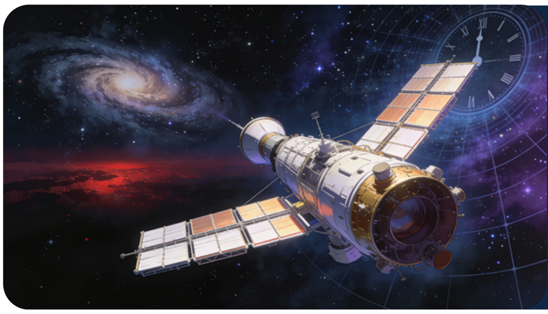
Telescopes or Time Machines?



TELESCOPES TO WATCH THE EARLY UNIVERSE

Einstein's Theory of Relativity and the Flow of Time

According to Einstein's theory of relativity, time is relative to the observer, which would also mean that the faster you move, the slower time ticks for you, and similarly, the stronger the gravitational force, the slower the time ticks relative to the observer.

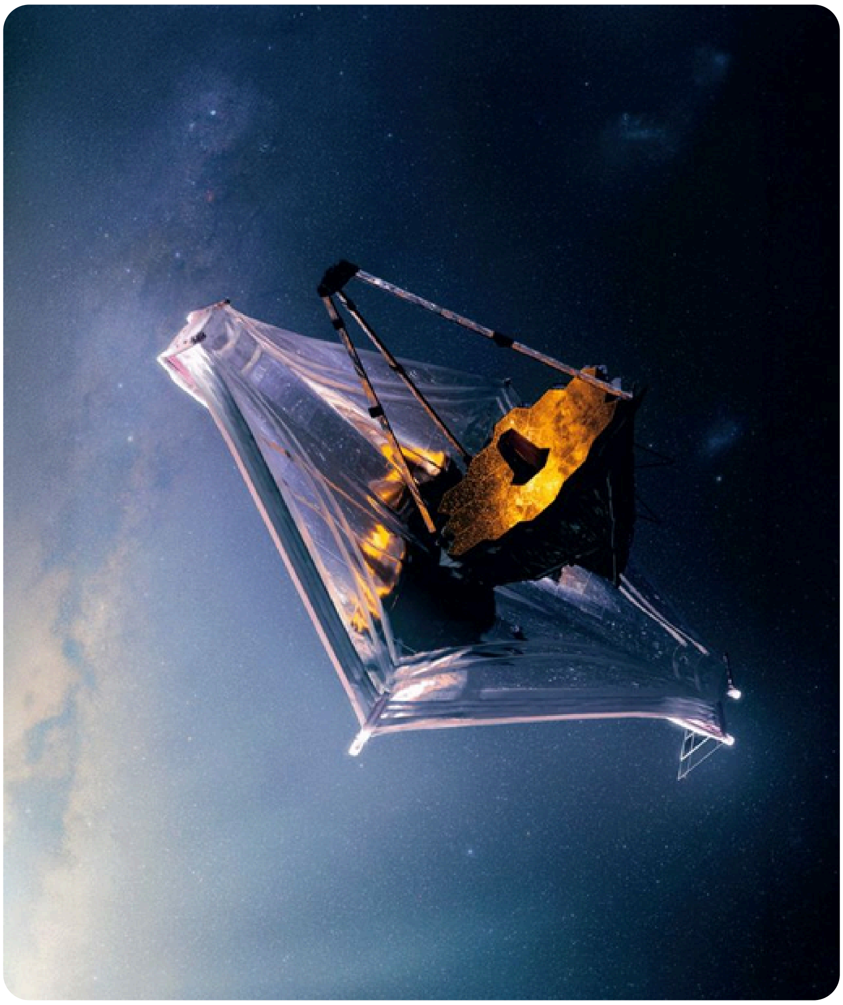
If we are moving very, very close to the speed of light, time for us would be very slow, so for a photon, which basically is the light, time never ticks (a photon never has a rest frame). So when a photon falls on our telescope from, let's say, 10 light-years away, relative to us, the photon travelled for ten years, but from the photon's perspective, those ten years never happened. Now, if we think about it, that's an interesting concept, but the real question here is, what does it make the telescope we used to observe the photon that travelled ten years, just another instrument used to focus light or a time machine?

