

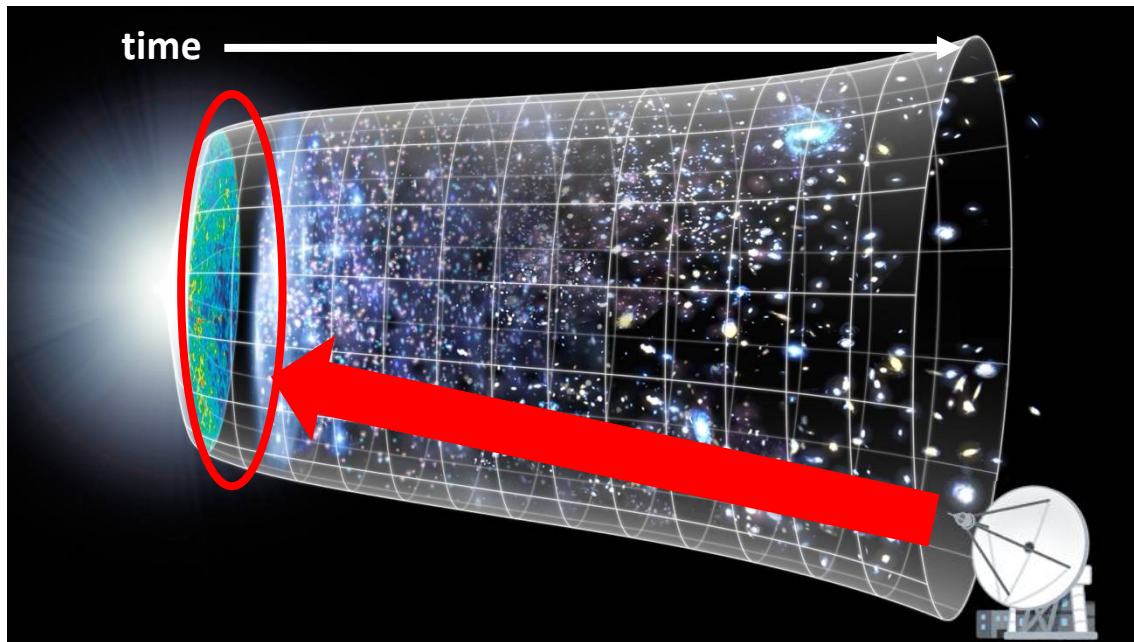
Shedding light on the dark universe

Author: Amiri Hirayama

How do you think you can explore what the universe was like a long time ago?

The answer is that you should investigate the distant universe. Since the light from a faraway place has traveled for millions of years, observing the distant universe means observing the past universe. So, humans have investigated the past universe by observing various kinds of light (ex. visible light, ultraviolet light, and so on) emitted from distant stars and galaxies. However, before those stars and galaxies were born – just one hundred million years after the beginning of the universe – there were just clouds of neutral hydrogen atoms, which didn't emit any of those kinds of light. Then, how can you investigate this era, "the Dark Age"?

We have the only solution for this problem. Neutral hydrogen clouds emit the 21cm line, whose name comes from its wavelength. This light is generated through the interaction between a hydrogen nucleus and an electron orbiting it, which is known as a hyperfine transition of hydrogen. By observing this light, you can investigate the early universe, including the Dark Age! Unlike the other kinds of light, the observation of the 21cm line has just begun. This is because we must cope with significant contamination from the atmosphere, galaxies, and so on to observe the desired 21cm signal. You can still observe later periods than the Dark Age from Earth, but the atmosphere becomes a more serious problem as you go back in time. So, to reach the Dark Age, you must build telescopes on the Moon! However, the day is approaching when we can start precise 21cm cosmology, thanks to the recent development of analytical and experimental methods to overcome these challenges. We will also be able to observe the Dark Age in the not-too-distant future.



(image taken from NASA/WMAP Science Team)

Since the Dark Age is a period we have never investigated, it will provide us with much information about the universe. One example is the detail of the cosmic beginning. The universe is assumed to have experienced an accelerated expansion at its beginning, "inflation." Inflation generated fluctuation in the matter density distribution, which gradually grew with gravity to form stars and galaxies. However, the fluctuation still didn't grow so much by the Dark Age, so the matter density distribution at that time well preserved the information on the inflation process. Therefore, by measuring the density distribution of hydrogen clouds during the Dark Age through the 21cm line intensity, you can extract information on the inflation process. My research topic is to estimate the amount of information on inflation extracted through this method, taking into consideration the influence of various types of contamination.

One of the reasons I feel excited about this research is that it proceeds human endeavor to explore the reason for our existence. The fluctuation generated by inflation is the origin of everything, from stars and galaxies to even ourselves. So, investigating

the property of it means approaching the origin of ourselves. I suppose nobody wouldn't get curious about this topic. Another thing I feel excited about is that the 21cm line is a new probe of cosmology we have hardly ever used. When our research progresses successfully to realize the future 21cm observation - although it may be quite a ways down the road - we might see not only the desired results but unexpected facts.

Before I started this research, I had trouble deciding my research topic because I didn't have a strong preference or knowledge about specific fields of astronomy. Although I had an interest in astronomy since I was young, I didn't explore it further until I entered university, partially because I only focused on things right in front of me, such as my homework, examinations, and club activities during my middle and high school days. So, I would advise my 12-year-old self to spend more time digging into what you want to learn rather than what you must. Astronomy isn't what you can never understand until you get enough knowledge on required math and physics, as you may think. You can find many books explaining it precisely and plainly. Knowing just abstract concepts of various fields of astronomy would surely help you find the right ways to explore your interests further in university. For example, it will help you choose appropriate fields of physics to study in advance before understanding a specific field of astronomy.

Another piece of advice is that you shouldn't restrict your desire for knowledge to what you currently think is related to your future. Academic fields interact with each other, so it's highly likely that seemingly unrelated things play a crucial role in your field. For example, you might see no relation between machine learning and astronomy. However, machine learning is gradually becoming important in the analysis of observational data of the universe. So, if you find something interesting, you should

consciously pursue the details of it. That might lead you to unexpected exploration into a new aspect of the world.

I used Grammarly to check the grammar.