Looking back into the Big Bang

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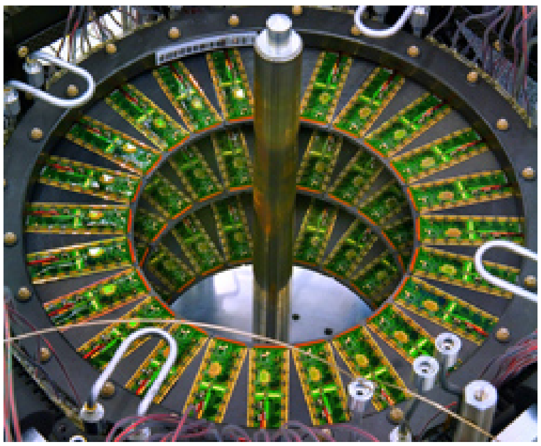

ATLAS Experiment Searches for the Forces That Shaped the Universe. Credit: Lawrence Berkeley National Laboratory

A Q&A with physicist William Trischuk about the Large Hadron Collider.

Did you know that only four per cent of the universe is visibly accounted for? The vast majority is what's called dark matter and dark energy—we can observe its effects, but we don't know what it is.

Did you know that every particle of matter has a corresponding anti-matter particle out there somewhere and that these two particles should annihilate each other? So why are we still here?

These are some of the head-scratchers that particle physicists are hoping the experimental Large Hadron Collider will answer. We spoke to U of T physics professor William Trischuk, one of the scientists working at the Large Hadron Collider to find out how the ambitious project is going.

What is the Large Hadron Collider?

It's the highest energy particle accelerator anywhere in the world. It's a 27-kilometre circular tunnel built 100 metres below France and Switzerland, operated by the European Organization for Nuclear Research (CERN). It allows us to accelerate subatomic particles to previously unimagined energies. There are other places in the universe—the Big Bang—where these kinds of energies have existed, but this is our only controlled way of studying what goes on at these energies.

Why do we want to do this?

If we produce higher energies and collision rates, these can be converted for brief instants in time to mass, to new particles. We know protons are all around us. We are putting energy into them, accelerating them to energies that are 7,000 times what the protons have when they are not moving, and then colliding them. In principle, we can produce energies 14,000 times as high as the protons have on their own.

These are the types of energies that existed after the Big Bang. Particle physics has been chasing the Big Bang backwards to higher and higher energies. We now understand how things work at a millionth of a second after the Big Bang. We're trying to go to a billionth of a second. Producing higher and higher energy collisions takes us back farther and farther toward the beginning of the Big Bang, when all the particles in the universe were made, but before they had coalesced to form protons and neutrons.

And why do we want to reproduce the Big Bang?

We have a Standard Model of physics that has allowed us to explain the world. Everything seems to fit together but we don't understand why. The Standard Model is very rational. We can write down how it works. But we don't understand why it works.

Colleagues in theoretical physics have got lots of great ideas and have written hundreds of papers, but physics is an observational science. We want to peel back the next layer of the Standard Model and put some order to it. The chemist Mendeleev catalogued the periodic table of the elements, but he didn't know about nuclei and atoms and electrons. When science developed more sophisticated measurements it became clear why the periodic table has the structure it has. That's what we're trying to do now in particle physics.

As scientists, first we tried to understand how the atoms and molecules work in chemistry. Chemistry describes the periodic table and allows us to understand why some things are very reactive and some things are not. Then we tried to understand how the protons and neutrons work in nuclear physics. Neutrons and protons tell us how nuclei formed and why some can give us nuclear energy and others are stable and can't. Now we're trying to understand how different combinations of quarks make different particles.

Are there practical applications?

I bring up chemistry and nuclear physics because we've made something of them. When Mendeleev discovered the periodic table, nobody knew what chemistry would allow us to do in everyday life. When Rutherford discovered the nucleus, he was just trying to understand how things were put together, but for better worse, we found things to do with nuclei. We can get energy from them because we mastered the physics that explains to us how nuclear physics work.

This is the same kind of thing that one could imagine doing with the particles—this is the next phase. But all of these applications took 30 to 50 years. It's still 10 years in our future before we begin to learn all the Large Hadron Collider can teach us about particle physics, and then we can begin to explore applications.

This is the way science and engineering have worked together for hundreds of years, going back to Newton with an apple falling on his head. Once we understand the principles, we find applications. I'm firmly convinced that we will find something, whether it will be science-fiction like warp drives, anti-matter, I don't know. But understanding how it all fits together is the first step.

What is your interest in the Large Hardon Collider?

My interest is more in seeing what happens. Others are more focused on analyzing the data the LHC will yield. My specialty is in building pieces of the particle detector. It takes hundreds, maybe even a thousand people to build and maintain the facility. It's an experiment that I do with 3,000 of my closest friends!

Does the detector work like a camera? You accelerate and then collide particles, but do you then take pictures of them?

There are many layers but the innermost layer is very similar to the way a camera collects light, classifies it in terms of colours and digitizes it.

Our detectors are very much like digital cameras—except your digital camera is hard pressed to take a picture a second. We take 40 million pictures a second.

So there are also practical technologies being spun-out of the Large Hadron Collider, aside from any future applications of what we learn about the particles?

Yes. There are many things that we do with the technology that people do turn into something. We push big computers to work together all around the world. We're pleased to take credit for having invented the worldwide web. It was physicists at CERN in the early 1990s who needed to share data and control their experiments, because they couldn't be there all the time, who developed the protocols for sending information back and forth. The web protocols were invented at CERN.

Another example: a couple years ago we had an accident. There was a power outage and a short circuit and it ended up being almost a year-long repair effort. We were pushing the French electricity grid. These lessons will find their way back into the general power distribution system. We're doing electrical transfers that are 100 times more concentrated than anything you would see in normal civilian electric grid. We make mistakes, try to learn from them and disseminate what we learn back to the electricity providers.

There was a leak to the media a few months ago suggesting that the Higgs particle, often called the "God Particle," had been detected. What is the Higgs and did you find it?

The Higgs particle is theorized to interact with everything. It's a mechanism that Peter Higgs, a theorist who worked in the 1960s, described. He did a thought experiment and looked at what kind of thing could explain the array of particles we have in front of us now. It's a beautiful and very economic theory, but we have no direct evidence for its existence. Unfortunately with the data we have now, we aren't able to see Peter Higgs's theorized particle. In fact, with more data, it turns out we had only seen a hint. The additional data is telling us it was just a statistical fluctuation.

When do you think the group will have any findings of note to report?

When we're able to say we've "discovered" something it will have been based on data we've taken for six months to a year. There's also another experiment, called CMS, doing the same thing we're doing. We don't want to get scooped by them and they don't want to get scooped by us. There is pressure to do things as efficiently as we can, and yet not to get it wrong. We want to discover what's there. We don't want to discover what's not there! There are lots of examples of people discovering what's not there and then six months or six years later somebody comes up with unequivocal evidence showing that it was a mistake.

Provided by University of Toronto

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