

UC Newsroom

Ask it! - black holes

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Q. This summer, CERN (the European Organization for Nuclear Research) will launch operations of the Large Hadron Collider - a 17-mile, circular particle accelerator buried 300 feet below Switzerland and France. There is a lot of controversy about the safety of the collider, especially its potential to create black holes, which could annihilate the Earth. Is this dangerous?

A. The Large Hadron Collider does indeed represent a quantum leap for particle colliders. In addition to providing insight into why particles have



mass, the LHC may discover new forces or produce dark matter, the mysterious particles that make up most of the matter in the universe.

Any of these would be a revolutionary discovery, but there are also other possibilities that are even more exotic and speculative. The production of black holes is one of these. A black hole is a region of space in which mass is packed so densely that even light cannot escape its gravitational pull. Black holes are predicted to exist by Einstein's theory of general relativity and are by now standard in astrophysics – there is strong evidence that many galaxies, including our own, have black holes at their centers, with masses that are millions to billions times that of our Sun.

General relativity also predicts, however, that black holes cannot be produced at the LHC. The reason is simple – for all its power, the LHC's energy is still 17 orders of magnitude too small to produce the matter densities required to form a black hole. If there are extra spatial dimensions beyond the three we observe, however, this discrepancy can be removed, and black holes can be produced at the LHC. In stark contrast to their astrophysical cousins, however, the LHC's black holes would be much smaller than a proton and would vanish in a burst of electrons, photons, and other standard particles through a process called Hawking radiation in less than 10^{-27} seconds, long before they could grow by accreting other matter. Thus, even if black holes are produced at the LHC, they will not annihilate the Earth.

Still, one might ask: What if black holes are produced and the theory of Hawking radiation is simply wrong? Could the LHC's black holes then catalyze a global catastrophe? It turns out that, although the LHC has yet to begin operation, collisions far above the LHC's energies are already taking place all around us, because the Earth is constantly being bombarded by extremely high energy particles, called cosmic rays. If black holes can be produced at the LHC, cosmic rays should be producing them at the rate of a few per minute somewhere in the Earth's atmosphere. The fact that the Earth has survived these collisions provides further evidence against Earth-eating black holes.

For all of these reasons, researchers have failed to identify an even remotely plausible scenario in which the doomsday catastrophe is realized. In fact, more typical is the opposite problem, that new phenomena, whether they be new particles, new forces, or black holes, may appear very subtly, and physicists are now straining to ensure that new discoveries are not lost in the flood of data when the LHC begins operation in the coming year.

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Due to the volume of Ask it! submissions, not all questions can be answered online.

Previous Ask it! questions:

Q. With so many birds in the world, and in our urban environment, you would think we would see dead birds all over the place. But we don't. So, where do birds go to die?

Q: Weight loss is based on expending more energy than consumed, and for every 3,000 calorie deficit you lose one pound. Assuming both an obese person and someone slightly overweight eat proportionate calories and exercise at equal levels,