Robert Hooke, Lewis Caroll and Quantum Physics

By Peter Russell

Robert Hooke was born in 1635 just prior to a period in history known to philosophers as 'The Age of Enlightenment'. The Enlightenment included a range of ideas; the main one being that the evidence of the senses and reasoning should be the primary sources of knowledge. It is no coincidence that this period was preceded by the so-called 'scientific revolution' which was marked by the emergence of modern scientific methodology with an emphasis on experimentation, observation and reductionism, and less reliance on religious scriptures as a source of knowledge. Observations in astronomy and human anatomy and developments in mathematics and physics during this period influenced opinions throughout Europe. There is no precise date for the start of the Age of Enlightenment but many regard the publication of Isaac Newton's Principia Mathematica (1687) as the culmination of the Scientific Revolution and the beginning of the Enlightenment.

Science during Hooke's lifetime was principally physics. The chemistry of that time largely consisted of alchemy; it was not until the middle of the nineteenth century that the modern concept of atomic chemistry was propounded by John Dalton. Although enormous advances were made in our understanding of scientific laws in the seventeenth century, they were limited to the macroscopic world. This branch of physics came to be known as classical mechanics or Newtonian physics which describes forces acting on matter and the motion of large objects, from projectiles to parts of machinery, and astronomical objects, such as planets, stars, and galaxies. Hooke's Law of Springs, somewhat insultingly, is an example of Newtonian physics. Throughout the period of Hooke's life, and the first three centuries following his death, the Universe was assumed to be deterministic and predictable. Newtonian physics provides extremely accurate results when studying the motion of large objects that are not approaching the speed of light.

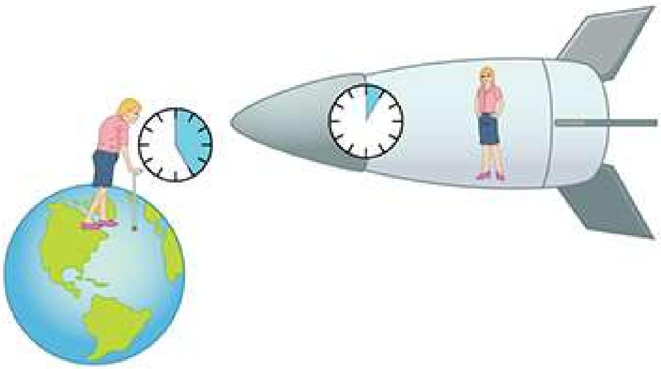
There have been many more discoveries made by classical physicists since Hooke's death that have provided an insight into the physical world; electromagnetism and thermodynamics are two examples. I doubt that Hooke would have had any difficulty comprehending the science that followed him and he would have been very familiar with the experimental hypothetical-deductive methodology.

It is rumoured that Lord Kelvin said at the turn of the twentieth century, "There is nothing new to be discovered in physics now. All that remains is more and more precise measurement" although it is doubtful that he made any such remark. Nevertheless, it was assumed by most scientists at the time that Newtonian physics would soon complete our understanding of the Universe. Just when the physicists of the day thought that they had things almost wrapped up, there were two developments that shocked the scientific world to its core; namely relativity and quantum mechanics.

It soon became apparent that the subatomic world was very different from the world we experience in our everyday lives and it was a world in which Newtonian physics didn't apply. It was more than just different; it was downright weird. The ideas that started to emerge from this new branch of physics seemed worthy of that other occasional resident of the Isle of Wight, Lewis Carol. Some wondered if the proponents of relativity and quantum mechanics had fallen down a rabbit hole and entered a world of fantasy. Many scientists in the early part of the twentieth century simply refused to accept these new ideas.

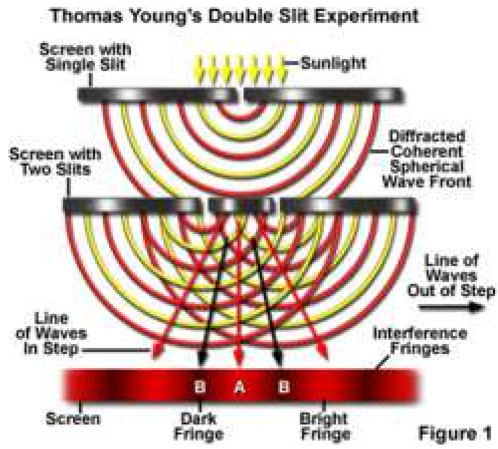
In 1905, Einstein published his first paper on relativity. By the turn of the last century, it had been firmly established that light had the qualities of a wave and it was therefore assumed that there must be a medium in which the wave was being propagated. In actual fact there's not, but two scientists Michelson and Morley, were unaware of that at the time and performed an experiment to detect its existence. The experiment compared the speed of light in perpendicular directions in an attempt to detect the relative motion of matter through the stationary imagined 'luminiferous aether'. Michelson and Morley expected to see a difference in the speed of the light. They discovered that the speed of light remained constant and could make no sense of their results. Einstein realised that if the speed of light was a constant, the only explanation was that time was a variable. The concept that time was not passing at the same rate throughout the Universe and its passage was related to motion was mind-blowing. We don't notice the effect at the speeds with which we are familiar but at speeds close to that of light, the effect is profound.

