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The LHC: Worth the Risk?

Last summer, I saw the worst movie. It was a 2006 production called "The Black Hole". And you know a movie is bad when its Wikipedia page looks like this (slide 1), with a 1 line plot summary. (click) I quote, "Something goes awry at a particle accelerator facility and a black hole begins to form. It takes much of St. Louis in its wake. There is also an energy-based monster that appears from the black hole that causes havoc." That is basically what happens and pretty much all you need to know about the movie. Needless to say, it was so bad that I bought it. And now I own it. (slide)

So, why do I bring this up now? Well, it has come to my attention that apparently far more people have watched and internalized the premises of this straight-to-DVD movie than I could have ever thought possible. And they're concerned, and they're angry, and this is all coming out because of a little thing called the LHC.

LHC stands for the Large Hadron Collider. (Slide 3) A new particle accelerator at CERN built underground outside Geneva, Switzerland through the collaboration of scientists from 100 different countries. It is an enormous undertaking and has already cost several billion dollars. (Slide 4) And the whole *huge* thing? It is to accelerate, collide, detect the interactions between very *small* things, namely, protons. And it is the most powerful facility of its kind by an order of magnitude, capable of accelerating protons up to an energy of 7 TeV. (Slide 5) Converted to velocity, 7 TeV protons travel at 99.9999991% the speed of light.

Essentially, that's all that this enormously complex piece of machinery does. It forces particles to interact with one another at high energies, and allows us to monitor very precisely the results. It may not seem like much, but consider that everything we know about the world around us we know by interacting with it. You're looking at me right now, and listening, maybe, (at least hearing) and you're taking for granted that I am here in this room, and talking, but your only information regarding that comes from the photons bouncing around the room and the vibrations propagating through the air. By chance, they enter your eyes and ears, and by chance, you are programmed to be able to interpret them, and that's how you know. This experiment isn't too different. Physicists are trying to observe phenomena that have never observed before, so we need a new set of eyes and ears. You can think of it like this: The answers, the secrets to the Universe, well, they're right here in front of our faces, and they've been here all along, *in this space*. We can guess all we want at what's actually there, but what we really need, is to *see* it.

(Slide 6) I think we're at a pretty significant crossroads in our understanding of it all. For centuries, the study of physics has stepped toward this ultimate goal. Mass was probably one of the earliest discoveries: we pushed on an object and it resisted. We called this inertial mass. We lifted an object up off the ground and it had weight, we called this gravitational mass. (Click) Then one day, we discovered those are actually equal, something that we now take for granted, but was never so obvious before. And then there was electricity and magnetism. Discovered separately, found later to be related through merely a shift in reference frame, unified through Maxwell's Equations (Click). And then it was space and time, particles and waves, mass and energy... (click click click) And where are we now? And what will it be in the end? (click) This is the standard model of particle physics. And so far it's the most promising candidate for eventually becoming a theory of everything. What does it say? All matter is made up of these, the quarks and leptons, the former are components of protons, neutrons, and the electron is a lepton. And every force, every interaction, is one of a combination of these four fundamental forces acting on the fundamental particles: strong, weak, electromagnetic, and gravitational, with the gravitational force being by far the weakest. (click) But could they be different manifestations of the *same* interaction?

So far, nearly every experiment performed has confirmed the Standard Model of Particle

Physics, but there is one particle, the Higgs particle, responsible for giving other particles the property of “mass”, predicted by the Standard Model, that has never before been observed. We simply haven't had the tools to even look. And imagine, once we have this tool in our hands, this new way of seeing the world, we may find the Higgs particle, or we may not, and either way the world would look different from the day before. But more importantly, what else might we see?

Scientists have some ideas. We might find out what makes the gravitational force so weak compared with the others. We may finally learn what makes up all the dark matter and dark energy in the universe. We may discover extra dimensions. We may even find the mechanisms behind the unidirectional flow of time. We certainly stand much to gain from these experiments.

