A giant leap for science

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2012

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The Economist

JULY 7TH–13TH 2012

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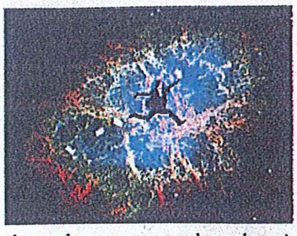
Science's great leap forward

After decades of searching, physicists have solved one of the mysteries of the universe



HISTORICAL events recede in importance with every passing decade. Crises, political and financial, can be seen for the blips on the path of progress that they usually are. Even the horrors of war acquire a patina of unreality. The laws of physics, though, are eternal and universal. Elucidating them is one of the triumphs of mankind. And this week has seen just such a triumphant elucidation.

On July 4th physicists working in Geneva at CERN, the world's biggest particle-physics laboratory, announced that they had found the Higgs boson (see page 67). Broadly, particle physics is to the universe what DNA is to life: the hidden principle underlying so much else. Like the uncovering of DNA's structure by Francis Crick and James Watson in 1953, the discovery of the Higgs makes sense of what would otherwise be incomprehensible. Its significance is massive. Literally. Without the Higgs there would be no mass. And without mass, there would be no stars, no planets and no atoms. And certainly no human beings. Indeed, there would be no history. Massless particles are doomed by Einstein's theory of relativity to travel at the speed of light. That means, for them, that the past, the present and the future are the same thing.

Deus et CERN

Such power to affect the whole universe has led some to dub the Higgs "the God particle". That, it is not. It does not explain creation itself. But it is nevertheless the most fundamental discovery in physics for decades.

Unlike the structure of DNA, which came as a surprise, the Higgs is a long-expected guest. It was predicted in 1964 by Peter Higgs, a British physicist who was trying to fix a niggle in quantum theory, and independently, in various guises, by five other researchers. And if the Higgs—or something similar—did not exist, then a lot of what physicists think they know about the universe would be wrong.

Physics has two working models of reality. One is Einstein's general relativity, which deals with space, time and gravity. This is an elegant assembly of interlocking equations that poured out of a single mind a century ago. The other, known as the Standard Model, deals with everything else more messily.

The Standard Model, a product of many minds, incorporates the three fundamental forces that are not gravity (electromagnetism, and the strong and weak nuclear forces), and also a menagerie of apparently indivisible particles: quarks, of which protons and neutrons, and thus atomic nuclei, are made; electrons that orbit those nuclei; and more rarefied beasts such as muons and neutrinos. Without the Higgs, the maths which holds this edifice together would disintegrate.

Finding the Higgs, though, made looking for needles in haystacks seem simple. The discovery eventually came about using the Large Hadron Collider (LHC), a machine at CERN that sends bunches of protons round a ring 27km in circumference, in opposite directions, at close to the speed of light, so that they collide head on. The faster the protons are moving, the more energy they have. When they collide, this energy is converted into other particles (Einstein's $E=mc^2$), which then decay into yet more particles. What these decay particles are depends on what was created in the original collision, but unfortunately there is no unique pattern that shouts "Higgs!" The search, therefore, has been for small deviations from what would be seen if there were no Higgs. That is one reason it took so long.

Another was that no one knew how much the Higgs would weigh, and therefore how fast the protons needed to be travelling to make it. Finding the Higgs was thus a question of looking at lots of different energy levels, and ruling each out in turn until the seekers found what they were looking for.

Queerer than we can suppose?

For physicists, the Higgs is merely the LHC's aperitif. They hope the machine will now produce other particles—ones that the Standard Model does not predict, and which might account for some strange stuff called "dark matter".

Astronomers know dark matter abounds in the universe, but cannot yet explain it. Both theory and observation suggest that "normal" matter (the atom-making particles described by the Standard Model) is only about 4% of the total stuff of creation. Almost three-quarters of the universe is something completely obscure, dubbed "dark energy". The rest, 22% or so, is matter of some sort, but a sort that can be detected only from its gravity. It forms a giant lattice that permeates space and controls the position of galaxies made of visible matter (see page 68). It also stops those galaxies spinning themselves apart. Physicists hope that it is the product of one of the post-Standard Model theories they have dreamed up while waiting for the Higgs. Now, they will be able to find out.

For non-physicists, the importance of finding the Higgs belongs to the realm of understanding rather than utility. It adds to the sum of human knowledge—but it may never change lives as DNA or relativity have. Within 40 years, Einstein's theories paved the way for the Manhattan Project and the scourge of nuclear weapons. The deciphering of DNA has led directly to many of the benefits of modern medicine and agriculture. The last really useful subatomic particle to be discovered, though, was the neutron in 1932. Particles found subsequently are too hard to make, and too short-lived to be useful.

This helps explain why, even at this moment of triumph, particle physics is a fragile endeavour. Gone are the days when physicists, having given politicians the atom bomb, strode confidently around the corridors of power. Today they are supplicants in a world where money is tight. The LHC, sustained by a consortium that was originally European but is now global, cost about $10 billion to build.

That is still a relatively small amount, though, to pay for knowing how things really work, and no form of science reaches deeper into reality than particle physics. As J.B.S. Haldane, a polymathic British scientist, once put it, the universe may be not only queerer than we suppose, but queerer than we can suppose. Yet given the chance, particle physicists will give it a run for its money. ■