Einstein's theory was demonstrated mathematically but it was also proven experimentally when four phenomenally accurate caesium clocks were flown twice around the world, once eastward and once westward then compared with reference clocks at the U.S. Naval Observatory. The difference was measured in nanoseconds but it confirmed Einstein's theory that the passage of time is related to motion.



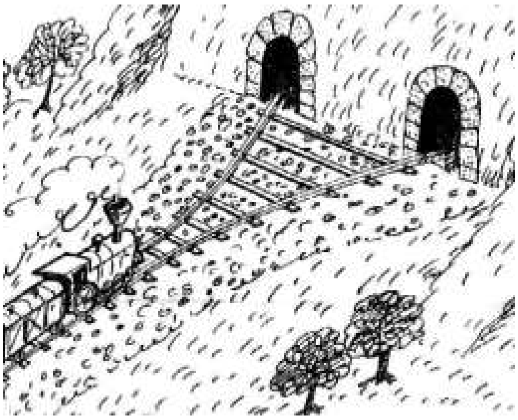
Hot on the heels of relativity came quantum mechanics. Throughout Hooke's life, there had been an ongoing debate about the nature of light. One theory stated that light is made up of small discrete particles called "corpuscles" (little particles). Isaac Newton was a pioneer of this theory. The alternative view was that light was a wave. I am not aware of any evidence that that would indicate Hooke favoured one theory over the other. In 1801, Thomas Young conducted an experiment based on the hypothesis that if light were wave-like in nature, then it should behave in a manner similar to ripples or waves on a pond of water. When visible light is passed through a narrow slit, it is diffracted by the edges of the slit. When the light is passed through two slits side by side, two regions of diffracted light are created (see fig 1). In some places, the peaks of the waves will coincide and augment. In other places the peak of one wave will coincide with the trough of another and so cancel each other out thereby creating bands of light and dark

Young's now famous 'double slit' experiment clearly demonstrated that light had the properties of a wave.



Yet Einstein's equation $E=MC^2$ means that light also has mass like a particle so both theories about light were correct. Much later, the double slit experiment was repeated using electrons (a particle) instead of visible light. The results obtained showed an identical pattern of light and dark so electrons were also behaving like waves.

With particles possessing the properties of waves and waves possessing the qualities of particles, (wave particle duality) it was clear that the previously held mental model of the subatomic world was very over-simplified. This alone was too much for many to accept but a more puzzling observation was yet to come. When the double slit experiment was conducted using one electron at a time, each individual electron passed through one of the slits alone and yet the results still revealed an interference pattern. The explanation is that the electron is not a solid object occupying space in a precise location but a wave of probability of infinite possibility. It is only after this probability wave has been stopped by the screen and been observed does the infinite possibility collapse into a singularity and the electron becomes real. (The observer effect)



"Once and for all I want to know what I'm paying for. When the electric company tells me whether light is a wave or a particle I'll write my check."

Quantum mechanics takes a probabilistic view of nature, sharply contrasting with classical mechanics, in which all precise properties of objects are, in principle, calculable. Quantum mechanics is mainstream physics today but it is easy to see why many of those who were only previously familiar with Newtonian physics rejected the theory. It was not that the experiments were poorly designed or the results unrepeatable, nor was it because the maths was not rigorous or the logic faulty, it was because it required a root and branch reappraisal of everything they thought that they understood about the nature of the Universe. The German physicist Max Planck said, “A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die.” Scientists and philosophers are still struggling to explain how the unpredictable and non-deterministic world of quantum mechanics gives rise to the measurable reality we observe.

It would be fascinating to know what Robert Hooke would have made of relativity and quantum mechanics. Would he have embraced the concepts or would he have been one of those who dismissed them as absurd? I suspect that he would have been open to the ideas. I formed that opinion based on what we know of his character. We know that he was the first to recognise that the earth was not a static place but that geological change occurred; sometimes catastrophically and sometimes gradually. We also know that his observations at Freshwater Bay led him to conclude that speciation was not a one-off creation and most amazingly, that he speculated about the possibility of continental drift. This demonstrates that Hooke’s thinking was not limited by the conventions of his day and that he was willing to consider wide ranging ideas, no matter how outlandish they appeared to be at the time. I have therefore concluded that Hooke would probably have been willing to accept relativity and quantum mechanics based on the experimental observations, albeit they are stranger than he could have imagined in the seventeenth century.