Christopher Jacobs

12/1/17

Modern Physics

Fast Radio Burst

Imagine surfing through data from six years prior and finding a huge blip of energy. This said blip of energy is so large that over one billion 1200-watt microwaves could be run for approximately five milliseconds, or even more astounding, but comparable, they produce “as much energy as 500 million suns” in the five milliseconds that the bursts last (Strauss). This exact imagined scenario occurred in 2007 when astronomers at the National Radio Astronomy Observatory in Green Bank, West Virginia observed what is now known as the Lorimer Burst (Lorimer). The Lorimer Burst, named after the lead scientist on the observation team, is the specific name of the first observed Fast Radio Burst. A Fast Radio burst, in short, is a large burst of energy over a miniscule duration of time. After 2007 approximately twenty-four Fast Radio Burst have been observed while it has been estimated by Chatterjee that “between 5,000 and 10,000” are passing the earth on any given day. Excitingly, these bursts can be used to map out both the universe in-between where the bursts originate from to where they are observed and how the medium changed over time.

Beginning in 2007 when the first Fast Radio Burst had been observed, major skepticism of these bursts spread throughout the scientific community. Skeptics thought the bursts to have more likely have been created terrestrially rather than extra galactically, they offered a multitude of options that would support their hypothesis of an Earth based origin. Most of these options were ones that would create a large amount of energy in a short period of time: the most interesting theory is farm animals running into electrical fences (Strauss). In 2015 this skepticism was supported by radio signals that appeared to look the same as Fast Radio Burst. These false Fast Radio Burst, coined perytons, after a mythical creature that is a stag-bird fusion, were found by researchers in Australia at the Parkes radio telescope. The researchers, surprisingly, did not find these perytons while manning the telescope, but while interrupting a microwave mid-cycle. They saw this was what was producing the perytons. This interruption of the microwave turned out to create a similar looking signal that a Fast Radio Burst would produce (Hall). Other viable options, other than a microwave, to create Fast Radio Burst like signals: signals omitted from aircraft, lighting, solar flares, gamma-ray burst, and electrical discharges between clouds. Scientist at the Parkes radio telescope are quite sure that these predictable perytons and erratic Fast Radio Burst are two entirely different events, even though the two have a similar specific look, where the “lower frequencies arrive noticeably later than the higher ones.” (Hall). Knowing that “lower frequencies arrive noticeably later than the higher ones” allows scientist to more easily determine if a signal is a Fast Radio Burst or noise i.e. if frequencies do not arrive in the expected order then there is no way it is a Fast Radio Burst.

Fast Radio Burst are coined they way they are because they last less than five milliseconds (Fast), are detected by radio telescopes (Radio), and show up just as fast they leave (Burst) (Stierwalt). Due to the nature of the burst they are extremely difficult to observe. While it is estimated that Fast Radio Burst occur at a rate of about one for every ten seconds these are not captured simply because of the vastness of the sky; combined with the limited view of the radio telescopes they are even more elusive. The Green Banks Telescope specifically only has a viewing field of one arc minute of the sky, approximately one twenty-one thousand six hundredths. This means the observing telescopes must be pointed exactly where and exactly when the burst occurs, so they can be seen. That is why only approximately two dozen from estimated thousands have been seen.

While only a small fraction of Fast Radio Bursts have been observed they are even more elusive when trying to locate where they are coming from. Hilariously, there are as many theories of where the burst originate as there are observations. While there are some unlikely ideas, far-fetched theories such as the burst coming from the engines of unidentified alien space craft have not been counted out. There are a multitude of more legitimate theories which are any event that would create a quick large burst of energy once, is an accepted theory at this point.

One of the most interesting Fast Radio Burst comes from FRB121102, which was discovered on November 2nd, 2012. A radio burst from this region came in at 5 to 8 GHz. This burst is the most interesting, since it is a repeater unlike all the others. Due to the fact that the burst is repeating it is the most studied burst; it has a known location in the universe, rather than being ambiguous in its’ position like the nonrepeating ones. Also, because of its repeating nature it is used to test equipment for precision and accuracy (Drake). FRB121102 is located three billion light-years from Earth (Strauss). Chatterjee suggests that the causation of the burst may have something to do with the “evolution of the universe.” Due to the reoccurrence of the Fast Radio Burst scientist with the Breakthrough Listen project, using the Green Bank Telescope, kept a close eye on that region of space. That region of space had appeared to go into a dormant state in the beginning of 2017 because of this, as Law, a scientist at Green Bank, states that the group had feared they missed their chance to study the bursts. Though, on August 26th, relief had spread across the team when a staggering fifteen bursts were collected in under an hour! This put forth the idea that the repeating may be more likely during specific seasons when the viewing planes would be more optimal, for example during the summer the universe “aligns” in such a way that allows the Fast Radio Burst to be more optimally collected. This suggest we are always getting burst from this area in space, but can only view them during the correct season. This is supported from the fact that over the years that region of space has “lit up” close to August and has died out after that. This could help aid in figuring out these Fast Radio Burst are, if scientist could determine why the burst are seasonal then a piece of the puzzle would be put into place (Drake).

