A Lawyer's View of the Risk of Black Hole Catastrophe at the LHC

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Is an LHC doomsday scenario a groundless fear or a legitimate concern? Image credit: CERN.

(PhysOrg.com) -- Just bringing up the topic of the Large Hadron Collider (LHC) creating a black hole that destroys the Earth might seem unscientific and out of place on a science news website. After all, the subject is generally considered to be out of place in the particle physics community, since peer-reviewed studies have shown that there is no significant risk of an LHC doomsday scenario.

But, right or wrong, many people continue to voice their concern about the LHC's potential to produce a worldwide catastrophe. Some of these concerns clearly go overboard, stemmed by fear and ignorance. In the midst of this extremism, is it possible for someone outside the physics community to analyze the LHC's risk of producing an Earth-swallowing

black hole in a rational way?

Eric E. Johnson, an assistant professor of law at the University of North Dakota, has undertaken this task from a legal point of view. He has recently published a paper in the *Tennessee Law Review* in which he investigates how the courts might handle the LHC case and other future cases of largely unprecedented, potentially dangerous sci-fi-like experiments. The 90-page paper is highly readable for non-scientists, and is available at arxiv.org. Johnson, who admits that he is "unanxious" about a doomsday scenario, has two reasons for writing the paper: first, to present a kind of case study for debate among lawyers; and second, to prepare to solve such a legal case in real life.

"I intend to provide a set of analytical and theoretical tools that are usable in the courts for dealing with this case and cases like it," Johnson writes. "If litigation over the LHC does not put a judge in the position of saving the world, another case soon might. In a technological age of human-induced climate change, genetic engineering, nanotechnology, artificially intelligent machines, and other potential threats, the odds of the courts confronting a real doomsday scenario in the near future are decidedly non-trivial. If the courts are going to be able to play their role in upholding the rule of law in such super-extreme environments, then the courts need analytical methods that will allow for making fair and principled decisions despite the challenges such cases present."

The Science

In his paper, Johnson begins with an overview of the background of the LHC, as well as the lab at which it's located, the European Organization for Nuclear Research (CERN) in Geneva, Switzerland. This overview is followed by a short history of one of the LHC's predecessors, the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory in Upton, New York, and then a brief explanation of alleged

dangers such as strangelets, magnetic monopoles, bosenovae, and vacuum transitions. Regarding the safety of these potential disaster scenarios, CERN's argument is the same for each of them: high-energy cosmic-ray collisions (which are similar to those produced in particle colliders) have been occurring in Earth's atmosphere throughout the planet's history - so anything dangerous that the LHC could create would already have been produced by cosmic rays long ago. The fact that the Earth still exists is living evidence of the safety of these scenarios.

The question of the black hole risk came up recently in 1999, inspiring particle physicists at the RHIC to analyze the possibility. They found that the forces created by modern accelerators were insufficient to create a black hole - at least in a four-dimensional world. Shortly after, physicists found that black holes could be produced if there were extra dimensions, a possibility in some theories. In light of these findings, CERN physicists reexamined the safety issue and found that the LHC would likely produce black holes, but that they would rapidly evaporate due to Hawking radiation.

While very few particle physicists have challenged the orthodoxy of Hawking radiation, the theory does have a few outside critics. Johnson highlights a few of these critics, including chaos theoretician Otto Rossler, who calculated that "LHC-produced black holes might grow fast enough that the world might end slightly more than five years after the LHC's first full-energy collisions." Although CERN physicists didn't respond directly to Rossler's shocking argument, media and citizen inquiries regarding the LHC's safety prompted CERN to set up the LHC Safety Assessment Group (LSAG).

In a paper written in 2008, Mangano (a CERN employee) and Giddings (who accepted a future visiting position at CERN) turned to the cosmic ray argument rather than the Hawking radiation argument, which was becoming less persuasive. However, they found that black holes

produced by cosmic rays could potentially slip through the Earth, which is made mostly of empty space, while black holes produced by the LHC could remain in the vicinity for a long time, slowly gaining mass. Looking deeper into the universe, the physicists found that a kind of white dwarf star, eight of which have been observed, could likely hold black holes for a long time, and so their continued existence must serve as living evidence that the LHC is safe.

Although Giddings and Mangano concluded that there is no risk of "any significance" from black holes produced by the LHC, Johnson notes that CERN's Scientific Policy Committee (SPC) took an extra step, announcing to the public that the results excluded "any possibility" of risk. When the Giddings and Mangano paper was posted publicly in 2008, astrophysicist Rainer Plaga wrote an unpublished paper arguing that Giddings and Mangano's paper did not exclude all possibilities of disaster. In one argument, Plaga showed that, if black holes were smaller than the CERN physicists calculated, they could conceivably sail through white dwarfs as well as the Earth, showing that the white dwarf argument isn't conclusive.

Johnson said that, while researching the subject, he was surprised at the legitimate science controversy surrounding the crazy-sounding idea of black holes destroying the Earth.

"Many of the physicists quoted in the media on LHC safety issues seem not to have engaged with the literature in any depth," Johnson told *PhysOrg.com*. "Physicists speaking to the public about the black-holes question portray it as a simple matter. It really is not. At the end of the day, the LHC may or may not be safe, but most of the arguments you hear in favor of the collider lack robustness."

The Law

Complex disagreements such as these lead to great challenges when it comes to analyzing the risks of science experiments in a court of law. First of all, the only people who have the qualifications to understand the physics are the physicists themselves, which creates an obvious conflict of interest. The problem of insider testimony is just one of the unique problems in this kind of unprecedented case, which Johnson describes as a "jurisprudential singularity." He explains that the legal problems posed by black holes mirror the problems they create for physics.

