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A Blip That Speaks of Our Place in the Universe

By LAWRENCE M. KRAUSS

ASPEN, Colo. — Last week, physicists around the world were glued to computers at very odd hours (I was at a 1 a.m. physics “party” here with a large projection screen and dozens of colleagues) to watch live as scientists at the Large Hadron Collider, outside Geneva, announced that they had apparently found one of the most important missing pieces of the jigsaw puzzle that is nature.

The “Higgs particle,” proposed almost 50 years ago to allow for consistency between theoretical predictions and experimental observations in elementary particle physics, appears to have been discovered — even as the detailed nature of the discovery allows room for even more exotic revelations that may be just around the corner.

It is natural for those not deeply involved in the half-century quest for the Higgs to ask why they should care about this seemingly esoteric discovery. There are three reasons.

First, it caps one of the most remarkable intellectual adventures in human history — one that anyone interested in the progress of knowledge should at least be aware of.

Second, it makes even more remarkable the precarious accident that allowed our existence to form from nothing — further proof that the universe of our senses is just the tip of a vast, largely hidden cosmic iceberg.

And finally, the effort to uncover this tiny particle represents the very best of what the process of science can offer to modern civilization.

If one is a theoretical physicist working on some idea late at night or at a blackboard with colleagues over coffee one afternoon, it is almost terrifying to imagine that something that you cook up in your mind might actually be real. It’s like staring at a large jar and being asked to guess the number of jelly beans inside; if you guess right, it seems too good to be true.

The prediction of the Higgs particle accompanied a remarkable revolution that completely changed our understanding of particle physics in the latter part of the 20th century.
Just 50 years ago, in spite of the great advances of physics in the previous half century, we understood only one of the four fundamental forces of nature — electromagnetism — as a fully consistent quantum theory. In just one subsequent decade, however, not only had three of the four known forces succumbed to our investigations, but a new elegant unity of nature had been uncovered.

It was found that all of the known forces could be described using a single mathematical framework — and that two of the forces, electromagnetism and the weak force (which governs the nuclear reactions that power the sun), were actually different manifestations of a single underlying theory.

How could two such different forces be related? After all, the photon, the particle that conveys electromagnetism, has no mass, while the particles that convey the weak force are very massive — almost 100 times as heavy as the particles that make up atomic nuclei, a fact that explains why the weak force is weak.

What the British physicist Peter Higgs and several others showed is that if there exists an otherwise invisible background field permeating all of space, then the particles that convey some force like electromagnetism can interact with this field and effectively encounter resistance to their motion and slow down, like a swimmer moving through molasses.

As a result, these particles can behave as if they are heavy, as if they have a mass. The physicist Steven Weinberg later applied this idea to a model of the weak and electromagnetic forces previously proposed by Sheldon L. Glashow, and everything fit together.

This idea can be extended to the rest of particles in nature, including the protons and neutrons and electrons that make up the atoms in our bodies. If some particle interacts more strongly with this background field, it ends up acting heavier. If it interacts more weakly, it acts lighter. If it doesn’t interact at all, like the photon, it remains massless.

If anything sounds too good to be true, this is it. The miracle of mass — indeed of our very existence, because if not for the Higgs, there would be no stars, no planets and no people — is possible because of some otherwise hidden background field whose only purpose seems to be to allow the world to look the way it does.

Dr. Glashow, who along with Dr. Weinberg won a Nobel Prize in Physics, later once referred to this “Higgs field” as the “toilet” of modern physics because that’s where all the ugly details that allow the marvelous beauty of the physical world are hidden.

But relying on invisible miracles is the stuff of religion, not science. To ascertain whether this remarkable accident was real, physicists relied on another facet of the quantum world.

Associated with every background field is a particle, and if you pick a point in space and hit it hard enough, you may whack out real particles. The trick is hitting it hard enough over a small enough volume.

And that’s the rub. After 50 years of trying, including a failed attempt in this country to build an accelerator to test these ideas, no sign of the Higgs had appeared. In fact, I was betting against it, since a career in theoretical physics has taught me that nature usually has a far richer imagination than we do.

Until last week.

Every second at the Large Hadron Collider, enough data is generated to fill more than 1,000 one-terabyte hard drives — more than the information in all the world’s libraries. The logistics of filtering and analyzing the data to find the Higgs particle peeking out under a mountain of noise, not to mention running the most complex machine humans have ever built, is itself a triumph of technology and computational wizardry of unprecedented magnitude.

The physicist Victor F. Weisskopf — the colorful director in the early 1960s of CERN, the European Organization for Nuclear Research, which operates the collider — once described large particle accelerators as the gothic cathedrals of our time. Like those beautiful remnants of antiquity, accelerators require the cutting edge of technology, they take decades or more to build, and they require the concerted efforts of thousands of craftsmen and women. At CERN, each of the mammoth detectors used to study collisions requires the work of thousands of physicists, from scores of countries, speaking several dozen languages.

Most significantly perhaps, cathedrals and colliders are both works of incomparable grandeur that celebrate the beauty of being alive.
The apparent discovery of the Higgs may not result in a better toaster or a faster car. But it provides a remarkable celebration of the human mind’s capacity to uncover nature’s secrets, and of the technology we have built to control them. Hidden in what seems like empty space — indeed, like nothing, which is getting more interesting all the time — are the very elements that allow for our existence.

By demonstrating that, last week’s discovery will change our view of ourselves and our place in the universe. Surely that is the hallmark of great music, great literature, great art ...and great science.

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This article has been revised to reflect the following correction:

Correction: July 12, 2012

An essay on Tuesday about the significance of physicists’ discovery of a particle thought to be the Higgs boson described the physicist Victor F. Weisskopf incorrectly. Dr. Weisskopf was, from 1961 to 1965, the director of CERN, the European Organization for Nuclear Research, which was established in 1954; he was not the center’s first director.