Telescopes as Time Machines

Our universe is thought to have formed 13.8 billion years ago, in a big explosion where the heat reached Planck's temperature, the hottest the universe had ever been. Even today, mysteries regarding the formation of the universe linger in every curious mind. Every passing day, astronomers are striving to build bigger and better telescopes that will collect even the faintest light from faraway galaxies, quasars, and other celestial bodies. If we could collect the light coming from centuries away, maybe we could see the early universe, giving us more insight towards the formation of celestial bodies.

The James Webb Space Telescope and the Extremely Large Telescope, under construction, are explicitly made to study the early universe. This is through telescopes that we are aiming to see the past of the universe we live in, using the finite speed of light.

James Webb Space Telescope

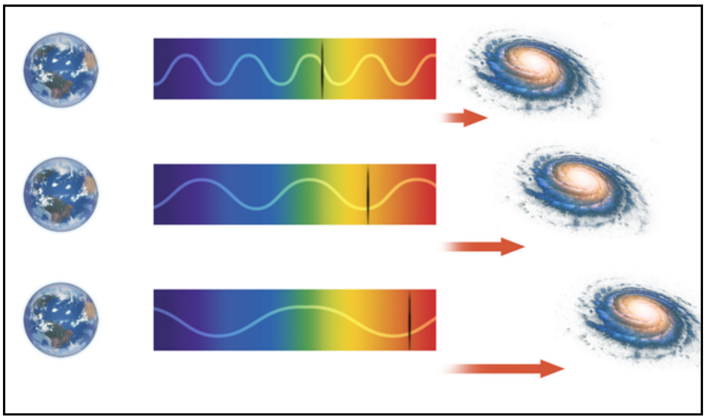


Putting a Date on the Photons

When the light from a distant galaxy travels through the universe, which is in a state of constant expansion, the light's wavelength stretches. The farther the galaxy or star, the more the light would stretch towards longer wavelengths (red light). This shift of light towards the longer wavelength is called Redshift.

Using this phenomenon, astronomers calculate the distance and the cosmic age of the celestial body they observe. For relatively nearby galaxies, a larger redshift usually means greater recessional speed, and through Hubble's law, a larger distance from Earth. For very distant galaxies and quasars, it would mean we are looking so much farther into the past, into the younger universe, which makes the redshift act like a cosmic clock.

Redshift



Early Universe

Fermi (Gamma Ray Telescope)

When the universe was formed, the heat from the big explosion reached Planck's temperature, and the light couldn't travel freely, as the universe was too hot and dense. In a nutshell, light was trapped in an opaque plasma. The Radiation was at gamma-ray energies, but it was constantly scattered by charged particles; it could not stream freely.

Today, we have gamma-ray telescopes, which study high-energy events in space and help us test ideas from the Big Bang theory and cosmic evolution. However, they are not designed to detect gamma rays from the actual Big Bang, as they have cooled into the CMB (Cosmic Microwave Background, the cooled afterglow we detect today) and moved out of the gamma ray part of the spectrum.

Conclusion

Even though a telescope doesn't look like all the fictional time machines we've imagined, if we think about it, this instrument, which has polished surfaces of lens or mirror carefully aligned to capture the photons, shows us the story of the universe, which took place before us, through the physics encoded in the photons it catches.

What is important for all of us to understand here is that when we are looking into the past of the universe, the galaxy, the star, or the quasar, we are not seeing their present either; time has been passing for the object as the light has been travelling. So, essentially, we are looking at the photograph of what the object looked like, let's say 10,000 years ago, if it is located 10,000 light-years away.