So then, why did AOL and BBC find, (Slide 8) that when asked if they supported the LHC, the public only responded with a small majority? (Hold up DVD) Certain theoretical models postulate the existence of extra dimensions accessible by the carrier of the gravitational force – the graviton – but not by any other particles. Under these conditions, it then becomes theoretically possible for two particles to pass close enough to one another to form a microscopic black hole. (slide) What was (and continues to be) an exciting possibility for physicists has grown into a public concern, that once a black hole is formed, it cannot be unformed and will proceed to swallow the Earth. In the Sci-Fi thriller, the scientists outwit the black hole and annihilate it using the electricity monster, and the world is saved but everyone knows that part isn't real.

In all seriousness, given the strangeness of the theories involved, it is no wonder that these questions are being asked. Some things to remember though: particle accelerators merely recreate the natural occurrence of cosmic ray collisions in a controlled setting. (Slide) Cosmic ray protons have been known to have energies millions of times greater than the maximum energies produced by the LHC, and they have been colliding since the early universe. Any delocalized effects, such as destroying the universe as we know it, would have probably been observed by now. But what about the microscopic black holes?

(Slide) First of all, it's easy to confuse the exotic with the terribly dangerous and forget the fact that black holes are really no big deal. A black hole by definition is an object contained entirely within its event horizon. Every object has an event horizon, me, you, Professor Strang. If he were about 1e-25 meters tall, he would very likely be a black hole. But his gravitational effect on the rest of the class would remain unchanged, you won't suddenly feel a vacuum-like tug toward him if you don't feel one now. And Professor Strang is many times the mass-energy of a proton. A microscopic black hole created by the head-on collision of two protons is miniscule (SR = 1e-50m) and should evaporate via Hawking's Radiation in a time orders of magnitude shorter than Planck time, which happens to be the smallest measurable unit of time in nature, which means it can't be created at all. Some may say they don't believe in Hawking's Radiation, well, in that case, they definitely shouldn't believe in the extra dimensions responsible for these microscopic black holes in the first place, since that theory is far less robust than Hawking's theory of black hole evaporation.

In the interest of a good time, let's say a black hole, against all our current physical comprehension, has been created. (slide) It will most certainly shoot straight out of the gravitational field of the earth, granted that escape velocity on earth is only about 11 km/s and these particles are traveling at approximately the speed of light. But say it doesn't, and the particles collide in precisely the right way as to cancel out their momentum entirely. Even a shoddy calculation immediately reveals that a black hole of that size falling straight through the center of the earth, and oscillating thereafter, would not swallow a gram of mass in 5 billion years, at which point the Earth, and I guess the still microscopic black hole, would be swallowed by the Sun. And this is the absolute worst case scenario.

I hope I've convinced you that microscopic black holes which behave like we expect black holes to behave are nothing to worry about. But some very intelligent people have put forth theories about how the strangest things could happen with a nonzero probability and nothing could behave like we expect and the world would *find* a way of ending anyhow. To this, I throw up my hands and merely say that, it is true, at least according to our current theories, that nothing is ever certain to either occur or not occur. But I wonder why you've focused all your woes on this particular freak occurrence, you might as well be worried about the Earth spontaneously combusting or evaporating or teleporting into the center of the sun as these are all also possible, but highly unlikely scenarios. (slide)

In the end, I hope everyone relaxes a bit. Yes, there is a very small chance of the universe or Earth as we know it ending as a result of this experiment, but it's rather out there. Personally, though, I wouldn't care too much either way. I'd be pretty thrilled if we learn something deep from these experiments and not too sorry if we lose some weird cosmic lottery and end up destroying the planet. Because, look at us. Look at all of this. Why are we here? We live for a while and then we die anyways. If there's a chance at all we might figure all this out in our lifetime, I'm happy to take it.

Works Cited

CERN. "The Safety of the LHC." http://public.web.cern.ch/Public/en/LHC/Safety-en.html 2008.

LHCfacts.org. "Some Scientists Are Concerned." http://www.lhcfacts.org

Quigg, Chris. "The Coming Revolutions in Particle Physics." Scientific American. January, 2008.

Discover Magazine. "The Extremely Long Odds Against the Destruction of Earth." July 24, 2008. http://discovermagazine.com