Diabologic: Higgs
by Frank Dolinar

Prior to the mid-1960s, the world of physics was awash with a veritable (and growing) zoo of unique sub-atomic particles that appeared to have no discernable relation to one another. None, that is, until Dr. Murray Gell-Mann codified his theory, known as the “Eightfold Way” (alluding to the Eightfold Path of Buddhism), that organized subatomic particles into families and led to the prediction and subsequent famous discovery of the Ω– (Omega minus) particle. For this work, Dr. Gell-Mann was awarded the Nobel Prize in Physics in 1969.

Follow-on work by Gell-Mann and other researchers led to theoretical descriptions and experimental confirmation of quarks, among other discoveries. Many of these results added confirming data to the so-called "Standard Model" of physics, of which the well known concept of the Big Bang is a hallmark.

One of the truths about studying physics is that you have to know math – a lot of math – and understand what it's telling you or the physics doesn't make any sense at all. I know. I've been there.

This has become particularly true given the recent developments in "String Theory" whose complex math is opaque to all but those dedicated and creative physicists who return to the equations repeatedly until they begin to glean some understanding. The Standard Model, while more familiar, depends on math only slightly less esoteric than String Theory. Both are steeped in the concepts of quantum mechanics, which to my understanding is the very definition of counterintuitive. To say that quantum mechanics is "really weird", significantly understates the case.

I have had a fairly serious, long term, interest in physics I have read with relish and tried to understand some excellent science articles about the current state of physics, from cosmology (which describes the structure and evolution of the universe) to elementary particles (the building blocks of all matter).

Over the years, I have repeatedly returned to a question / puzzle. I find myself wondering how much of our theoretical physics, and the data we acquire based on tools and experiments derived from that theory, are artifacts of the tools we use (e.g. particle accelerators) to acquire the data. There's a related question about the math. The mathematics of quantum mechanics, cosmology, particle theory, and string theory are all necessarily complex and rigorous. Yet, I wonder if the math is placing way too many trees between us and our appreciation of the forest.

Which in 2008 brings me to consider the Higgs boson.

The Higgs boson is a hypothetical massive, scalar, elementary particle predicted by the Standard Model of physics. The standard model does a good job and seems to have nailed down the theoretical explanations with solid, verifiable experimental evidence across the board… except for one little problem. Physicists have theorized the so-called “Higgs” field but have yet to experimentally find the Higgs particle.

It is the only particle of the Standard Model not yet observed.

When a field, such as the electric field exists, theory states that there must be a particle to carry (i.e. to be the physical embodiment of) that field. In the case of the electric field the particle is the electron, the understanding of which makes our modern electronic gadgets possible.

According to theory, the Higgs field gives every bit of matter in the universe its mass.

Having said that, I have to admit that this assertion confuses me and is, therefore, a bit disconcerting. Mass is a fundamental property of matter. What does it mean to have a field and a particle that gives all the matter in the universe its mass, including itself? I simply don't know.

The community of physicists thinks it does know.

In pursuit of a definitive answer, physicists (and engineers and mathematicians and the organizations and governments they work for) have built what is arguably the most complex and expensive device in all of human history – the Large Hadron Collider (LHC) at CERN in Switzerland – the largest, most powerful particle accelerator in the world.

It is now September 2008. Construction on the LHC has been completed and the preliminary testing of the systems needed to operate this new laboratory is underway. When it becomes operational – currently scheduled for September 10, 2008, the LHC's goal will be to confirm the existence of the Higgs boson. It will do this by accelerating protons, the particles at the center of the hydrogen atom, to nearly the speed of light (186,000 miles per second, or – if you prefer – 300,000 kilometers per second) and then creating head-on collisions of these particles to see what the debris looks like (based on its behavior immediately after such collisions).

Why do physicists need the LHC?

The answer is found in the most famous equation in physics, Albert Einstein's $E=mc^2$. This equation says – in simple language – that the energy equivalent of a bit of matter is calculated as its mass times the speed of light (designated as 'c') squared. This is a very large number. But note two things:

1) the equation says that mass and energy are simply different forms of the same stuff; and
2) it takes a ***lot*** of energy to make up the difference for even a little bit more mass.

Theory expects the Higgs particle to be considerably more massive than the rest of its "family". It will take a lot more energy to create it in the debris of the collisions. The LHC will have all the energy needed to create the Higgs particle in these collisions – and more.

Given the energy levels required for these experiments, there have been questions and concerns about the safety of the LHC. I believe they are unfounded. If ever there was a device that was over-engineered on purpose with layers of failsafe features, it is the LHC. Based on what I know, it is my opinion that the LHC will work flawlessly as a laboratory for high-energy particle physics.

The Higgs particle isn't the only thing the physicists working at the LHC are looking for, it's just the experiment that has garnered the most press. Among the other things being sought are evidence of:

1) additional dimensions beyond the familiar three dimensions of daily experience;
2) dark matter; and
3) supersymmetry…

all of which are topics far beyond the scope of this short article.

I don't know if the LHC will find the Higgs particle. If it does, then the last bit of proof for the Standard Model will have been found and we will pretty much know how the universe works.

On the other hand, if the Higgs particle is not found, then physicists will have a problem. Should this scenario come to pass, I believe that somewhere in the last three hundred years of theory and experiment the discipline of physics has missed some detail (perhaps tiny, but nonetheless significant) and our understanding of how the universe works is flawed.

Such a flaw, if it exists, it will need to be found and corrected.

From my point of view, failure to find the Higgs particle using the LHC could be the most exciting development in physics in decades.