 years later his parents moved to northern Italy and left Albert behind in Munich to finish his schooling. He didn't. A year later he joined his family and sat the entrance exam for the Swiss Federal Institute of Technology in Zurich. He failed to get in. He went to school for a year in Aarau in Switzerland, left with their diploma and was accepted at last into the ETH Zurich, the Eidgenössische Technische Hochschule Zürich. He acquired something of a reputation for skipping classes and studying on his own. Four years later he graduated with 3 others, with good marks in physics, astronomy and mathematical analysis. No-one recorded seeing any signs of genius. Indeed, his fellow 3 graduates were all offered assistant posts at the Hochschule but Einstein wasn't. Einstein didn't like the experience of the final exam. He said later *One had to cram all this stuff into one's mind for the examination, whether one liked it or not. This coercion had such a deterring effect on me that, after I had passed that final examination, I found the consideration of scientific problems distasteful for me for an entire year.* On another occasion he remarked *Education is what remains after one has forgotten everything one learned in school.* There's some truth in this. We're now in the year 1900 in our story.

In 1901 Einstein was sworn in as a Swiss citizen, having renounced his German nationality in 1896 and been stateless for several years. He got temporary jobs as a school-teacher and during one job he wrote what he hoped would be a doctoral dissertation on the kinetic theory of gases, which he submitted to the ETH. It was not accepted. Finally he secured a job in the Patent Office in Bern in 1902. 'Secured' is a bit too strong. He was on probation at first and the job was not secure until over 2 years later. He had fallen in love with a Serbian physics student in Zurich, Mileva Maric, and in 1902 she gave birth to an illegitimate daughter by him. He's now 22, a lad with a modest educational record, a modest means, a modest job and an illegitimate daughter. Not even the most reckless gambler would put money on this man becoming 'person of the century'. He seemed to be like a thousand others at the time. Would anyone have given him a research grant, had there been such things? Possibly not. Einstein never applied. He had applied for University jobs and failed to excite any interest. He married Mileva the following year and they had their first son, Hans Albert in 1904. [Many years later Hans Albert would become a well-known Professor of Hydraulic Engineering in Berkeley, California].

What I have clearly missed out of the story so far is Einstein's passionate interest in Physics in general and in fundamental questions that were taxing physicists at the time. Historians have had to dig deep for the evidence because we now come to 1905 when Einstein as a clerk (3rd class) in the Patent Office sent his first paper of the year to *Annalen der Physik* in March. It was on the light quantum and the photoelectric effect, and urban myth says that he asked if it could be published '*if they had room*'. Max Planck was an editor of the *Annals*. He was one of the most respected figures in German science and the person who had introduced the light quantum into physics a few years earlier. Einstein's paper represented a new way of looking at light. This was the paper that was particularly mentioned in Einstein's Nobel Prize citation. In April he completed a new doctoral dissertation, not on light but 'On a new determination of molecular dimensions'. ETH Zurich accepted it in July. In May he submitted his ground-breaking paper on Brownian Motion that became the most quoted physics paper of the year. It was the basis for Jean Perrin's Nobel Prize winning experimental work a few years later that finally convinced high profile sceptics that atoms really existed. In June he submitted his very famous paper setting down the fundamentals of the theory of Special Relativity; in September a second paper on Special Relativity followed, giving his even more famous equation $E = mc^2$. In December he submitted a second paper on Brownian motion. All this time he was patent officer 3rd class in Bern. It is said that the only first-class theoretical physicist he had seen at that stage in his life was himself in the mirror. These papers changed physics across the world. Where did they come from? I suspect they were based on a good ten years of thinking intensely about physics and forming his own ideas, with an intuitive grasp of what was right and what wasn't. When he was asked much later how long it took him to conceive of special relativity he said *The idea came to me quite quickly but I have been thinking about it all my life.*

The 1905 papers didn't make Einstein an instant celebrity, either in the world of Physics or in the public eye. Celebrity wouldn't come for another decade, more before the public knew of Einstein. A few years later he did become a Professor of Physics, starting off in 1909 as an associate prof in his alma mater in Zurich. He spent a year as full professor in Prague before moving back again to Zurich and then to Berlin in 1914. At this time he separated from Mileva, who moved with the family back to Zurich. There is a story that one of his students while he was teaching came up to him and said "*Professor, the questions in this year's exam are the same as in last year's exam*". "*True*", said Einstein, "*but this year's answers are all different.*" I'm not sure our own courses move forward that quickly.

