ISSN 2616-7433 Vol. 3, Issue 6: 1-3, DOI: 10.25236/FSST.2021.030601

The Inflation Period and the Search for Dark Matter

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Abstract: *This summer PBL is designed to help us understand the formation of the universe, as well as the formation of galaxies. We spent the class time going through vocabulary words, the stages of universe expansion, signs of the big bang, researching dark matter, dark energy, the theory of relativity, etc. During our final session of class time, we researched a lot of information about the inflation period, specifically how the inflation period solved 4 major issues, as well as 3 different experiments that are searching for dark matter. In this write-up, I am going to summarize and explain all of the research we did.*

Keywords: *inflation period; Dark Matter; Horizon Problem; Flatness Problem; Monopole Problem*

1. Inflation

1.1 What is inflation

Inflation is a period of time when the Universe was rapidly expanding(exponentially) in size right after the Big Bang. It was developed around the 1980s to tackle some problems that arose because of the Big Bang, which stated that the universe expanded gradually after the explosion.

1.2 Some Underlying Problems with the Big Bang

Of course, the Big Bang Theory is not perfect, and for this class, we focused on three different issues plus a fourth one as a bonus: the Horizon Problem, the Flatness Problem, the Monopole Problem, and the Seed of Structure Formation Problem.

1.3 How each one of those problems is solved

1.3.1 The Horizon Problem.

The regions of space that are at the opposite ends of the sky are very far apart. Since they are so far apart, they could never be in frequent contact with each other because the amount of time that light needs to travel from one end to another is longer than the age of the universe. But based on the microwave background temperature, they must have been in frequent contact. But since inflation states that the universe expanded very rapidly during the first few moments of the universe, these regions could have been in close contact, but since the universe expanded so quickly, they were no longer close to each other and even light can’t reach from one end to the other in time, therefore solves the horizon problem.

1.3.2 The Flatness Problem.

NASA’s WMAP determined that the universe appears to be nearly flat. But following the Big Bang Theory, the curvature of the universe grows with time, so the universe should have some curvature by now. So there must have been some very rare events happening in the past to make the universe appear as flat as today, which is very unlikely. To explain this issue, we can think of our universe as a tennis ball, which is certainly very small, and we would see that the surface of the tennis ball is curved. Now let’s expand the scale to the Earth. We live on the Earth, but we barely notice that the Earth is actually curved, but we know it is, we just don’t notice it. Now let’s expand the scale to the size of the universe, which is so big that no one can comprehend it. At this point, even if the universe is curved, because of the extremely massive size of the universe, we cannot notice any curvature upon our observation.

1.3.3 The Monopole Problem.

As we all know, every magnet on Earth has two poles, even the Earth itself has two poles. If we try

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to cut a magnet in half, a new north and south pole will be formed to compensate for the double pole for each magnet principle. The Big Bang theory predicts that a very large amount of magnetic monopoles should have been produced, but we cannot find any. But the Inflation theory brings in the idea of density into this problem. If we have a lot of needles inside a small box, we can obviously see that the box is filled with needles. But if we drop the needles into an ocean, then we can hardly find any of those needles. The same theory applies to the Monopole Problem. There could have been large amounts of magnetic monopoles, it is just that the universe is way too massive for us to find any monopoles.

1.3.4 Bonus.

Relating to the structure of the universe. If we have a grain of sand inside a house, the grain of sand would hardly take up any space in the house. Compared to the house, the sand is unnoticeable. But if we expand the house to the size of the universe, then imagine how much space the grain of sand is going to take up now. And this is the theory of galaxy formation. When the universe was very small, like an atom, the "galaxies" were unnoticeably small, but as the universe expanded, the more dense parts of the universe became galaxies and stars.

2. Results

Inflation introduces an extremely massive model of the universe to tackle some of the most challenging problems lying within the Big Bang theory. By assuming that the universe is large to the point of incomprehensible, we can prove something that we normally cannot understand, such as the universe is so large that it is impossible for light to travel from one end to the other.

3. The Search for Dark Matter

3.1 CERN

CERN is best known for its large hadron collider. CERN's idea is to use their large hadron collider to create dark matter. The LHC consists of a 27-kilometre ring of superconducting magnets with a number of accelerating structures to boost the energy of the particles along the way. Inside the accelerator, two high-energy particle beams travel at close to the speed of light before they are made to collide. Since dark matter does not interact with any electromagnetic force, therefore dark matter is extremely hard to spot. CERN has been trying to make dark matter by colliding beams of protons.

3.2 China Dark Matter Experiment

The China Dark Matter Experiment is an experiment conducted to search for WIMP (weakly interacting massive particles) particles at the China Jinping Underground Laboratory. It uses a detector called p-type point contact germanium (PPCGe) detectors. The energy spectra induced by the elastic scattering between dark matter particles and target nucleons in the CDEX detector system could give the information of dark matter mass, spin, and other properties. The laboratory is located 2400 meters underground, which makes it the deepest laboratory in the world. This laboratory is surrounded by thick rock cover that prevents cosmic rays from reaching the lab. Since dark matter can penetrate through anything, the only thing that the detector will detect anything is when dark matters appear.

3.3 Stawell underground physics laboratory

This laboratory is built inside a gold mine, located 1025 meters below the ground surface, providing shielding against the background cosmic rays. The SABRE (Sodium Iodide with Active Background Rejection Experiment) is conducted to directly detect dark matter particles by their scattering off nuclei. This project has two detectors, one in the southern hemisphere location, which can possibly detect WIMP(weakly interacting massive particles), and the other one in the northern hemisphere, which is showing possible dark matter hits, making this experiment one of the most exciting experiments for dark matter detection in the world right now.

4. Summary

From these three experiments, we can see that in total, there are mainly two ways of detecting dark

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matter, either trying to block any kind of cosmic rays and radiation and directing, trying to detect dark matter, or trying to create dark matter by ourselves. The current status of dark matter detection is that there is still no signs of any possible detection, but with these two ways of detecting dark matter, and these amazing experiments conducted in effort of doing so, dark matter discovery can happen in the near future.

References

[1] Froborg, Francis. (2016). SABRE: WIMP Modulation Detection in the Northern and Southern Hemisphere Sheffield. p. 11. Retrieved August 20, 2021, from http://www.taup-conference.to.infn.it/2015/day3/parallel/dma/7_froborg.pdf

[2] Jonathan Webb (2015). "Large Hadron collider restarts after pause" BBC. Retrieved August 20, 2021, from https://www.bbc.com/news/science-environment-32160755

[3] Science China Press. (2021). The China Dark Matter Experiment Listens to the Sound of Cosmology From a Laboratory Deep Underground. SciTechDaily. Retrieved August 20, 2021, from https://scitechdaily.com/the-china-dark-matter-experiment-listens-to-the-sound-of-cosmology-from-a-laboratory-deep-underground/

[4] WMAP. (2010). What is the Inflation Theory?. Universe 101. Retrieved August 20, 2021, from https://wmap.gsfc.nasa.gov/universe/bb_cosmo_infl.html