Risk Taking Should be Mainstream in Science

By Avi Loeb on September 8, 2020

There is a common thread running through the Physics Nobel prizes in recent years. The ability to detect gravitational waves by LIGO, the existence of exo-planets, and the supermassive black hole at the Milky Way center, were doubted by most astronomers before they became trendy. And for each visible case, there must be many others that did not get public attention. Rai Weiss faced resistance from colleagues at MIT and beyond, and Andrea Ghez was not taken seriously by senior faculty at Caltech. These common experiences suggest that pioneers at the frontiers of science confront a fundamental dilemma. Paraphrasing on Hamlet's famous question, they ask themselves: "*to announce, or not to announce?*" One could wait for more data, but if the error lies in the interpretation, as was the case for the Mayans who believed in astrology, then more data will not bring clarity. Sharing the results publicly could allow other scientists to scrutinize the finding through an honest analysis process. Science is iterative and full of mistakes along the way. For example, in 1939, Albert Einstein published a paper in *Annals of Mathematics* doubting that black holes exist. The Physics Nobel prizes in 2017 and 2020 show that he was wrong.

The race among competitors sometimes triggers a premature decision, as was the case with the BICEP experiment - which reported detection of B-mode polarization from cosmic inflation just before the Planck satellite data was analyzed. But in other cases, such as the OPERA experiment - which reported faster-than-light neutrinos, the detection of phosphine as a sign of life in the cloud decks of Venus, or the EDGES experiment - which reported an unexpetedly strong 21-cm signal from hydrogen atoms in the early universe, there was no imminent threat by competing teams.

When the first interstellar visitor to the Solar system, `Oumuamua, appeared weird, the mainstream community declared business as usual and interpreted it as an unusual asteroid or comet, unlike any asteroid or comet that we have seen before. The response resembled a young kid who encountered cats at home and on a first visit to the Zoo, sees an elephant and calls it an unusual cat, unlike any other cat seen before. A couple of years ago, I suggested that the weirdness of `Oumuamua, regarding its extreme shape and excess push away from the Sun, may imply that it was a product of an alien technology, a lightsail. This suggestion generated impulsive resistance from the mainstream community. It was disappointing to see scientists react to it on Twitter rather than on Wikipedia, ignoring the advice of basketball coaches: "keep your eyes on the ball and not the audience".

In contrast, the search for Weakly Interacting Massive Particles (WIMPs) as the dominant constituent of matter in the universe, the so-called "dark matter", is regarded mainstream. This started several decades ago, when it was realized that the weak-interaction cross-section yields the appropriate relic abundance of the lightest, and hence stable,

supersymmetric particle, establishing the so-called "WIMP Miracle". As a result, hundreds of millions of dollars were spent by federal agencies, resulting in merely upper limits that ruled out the favored parameter space. In addition, supersymmetry was never found by the Large Hadron Collider.

Compare this state of affairs to the out-of-the-mainstream Search for Extraterrestrial Intelligence (SETI), which looks for analogs of a phenomenon we have here on Earth. Given that tens of billions of other planets in the Milky Way galaxy have a surface temperature similar to the Earth, the proposition that we are not alone is conservative and should be endorsed by the mainstream. Why is it not funded generously like the search for WIMPs?

The general public pays taxes that fund science and is much more eager to know the answer to the question: "are we alone?" than to the question: "are WIMPs the dark matter?", not to speak about speculative notions of "extra dimensions" or the "multiverse", which have no evidence to their credit. Why would the mainstream scientific community shy away from the public's interests and focus on esoteric questions with little relevance to the layperson? Is science intended to be an occupation of the elite, preoccupied with mathematical gymnastics, buried behind the walls of an opaque cocoon and playing the role of an oracle that lectures to the public as a traditional teacher would do in a class?

By supporting the mainstream orthodoxy during Galileo Galillei's days, we would have given justification to placing him in house arrest and not looking through his telescope. This would clearly be contrary to our current ambition to support evidence-based science.

If we wish to use evidence in guiding our decisions about vaccines during the COVID-19 era, then we should similarly not obsess with string theory, the multiverse or extra dimensions in our books, but rather describe the unusual evidence on `Oumuamua which makes it different from any comet or asteroid we have seen before. These facts are indeed what I describe in my forthcoming book, to be published in January 2021.

My personal experience exposed me to the strong headwinds that confront scientists who attempt to innovate. The fundamental question is when should a scientist announce a puzzling result given the inevitable backlash on Twitter? Kids never consider this dilemma and this is why they learn so fast. Perhaps scientists should adopt the same approach.

In another example involving the Cosmic Microwave Background (CMB) anisotropies, the common practice of experimentalists in the early 1990s was to set upper limits rather than report a discovery of a signal. This changed when the COBE satellite announced a detection with a high statistical confidence. As soon as that happened, teams of ground-based experiments announced a detection consistent with COBE. Some of these teams would have been contenders to COBE's Nobel Prize, if they had been bolder early on.

Science relies on reproducibility of results and independent tests. And so, the argument in favor of announcing a puzzling finding is that it would encourage other scientists to examine it. BICEP motivated the Planck satellite team to use their multi-frequency data and explain the reported signal in the context of dust emission in the Milky Way galaxy and not

the infant universe. The all-sky signal reported by EDGES motivates the HERA interferometer to achieve the sensitivity needed to check it by resolving the sky in a year. The admission that `Oumuamua is special relative to all the objects we previously witnessed in the Solar system provides a good motivation for the *Legacy Survey of Space and Time* (LSST) on the Vera C. Rubin Observatory, which will get its first light next year.

An improved scientific understanding of nature will ultimately prevail, no matter what tactical mistakes we make along the path to discovery. But progress can be faster if people are willing to stick their neck out with the humble recognition that they might be wrong. Mistakes are an inevitable part of our learning experience as students of mother nature, humbled by the fact that its splendor often exceeds our imagination.

ABOUT THE AUTHOR

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(Credit: Nick Higgins)