"Physicists relate that in the vicinity of a gravitational singularity, equations break down, and the known laws of physics seem to fail," he writes. "With reference to American law, I discuss three lines of legal doctrine that suffer similarly: preliminary-injunction analysis, expert-testimony gatekeeping, and cost-benefit analysis. Developed for a world of automobile accidents, toxic waste, and teratogenic pharmaceuticals, these doctrines all start to break down when confronted with the extreme facts of the black-hole case."

In order to stop the LHC from operating, a plaintiff would likely seek a preliminary injunction against CERN. As Johnson explains, "under American law, a preliminary injunction is a way for a court to order an immediate halt to a specified activity, without the necessity of going through a full course of discovery and trial." Preliminary injunction requests are used, for example, to stop impending plans to demolish buildings of historical significance and as restraining orders in domestic violence cases. After a preliminary injunction has been issued, the lawsuit would continue with a more comprehensive trial. Eventually, the defendant would either receive a permanent injunction, or the suit would be dismissed and the preliminary injunction removed.

Already, several suits to stop the LHC have been initiated by "a colorful assortment of plaintiffs," but none has been successful, for various reasons. For example, in a Hawaii lawsuit, the issue was considered one

of political policy. Also, CERN has signed treaties with its host states, Switzerland and France, that guarantee CERN immunity from legal processes.

As Johnson explains, it would not be difficult to get a preliminary injunction if CERN overtly threatened an illegal action, which of course it has not. On the other hand, getting an injunction against a perceived future risk is rare, aside from specific situations, such as domestic violence. A plaintiff would have to show that the defendant, CERN, has been negligent and not done what a reasonable entity would do to protect others from foreseeable risks. Such cases are rare because usually there are laws that explicitly prohibit negligence of various sorts (such as traffic laws to prevent accidents). In the arena of cutting-edge science research, there are no specific laws that CERN has broken because of the uncharted territory. In addition, by performing a cost-benefit analysis using the Hand formula, Johnson shows that the risk of the LHC destroying the world can be calculated to be either infinite or nothing simply by tweaking the inputs just a tiny bit - just like the singularity of a black hole, to further his analogy. This lack of certainty in risk analysis contributes to the difficulty of getting an injunction.

A Judge's Challenge

When deciding whether or not to issue an injunction against CERN, Johnson suggests that a judge should perform a meta-analysis of the case, going beyond the current scientific analysis to look at four issues: errors in the scientific theory on which the safety analysis is based, errors in the calculations or assumptions in the safety analysis itself, cognitive biases such as psychological and cultural biases, and non-innocent errors motivated by self-interest.

In the last 20 pages of his paper, Johnson provides several examples of these four issues. For instance, he points out how scientists tend to

exercise caution when presenting their research and readily admit to its limitations, yet on the issue of LHC safety, CERN seems to show a sense of absolute confidence. Even a relatively small observational error of the eight white dwarfs could undermine the safety argument, Johnson notes, since these eight objects are all that the ultimate conclusion rests upon. Such errors would not be unprecedented in science, as even scientists are subject to human fallibility. Johnson points out that, in 2003, it was found that the two papers written to address safety concerns about a potential strangelet disaster at the RHIC both contained conceptual math errors that affected their conclusions.

“Giddings and Mangano conclude that there is no conceivable risk,” Johnson writes. “But it does not follow that LHC risk is zero: An accurate assessment of risk must include the possibility that Giddings and Mangano themselves are mistaken.”

Finally, Johnson suggests that the courts should look at the psychological and sociological issues that contribute to the vulnerability of the scientific process. Stopping the LHC now would destroy the investment of billions of dollars and many physicists’ careers. In this sense, an individual physicist is better off concentrating on the science research than getting involved in safety and legal issues.

The CERN culture, which consists of thousands of physicists from around the world working together, is a great international collaboration that has pushed science forward. Yet, as Johnson notes, such a group culture also has the tendency to push dissenters to the fringe, and perhaps artificially inflate the certainty of unanimously enforced views. These sociological factors are difficult to acknowledge, since they are at odds with the field of science itself, which attempts to be as objective as possible. Nevertheless, from a judge’s point of view, all humans are subject to the same human law.

Scientists have a responsibility to the rest of the world to ensure that their experiments are safe. While scientists are not above the law, the case of the LHC is obviously a unique situation that deserves special treatment - especially since it may be setting a precedent for future cases as scientists continue to make extraordinary advancements. Without offending the profession, the question is fair to ask: what is the best way to continue to make scientific discoveries without risking human life? Is it possible to agree on an accepted level of risk?

Or, as Johnson puts it, "Can human law survive in a realm 'where physical law ends'?" He argues that the courts have the power to perform an in-depth analysis - involving a thorough review of the evidence and gathering testimony from scientists with no personal stake in the LHC - that could provide answers to these questions.

"At the end of the day, whether the LHC represents an intolerable danger is, in my view, an open question," Johnson concludes. "I have not endeavored to provide a definitive answer. But I think the courts should. … Courts must develop tools to deal meaningfully with such complexity. Otherwise, the wildly expanding sphere of human knowledge will overwhelm the institution of the courts and undo the rule of law - just when we need it most."

More information: Eric E. Johnson. "The Black Hole Case: The Injunction Against the End of the World." 76 *Tennessee Law Review* 819 (2009). Also available at arxiv.org/ftp/arxiv/papers/0912/0912.5480.pdf