THE MOST FAMOUS EQUATION IN THE WORLD.
By
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I was walking through my local shopping centre recently when a young boy ran past me wearing a T-shirt bearing the legend $E = MC^2$. This famous equation, formulated by Albert Einstein in the year 1907, is the only scientific equation to be popularly familiar. Just as the opening bars of the Fifth Symphony mean Beethoven to a great many people, so the equation $E = MC^2$ means physics and Einstein in the popular consciousness. However, although the equation is widely known, few people understand what it means.

In the equation, E stands for energy, which can be thought of in simple terms as that which makes things move. The unit of energy is called the Joule. M stands for mass (amount of matter), which can be thought of qualitatively as inertia, or resistance to movement. The unit of mass is the kilogram (kg). C stands for the speed of light, which is the maximum velocity allowed in the universe - 300,000 km per second (186,000 miles per second). The overall equation says something that is very surprising, i.e. it is possible to turn matter into energy and vice versa.

Because the square of C is such a huge number, the equation tells us that matter is equivalent to incredibly large amounts of energy. For example, to calculate the energy equivalent of a kilogramme of sugar (or of anything else) you simply multiply one kilogramme by C^2. The resulting figure represents an amount of energy approximately double the total energy usage of the United States of America in one year. Another illustration of the massive amount of energy locked up in matter is the calculation that the complete conversion of 1 gram of matter into energy would yield as much as the burning of 2,000 tons of gasoline.

The first large-scale application to come out of Einstein's famous equation was an unfortunate one - the atomic bomb. The original atomic bomb was based on a process called nuclear fission. Nuclear fission simply means the breakup (fission) of a heavy atom (either uranium or plutonium) into two daughter atoms, each approximately half the size of the parent atom. When you carefully add up the masses of the fission products you find that the total is slightly less than the mass of the parent atom. The "lost" mass has been converted into energy. If you take a concentrated lump of uranium or of plutonium you can generate an uncontrolled fission process in which all of the atoms breakdown in quick succession and a gigantic amount of energy is released - a nuclear explosion. This was the basis for the atomic bombs that were dropped on the cities of Hiroshima and Nagasaki in 1945.

A much more useful application of Einstein's equation was developed after the Second World War. This was to harness the energy contained in matter to generate useful electrical energy, and the process is called nuclear power. Nuclear power is also based on the process of nuclear fission. However, in nuclear power, the nuclear fission is managed so that it occurs in a controlled fashion, releasing amounts of energy that can be handled safely and never running away in the uncontrolled manner of an atomic explosion.

The birth of civil nuclear power in the 1950s was heralded with great fanfare as the dawn of a new age that would satisfy society’s energy requirements for the foreseeable future. Unfortunately, nuclear power has been persistently dogged by safety problem and by problems associated with the nuclear waste that it generates. Incidentally, the first civil nuclear power station in the world was the Calder Hall Nuclear Reactor located on the UK Sellafield site. This reactor began operations in 1956 and is still operating today.

The fact that energy and matter are interconvertible is not something we would predict from our everyday intuition. Nevertheless, of the two directions described by the equation, it is easier to get one's head around the conversion of matter into energy than it is to feel comfortable with the idea of the conversion of energy into matter. If we look at the equation $E = MC^2$ again, and rearrange it slightly, we see that $M = E/C^2$. Since C^2 is such a large quantity, and is the divisor in the equation, this tells us that in order to get even the tiniest bit of matter (M), we must convert gigantic amounts of energy (E). We are told that this is what happened at the birth of the universe, when the energy released in the Big Bang explosion radiated out in all directions and then "froze out" into the matter of the universe. Today, I am unaware of any large scale practical applications of the principle that energy can be converted directly into matter.

Albert Einstein was born in 1879 in Germany. He lived with his parents in Munich and then in Italy. He taught at the Polytechnic School in Zurich, became a Swiss citizen and was appointed an Inspector of Patents in Berne. During his spare time in the Patent Office, Einstein developed his Special Theory of Relativity, which he presented in 1905. The equation $E = MC^2$ flows from this theory. In 1909 he became a Professor of Theoretical Physics at the University of Zurich. In 1913 he took up a special post of Director of the Kaizer Wilhelm Institute for Physics in Berlin. In 1915 Einstein published his General Theory of Relativity.

Einstein received the Nobel Prize for Physics in 1921 for his explanation of the photoelectric effect (not for his theory of relativity). He emigrated to the US in 1933 after being deprived of his position in Berlin by the Nazis. He spent the remainder of his life in the USA and died in 1955. In addition to his scientific work he also helped many humanitarian causes. In a memorable statement in 1929 in Paris, Einstein declared - ‘If my theory of relativity is proven correct, Germany will claim me as a German and France will say I am a citizen of the world. Should my theory prove untrue, France will say that I am a German and Germany will declare that I am a Jew’.

Einstein is the archetypal scientific genius of the 20th century. Just as one can buy T-shirts bearing his famous equation, one can also buy large poster photographs showing Einstein in his later years. A conspicuous white halo of hair frames a wonderfully lined face. Many books have been written describing Einstein’s scientific work, and new books continue to emerge every year. Two well-written books on Einstein’s work are: ‘Was Einstein Right?’ by C. Will (Basic Books, 1986), and ‘Subtle is the Lord’ by A. Pais (Oxford University Press, 1982).

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