What brought Einstein the celebrity that he never really wanted was his General Relativity Theory, a theory that is the basis of today's cosmology, that he wrestled with for almost 10 years after Special Relativity before finally arriving at equations that have never been superseded. *To punish me for my contempt for authority, fate made me an authority myself*, he once said ruefully. I've mentioned his Nobel prize, which he received in 1922. By this time Einstein had divorced and re-married but he gave all his Nobel prize money to Mileva, his first wife. The 1920s finds Einstein increasingly arguing with the founding physicists of quantum mechanics, Bohr, Born, Heisenberg, Schrödinger, and others, over their interpretation of the subject. This had the effect of sharpening their arguments to the extent that the founding ideas they developed are still largely those taught today.

In 1932 Einstein left Germany for good to settle in the Institute for Advanced Studies at Princeton. In 1935 he published with 2 assistants the famous Einstein – Podolsky – Rosen paradox that highlighted the phenomenon of quantum entanglement that is at the heart of a today's active research field of quantum computing and quantum cryptography. By 1932, though, he was immensely famous. What he said, sometimes in jest, sometimes in earnest, was increasingly recorded. *The wireless telegraph is not difficult to understand*, Einstein is recorded as saying. *The ordinary telegraph is like a very long cat. You pull the tail in New York and it meows in Los Angeles. The wireless is the same, only without the cat.* Little wonder he became increasingly the public image of the eccentric professor, with his flying white hair and his penchant for not wearing socks. More appositely, he commented once *if we knew what it was we were doing, it would not be called research, would it*, words that it's tempting to quote on grant application forms these days when they ask for a month by month management plan of your research over the next three years. On related lines, he had a sign hanging up in his office in Princeton that read *Not everything that counts can be counted, and not everything that can be counted counts.* One to think about.

Einstein made big contributions to Physics beyond those I've mentioned – the Einstein specific heat model for solids (1907) that was the beginning of the quantum theory of solids; the Einstein radiation coefficients for stimulated and spontaneous emission that underpin the operation of lasers, another product of a second remarkable year in 1916; the Bose-Einstein condensation of 1925, a subject that is very much alive in today's ultra-low-temperature physics world; Einstein gravitational lensing, which he worked on as late as 1935 and is again a hot topic in astronomy today. However, the Nazi persecution of Jews increasingly turned Einstein's attention to the political stage in the 1930s. His famous letter to President Roosevelt in 1939 was certainly a factor that initiated the Manhattan project, which culminated in the first atomic bombs. In 1940

Einstein became an American citizen. He increasingly became an active pacifist, having detested the military mindset for most of his life. He was offered the Presidency of Israel in 1952, but famously declined.

Einstein throughout his life was a person who wanted to get to the bottom of what was going on. He shared with Heisenberg and Schrödinger, two people as opposite as could be, a genuine calling as a natural philosopher. His physics was driven as much by philosophy as by mathematics. I heard a lecture a couple of days ago by the Director of the Centre for Einstein Studies at Princeton who considered that Einstein would be remembered in centuries to come for making the philosophy of relational space-time the definitive basis of physical science. Late in his life when Einstein was pondering wave-particle duality, a subject that his 1905 photoelectric electric paper really introduced, he said *Fifty years of conscious brooding have brought me no closer to the answer to the question "What are light quanta?" Of course today every rascal thinks he knows the answer, but he is deluding himself.* Einstein spent much of his time at Princeton searching for a theory that would unify all the fundamental forces of physics. He didn't find this holy grail. It was a tough call. In the 50 years since his death on 18th April 1955, none of the 10 billion or so people who have been alive on the Earth have found it either.

In spite of all his connections and influence, Einstein was, in his own words, a bit of a *lone traveller*. His great achievements were prime example of lateral thought. He valued his imagination as much as any formal training in science. On several occasions he said words similar to these: *I am enough of an artist to draw freely upon my imagination. Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world.*

Einstein is seen as the personification of genius by the public. He once said in exasperation *I am no Einstein*. I'm sure, though, that he would appreciate praise from his fellow physicists one hundred years on from 1905. Occasionally I have reflected on the number of pivotal figures in Physics who were alive in my youth. Einstein was one of them. This Monday marks the 50th anniversary of his death. I'm sure that in 500 years time, long after Elvis Presley, Yitzhak Rabin and indeed many of his more famous contemporaries are names recognised by specialists only, Einstein will be a name still recognised around the world. Please lift your glass and toast to the achievements of *Albert Einstein*.

JSR