The Great Unknown

Every now and again, when I get into some slightly technical discussion, I ask, ’By the way, have you heard of James Clerk Maxwell?’

Most people look blank and shake their heads, saying, ‘Should I?’

This ignorance is puzzling, since Maxwell’s work was as profound as that of Isaac Newton, and has transformed the world as much as Newton’s work did. Newton is famed throughout the world.

A Dane, Oersted, discovered a link between an electric current and a magnet. Ampere developed his ideas, but it was Michael Faraday who discovered a second link, known as his Law of Induction: a moving magnet could induce an electric current in a wire. This discovery quickly led to the construction of electric generators in the 1830s.

One of those who worked in this field was William Thompson, a very bright lad who became Professor of Physics at Glasgow University, aged twenty-two. He established the absolute zero of temperature, and later laid the first telegraph cable across the Atlantic. William Thompson was very clever, but he was also ambitious. He mixed with ‘the right people’ and over the years received many honours, culminating in his election to the House of Lords as Baron Kelvin. He was regarded by many as the ultimate authority on physics and other scientific matters.

James Clerk Maxwell was younger than Thompson, but at least as brilliant. He also studied electricity and magnetism, and in 1864 he published a paper that revolutionised the subject. Like Newton, he disentangled a complex set of data, producing the elegant Maxwell’s Equations, which established a kind of symmetry between electricity and magnetism. He also showed that the unified Electromagnetic Field consisted of waves of all frequencies, but all travelling with the speed of light; this was embodied in Maxwell’s Wave Equation.

Maxwell predicted that electromagnetic waves existed which could pass through apparently solid bodies, but it was not until 1888 that Hertz generated electromagnetic waves that passed through the wall of a laboratory. Later, an article in the Glasgow Herald explained this twenty-four years of neglect of Maxwell’s work: Lord Kelvin, the great authority, insisted until he died in 1907 that Maxwell’s work was nonsense. So Maxwell, who died in 1879, never saw any practical confirmation of his ideas. The Glasgow Herald article was emphatic that Kelvin was not motivated by vindictiveness or jealousy; he simply did not understand what Maxwell had done! Kelvin should not, of course, have simply condemned the theory: he should have persuaded experimental physicists to test it, and base his judgment on experiment.

Mind you, Maxwell's ideas *were* hard to understand, since they conflicted with Newtonian physics. After Hertz's discovery, Fitzgerald and Lorenz realised that Newton's Laws had to be modified when speeds were close to that of light, and their modifications led Einstein in 1905 to expound the Special Theory of Relativity. At low speeds, Newton's Laws provided a very good approximation.

Hertz's experiments quickly attracted the attention of practical scientists: these included Marconi, who started in the 1890s to study waves with frequencies in the 'radio' range; he established wireless communication, first by Morse Code, and then through the spoken word. This was an emphatic proof of the existence of the invisible part of the electromagnetic field. It is hard to exaggerate the importance of wireless communication, including television, as a major unifying force throughout the world.

The part of the electromagnetic spectrum with which we are most familiar is the light and the less energetic 'infra-red' heat from the sun. We know to beware of the more energetic 'ultra-violet' radiation when we sun-bathe. This wider range of frequencies has become very important in astronomy. Following on from radio-astronomy, telescopes have been invented enabling us to form pictures from galaxies, from both infra-red and ultra-violet radiation, enabling us to view parts of galaxies which do not emit visible light.

Radiation has been important in medicine since Roentgen discovered X-rays in 1895, followed by Madame Curie's observation of this radiation from uranium, the beginning of our knowledge of radioactive decay of atoms. Nowadays we are familiar with radiation treatment as a cancer therapy.

We should not forget the very familiar use of domestic radiant heat for cooking and heating. Warmth from cooking stoves came long before Maxwell's time; now we have microwave ovens. It is easy to forget that a scientific understanding of everyday things, as well as our understanding of the universe, depends on Maxwell's Wave Equation.

While Maxwell's work eventually led to the Special Theory of Relativity, another major element had to be added before twentieth-century physics could emerge: Planck found that radiation from a black body could only be explained if he assumed that radiation was emitted in tiny lumps which he called Quanta. This idea was extended in 1910 to explain the discrete pattern of energy levels in the Bohr-Rutherford concept of the atom. The full development of Quantum Mechanics came from the 1920s work of Schrodinger, Pauli and Heisenberg, which was unified by Paul Dirac.

Just as Maxwell had established the speed of light as a universal constant, quantum mechanics established Planck's constant as another fundamental constant of nature. A third fundamental constant, the gravitational constant, emerged from the study of gravitation and Einstein's General Theory of Relativity. One of the big mysteries of the universe is the discovery of the fundamental constants of nature. In his book 'Just Six Numbers', Martin Rees has explained how the basic constants of nature, upon which the structure of the universe depends, can be expressed in terms of six pure numbers. We are left to wonder why these numbers have these particular values, which allow the universe to exist in the form we find it, and which allow us to exist. James Clerk Maxwell would have been fascinated by these ideas.