A Tale of Three Frontiers

By Abraham Loeb on November 18, 2019

Jim Peebles and Avi Loeb, Institute for Advanced Study, Princeton (2003)

Remarkably, two of the last three Nobel prizes in Physics were awarded to pioneers of new frontiers in the narrow branch of **astrophysics**. But even more surprising is the common delivery pain that all these frontiers shared early in their history. Let me explain.

In 1991 I was a postdoctoral fellow at Princeton seeking a faculty position. After inquiring about job opportunities, a highly distinguished professor at a prestigious university on the west coast consulted with his colleagues and replied: "we might entertain a junior faculty position in your field of theoretical cosmology if we could only convince ourselves that it is a science". Two years later, the COBE satellite team released its pathbreaking data on the primordial anisotropies of the cosmic microwave background, identifying the seeds of cosmic structure as predicted by theorists. In 2019, the Nobel Prize was awarded to my mentor and collaborator, Jim Peebles, for his pioneering research in theoretical cosmology.

Two decades later, as a tenured professor at Harvard University I decided to deliver a pedagogical lecture in which I highlighted the promise of gravitational wave astrophysics at the 30th Jerusalem Winter School for graduate students. After describing this field and my related research in the lecture, one of the other senior lecturers asked bluntly in front of the entire audience: "why are you wasting the time of these students on a subject that will clearly not be relevant for their future careers?" Two years later, the LIGO collaboration detected the first gravitational wave signal from a black hole merger, for which the Nobel Prize was awarded to Rai Weiss, Barry Barish and Kip Thorne in 2017. Most of the students who attended the Winter School in 2013 were still working on their PhDs in 2015, when LIGO discovered this source. The subsequent discoveries of many additional LIGO sources revolutionized astronomy from being focused on electromagnetic radiation to a multi-messenger discipline. The hostility voiced at the Winter School was common practice throughout the astronomy community for the preceding decades, when LIGO sought funding by NSF. Many argued that LIGO is a pipe dream that will take away funds from traditional astronomy and not provide anything in return. Similar skepticism accompanied the early days of microlensing searches for dark matter or planets, in which I participated.

The lack of foresight in recognizing unexplored discovery space by popular scientific cultures is not a new phenomenon. In 1952, Otto Struve wrote a paper in which he suggested searching for Jupiter-mass planets that orbit close to their host stars, just like tight binary star systems. For four decades, time allocation committees on major telescopes dismissed this suggestion based on the argument that "we understand why Jupiter is so far away from the Sun and there is no reason to expect the architecture of other planetary systems to be any different; in addition, there might not be any exoplanets, so why waste our precious telescope time?" Forty-three years after Struve's paper, the serendipitous discovery of the hot Jupiter 51 Pegasi b around a Sun-like star by Michel Mayor and Didier Queloz mainstreamed the study of exoplanets and earned this duo the 2019 Nobel Prize.

Once a research frontier is well established - as currently the case with studies of cosmology, gravitational-wave astronomy or exoplanets - young researchers are attracted to it. Unaware of the early bruises in the frontier's history, they assume that it was always vibrant and viable. There are two reasons to correct this naive notion by reminding everyone of the painful early histories of these research fields. First, we must educate the younger generation of scientists to be open-minded and tolerant towards emerging frontiers before these come to fruition. And second, historical memory would encourage innovators to persevere and not be afraid of the headwind they encounter. After all, delivery pains emerged as soon as modern science was born as a new discipline, when Galileo Galilei's suggestion to analyze data without prejudice was dismissed by philosophers who were deeply entrenched in their beliefs.

History repeats itself when it is forgotten by new generations of scientists. These days, the search for extraterrestrial technological civilizations, in which I am engaged, encounters even more hostility than that experienced in the above three examples. This has little to do with professional conservatism but more with social trends, since SETI is less speculative than some dark matter searches which are federally funded. And contemporary bullying is amplified even more by the megaphone of social media. In order to relieve future scientists from the recurring pain associated with the birth of new frontiers, it would be prudent to educate fledgling researchers to act as independent individuals rather than to close ranks with traditional group thinking.

Some may argue that a healthy dose of skepticism is helpful when resources are limited. But the early studies of theoretical cosmology or exoplanets did not require heavy funds. And even for an expensive experimental facility like LIGO, there is a distinction between legitimate physics-based criticism and unprofessional skepticism or intimidation as a tool for preserving traditions. Our community should avoid the "Ostrich choice"; if we bury our head in the sand, we will not see new horizons. Although such a choice would preserve our prior dogma, it will also signify self-imposed ignorance. Hostility to new frontiers delays progress and reduces the efficiency of the discovery engine that propels us forward.

What should we learn from history? My own take is that future generations of scientists should aim to do better than the above three examples demonstrate. Here's hoping that in order to win a Nobel prize in the future, an astrophysicist will not be destined to pursue a frontier that is initially ridiculed by colleagues.

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