Another Fast Radio Burst, this one not being a repeater like the last one, was observed coming from a galaxy located 6 billion light years from Earth. Astronomer Evan Keane, a scientist for the Square Kilometre Array, concludes that the burst probably came from two colliding neutron stars. Kiyoshi Masui states that this is the “measurement the field has been waiting for” because the burst can be used to peer into the past Universe. This specific burst was recorded in Australia and lasted for less than a thousandth of a second. Apparently, the viewing precision of the array in Australia was not fine enough, so the scientist there contacted those at the Square Kilometre Array and the scientist there determined that the burst came from a comparatively old galaxy, where the formation of stars does not occur. This strengthens the earlier premise that this burst came from two colliding neutron stars. The reason these bursts can come from two colliding neutron stars is because neutrons stars are very dense, high energy objects, so when two of them collide energy could be theoretically released as a Fast Radio Burst. The scientists had predicted a model of colliding neutron starts that was what they had observed. Had they not observed their prediction their confidence in the prediction would not have been noteworthy.

The Lormier Burst, the first detected burst in 2007, is thought to possibly come from several different events. Like the previous burst this burst could have come from merging neutron stars, or an even more interesting event: an evaporating black hole. The reason a Fast Radio Burst could come from an evaporating black hole is because a black hole is a massively dense object. This mass, when evaporating may evaporate into massive amounts of energy. This energy may be emitted as a Fast Radio Burst. This burst was spotted among the data from the Magellanic Cloud; the cloud is a dwarf galaxy near the Milky Way Galaxy(Lormier).

Originally Fast Radio Bursts were thought to have an origin in the Milky Way. Even an astrophysicist at Caltech made a thousand-dollar bet that the bursts come from within our galaxy (Gibney). While inter-galaxy bursts have not been ruled out multiple extragalactic burst have been observed, meaning that these high energy burst are even stronger than thought before, because they lose some of their energy travelling though the universe. Therefore, the non-intergalactic nature of a majority of these bursts have help scientist learn that they are from events that release more energy than could possibly be produced in our galaxy. Another helpful feature in figuring out what the bursts are is the fact that they could have “two or three populations” as stated by Petroff, meaning that there are the repeating kinds, non-repeating kind and perhaps another that has not even been observed yet. Though it is also argued that only repeating burst exist, but our telescopes are not sensitive or accurate enough to pick up all the repetitions. As a minimum though at least we know they are not from microwaves.

While Fast Radio Bursts are interesting one may ask what purpose do they hold in our understanding of the universe? These Bursts can be used to determine what was occurring at the time of their creation. For example, with the second burst that was discussed we could find out what was happening in that region of space 6 billion year ago, which would give a way to see how the universe formed. The further away the burst came from, the further into the universe’s past we can see. For example, researchers have demined that the burst came from two colliding black holes, meaning that in that region of space there was enough materials to create two black holes and enough time for the same black holes to collide with each other (Stierwalt). Also, we can map out the medium between the Earth and where the Fast Radio Burst originated from, such as a Fast Radio Burst that was observed to be spiraling suggesting that the burst crossed a strong magnetic field before reaching our telescopes (Schilling).

Fast Radio Burst are quick, high energy, burst that are detected by radio telescopes. While they last milliseconds the impact they have on our understanding of the universe will last lifetimes. The burst could come from aliens, catastrophic events or some unknown origin, such as evaporating black holes or colliding neutron stars. While it is not known from what these bursts come from we do know they end up here on earth allowing us to gain information about the medium of the vast universe around us. Perhaps, one day the origin of them will be determined and the universe will become an open book of understanding for the human species to simply read.

Bibliography:

Chatterjee, S., C. J. Law, R. S. Wharton, S. Burke-Spolaor, J. W. T. Hessels, G. C. Bower, and J. M. Cordes et al. 2017. "A Direct Localization Of A Fast Radio Burst And Its Host". *Nature* 541 (7635): 58-61. doi:10.1038/nature20797.

Gibney, Elizabeth. 2016. "Why Ultra-Powerful Radio Bursts Are The Most Perplexing Mystery In Astronomy". *Nature* 534 (7609): 610-612. doi:10.1038/534610a.

Hall, Shannon. 2015. "Microwave Ovens Spark Radio Signals - Sky & Telescope". *Sky & Telescope*. http://www.skyandtelescope.com/astronomy-news/microwave-ovens-spark-radio-signals-peryton-05122015/.

Lorimer, D. R., M. Bailes, M. A. McLaughlin, D. J. Narkevic, and F. Crawford. 2007. "A Bright Millisecond Radio Burst Of Extragalactic Origin". *Science* 318 (5851): 777-780. doi:10.1126/science.1147532.

"Mysterious Radio Bursts Originate Outside The Milky Way". 2017. *Science | AAAS*. http://www.sciencemag.org/news/2017/01/mysterious-radio-bursts-originate-outside-milky-way.

Photograph NRAO/AUI, Reuters. 2017. "Storm Of Strange Radio Bursts Emerges From Deep Space". *News.Nationalgeographic.Com*. https://news.nationalgeographic.com/2017/09/radio-bursts-galaxy-space-breakthrough-listen-science/.

Stierwalt, Sabrina. 2017. "What Are Fast Radio Bursts?". *Scientific American*. https://www.scientificamerican.com/article/what-are-fast-radio-bursts/.

Strauss, Mark. 2017. "Strange Radio Bursts Seen Coming From A Galaxy Far, Far Away". *News.Nationalgeographic.Com*. https://news.nationalgeographic.com/2017/01/fast-radio-bursts-galaxy-frb-121102-black-hole-space-science/.

Zastrow, Mark. 2016. "Mysterious Radio Burst Pinpointed In Distant Galaxy". *Nature*. http://www.nature.com/news/mysterious-radio-burst-pinpointed-in-distant-galaxy-1.19441.